

INTEGRATED INFRASTRUCTURE CAPITAL PLAN (IICP)

Prioritized Sanitary Capital Plan

Prepared for:

The City of Castlegar

August 2018

Submitted by:

URBAN
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Report for

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Prioritized Sanitary Capital Plan

Prepared for

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1.0 INTRODUCTION

Climate change is an important issue for British Columbia. One of the most serious impacts of climate change is the increase of extreme events – warm days and precipitation. Forecasts suggest that the province will experience temperature increases by mid-century, relative to historical average, of between 2 to 4°C. It is anticipated that the number of heavy precipitation events will increase in frequency and magnitude and there will be a shift in the seasonal pattern of occurrence. These changes will also result in a longer growing season, and increased likelihood of floods and droughts. These changes in climate will likely result in decreased infrastructure service-life and potential catastrophic infrastructure failures. For example, an increased frequency of freeze/thaw events will degrade roads (reduce service life), and increased frequency and magnitude of extreme precipitation events will result in floods and potential infrastructure damage due to undersized drainage capacity.

Incorporation of climate change into asset management and master plans has so far been limited, with the vast majority of new infrastructure continuing to be designed using established codes or history-based, asset-specific environmental criteria. The impacts of climate change will increase infrastructure replacement and maintenance costs as we move forward. The climate-related challenges that communities face are compounded by the maintenance, monitoring and replacement costs of aging infrastructure.

The objective of this report is to provide a risk-based approach and an intuitive process to integrate climate change with asset management into the capital planning process for the City's sanitary sewer infrastructure.

1.1 Background

In 2010, a PIEVC Engineering Protocol for Climate Change Infrastructure Vulnerability Assessment was completed for the City of Castlegar's stormwater infrastructure. The intent of this PIEVC Protocol was to improve the community's understanding of the context for developing local climate change adaptation strategies. To date, the results of this assessment have not been incorporated in any City plan. The City of Castlegar recently received funding under the Strategic Priorities Fund for the development of an Asset Management and Climate Change Prioritization Framework that incorporates the PIEVC results for the City's linear infrastructure assets.

The primary outcomes from this assignment are:

- To establish a good understanding of the existing sanitary sewer collection system by creating a reliable and accurate hydraulic model;
- To create a prioritized list of renewal (condition), capacity (growth) and regulatory (compliance) projects that embraces a triple bottom line approach and addresses all legislation/regulations, aging infrastructure and future growth (asset management plan) and has considerations for a changing climate;

- Conduct a climate change vulnerability assessment using the PIEVC results and create a scenario where these results are integrated with the asset management plan,
- Identify the funding requirements needed to meet the City's risk and service level requirements for infrastructure investment on an average annual basis,
- Utilize results to inform an integrated capital plan for roads, water, drainage and sanitary sewer (provided under separate cover); and
- To provide sufficient knowledge transfer to allow City staff to adopt and utilize the decision-making process for capital planning, infrastructure investment and climate change decision-making.

In parallel to this report, the City is completing a detailed assessment of the North Lagoons Treatment Facility to refine the costs and timing of the improvements needed to meet service and regulatory requirements.

The development of the Integrated Infrastructure Capital Plan (IICP) which combines the results of the water, sanitary, drainage and roads risk assessments will need to also consider the results of this study.

1.2 Technical Memoranda

Four (4) technical memoranda were completed throughout this study to inform the overall strategy. Each section of the master plan is derived from previous analyses discussed in these memoranda.

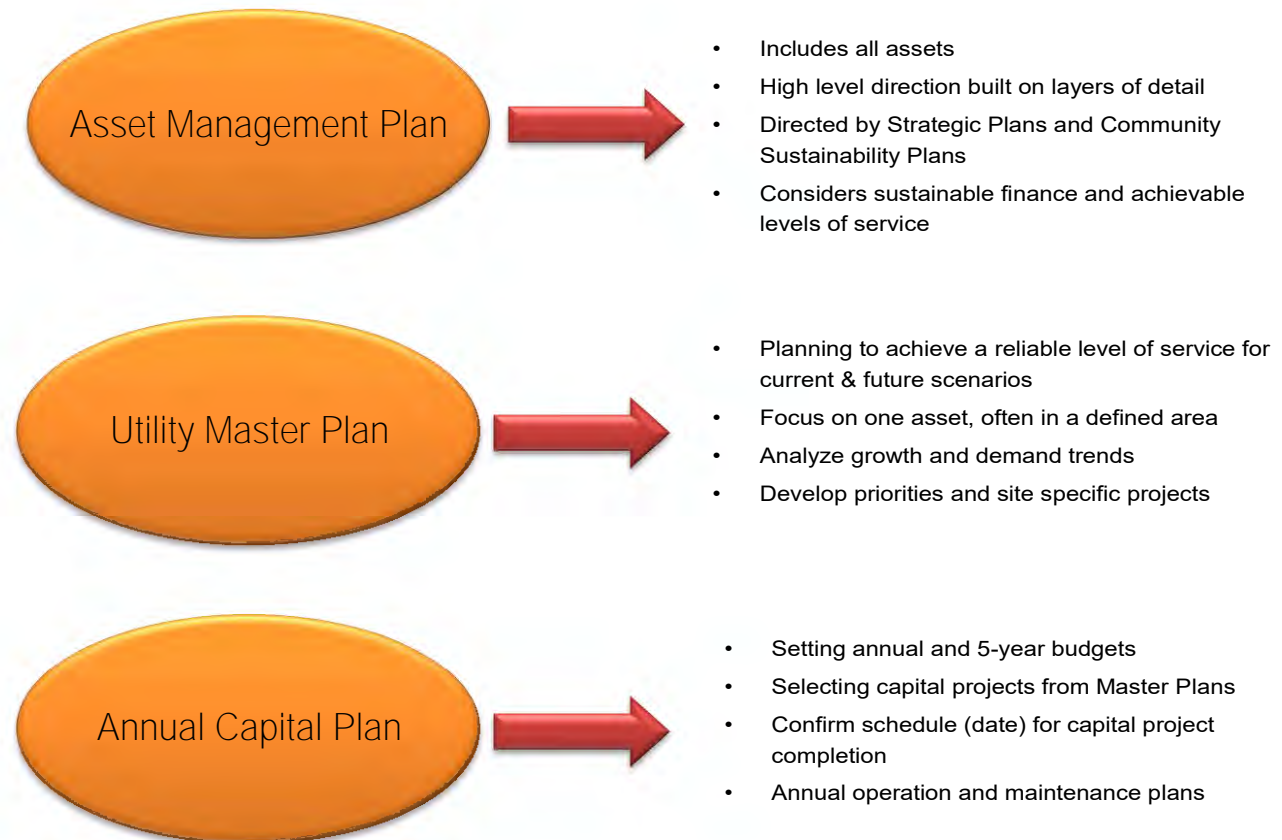
For readability, only summary information from each technical memorandum is provided in this report where required to support the capital plan. However, for convenience a reference note is provided in key sections for the location of the related technical memorandum to allow the reader access to more information, if desired. Furthermore, some key findings from the technical memoranda are also included in order to support conclusions. **Table 1.1** below lists the technical memoranda; they are located within **Appendix A**.

Table 1.1 – List of Technical Memoranda

	Description
1	Design Criteria and Analysis
2	Hydraulic Modelling Results
3	Sanitary Sewer Capacity Risk Assessment Methodology
4	Sanitary Sewer Condition Risk Assessment Methodology

1.3 Infrastructure Hierarchy and Governance

Levels of service and policy, asset management, master planning, capital planning, and annual programs are all related; however, they should be evaluated and implemented separately for clarity and maximum effect. The infrastructure hierarchy is illustrated below:



Using this hierarchy for infrastructure planning, it is clear that establishing service levels and risk for the City's sewer utility are a priority in determining where to invest the City's limited infrastructure renewal budget.

1.4 Guiding Approach

The approach to developing this plan was one that is holistic in nature. Master utility planning is currently undergoing a significant evolution as communities move from focusing solely on hydraulic servicing capacities and taking the perspective that "bigger is better", towards a more holistic and integrated risk-based approach that considers economic, social, and environmental and climate change factors.

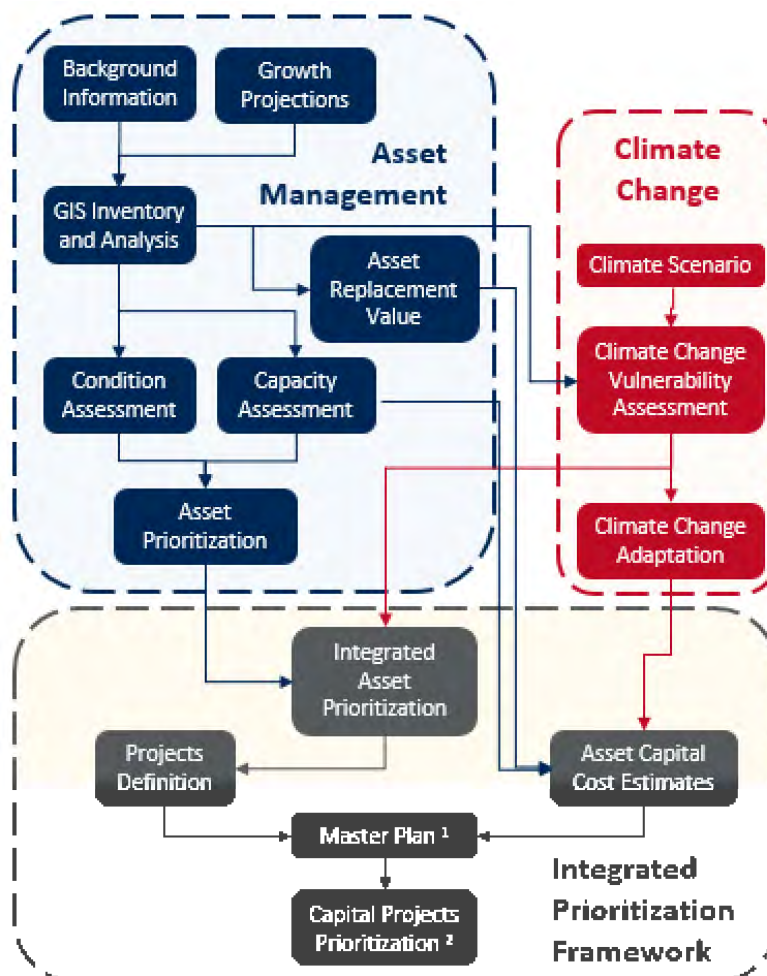
This approach looks to not only service future growth and address the potential impacts of a changing climate but to also help shape future infrastructure investment through capitalizing on existing infrastructure capacity.

Furthermore, this plan was developed in a collaborative fashion with City staff, building capacity within staff to fully understand the methodology utilized to develop the models and master plan; this is sure to support effective implementation of this plan over the long term.

Typically, identification of capital upgrades in an asset management context is completed based on an assessment of condition and/or capacity; however, the approach that guided this master plan includes *prioritization* of capital upgrades based on condition *and* capacity *and* risk with an additional scenario where changing climate conditions are considered.

Determining the list of capital priorities in Castlegar followed a scenario-based assessment of levels of service, which required two key analyses: network hydraulic modeling and a risk assessment with and without climate change. These analyses are summarized in **Section 3.0**.

The figure below illustrates the methodology and integration of climate change into the asset management planning process.



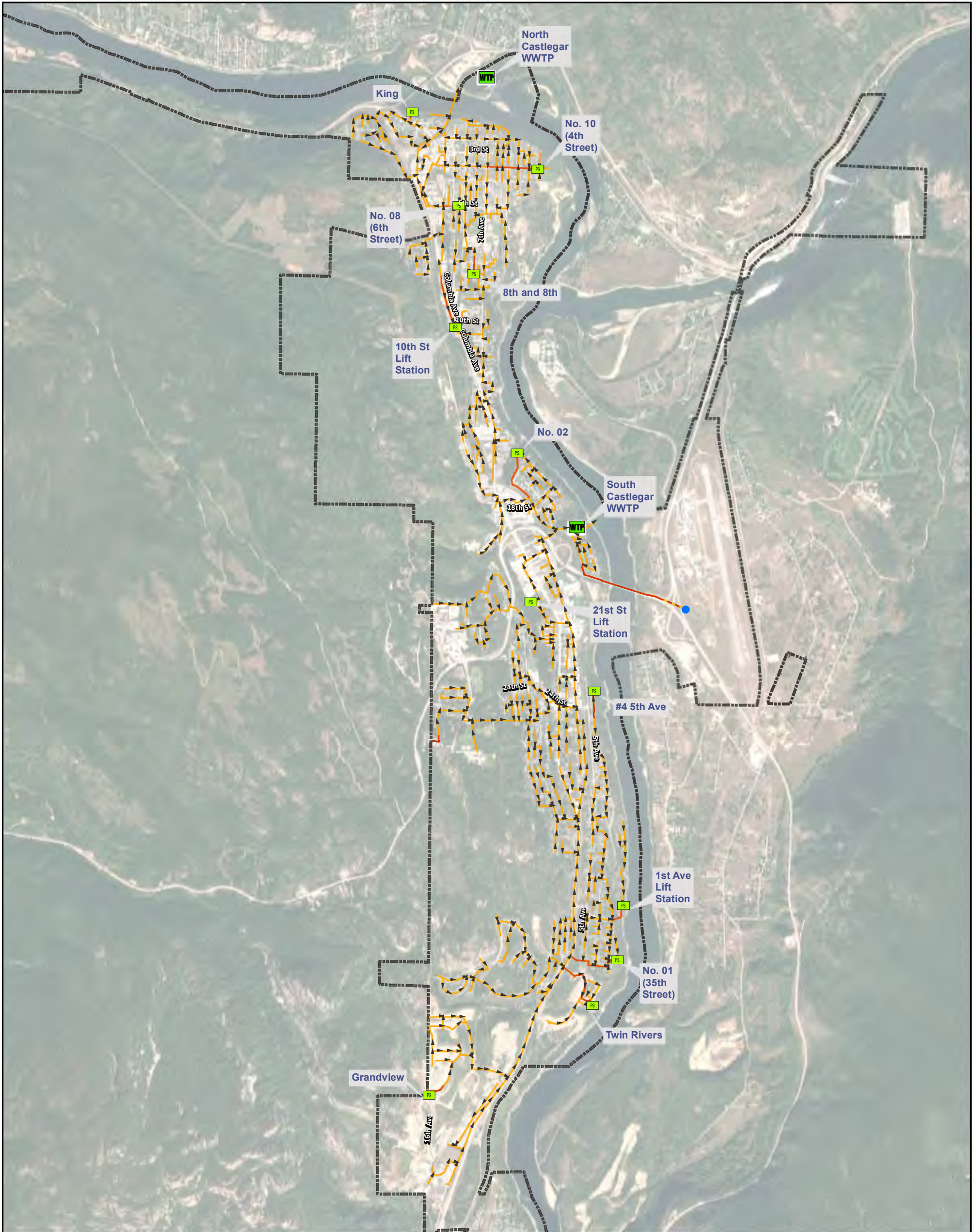
2.0 COMMUNITY CONTEXT

The City's vision for the community is to create a diverse, resilient, financially sustainable and healthy community through sound fiscal management, smart growth development, and wise capital asset reinvestment to ensure the sustainable delivery of municipal services. The goal of this vision has been incorporated into this plan.

2.1 Current Sanitary Sewer Infrastructure

The City operates a community sanitary sewer collection system with two wastewater treatment plants: the South Castlegar plant and the North Castlegar lagoons. The system relies on a gravity collection system made up of approximately 74 kms of pipe and 12 lift stations which gathers the sewerage and conveys it to the two treatment facilities and eventually discharges to the Columbia River.

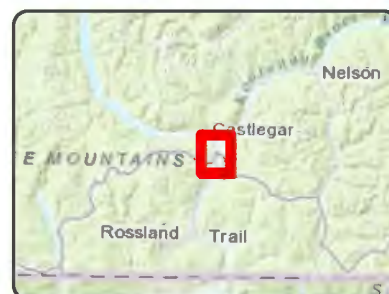
The City's existing sewer system is shown on **Figure A**. The total estimated replacement value for the existing assets is approximately \$50 million. These replacement costs include the existing collection system components such as mains, laterals, manholes, lift stations and both treatment plants including the lagoons.



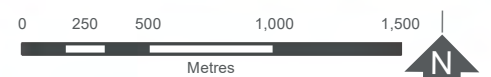
City of Castlegar
 Integrated Infrastructure
 Capital Plan (IICP)
Existing Sanitary System

Legend

- Lift Station
- Siphon Chamber
- WTP Treatment Plant
- Gravity Main
- Pressure Main



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



Coordinate System: NAD 1983 UTM Zone 11N
 Scale: 1:30,000

Data Sources:
 Data provided by -
 City of Castlegar
 Urban Systems

Project #: 0841.0099.01
 Author: BP
 Checked: SS
 Status: ~ DRAFT ~
 Revision: A
 Date: 2017 / 10 / 6



FIGURE A

3.0 SYSTEM HYDRAULIC PERFORMANCE

This section presents summary results of the hydraulic analyses for an existing conditions scenario and the future conditions scenario.

3.1 Hydraulic Modelling Summary

The latest edition of the MMCD design guidelines provides the basis for the design criteria utilized in the hydraulic model analysis.

EXISTING CONDITIONS MODEL

The model was developed and calibrated for accuracy and completeness using flow records from the City. The model development exercise included naming the pipe and manhole items to match the asset identifiers currently assigned by the City in GIS.

The inverts and depths were created to match record drawing information (where available), and to follow a fixed depth below existing grade where no records were available.

For calibration purposes, the City provided flow monitoring records from January 1 to December 31, 2016, for the North and South Castlegar Waste Water Treatment Plants. Calibration was conducted under dry-weather and wet-weather conditions. Dry-weather flow records were used to calibrate dry weather flow rates (base sanitary flow + groundwater infiltration) by adjusting per capita sanitary loading rates to match the average dry-weather flow observed at the treatment plants. Wet-weather flow records were used to calibrate I&I rates to match the peak wet-weather flow observed at the treatment plants.

The magnitude of existing sewer loading in the model was adjusted to match the data provided in the city-supplied SCADA data.

FUTURE CONDITIONS MODEL

All future sewer loads were applied using the design criteria as set out in Sanitary Sewer System Technical Memorandum #1. For each parcel, the projected unit count (or square meters of ICI) was converted to an equivalent flow in litres per second (L/s) and that flow was assigned to the upstream manhole of the pipe servicing the property.

MODELLING RESULTS

The analysis of the existing system under wet weather conditions estimates surcharging (but not flooding). The model assumes that I&I is evenly distributed throughout the City. The analysis identified 32 pipe segments where surcharging was present. Specific locations and details are provided in Technical Memorandum #2.

The analysis of future growth impacts to the existing system reveals the system is very robust which includes no lift station deficiencies being identified. The model does predict that the 6th Street Lift Station is near capacity; however, since the predicted 2037 PWWF is within 1 L/s of the operating point, no upgrades were recommended as it is within model accuracy.

4.0 RISK ASSESSMENT AND CLIMATE CHANGE

The previous section detailed how pipe performance was assessed on flows in the existing conditions scenario and the future conditions scenario in an asset management *capacity context*.

The risk assessment typically tells us how to prioritize these capacity-related upgrades so that pipes that present the highest risk can be upgraded first. In addition, assessments were completed on the facilities to identify expected remaining life, compliance with regulations and identified the costs and timing of recommended upgrades.

In order to consider climate change, these two scenarios were analyzed again using the climate parameters discussed later in **Section 4.7**.

ASSET MANAGEMENT PIPE ASSESSMENT

4.1 Methodology

The risk assessment was completed with a focus on the two primary drivers of pipe failure: **condition** and **capacity**. For each of these drivers, the risk assessment was broken down into three parts:

- *Likelihood* of failure (i.e., probability)
- *Consequence* of failure (i.e., severity of environmental, social, and economic impacts)
- Assignment of total *risk scores* (after modification, if any, and combination of scores)

Once risk scores were assigned, *prioritization of asset replacement* could be completed according to which assets had the highest combined risk scores. Prioritized projects are summarized in **Section 4.8**.

Definitions of each of these parts and assignment of risk scores for use in the risk assessment are provided below.

4.2 Risk Due to Pipe Capacity

Likelihood of Failure: The likelihood of pipe failure due to capacity was assessed by analyzing the hydraulic capacity, HGL, and flow velocity of the pipe under normal operating conditions. How criteria specifically correlate to likelihood of failure is described in **Technical Memorandum #3**.

Consequence of Failure: The consequence of failure is a function of the land use type and associated population. For example, the consequence of failure to single-family residential buildings is lower than that of multi-story apartment complexes or industrial, commercial, or institutional buildings. Risk scores assigned range from 1 to 5, with 1 indicating an insignificant consequence of failure and 5 indicating a severe consequence of failure. How criteria specifically correlate to likelihood of failure is described in **Technical Memorandum #3**.

4.3 Risk Due to Pipe Condition

Likelihood of Failure: The likelihood of condition-based failure is driven by the Structural Condition Grade (SCG) of the asset. The SGC's were derived by the City from their CCTV inspection and data. These were developed with a methodology consistent with the *WRc Sewer Rehabilitation Manual*, shown below:

Numeric Scale	Linguistic Scale	Description	Action	Adjustment to Remaining Life Estimate
1	Acceptable	No Intervention	Routine Monitoring	None
2	Adequate	Minor ponding (<15% of D)	Cleaning and Flushing	None
3	Moderate	Minor Cracks/Deformation, Medium Ponding (<50% of D)	Low Rehab Priority, further deterioration is likely	Reduce by 25%
4	Poor	Medium to severe cracks/deformation, service connection defects + user complaints of back-ups (ponding is >50% of D)	Collapse is likely, high rehab priority	< 2 years remaining
5	Critical	Severe cracks/deformation, service connection defects, + extreme risk of basement flooding/property damage	Collapse is imminent, immediate repair	0 years remaining

Based on this rating, and as advised by the City, pipes with a score of 4 or greater were assigned the maximum score for condition risk. Pipes with a score of 3 were prioritized into the list of pipes for the City to keep an eye on and assess condition routinely.

For non-pipe assets and if pipe SCGs were not available, the asset was assigned a risk score based on its age. Asset age directly relates to the principles of asset management and tangible capital asset inventories. To exemplify the sensitivity of pipe age to the overall risk score, we provided two additional risk scenarios – one extended service lives by 25% and the other by 50%. These scenarios allow the City to easily observe the financial impact of choosing to take on more or less risk related to timing of asset replacement. Risk scores range from 1 to 5, with 1 indicating a low likelihood of failure and 5 indicating a high likelihood of failure. How criteria specifically correlate to likelihood of failure is described in **Technical Memorandum #4**.

Consequence of Failure: The consequence of failure is driven by two key factors: the cost to restore service and cover third-party liability (potential financial consequence) and the actual location of the infrastructure (potential traffic disruption consequence). How criteria specifically correlate to likelihood of failure is described in **Technical Memorandum #4**.

For this assessment, we also considered a primary driver of failure consequence to be whether a pipe is located within a road and if so, what the associated road classification is, as this indicates the level of traffic disruption that may occur due to failure. The cost to repair a sewer main break is closely linked to the type of road (and associated volume) that might be damaged as a result; for example, a failure within an arterial road presents greater traffic control and road reconstruction requirements than a failure within a local road. The City's GIS data set was used to analyze if a pipe is physically located within a road and if so, what the road classification and volume is.

4.4 Modification of Consequence Risk Scores

Due to their larger size or nearby surroundings, some sewer mains present an increased level of consequence of failure. For this risk assessment, consequence risk scores were increased by one (with no score greater than five) for pipes that met certain requirements regarding:

- **Pipe diameter:** higher consequences for pipes carrying larger flows
- **Proximity to ICI land use:** greater disruption and higher costs for repairs and upgrades if servicing Industrial, Commercial, or Institutional land use
- **Proximity to an environmentally sensitive area:** higher environmental consequences if adjacent to, or crossing, a sensitive watercourse, within an OCP designated ESA, or within a steep slope area

4.5 Combining Risk Scores

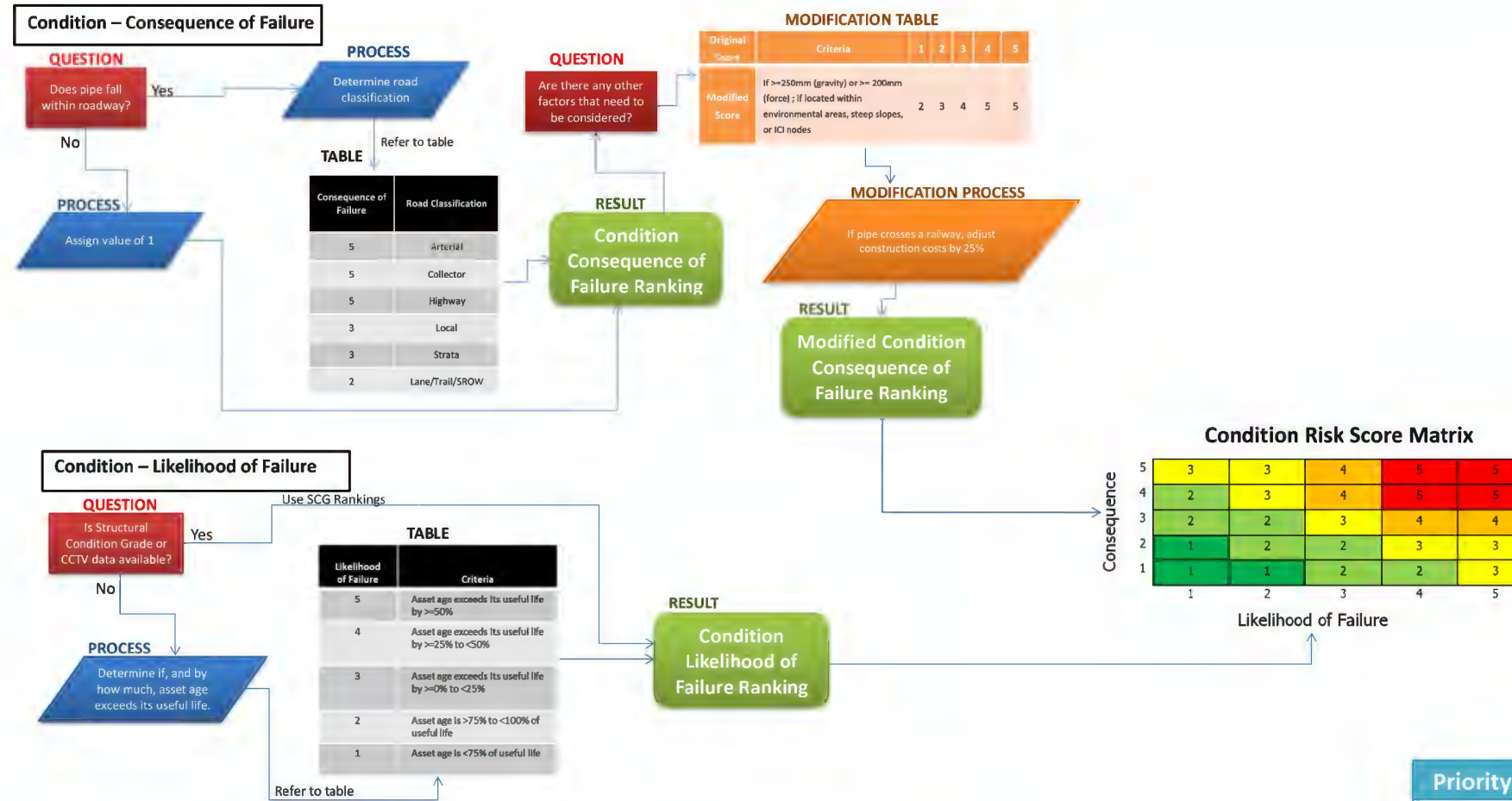
The combined risk score incorporates the likelihood of failure score and consequence of failure score into a single score ranging from 1 to 5, with 1 indicating a low risk and 5 indicating a high risk. In cases where video evidence or manual investigation proves that a sewer main has already failed, the combined risk score will be automatically set to 5.

By combining risk scores, the social (land use), environmental (proximity to watercourses) and economic (cost to restore service) impacts of pipe failure are considered. This triple-bottom-line methodology is the basis of the infrastructure plan for the City.

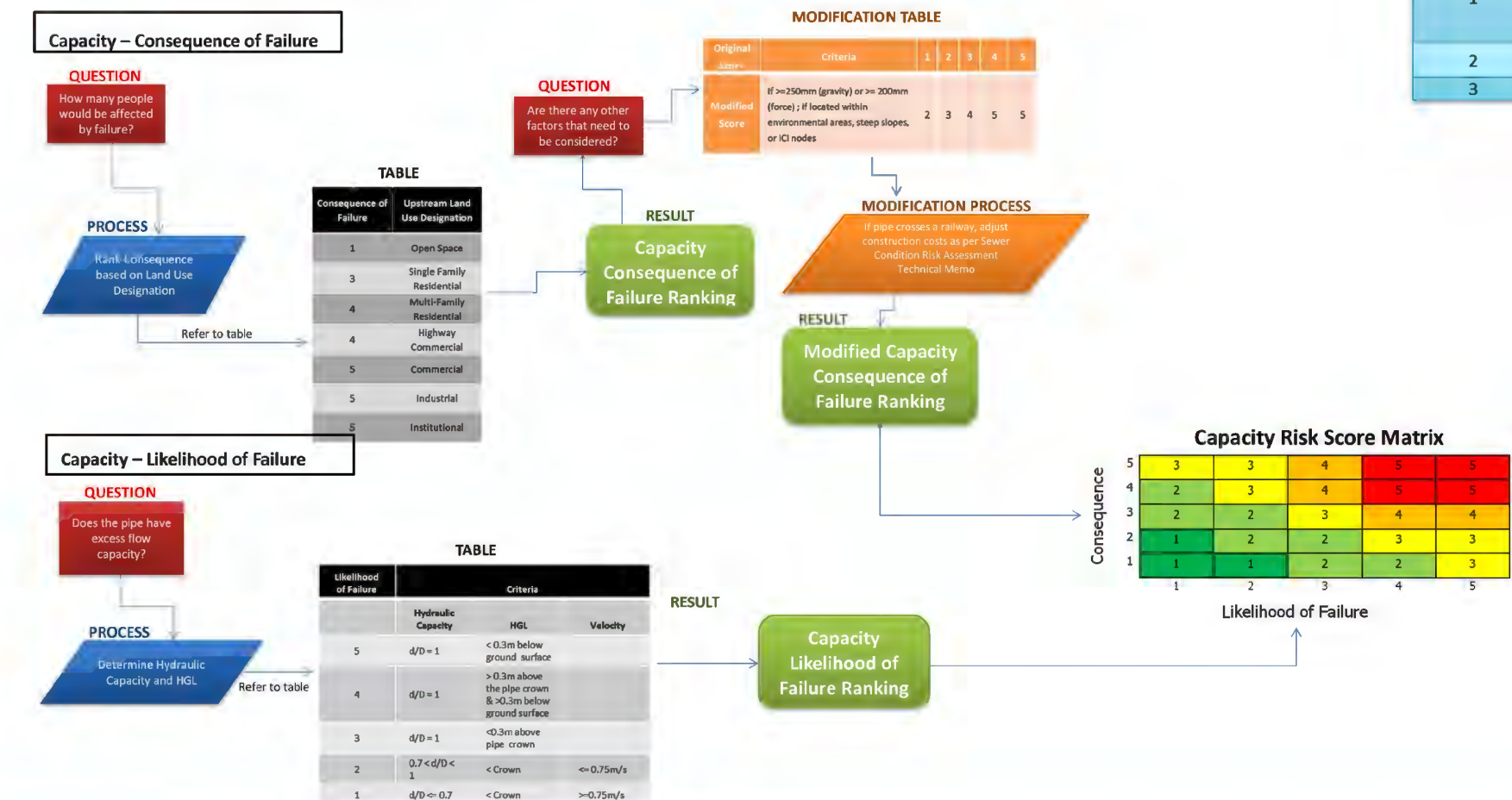
To illustrate this methodology and for convenient reference, a pullout schematic (**Figure B**) is included on the following page. It shows how the methodology is applied to one example pipe; once familiar with the definitions, the schematic should be an effective tool for the City to use for visualizing the process.



ASSET CONDITION



ASSET CAPACITY



Priority	Project Trigger
1	((Existing Capacity >= 3 or Future Capacity >= 4) and Existing Condition >= 4) OR ((Existing Capacity >= 3 or Future Capacity >= 4) and Future Condition >= 4)
2	Condition or Capacity Combined Risk Score >= 4
3	Condition or Capacity Likelihood of Failure >= 4



Figure B

4.6 Facility Assessments

The City operates a community sanitary sewer collection system with two wastewater treatment plants: The South Castlegar plant and the North Castlegar lagoons. It also operates 12 sewage lift stations throughout the City.

SEWAGE LIFT STATIONS

The sewage lift station assessments are provided on the facility data sheets in **Appendix B**. A summary of the estimated replacement costs within the 20-year horizon follows:

Table 4.1 – Estimated Replacement Costs

Sanitary Lift Station Identifier	Sanitary Lift Station Name	Estimated Cost	Estimated Timing
SLS0001	LS 01 (35 th St)	\$272,000	2029
SLS0002	LS 02 (Silverwood)	\$332,000	2020
SLS0003	LS 03 (1 st Ave)	\$78,000	2038
SLS0004	LS 04 (5 th Ave)	\$29,000	2022
SLS0005	LS 05 (8 th /8 th)	\$105,000	2026
SLS0006	LS 06 (21 st St)	\$35,000	2019
SLS0007	LS 07 (4 th St)	\$188,000	2026
SLS0008	LS 08 (6 th St)	\$171,000	2029
SLS0010	LS 10 (10 th St)	\$168,000	2024
SLS0012	King Ave	\$10,000	2038
SLS0013	Twin Rivers	\$0	-

SOUTH CASTLEGAR WWTP

This plant is an extended aeration activated sludge plant that was upgraded and expanded in 2006. The design life of the new components is in excess of 30 years, so capital replacement costs fall outside the 20-year horizon.

The original plant components date back to 1974, although significant refurbishment was undertaken in the 2006 expansion. The 2006 expansion included a new bio-reactor and clarifier, repair of the sludge drying ponds, new blowers, caustic dosing system for pH adjustment, new degritter and auger screen, replacement of diffusers in the old bio-reactor and UV lamps for disinfection. The plant also has a new SCADA system.

Blowers are reported to wear out before 20 years and the 20-year budget should include blower replacement. It should also include provision of a cover for the UV disinfection system as weather is deteriorating the UV apparatus faster than normal. The UV system is predicted to have 19 years of remaining service life.

Sludge drying in ponds using sawdust as a cover and bulking material appears to be functioning adequately. However, as the amount of waste sludge increases with population increases, it may be prudent to plant for a more compact form of dewatering.

The estimated budget for blower replacement and UV retrofit is approximately **\$300,000**.

NORTH CASTLEGAR LAGOONS

The North Castlegar lagoons were originally constructed in 1963 as non-aerated ponds. The conversion to aerated ponds occurred in 1975 and the Discharge Permit was amended in 1975 to include two aerated lagoons and a facultative lagoon. A further upgrade occurred in 1996 by upgrading the aeration system and de-sludging the ponds.

The current situation at the lagoon site includes a number of deficiencies as follows:

- Many of the sub-surface diffusers are not operating and should be replaced
- Islands of sludge are evident throughout and de-sludging is required
- One corner of the lagoon is used as a sani-dump (for trucked waste) and this is impairing the treatment capacity
- Ammonia has become an issue since the Federal Wastewater Regulations restrict Ammonia concentrations for discharges to surface waters.
- Chlorine residual must be removed after chlorination since chlorine is toxic to fish. Sodium sulphite is being used for de-chlorination but the concentrations are difficult to control with the use of “pucks”
- A berm failure occurred in 2014 and corrected with rock armouring in 2015.

It is evident that some significant investments are required to keep this facility operating successfully. The City is currently finalizing a more detailed assessment to determine the actual needs, costs, and timing of the upgrades, entitled, “*Assessment of North Lagoons Wastewater Treatment Facility*”. For more detail, please see this report. For the purpose of this document, we have assumed an estimate of **\$5,900,000** in 2019, as suggested in the draft detailed lagoon assessment report. The same report also discusses the optional item of nutrient removal, which would add an additional \$3,600,000.

4.7 Integrating Climate Change

Two primary factors are considered within the context of asset management – condition, which is an indication of service life; and capacity, which can trigger replacement or upgrades before service life has been reached. Therefore, for the purposes of asset management, only climate changes that impact condition or capacity of an asset have been considered. While it's true that an asset can be affected by catastrophic events such as floods, landslides, stream bank erosion, and/or forest fires – all potentially impacted by climate change – the occurrence of such events is typically not a factor in determining when to replace or upgrade a capital asset. The exception is for drainage assets, which are designed to protect most other infrastructure from surface runoff, and which can be impacted by climate change.

Risk is defined as the product of likelihood and consequence of failure. Since the consequence of failure has already been determined as part of the asset management assessments, the climate change risk assessment focuses on developing the likelihood that a future change in climate variables will result in a material change in the processes that cause reduced capacity and/or reduced service life for each infrastructure asset. This approach has been taken since it is often the combination of climate variables, rather than a single climate variable, that contributes to the impact that each process has on an asset's capacity and/or longevity.

In keeping with the likelihood scoring method outlined for the asset management risk assessment (a 1-5 scale), weighted likelihood scores were also developed for the climate change risk assessment. This was done using the following methodology:

- Identify processes that impact an asset's capacity and/or service life. These are called "failure processes" for the purposes of this assessment since, over time, these contribute to an asset's ultimate failure.
- Determine the climate variables that impact each identified process.
- Obtain the baseline value for each climate variable.
- Obtain the projected values (or projected change in values) for each climate variable for applicable time periods. In this case, the time periods are:
 - a. Baseline (1961-1990)
 - b. 2020s (2010-2039)
 - c. 2050s (2040-2069)
- Assign a likelihood score to each climate variable change. Scoring is an integer from 1 to 5, with 1 being very unlikely and 5 being very likely.
- Assign "climate contribution scores" to reflect the contribution that the projected change in each climate variable associated with each process has on that process. A scoring range of -2 to +2 was used, with the allowance of decimal fractions within that range. A score of -2 indicates that the projected change in the subject climate parameter significantly impacts the process but reduces or perhaps even reverses the reduction in capacity

and/or service life. A score of +2 also significantly impacts the process but increases the reduction in capacity and/or service life. Note that this process relies heavily on engineering judgement based on experience.

- Calculate the weighted likelihood for each failure process using the climate variable likelihood scores and weighting them by the absolute value of the corresponding contribution scores.

Note that the projected climate values are based on the PCIC ensemble of SRES AR4 - A1 runs. These represent the “business as usual” approach which means increasing concentrations of greenhouse gases at current rates.

Appendix C provides a more detailed explanation of the above methodology.

RESPONSE TO CLIMATE CHANGE

Most resources that address climate change impacts to sanitary sewer systems focus on flood damage, treated-effluent receiving water quality, and inflow/infiltration quantities. However, from an asset management perspective (capacity and condition) potential responses to climate change are as follows:

- Changes to inflow from individual rainfall events,
- Changes to infiltration from water moving through the soil, and
- Pipe breakage due to soil movement due to increased or decreased soil moisture (Wols et al). Note that the referenced study addresses only water distribution pipes, which are pressure pipes. Therefore, this failure mechanism has been applied to only sanitary forcemains, and not to the gravity sewers. The potential for breakage by this process is dependent on soil type and pipe material. Asbestos cement pipes in clay or peat soils are most at risk under these conditions, while PVC pipes in sandy soils are least at risk.

CLIMATE CHANGE RISK ASSESSMENT

The identified responses to climate change may primarily affect the capacity of the sanitary sewer system, but the condition of some infrastructure elements may also be impacted. The following climate variables were selected for the sanitary sewer climate change risk assessment since each can impact one or more of the failure processes.

<i>Climate Variable</i>	<i>Rational</i>
Temperature - Average Annual	Soil moisture is also a function of evapo-transpiration (ET), which to some degree, is a function of temperature. Warmer summer temperatures and longer growing seasons may change the type of vegetation that flourishes – which can impact ET.

Precipitation - Average Annual	Precipitation contributes to the overall volume of water in the soil matrix, and contributes to water infiltration through the soil.
Precipitation – High Intensity	High-intensity rainfall events have the potential to contribute more inflow because inlets are overwhelmed, surface flows are deeper, and ponded water at low points is more likely.
Soil Moisture - Average Annual	Average annual soil moisture contributes to potential soil acidification.
Soil Moisture Content - Annual Fluctuation	Annual soil moisture fluctuation contributes to potential soil movement.

The following sub-sections summarize the assessment of each failure process, and the rationale for the values summarized in Table 4.2.

Table 4.2 - Climate Change Risk Assessment (Weighted Likelihoods)

		Climate Parameters					
		Temperature - Average Annual	Precipitation - Average Annual	Precipitation - High Intensity (10 Y; 15 min)	Precipitation - High Intensity (100 Y; 12 hr)	Soil Moisture - Average Annual	Soil Moisture Content - Annual Fluctuation
Baseline		1.8	897.9	48.0	4.0	567.8	94.1
Baseline Units		°C	mm	mm/hr	mm/hr	mm	mm
Projected Change (2050s) in Baseline Units		4.1	916.0	62.2	4.7	568.2	109.6
Projected Change (2050s) from Baseline (%)		127%	2.0%	30%	18%	0.1%	16%
Climate Variable Change Likelihood		5	5	4	4	3	3
Failure Process	Weighted Likelihood	Climate Contribution to Failure Mechanism (-2 to +2)					
Surface stormwater runoff	4.0			2.0	2.0		
Groundwater infiltration	0.4	-0.1	0.5			0.1	
Soil movement due to soil moisture change	0.8					0.1	1.0
Soil acidification	0.8	0.5	0.1				

INFLOW – SURFACE STORMWATER RUNOFF

The weighted likelihood score that inflow to the sanitary sewer system will increase from a change in surface stormwater runoff due to climate change is +4.0. This indicates a high likelihood, and reflects:

- The high likelihood that rainfall intensities will increase significantly – especially for more frequent storm events (10 year);
- The direct correlation between rainfall and inflow.

This is expected to reduce the time it takes for an asset to reach its capacity threshold, assuming no changes in maintenance and I&I mitigation work.

GROUNDWATER INFILTRATION

The weighted likelihood score that groundwater infiltration into the sanitary sewer system will increase from a change in climate is +0.4. This indicates a very low likelihood, and reflects:

- A high likelihood that the average annual temperature will increase, contributing to *potentially less* water moving through the soil;
- A high likelihood that the average annual precipitation will increase only slightly, contributing to potentially more water moving through the soil; and
- A moderate likelihood that the average annual soil moisture will increase only slightly.

This is expected to reduce the time it takes for an asset to reach its capacity threshold, but only slightly.

SOIL-MOVEMENT INDUCED PIPE BREAKAGE

The weighted likelihood score that pipes would break due to this process was determined to be +0.8. This indicates a very low probability that pipe breakage due to soil movement will increase with climate change. It also reflects that most of the soils in Castlegar are well-drained sandy soils. Only pressure forcemains were assessed for this risk.

PIPE DEGRADATION DUE TO ACIDIC SOIL

The likelihood that ferrous pipes will degrade from increased soil acidification is represented by a weighted likelihood score of +0.8, which means that the likelihood is very low. Even though there is a high likelihood that the average annual temperature is projected to increase significantly, and that average annual precipitation has a high likelihood of increasing slightly, the overall weighted likelihood is still low because climate contributes only marginally to the failure process. Only pressure forcemains were assessed for this risk, since these were the only ferrous pipes.

ASSET MANAGEMENT RISK ASSESSMENT – CLIMATE CHANGE SCENARIO

The weighted likelihoods of the identified failure processes contributing to decreased capacity and/or service life were evaluated to develop an asset management risk assessment scenario that includes climate change as follows:

Table 4.3 – Risk Assessment Methodology

Trigger	Modeled Parameters	Assets Impacted
Soil acidification caused by changes in soil moisture	Decrease service life by 3%	Ferrous sanitary pressure mains
Weakening of pipes caused by increased soil moisture	Decrease service life by 3%	Concrete sanitary pressure mains
Increased scouring of pipe due to higher sediment load from Inflow/Infiltration	Decrease in service life: <ul style="list-style-type: none"> • PVC/HDPE 3% • Steel 5% • Concrete 7% • CMP 15% 	All Mains
High vulnerability risk assets as identified through PIEVC	Risk scores for 2037 scenario set to 5 (max)	Storm mains as identified through PIEVC as well as sanitary and water mains in immediate proximity to vulnerable storm infrastructure

4.8 Results and Prioritization

PRIORITIZATION METHODOLOGY

The risk analysis described above was applied to each pipe asset in the City sewer system. The result was a database of over 1,100 assets with their own unique classification, including over 206 assets with a combined risk score of 4 or 5 for either Condition or Capacity, or both.

In order to prioritize the inventory of risks into a strategic list of assets, in sequence of importance, a three-step merging process was completed to yield a hierarchy of upgrades based on risk scores. This hierarchy relates directly to levels of service.

METHODOLOGY

Step 1: **Level of Service 1:** Apply triple-bottom-line analyses to determine risk scores based on considerations for social (population/land use), economic (cost implications) and environment (water resources). This step combines multiple facets of risk, including conditions *and* capacity, likelihood *and* consequence of failure, and existing *and* future scenarios. The projects triggered here are considered **Priority 1 (highest priority)** because they are classified comprehensively.

Step 2: **Level of Service 2:** Determine which assets had a combined score of 4 or greater for *either* condition or capacity (still based on both likelihood and consequence of failure). Although this step does still incorporate the triple-bottom-line analyses of the previous step, it triggers projects that demonstrate sufficient risk for either condition *or* capacity. These projects are considered **Priority 2 (moderate priority)**. It is possible that a Priority 2 project could be prioritized above a Priority 1 project if it is deemed to have sufficient impact on the system due to capacity *or* condition issues. For example, a pipe with plenty of remaining life may have capacity issues due to recent development. Alternatively, a pipe may have excess capacity, but be experiencing frequent breaks.

Step 3: **Level of Service 3:** Determine which assets scored a 4 or greater under *likelihood of failure* for *either* condition or capacity. Therefore, projects arising from Step 3 are triggered by their probability of failure, but not by the impact of that failure. These projects are considered **Priority 3 (low priority)**.

This methodology results in a three-tiered prioritization of projects, which was used to create a list of capital priorities.

CAPITAL PRIORITIZATION: RESULTS - ASSET MANAGEMENT SCENARIO

The results of the capital prioritization process are categorized by priority rank (1,2, or 3) and by priority trigger (condition or capacity). A list of capital upgrades under each category was compiled from the outputs of the risk assessment. The scope of upgrade depends on the primary trigger: for example, if a pipe was triggered for an upgrade due to capacity, the pipe will be replaced with one of greater diameter. Alternatively, if a pipe was triggered for an upgrade due to condition (with a capacity score of less than 3) the pipe will be replaced by one of equivalent diameter.

It should be noted that Priority 3 projects only relate to the *likelihood of failure for capacity* projects, whereas Priority 2 projects include those triggered by both *likelihood of failure* and *consequence of failure*.

The results of the prioritization of pipe assets are summarized in **Table 4.4**.

Table 4.4 – Capital Prioritization Results of Pipe Assets

Prioritization - Asset Management Scenario									
Asset Category	# of Pipes	Length of Pipe (km)	0-5 Year	0-5 Year Replacement Cost	5-10 Year	5-10 Year Replacement Cost	10-20 Year	10-20 Year Replacement Cost	Total Replacement Cost
Priority 1	139	9.1	32	\$ 961,159	23	\$ 614,489	84	\$ 2,163,834	\$ 3,739,483
Priority 2									
<i>Condition</i>	56	3.6	0	\$ -	18	\$ 510,353	38	\$ 766,426	\$ 1,276,779
<i>Capacity</i>	2	0.2	0	\$ -	0	\$ -	2	\$ 210,831	\$ 210,831
Priority 3									
<i>Condition</i>	32	2.4	0	\$ -	0	\$ -	32	\$ 892,099	\$ 892,099
<i>Capacity</i>	0	0.0	0	\$ -	0	\$ -	0	\$ -	\$ -
New Pipes	-	-	-	-	-	-	-	-	\$ -
Facilities									\$ 7,038,000
Total	229	15.4	32	\$ 961,159	41	\$ 1,124,842	156	\$ 4,033,189	\$ 13,157,191

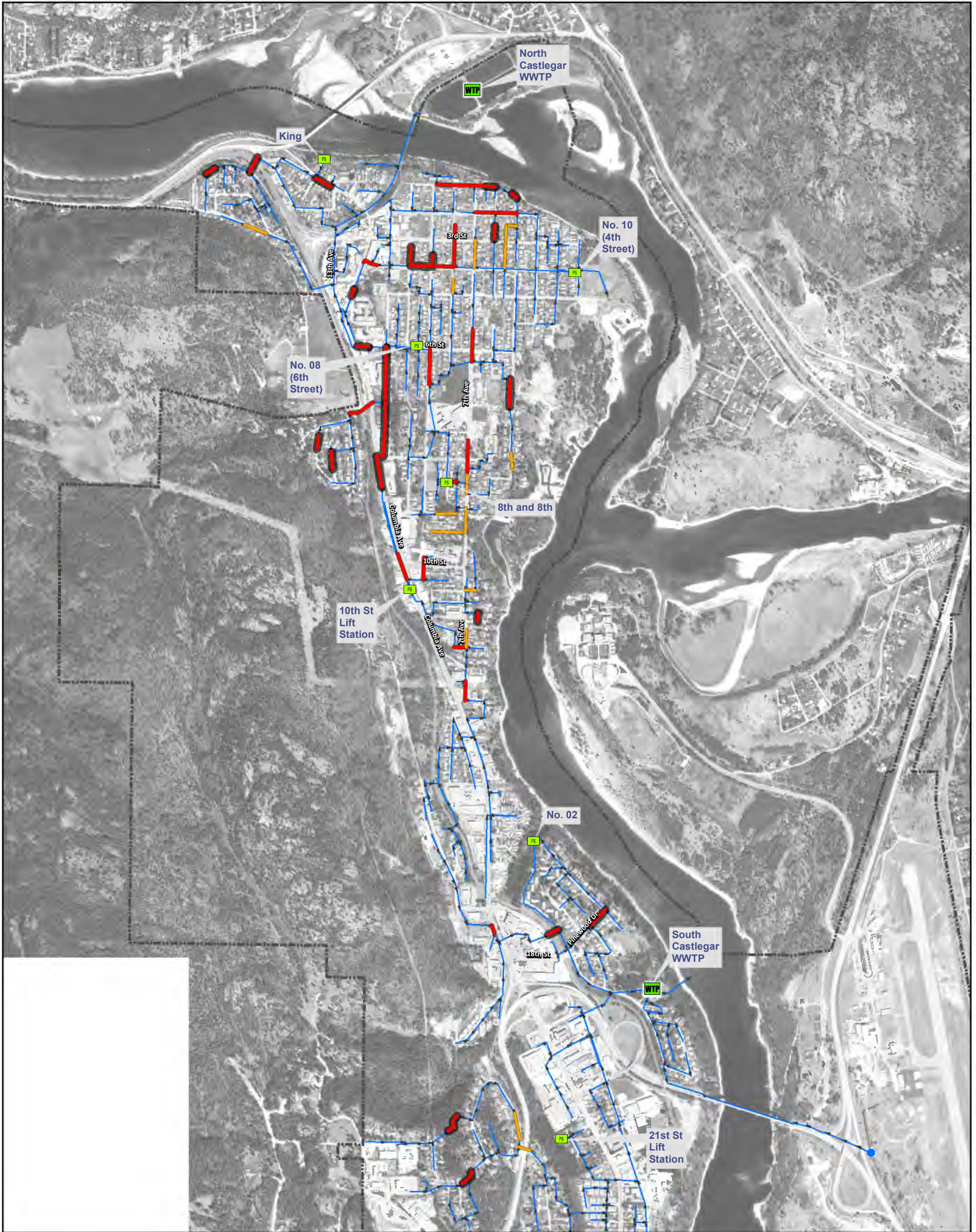
The average annual cost of for 'critical' assets is **\$658,000**. This amount includes:

- Priority 1 pipes,
- Priority 2 pipes,
- Priority 3 pipes, and
- Renewal of existing facilities.

It should be noted that 10% of the annual cost is related to priority 2 condition triggered pipes. There are opportunities for costs related to this category to be significantly reduced, for several reasons:

- These pipes are potential candidates for trenchless rehabilitation. A separate investigation can be undertaken to determine trenchless candidates, and to calculate the cost savings that this rehabilitation method can realize.
- Condition-only triggers are highly dependent on the assumed service life of the pipe, since limited CCTV information for the sanitary system was available. It is very likely that many of these pipes will outlive their assumed service life and last well beyond the 20-year planning horizon. A CCTV inspection of these pipes (if they have not yet been inspected) could help refine this list.

Figures C and D illustrate the locations of the Priority 1 and 2 pipes, with emphasis on the pipes flagged under the 0-5 year timeframe.



City of Castlegar
Integrated Infrastructure
Capital Plan (IICP)

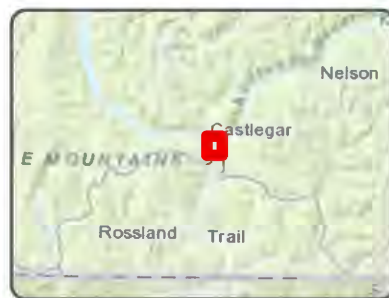
Sanitary Priority Pipes - North

Legend

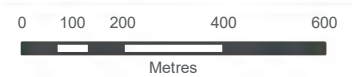
- PS Lift Station
- Siphon Chamber
- WTP Treatment Plant
- Priority 1 Sanitary Main
- Priority 2 Sanitary Main

Timing

- 0-5 Years



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



Coordinate System:
NAD 1983 UTM Zone 11N

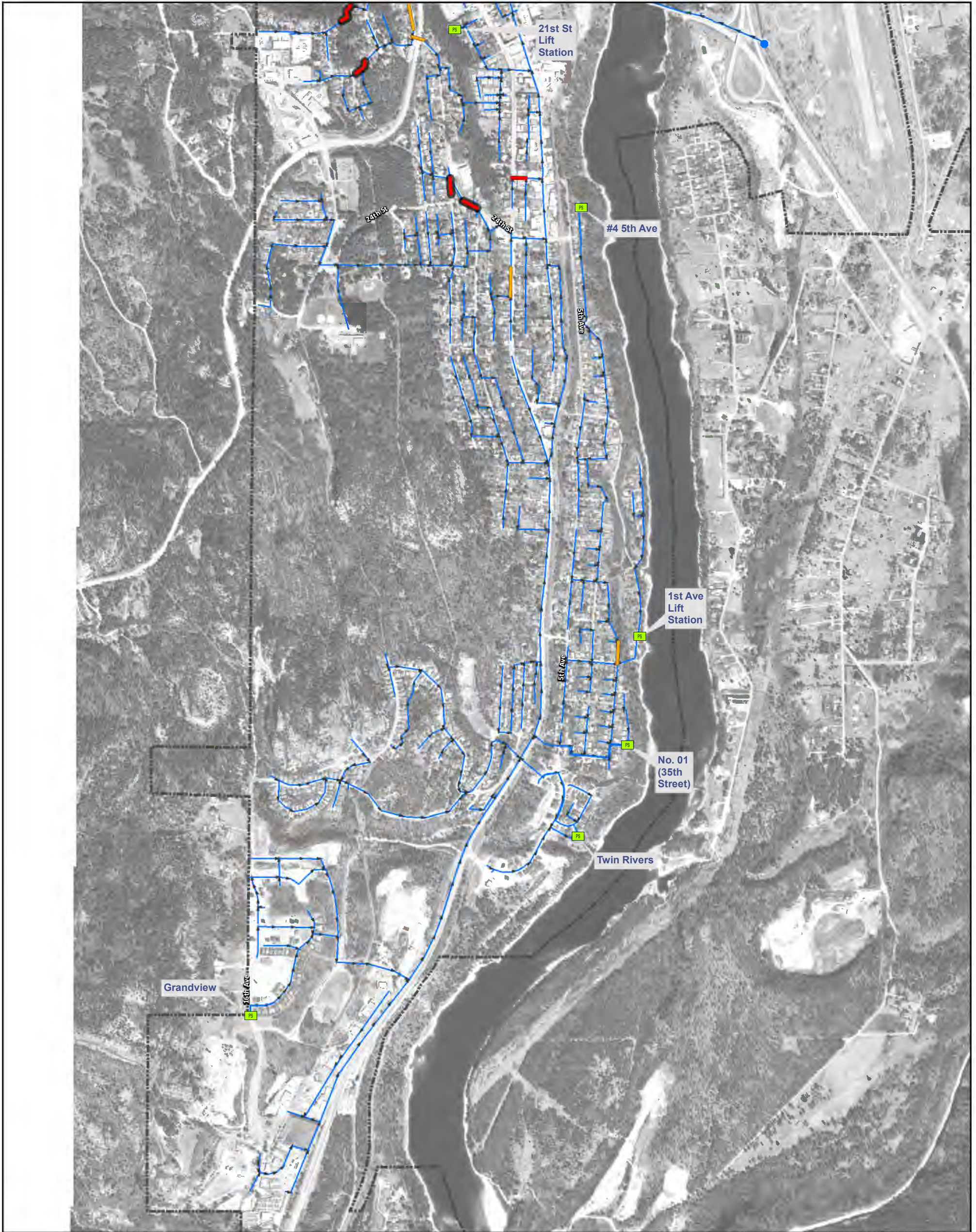
Scale:
1:15,000

Data Sources:
Data provided by -
City of Castlegar
Urban Systems

Project #: 0841.0099.01
Author: BP
Checked: SS
Status: **- DRAFT -**
Revision: A
Date: 2017 / 12 / 7



FIGURE C



City of Castlegar
Integrated Infrastructure
Capital Plan (IICP)

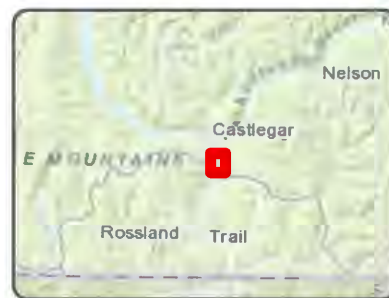
Sanitary Priority Pipes - South

Legend

- Lift Station
- Siphon Chamber
- WTP Treatment Plant
- Priority 1 Sanitary Main
- Priority 2 Sanitary Main

Timing

- 0-5 Years



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



Coordinate System:
NAD 1983 UTM Zone 11N

Scale:
1:15,000

Data Sources:
Data provided by -
City of Castlegar
Urban Systems

Project #: 0841.0099.01
Author: BP
Checked: SS
Status: ~ DRAFT ~
Revision: A
Date: 2017 / 12 / 7



FIGURE D

CAPITAL PRIORITIZATION: RESULTS – EXTENDED SERVICE LIFE SCENARIOS

As discussed in Section 4.3, two scenarios were run that extended infrastructure service lives using factors of 125% and 150%. These scenarios show how annual costs can be reduced if the City is willing to accept the risk of waiting to replace infrastructure. Some pipe materials can last well past their expected service lives depending on factors such as installation technique and soil chemistry. Other pipe materials are still relatively new (i.e. PVC), so the full extent of the service life has not been adequately tested. It is possible that these pipes could maintain good condition many years past industry expectations, saving the City the cost of early replacement.

On the flip side, some pipes fail much earlier than expected. Choosing to extend service lives may lead to increased pipe breaks or failures, making staff reactive rather than proactive. Either way, it is an informed, risk-based level of service decision that the City must make. The following two tables show the replacement costs of the 125% and 150% service life scenarios.

Table 4.5 – 125% Increased Service Life Prioritization Results of Pipe Assets

Prioritization – 125% Service Life Scenario									
Asset Category	# of Pipes	Length of Pipe (km)	0-5 Year	0-5 Year Replacement Cost	5-10 Year	5-10 Year Replacement Cost	10-20 Year	10-20 Year Replacement Cost	Total Replacement Cost
Priority 1	41	2.6	23	\$ 437,135	18	\$ 499,511	0	\$ -	\$ 936,646
Priority 2									
Condition	18	1.4	0	\$ -	18	\$ 510,353	0	\$ -	\$ 510,353
Capacity	16	1.2	9	\$ 524,024	5	\$ 114,979	2	\$ 210,831	\$ 849,834
Priority 3									
Condition	32	2.4	0	\$ -	0	\$ -	32	\$ 892,099	\$ 892,099
Capacity	0	0.0	0	\$ -	0	\$ -	0	\$ -	\$ -
New Pipes	-	-	-		-				\$ -
Facilities									\$ 7,038,000
Total	107	7.6	32	\$ 961,160	41	\$ 1,124,843	34	\$ 1,102,930	\$ 10,226,932

Table 4.6 – 150% Increased Service Life Prioritization Results of Pipe Assets

Prioritization – 150% Service Life Scenario									
Asset Category	# of Pipes	Length of Pipe (km)	0-5 Year	0-5 Year Replacement Cost	5-10 Year	5-10 Year Replacement Cost	10-20 Year	10-20 Year Replacement Cost	Total Replacement Cost
Priority 1	41	2.6	23	\$ 437,135	18	\$ 499,511	0	\$ -	\$ 936,646
Priority 2									
Condition	18	1.4	0	\$ -	18	\$ 510,353	0	\$ -	\$ 510,353
Capacity	16	1.2	9	\$ 524,024	5	\$ 114,979	2	\$ 210,831	\$ 849,834
Priority 3									
Condition	32	2.4	0	\$ -	0	\$ -	32	\$ 892,099	\$ 892,099
Capacity	0	0.0	0	\$ -	0	\$ -	0	\$ -	\$ -
New Pipes	-	-	-		-				\$ -
Facilities									\$ 7,038,000
Total	107	7.6	32	\$ 961,160	41	\$ 1,124,843	34	\$ 1,102,930	\$ 10,226,932

Significant differences in costs can be seen between Table 4.4 (baseline scenario) and the two extended service life scenario tables (4.5 and 4.6). There is a large group of assets that were installed in the same time period, which all come up for renewal in the next 20 years under the baseline scenario. Increasing service lives has deferred those assets past the 20-year horizon and lowered immediate costs significantly.

There is no difference between the 125% and 150% service life scenarios in this analysis. Essentially, there are no pipes that come due for replacement in the time window between the two scenarios. Therefore, at this point in time, there is little benefit for the City to adopt a 150% service life extension since it does not show any savings. If the City is willing to accept increased risk and chooses an extended service life scenario, the 125% scenario provides the greatest cost savings with the lowest amount of increased risk compared to the 150% scenario.

Based on the 125% scenario, the average annual cost for critical assets is **\$511,000**, or \$147,000 less than the standard service life scenario.

CAPITAL PRIORITIZATION: RESULTS – CLIMATE CHANGE SCENARIO

Using the methodology outlined in Table 4.3 (where service lives of the existing pipes were reduced to incorporate climate change) climate change was integrated into the linear asset risk assessment and the model re-run. The baseline service life scenario was used as the input into the climate change scenario (no extension of service lives).

The results of the prioritization of pipe assets are summarized in Table 4.7.

Table 4.7 - Climate Change Prioritization Results of Pipe Assets

Capital Scheduling - Climate Change Scenario									
Asset Category	# of Pipes	Length of Pipe (km)	0-5 Year	0-5 Year Replacement Cost	5-10 Year	5-10 Year Replacement Cost	10-20 Year	10-20 Year Replacement Cost	Total Replacement Cost
Priority 1	143	9.4	22	\$ 831,066	112	\$ 2,874,468	9	\$ 130,506	\$ 3,836,040
Priority 2									
Condition	59	3.8	2	\$ 43,354	57	\$ 1,320,039	0	\$ -	\$ 1,363,394
Capacity	2	0.2	0	\$ -	2	\$ 210,831	0	\$ -	\$ 201,831
Priority 3									
Condition	34	2.6	0	\$ -	0	\$ -	34	\$ 986,354	\$ 986,354
Capacity	0	0.0	0	\$ -	0	\$ -	0	\$ -	\$ -
New Pipes									\$ -
Facilities									\$ 7,038,000
Total	238	16.1	24	\$ 874,420	171	\$ 4,405,339	43	\$ 1,116,860	\$ 13,434,619

Based on the modelled adjustments for climate change, total replacement cost has marginally increased and the average annual cost of replacement for critical assets has increased from the status quo scenario by \$15,000 to **\$672,000**.

4.9 Levels of Service, Risk and Cost: Results

The benefit of the risk assessment is the connection between levels of service, risk, and priorities. This section advances the methodology described above to define which types of projects will be funded based on the priority level and affordability limits using the asset management scenario results. If the City intends to fund the integration of climate change into the service levels, the numbers would increase to match Table 4.7. The baseline service life scenario is used in this section.

PRIORITY 1 – LEVEL OF SERVICE 1

- **Risk Level:** Asset replacements are selected when assets exhibit *both* condition and consequence of failure risk scores greater than or equal to 4.
- **What this means:** We will ensure that all pipes are maintained to a condition and capacity risk score of 3 or less. To do this, we will fund and construct projects that are of high risk (4 or 5) for both condition and capacity failures.
- **Cost Implications:** **\$3,739,483** over 20 years.

PRIORITY 2 – LEVEL OF SERVICE 2

- **Risk Level:** Asset replacements are selected when assets exhibit risk scores greater than or equal to 4, for *either* condition or capacity.
- **What this means:** We will ensure that all pipes are maintained with a condition or capacity risk score of 3 or less. To do this, we will fund and construct projects that are high risk (4 or 5) for either condition or capacity.
- **Note:** Selecting this risk level would also trigger all the Priority 1 pipes.
- **Cost Implications:** Additional **\$1,487,610** over 20 years.

PRIORITY 3 – LEVEL OF SERVICE 3

Selecting this risk level where assets scored a 4 or greater under *likelihood of failure* for *either* condition or capacity would trigger all Priority 1, 2 and 3 pipes which has a cost implication of **\$6.1M** over 20 years.

LEVEL OF SERVICE RECOMMENDATIONS

Selecting the preferred level of service to provide often comes down to community preferences and affordability. Willingness to pay for environmental protection or enhancement is also inherent in affordability. Based on discussions following the review of the preliminary results earlier in the study, it was determined that the following level of service and funding would be pursued, with confirmation occurring after the long term financial analysis is completed:

- Priority 1 & 2 – to be funded and implemented as quickly as possible
- Priority 3 – aim to gradually increase revenues over the 20-year time frame so that this level of service is achieved by 2037

ADDITIONAL INFORMATION IN APPENDICES

This Plan is submitted along with a GIS geodatabase (to be delivered with the final version of this report) which includes all the results of the modelling analysis. The geodatabase will be submitted in electronic form to allow GIS personnel to manipulate and present the information in a variety of ways, depending on the needs of City staff.

Lastly, each asset ID has a risk score for existing and future conditions. These risk scores are the basis of the prioritization (ranking) of the assets and all pipes in Priority 1/2/3 are listed in decreasing order of risk. This allows engineering staff to work with GIS staff to assemble projects based on risk, adjacent utility or roadworks projects (synergies), proximity and timing.

Generally, however, the tables work like a check-list where each project completed results in less risk, thereby achieving the City's stated level of sanitary servicing.

4.10 Next Steps and Implementation

The assets identified in this study were prioritized and sequenced based on their level of risk, which was further categorized based on various rankings or risk scores and translated into levels of service. The identified Priority 1, Priority 2, and Priority 3 projects provide a high level of service for customers. The estimated costs for the critical assets is \$0.658M annually. Castlegar's sewer utility currently budgets approximately \$0.460M per year in capital funding. This equates to a shortfall of approximately \$198,000/year.

If the City were to adopt the climate change scenario, it would add \$15,000/year, bringing the shortfall to \$213,000/year.

If the City were to adopt the 125% service life extension scenario, the estimated annual costs for the critical assets would be \$511,000. This reduces the shortfall to \$51,000. A further option that many communities have taken to align costs with available funding is to defer or greatly reduce Priority 3 projects. If the City of Castlegar were to focus solely on Priority 1, 2, and facilities projects, while applying the 125% service life scenario, the current budget of \$460,000/yr would be adequate.

The aim of the funding strategy for this study is to organize the costs and expenditures over 20 years and to inform the City's Sewer Rates Study. The refinement of timing, phasing and affordability of projects will be completed as part of the City's financial planning and integrated capital planning process.

Table 4.6 – Current Funding Strategy

Historical Capital Costs	Year
\$805,447	2016
\$390,277	2015
\$511,143	2014
\$224,634	2013
\$450,641	2012
\$370,832	2011
\$458,000	Average Year

4.11 Capacity Based Pipe Needs

Capacity-based pipe projects enable the sewer utility to meet hydraulic levels of service now and going forward as flows increase with an increase in population. Projects in the 0-5 and 5-10 year timeframe are typically required to address current service level deficiencies whereas 10-20 year capacity-based projects are required to deliver on growth plans. Each of these types of projects can be eligible for development cost-sharing, which is denoted by the developer share estimate.

4.12 Condition Based Pipe Needs

Based on the utility's current capital funding level of \$0.46M, it appears that additional funding will be required over the 20-year horizon to meet pending condition renewal and backlog investments. If the City is willing to assume more risk by increasing service lives of linear assets, and/or deferring lower priority projects, then the current capital funding level hits closer to the target. While these investment levels are based on macro-funding objectives, the results of the risk analysis work from the bottom up, to develop a list of asset-specific condition upgrades. Several of these assets (condition driven) may be candidates for trenchless technology rehabilitation and the overall costs may be reduced. Further investigation would be required for each asset to determine the feasibility of a trenchless rehabilitation solution.

In summary, the proposed annual average level of renewal spending over the 20-year horizon is less than the current utility capital spending level but options are available for the City to better align the two numbers.

4.13 Implementation Plan and Recommendations

The intent of the Prioritized Sanitary Capital Plan is to organize the costs and expenditures over 20 years. The refinement of timing, phasing and affordability of projects will be completed as part of the financial planning and integrated capital planning process for the IICP (integrating with roads, water and drainage).

The Prioritized Sanitary Capital Plan includes the following recommendations:

- Complete the assessment on the North Castlegar Lagoons
- To phase in capital projects based on their risk trigger; i.e., condition or capacity (**Figures C & D**). Existing condition and capacity is the primary driver for projects in the catchment and preparing for significant projects should start immediately.
- To budget for Priority 1 pipe replacement in the 5-year Capital and Financial Plans. Priority 1 pipes should generally be selected over Priority 2 pipes, unless critical capacity or condition issues occur.
- To pursue trenchless rehabilitation program for Priority 2 condition-based replacement. The scope of trenchless rehabilitation should be completed following CCTV assessment of each pipe identified as potential. This is a cost-containment program that must be scoped out after more detailed information on the existing infrastructure is collected.

- Determine funding requirements to address the municipal contribution gap in part, by potentially updating user fees/rates in 2018/19.
- To fund and replace the Priority 2 pipes by completing the highest order projects by capacity risk score first.
- To phase in capital projects based on their risk trigger; i.e., condition or capacity (**Figures C & D**). Existing condition and capacity is the primary driver for projects in the catchment and preparing for significant projects should start immediately.
- Consider increasing investment into asset renewal to account for the potential impacts of climate change on sewer infrastructure, and to begin funding Priority 3 pipes.

Appendix A

Technical Memoranda

TECHNICAL MEMORANDUM

Date: September 21, 2016
 File: 0841.0099.01
 Subject: Technical Memo – Design Criteria and Analysis
 Page: 1 of 2



This section presents a summary of the design criteria and hydraulic analyses for an existing conditions scenario and the future conditions scenario.

Design Criteria

The tables below include the design criteria and assumptions used in the analysis.

Flow Velocity Criteria (MMCD)		
Pipe Class	Velocity	Units
Gravity (Minimum)	0.60	m/s
Gravity (Maximum)	6.00	m/s
Forcemain (Minimum)	0.75	m/s

Per Capita Flow For Future Growth (MMCD)		
Class	Rate (L/c/d)	
ADWF (Unmetered)	350	
ADWF (Metered)	240	
<i>*Assumed all future flow will be unmetered to be conservative</i>		
Condition	Rate	Units
Old system (25 years or older) and/or pipes below groundwater table	1.0	L/mm dia./100 m length/hour

Peaking Factor (Harmon)		
Formula:	$1 + (14 / (4 + (P / 1000)^{0.5}))$	
Capita per Lot/Unit	2.4	people

d/D Ratio for New Gravity Mains	
Diameter (D)	Max d/D Ratio
D <= 200 mm	0.5
200 mm < D <= 300 mm	0.6
D > 300 mm	0.7

TECHNICAL MEMORANDUM

Date: September 21, 2016
 File: 0841.0099.01
 Subject: Technical Memo – Design Criteria and Analysis
 Page: 2 of 2



Existing Demand Calculation (Source: 2016 WWTP Flow Records)							
	Population (cap)	Average Dry Weather Flow (L/s)	Peaking Factor (L/s)	Peak Dry Weather Flow (L/s)	RDI&I (L/s)	PWWF (L/s)	
2016	8,039	28.95	3.05	88.30	44.53	132.83	
<i>*A per capita rate was determined using inflow records at the North WWTP and serviced population at the South WWTP (http://fh1v81zxfik3reuwwq1t1pdwt.wpengine.netdna-cdn.com/wp-content/uploads/2012/10/plants-Castlegar.pdf)</i>							
	2016 ADWF (L/s)	Residential Growth (L/s)	ICI Growth (L/s)	Peaking Factor (L/s)	Peak Dry Weather Flow (L/s)	RDI&I (L/s)	PWWF (L/s)
2037	28.95	7.57	4.42	2.91	119.14	44.53	163.67
Zoning	Land-Use Type	Units		P/u	Population Growth		
SF Residential	Single Family	32	Lots	2.4	77		
Duplex or SF + Suite	Single Family	262	Lots	4.8*	1,258		
Multi-Family	Multi-family	33	Units	2.4	79		
Seniors	Multi-family	190	Units	2.4	456		
Commercial	Commercial	10.60	Hectares	90	954		
Industrial	Industrial	0.64	Hectares	50	32		
Institutional	Institutional	1.16	Hectares	90	104		
<i>*Assumes each lot contains two "units"</i>							

TECHNICAL MEMORANDUM

Date: September 21, 2016
 File: 0841.0099.01
 Subject: Technical Memo – Modelling Results
 Page: 1 of 7



This memorandum presents a summary of the results from the hydraulic analyses for an existing conditions scenario and the future conditions scenario.

2016 Gravity Main Deficiencies (q/Q >= 1.0)

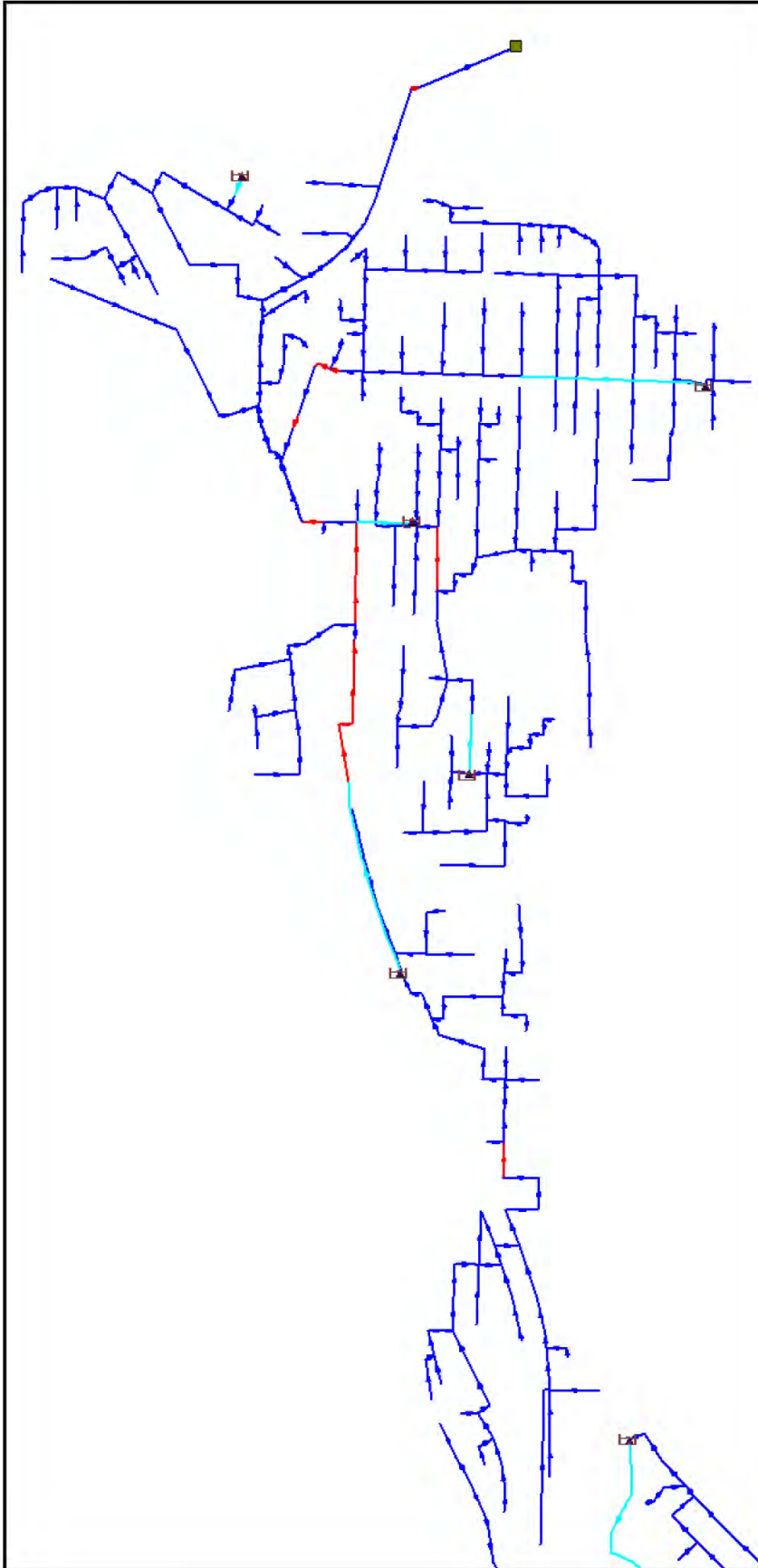
The tables below summarize the mains that have exceeded their capacity.

ID	Diameter (mm)	Length (m)	Slope	Total Flow (L/s)	d/D	q/Q
SMN0007	200	141.8	0.003	18.1	1.0	1.0
SMN0016	250	116.6	0.002	38.8	1.0	1.7
SMN0132	200	9.3	0.004	23.3	1.0	1.1
SMN0133	200	30.4	0.002	23.1	1.0	1.7
SMN0134	200	22.7	0.003	22.7	1.0	1.3
SMN0137	250	30.0	0.001	23.6	1.0	1.1
SMN0208	200	110.2	0.001	38.5	1.0	3.1
SMN0209	250	48.9	0.003	35.8	1.0	1.2
SMN0211	250	139.2	0.001	35.6	1.0	1.6
SMN0214	200	28.2	0.002	35.4	1.0	2.4
SMN0217	200	129.5	0.002	35.2	1.0	2.4
SMN0241	350	48.1	0.001	63.7	1.0	1.4
SMN0252	350	64.6	0.002	88.6	1.0	1.4
SMN0253	350	21.4	0.001	88.9	1.0	1.8
SMN0254	375	50.6	0.001	90.2	1.0	1.7
SMN0255	375	80.5	0.001	91.2	1.0	1.7
SMN0256	375	44.6	0.001	91.4	1.0	1.7
SMN0260	375	39.1	0.001	92.2	1.0	1.5
SMN0324	350	107.8	0.003	98.6	1.0	1.2
SMN0325	350	26.1	0.001	99.0	1.0	2.2
SMN0326	350	21.5	0.004	99.2	1.0	1.1
SMN0327	350	89.2	0.002	99.4	1.0	1.5
SMN0328	350	128.5	0.001	100.0	1.0	1.9
SMN0330	375	17.1	0.001	100.9	1.0	1.6
SMN0388	200	78.7	0.000	7.3	1.0	2.2
SMN1076	200	66.5	0.001	8.4	1.0	1.1
SMN1212	375	18.1	0.001	91.5	1.0	1.7
SMN1254	350	21.4	0.001	88.7	1.0	2.0
SMN1476	250	30.5	0.000	35.9	1.0	N/A*

*No q/Q value available for flat or adverse pipes.

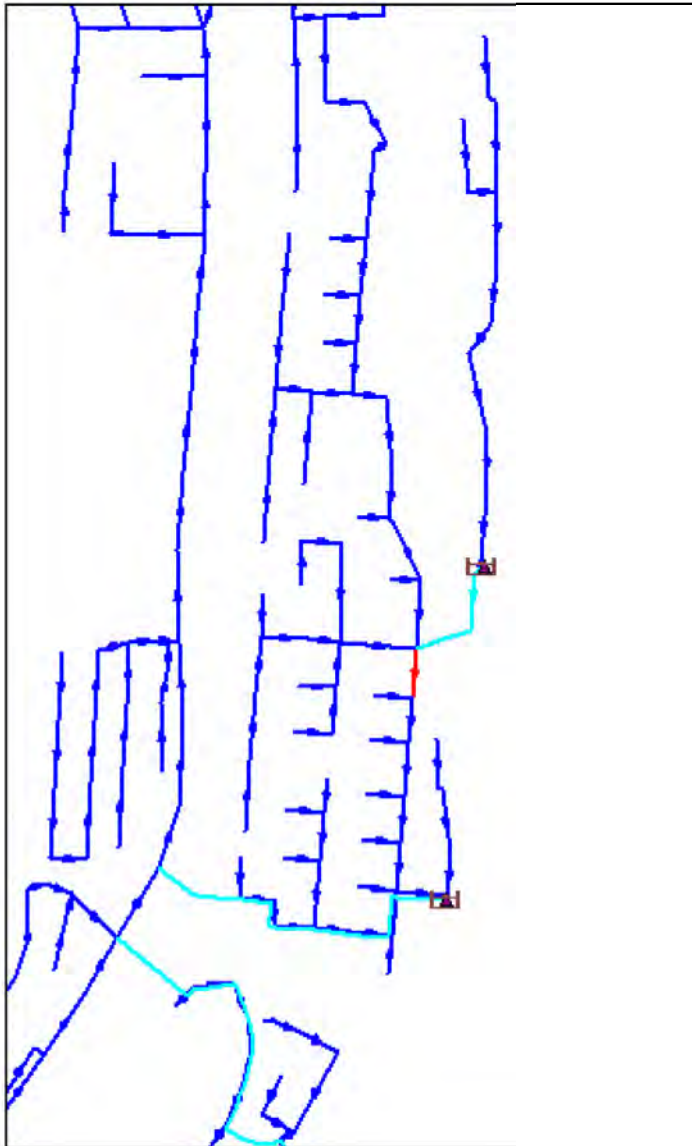
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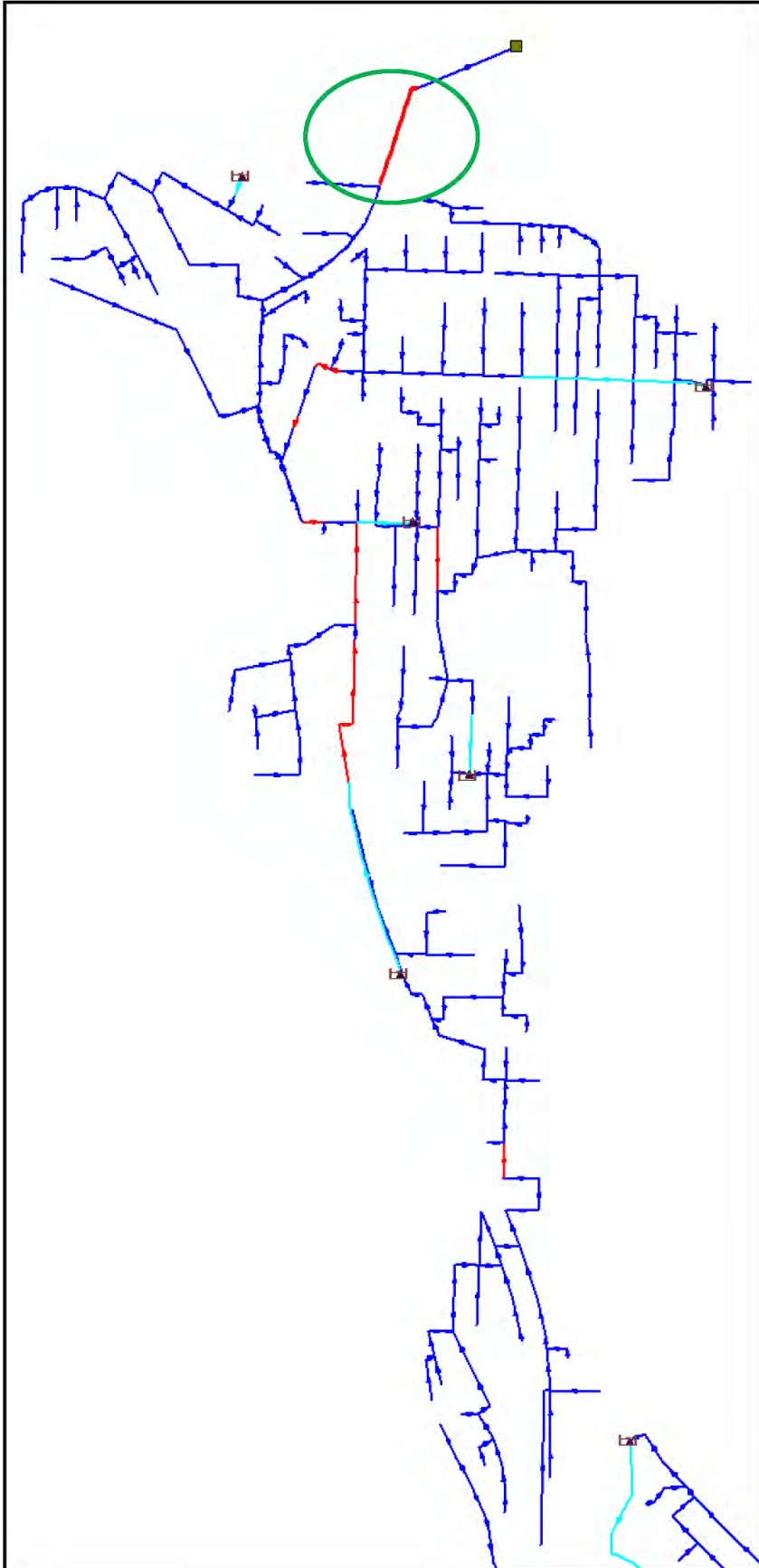
2037 Gravity Main Deficiencies (q/Q >= 1.0)

The tables below summarize the single main that has exceeded its capacity.

ID	Diameter (mm)	Length (m)	Slope	Total Flow (L/s)	d/D	q/Q
SMN0329	450	227.2	0.001	105.9	1.0	1.0

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Lift Station Results

Lift Station Name	Pump Operating Point		2016	2037	2016	2037	Forcemain Diameter (mm)	Forcemain Velocity (m/s)
	Pump Flow (L/s)	Total Dynamic Head (m)	Peak Inflow (L/s)	Peak Inflow	Reserve Capacity (L/s)	Reserve Capacity (L/s)		
No. 01 (35th Street) Lift Station	30.1	41.0	10.7	12.8	19.3	17.2	200	1.0
Lift Station No. 2	13.3	42.7	2.4	3.0	10.9	10.3	100	1.7
1st Ave Lift Station	Ideal Pump*		1.2	1.4	N/A	N/A	100	0.2
#4 5th Ave Lift Station	0.9	7.8	0.2	0.3	0.6	0.6	38	0.8
8th & 8th Lift Station	10.3	10.7	4.3	4.8	6.1	5.5	375	0.1
21st Street Lift Station	0.9	4.9	0.1	0.1	0.8	0.8	38	0.8
10th Street Lift Station	35.0	22.4	1.6	1.9	33.4	33.1	150	2.0
6th Street Lift Station (Lift Station No. 8)	24.3	26.1	22.7	24.9	1.6	-0.6	100	3.1
4th Street Lift Station (Lift Station No. 10)	17.8	24.2	8.8	10.0	9.0	7.8	150	1.0
King Lift Station	0.9	6.5	0.1	0.1	0.7	0.7	150	0.1
Twin Rivers Lift Station	Ideal Pump*		2.2	3.0	N/A	N/A	100	0.4

*Modeled as ideal pump
 (inflow = outflow)

No lift station deficiencies were identified. The model predicts that the 6th Street Lift Station is near capacity; however, since the predicted 2037 PWWF is within 1 L/s of the operating point, no upgrades were recommended as it is within model accuracy.

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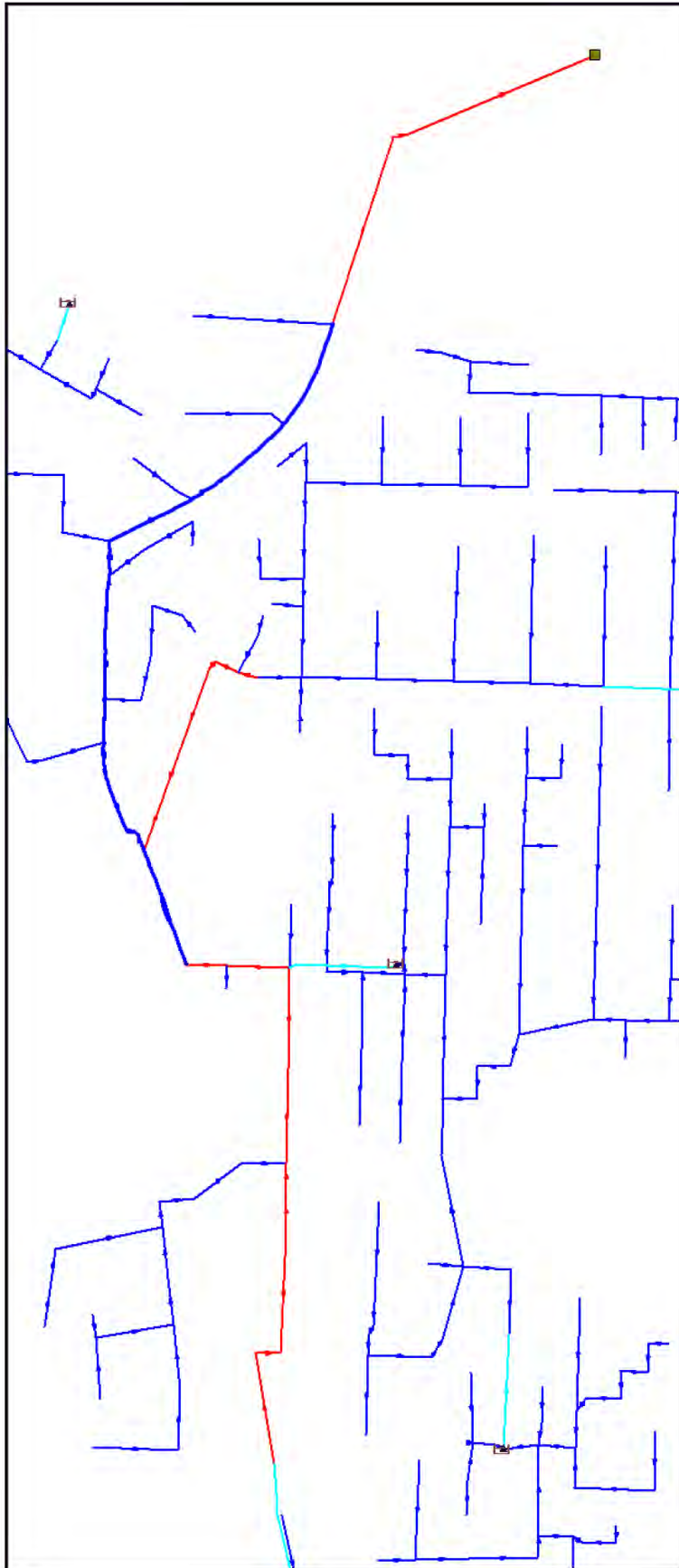
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Recommended Gravity Main Upgrades						
SMN0016	116.6	0.002	250	375	39.6	0.55
SMN0018	72.5	0.002	350	450	64.4	0.50
SMN0131	116.3	0.022	200	300	24.7	0.28
SMN0132	9.3	0.004	200	300	24.5	0.44
SMN0133	30.4	0.002	200	300	24.3	0.56
SMN0134	22.7	0.003	200	300	23.8	0.49
SMN0137	30.0	0.001	250	375	24.9	0.43
SMN0138	78.5	0.003	250	375	25.1	0.34
SMN0208	110.2	0.001	200	375	39.3	0.55
SMN0209	48.9	0.003	250	375	35.9	0.44
SMN0211	139.2	0.001	250	375	35.6	0.52
SMN0214	28.2	0.002	200	375	35.4	0.47
SMN0217	129.5	0.002	200	375	35.2	0.47
SMN0241	48.1	0.001	350	450	64.9	0.62
SMN0242	4.0	0.004	350	450	65.1	0.43
SMN0248	10.0	0.007	375	450	91.1	0.43
SMN0252	64.6	0.002	350	450	91.4	0.63
SMN0253	21.4	0.001	350	525	91.7	0.58
SMN0254	50.6	0.001	375	525	93.4	0.62
SMN0255	80.5	0.001	375	525	94.6	0.62
SMN0256	44.6	0.001	375	525	94.8	0.62
SMN0260	39.1	0.001	375	525	95.8	0.59
SMN0324	107.8	0.003	350	525	103.4	0.46
SMN0325	26.1	0.001	350	525	103.9	0.67
SMN0326	21.5	0.004	350	525	104.1	0.45
SMN0327	89.2	0.002	350	525	104.4	0.51
SMN0328	128.5	0.001	350	525	105.1	0.61
SMN0329	227.2	0.001	450	525	105.9	0.61
SMN0330	17.1	0.001	375	525	106.1	0.61
SMN1212	18.1	0.001	375	525	95.0	0.63
SMN1254	21.4	0.001	350	525	91.5	0.61
SMN1476	30.5	0.000	250	375	36.1	1.00*
SMN1524	234.4	0.008	375	525	106.5	0.36
*Adverse pipe. d/D = 1.00 regardless of diameter (software limitation).						

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TECHNICAL MEMORANDUM

Date: June 01, 2016
To: Chris Barlow, City of Castlegar
cc:
From: Scott Shepherd
File: 0841.0099.01
Subject: **TECHNICAL MEMO–SEWER CAPACITY RISK ASSESSMENT METHODOLOGY**

This memo outlines the proposed methodology on how capacity risks of pipe are identified, and how the risks will be applied in assessing pipes in the City of Castlegar. The methodology is broken down into three parts: an assessment of the likelihood of failure; an assessment of the consequence of failure; and, a risk score. These capacity risk scores will be used in conjunction with condition risk scores (methodology outlined under separate cover) to help guide the prioritized infrastructure capital replacement process.

PART 1 – LIKELIHOOD OF FAILURE

The likelihood of failure was assessed by the hydraulic capacity, hydraulic grade line (HGL) and flow velocity of the pipe, under normal operating conditions. **Table 1** defines how the criteria listed above are correlated to the likelihood of failure.

Table 1 - Normal Operating Conditions Likelihood of Failure

LIKELIHOOD OF FAILURE	CRITERIA		
	HYDRAULIC CAPACITY	HGL	VELOCITY
5	d/D=1	Sewer Level <0.3m below ground surface	
4	d/D=1	Sewer Level >0.3m above the pipe crown & Sewer Level >0.3m below ground surface	
3	d/D=1.0	Sewer Level<0.3m above pipe crown	
2	0.7<d/D<1 d/D<0.7	<Crown	<=0.75 m/s
1	d/D<0.7	< Crown	>= 0.75 m/s

* MBE information is not available therefore a proxy for surcharge relating to depth below surface was selected at 2 metres.

PART 2 – CONSEQUENCE OF FAILURE

The consequence of failure is a function of the land use type and their associated populations. With single family residential dwellings, the consequence is lower than with multi-story apartment complexes or

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commercial, industrial or institutional buildings. **Table 2** and **Table 3** correlate the consequence of failure to the population and land use respectively. The populations in **Table 2** refer to total equivalent population, irrespective of land use.

Table 2 - Consequence of Failure Definitions

CONSEQUENCE				
1	2	3	4	5
INSIGNIFICANT	MINOR	MODERATE	MAJOR	SEVERE
n/a	< 10 people impacted or property loss < \$0.5MM	10-50 people impacted or property loss 0.5MM-1.0MM	50-100 people impacted or property loss 1.0MM-5.0MM	>100 people impacted or property loss >5.0MM

Table 3 - Consequence of Failure by Land Use Designation

UPSTREAM LAND USE DESIGNATION	CONSEQUENCE OF FAILURE
Open Space	1
Single Family Residential	3
Multi-Family Residential	4
Highway Commercial	4
Institutional	5
Industrial	5
Core Commercial	5

Modified Consequence Score

Due to their larger size or nearby surroundings, some sewer mains present an increased level of consequence should they fail. For the analysis, pipe size, stream crossings, and pipes in special community areas are treated differently so as to elevate their priority sequencing in capital projects. Three areas of modified consequence are:

- **Gravity mains of 250mm and larger and forcemains of 200mm and larger** present greater failure consequences and a modified score is added to the normal risk rating (**Table 4** below).
- **Sewer mains located within environmentally sensitive areas** (as mapped in the OCP and steep slope areas) or **mains that cross or are adjacent to watercourses** present greater failure consequences and a modified score is added to the normal risk rating (**Table 4** below).

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- Sewer mains in **ICI areas** (Industrial, Commercial, and Institutional) demonstrate a greater consequence on community well-being. Therefore, sewer assets within these areas will be assigned a modified consequence score based on **Table 4**.

Table 4 – Modified Consequence Score

ORIGINAL SCORE	1	2	3	4	5
>=250mm (gravity) or >=200mm (force), or adjacent to/cross sensitive watercourses, or located within environmental, or ICI areas	1	3	4	5	5

PART 3 – RISK SCORE

The risk score combines the likelihood of asset failure and the consequence of asset failure into a single 1 to 5 rating. A risk score of 5 represents the highest risk and a score of 1 the least risk. **Table 5** correlates the consequence and the likelihood of failure to the risk score. In cases where a sewer main is known to have failed, based on video inspection or manual investigation, the risk score is automatically set to 5, no matter what the consequence and likelihood scores may be.

Table 5 – Risk Score

Consequence	5	3	3	4	5	5
	4	2	3	4	5	5
	3	2	2	3	4	4
	2	1	2	2	3	3
	1	1	1	2	2	3
	1	2	3	4	5	
	Likelihood of Failure					

Likelihood of Failure

It is important to recognize that an asset that has a moderate or low risk attached to it may transition to having a higher risk over time due to changes in demand from growth or increased flows. Further, as more detailed data becomes available, the risk assessment could change. With this in mind, there must be emphasis on keeping the risk assessment a dynamic and living process.

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Subject: Technical Memo – Sewer Condition Risk Assessment Methodology
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Date: June 01, 2016
To: Chris Barlow, City of Castlegar
cc:
From: Scott Shepherd
File: 0841.0099.01
Subject: **TECHNICAL MEMO – SEWER CONDITION RISK ASSESSMENT METHODOLOGY**

This memo outlines the proposed methodology on how condition risks of sewer pipes are identified, and how the risks will be applied in assessing pipes in the City of Castlegar. The methodology is broken down into three parts: an assessment of the likelihood of failure; an assessment of the consequence of failure; and, a risk score. These condition risk scores will be used in conjunction with capacity risk scores (methodology outlined under separate cover) to help guide the prioritized infrastructure capital replacement process.

PART 1 – LIKELIHOOD OF FAILURE

The likelihood (probability) of asset failure for pipes is based on the Structural Condition Grade (SCGs) of the asset. The SCGs will be supplied by the City of Castlegar (where available) and will be developed with a methodology consistent with the WRc Sewer Rehabilitation Manual. Where SCG's are not available or deemed unreliable, we will utilize asset age (approximate year of installation) as a proxy for likelihood of failure, based on **Table 1**.

Table 1 - Condition Ranking (where SCG not available)

LIKELIHOOD OF FAILURE	CRITERIA
5	Asset age exceeds its SL* by 50%
4	Asset age exceeds its SL* by 25% - 50%
3	Asset age exceeds its SL* by 0% - 25%
2	75% of its SL* < Asset Age < 100% of its SL*
1	Asset age < 75% of its SL*

* **SL** = Service Life: Service life is the number of years that an asset is estimated to be able to fulfill its intended function to the community before it needs to be replaced.

For non-pipe assets (similarly if condition ratings are not available), a simple 1 to 5 scale is applied; a condition score of 5 indicates that the likelihood of failure is very high and a score of 1 indicates that the likelihood of failure is very low.

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Estimated Service Lives

The following table summarizes the estimated service lives used in the analysis. The table is based on discussions with staff on their experience in the Castlegar area, materials testing, and on the Province of BC's 2008 *Guide to the Amortization of Tangible Capital Assets*.

Table 3 – Estimated Service Lives

Material	Estimated Service Life
AC	70
VCT	60
CON	60
Steel	60
PVC	80

PART 2 – CONSEQUENCE OF FAILURE

The consequence of failure is based on the actual location of the infrastructure and the financial consequence that might occur, if the infrastructure failed. A simple 1 to 5 scale is used to classify the consequence of failure. **Table 3** details how each category is defined.

Table 3 - Consequence of Failure Definitions

CONSEQUENCE				
1	2	3	4	5
INSIGNIFICANT	MINOR	MODERATE	MAJOR	SEVERE
Total cost to restore service and 3rd party liability (< \$500)	Total cost to restore service and 3rd party liability (\$500 - \$5,000)	Total cost to restore service and 3rd party liability (\$5,000 - \$15,000)	Total cost to restore service and 3rd party liability (\$15,000 - \$50,000)	Total cost to restore service and 3rd party liability (> \$50,000)

For this project, we will consider the primary driver of failure consequence to be whether the pipe is located within a road, and if so what the associated road classification is. The cost to repair a sewer main break is closely linked to the type of road (and associated volume) that might be damaged; for example, a failure within an arterial road presents greater traffic control and road reconstruction requirements than a failure within a local road. The City's GIS data set is used to analyze if a pipe is physically located in a road and if it is, what the road classification (and associated volume) is. **Table 3** summarizes the consequence of failure ranking by road classification and daily 2-way volume.

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Table 2 - Consequence of Failure by Road Classification

ROAD CLASSIFICATION	CONSEQUENCE OF FAILURE
Arterial	5
Collector	5
Highway	5
Local	3
Strata	3
Lane	2
*SROW/Trail	1

*SROW - For pipe corridors in rights-of-way that are not overlaid by road networks.

Modified Consequence Score

Due to their larger size or nearby surroundings, some sewer mains present an increased level of consequence should they fail. For the analysis, pipe size, stream crossings, and pipes in special community areas are treated differently so as to elevate their priority sequencing in capital projects. Three areas of modified consequence are:

- **Gravity mains of 250 mm and larger and forcemains of 200mm and larger** present greater failure consequences and a modified score is added to the normal risk rating (Table 4 below).
- **Sewer mains located within environmentally sensitive areas** (as mapped in the OCP and steep slope areas) or **mains that are adjacent to or cross watercourses** present greater failure consequences and a modified score is added to the normal risk rating (Table 4 below).
- Sewer mains in **ICI areas** (Industrial, Commercial, Institutional) demonstrate a greater consequence on community wellbeing. Therefore, sewer assets within these areas will be assigned a modified consequence score based on Table 4.

Table 4 – Modified Consequence Score

ORIGINAL SCORE	1	2	3	4	5
>=250mm (gravity) or >= 200 (force) or adjacent to/cross a sensitive watercourse, or located within either ICI or environmental areas	1	3	4	5	5

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Construction Cost Notes

There are scenarios in which a main will present a greater cost of construction due to any proximity to structures and railways. **Table 5** presents modifications that are to be incorporated into the estimated cost of construction for use in funding strategies.

Table 5 – Modified Construction Cost

POTENTIAL OBSTRUCTION	CONSTRUCTION COST MODIFICATION
Pipe crosses railway	Increase by 25%

PART 3 – RISK SCORE

The risk score combines the likelihood of asset failure and the consequence of failure into a single 1 to 5 rating. A risk score of 5 represents the highest risk and a score of 1 the least risk. **Table 6** correlates the consequence and the likelihood of failure to the risk score. In cases where a sewer main is known to have failed, based on video inspection or manual investigation, the risk score is automatically set to 5, no matter what the consequence and likelihood scores may be.

Table 6 – Risk Score

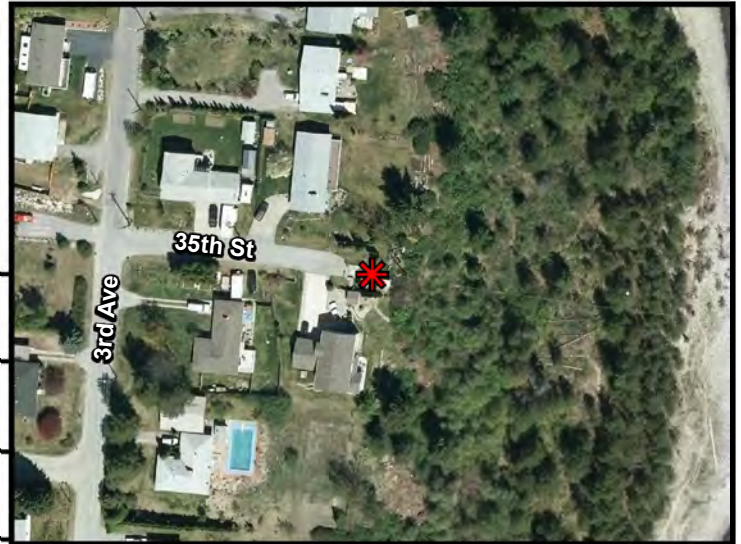
	1	2	3	4	5
5	3	3	4	5	5
4	2	3	4	5	5
3	2	2	3	4	4
2	1	2	2	3	3
1	1	1	2	2	3
	1	2	3	4	5

Likelihood of Failure

It is important to recognize that an asset that has a moderate or low risk attached to it may transition to having a higher risk over time due to the simple aging of the asset. Further, as more detailed data becomes available, the risk assessment could change. For example, if new condition assessment data suggests that an asset is in better condition than its age would indicate, the risk assessment would be altered. With this in mind, there must be emphasis on keeping the risk assessment a dynamic and living process.

Appendix B

Facility Assessment Sheets



Project Title: AMIP - Facilities Assessment

System Type: Sanitary System

Facility Name: LS 01 (35th St)

Asset ID: SLS0001

Major Equipment	Install Year	Condition	Remaining Life	Replace		Upgrade	
				Year	Cost	Year	Cost
2 Flygt 30 HP Pumps	1998	Good	12	2029	\$72000		\$0
Simpower Standby	1998	Good	30	2047	\$30000		\$0
Minor Equipment							
Valves / Fittings	1998	Good	12	2029	\$36000	2020	\$8000
					\$		\$
Structures							
	1998	Good	30	2047	\$40000	2020	\$6000
Electrical/Mechanical							
	1998	Good	12	2029	\$150000		\$0

Comments:

Missing intermediate platform; No provision for emergency pump-out; Reported odour issues; No corrosion evidence; Uses separate valve chamber; Safety issues have been addressed



Project Title: AMIP - Facilities Assessment

System Type: Sanitary System

Facility Name: LS 02

Asset ID: SLS0002

Major Equipment	Install Year	Condition	Remaining Life	Replace		Upgrade	
				Year	Cost	Year	Cost
2-23 hp Flygt	1986	Poor	3	2020	\$55000		\$
Standby Power					\$	2020	\$46000
Minor Equipment							
Valves / Fittings	1986	Poor	3	2020	\$36000		\$
SCADA	2012	Fair	15	2032	\$20000		\$
Structures							
	1986	Fair	15	2032	\$40000		\$
Electrical/Mechanical							
	1986	Fair	15	2032	\$115000		\$

Comments:

Fencing required; No standby power-old tank used for standby storage



Project Title: AMIP - Facilities Assessment

System Type: Sanitary System

Facility Name: 1st Ave LS #3

Asset ID: SLS0003

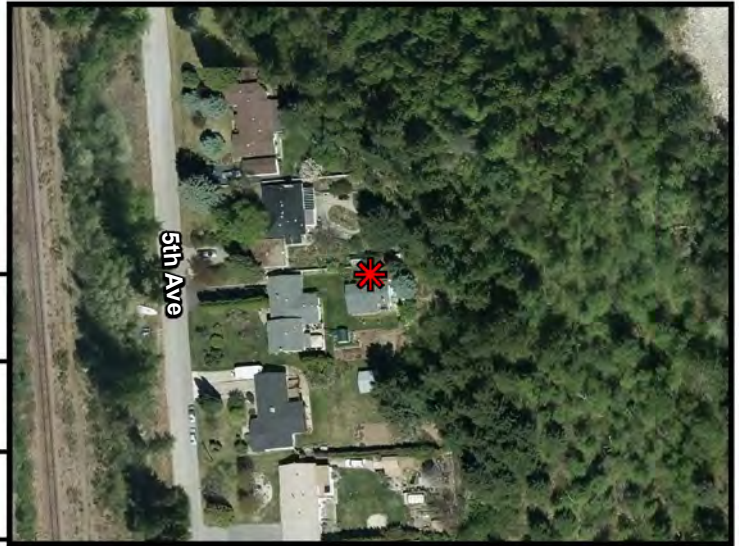
Major Equipment	Install Year	Condition	Remaining Life	Replace		Upgrade	
				Year	Cost	Year	Cost
Flygt 30 HP	2008	Good	21	2038	\$72000		\$
Standby Power					\$	2020	\$60000
Minor Equipment							
Valves / Fittings	2008	Good	21	2038	\$40000	2020	\$10000
Ventilation					\$	2020	\$8000
Structures							
	2008	Good	41	2058	\$40000		\$
Electrical/Mechanical							
	2008	Good	21	2038	\$150000		\$

Comments:

No ventilation; No standby power - storage tank used for standby; No flowmeter



CASTLEGAR



Project Title: AMIP - Facilities Assessment

System Type: Sanitary System

Facility Name: 5th Ave LS #4

Asset ID: SLS0004

Major Equipment	Install Year	Condition	Remaining Life	Replace		Upgrade	
				Year	Cost	Year	Cost
E-1 2hp Grinder Pump	2006	Fair	5	2022	\$3000		\$
Standby Power					\$	2022	\$2000
Minor Equipment							
SCADA	2015	Good	10	2027	\$4000		\$
					\$		\$
Structures							
	2006	Good	20	2037	\$10000		\$
Electrical/Mechanical							
	2015	Good	10	2027	\$10000		\$

Comments:

Limited access; No flowmeter; No standby power; Pumps replaced in 2015; Serves 5 houses




Project Title: AMIP - Facilities Assessment

System Type: Sanitary System

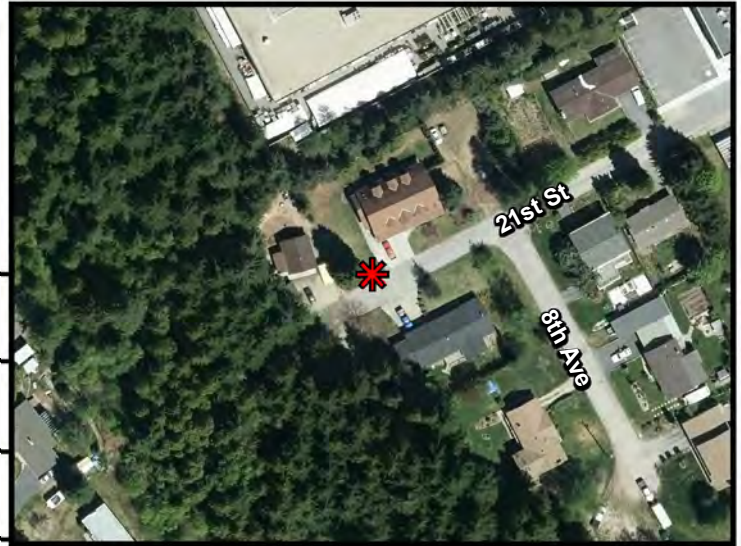
Facility Name: 8th/8th LS #5

Asset ID: SLS0005

Major Equipment	Install Year	Condition	Remaining Life	Replace		Upgrade	
				Year	Cost	Year	Cost
SHPFlygt Pumps (2)	1995	Fair	9	2026	\$12000		\$
Standby Power					\$	2022	\$10000
Minor Equipment							
Valves / Fittings	1995	Fair	9	2026	\$10000		\$
Ventilation					\$	2022	\$8000
Structures							
	1980	Fair	13	2030	\$40000		\$
Electrical/Mechanical							
	1995	Fair	9	2026	\$25000		\$

Comments:

No standby power generator; No ventilation



Project Title: AMIP - Facilities Assessment

System Type: Sanitary System

Facility Name: 21st ST.LS #6

Asset ID: SLS0006

Major Equipment	Install Year	Condition	Remaining Life	Replace		Upgrade	
				Year	Cost	Year	Cost
2 HP Grinder Pumps	1992	Poor	2	2019	\$5000		\$
Standby Power					\$	2019	\$4000
Minor Equipment							
Valves / Fittings	1992	Poor	2	2019	\$4000		\$
Ventilation					\$	2019	\$2000
Structures							
	1992	Fair	10	2027	\$10000		\$
Electrical/Mechanical							
	1992	Poor	2	2019	\$10000		\$

Comments:

Serves 4 houses; Requires control system upgrade; No standby power; Requires electrical upgrade



Project Title: AMIP - Facilities Assessment

System Type: Sanitary System

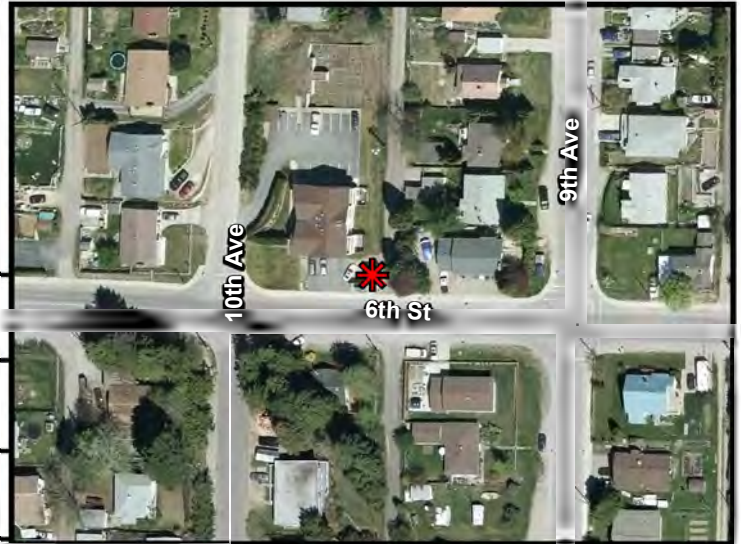
Facility Name: 4th ST.LS #7

Asset ID: SLS0007

Major Equipment	Install Year	Condition	Remaining Life	Replace		Upgrade	
				Year	Cost	Year	Cost
Flygt Pumps	1996	Good	9	2026	\$48000		\$
Standby Power					\$	2020	\$40000
Minor Equipment							
Valves / Fittings	1996	Good	9	2026	\$10000		\$
Ventilation					\$	2020	\$10000
Structures							
	1996	Good	29	2046	\$40000		\$
Electrical/Mechanical							
	1996	Good	9	2026	\$80000		\$

Comments:

No standby power - overflow to soccer fields; Require electrical & plc upgrade; No ventilation

Project Title: AMIP - Facilities Assessment

System Type: Sanitary System

Facility Name: 6th ST LS #8

Asset ID: SLS0008

Major Equipment	Install Year	Condition	Remaining Life	Replace		Upgrade	
				Year	Cost	Year	Cost
2-HP Flygt	1999	Fair	12	2029	\$36000		\$
Standby Generator	1999	Good	32	2049	\$30000		\$
Minor Equipment							
Valves / Fittings	1999	Good	12	2029	\$12000		\$
Ventilation					\$	2020	\$8000
Structures							
	1976	Fair	12	2029	\$40000		\$
Electrical/Mechanical							
	1999	Fair	12	2029	\$75000		\$

Comments:

Original station is over 40 yrs old;
Upgrade in 1999; No ventilation



Project Title: AMIP - Facilities Assessment

System Type: Sanitary System

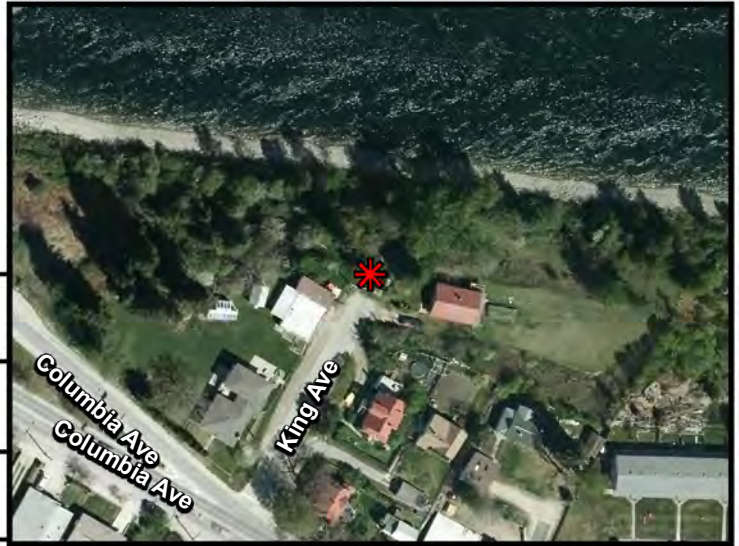
Facility Name: 10th ST LS #10

Asset ID: SLS0010

Major Equipment	Install Year	Condition	Remaining Life	Replace		Upgrade	
				Year	Cost	Year	Cost
20-HP Flygt	1994	Good	7	2024	\$48000		\$
Standby Generator	2015	Good	48	2065	\$40000		\$
Minor Equipment							
Valves / Fittings	1994	Good	7	2024	\$12000		\$
Ventilation					\$	2020	\$8000
Structures							
	1994	Good	27	2044	\$40000		\$
Electrical/Mechanical							
	1994	Good	7	2024	\$100000		\$

Comments:

Most comments in good condition;
Standby power added in 2015; Requires ventilation



Project Title: AMIP - Facilities Assessment

System Type: Sanitary System

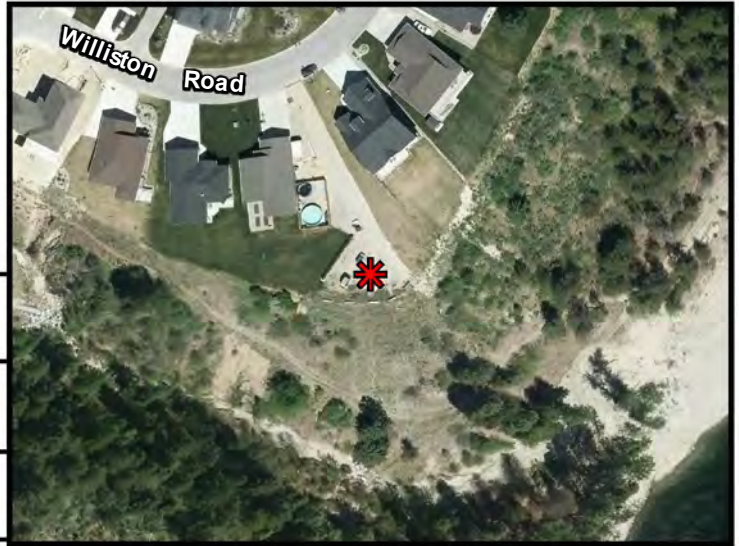
Facility Name: King Ave LS

Asset ID: SLS0012

Major Equipment	Install Year	Condition	Remaining Life	Replace		Upgrade	
				Year	Cost	Year	Cost
E-1 Grinder Pumps	1998	Fair	11	2028	\$3000		\$
					\$		\$
Minor Equipment							
Valves / Fittings	1998	Fair	11	2028	\$3000		\$
					\$		\$
Structures							
					\$		\$
Electrical/Mechanical							
	1998	Fair	11	2028	\$4000		\$

Comments:

Small grinder pump; Service one house;
No standby power



Project Title: AMIP - Facilities Assessment

System Type: Sanitary System

Facility Name: Twin Rivers LS

Asset ID: SLS0013

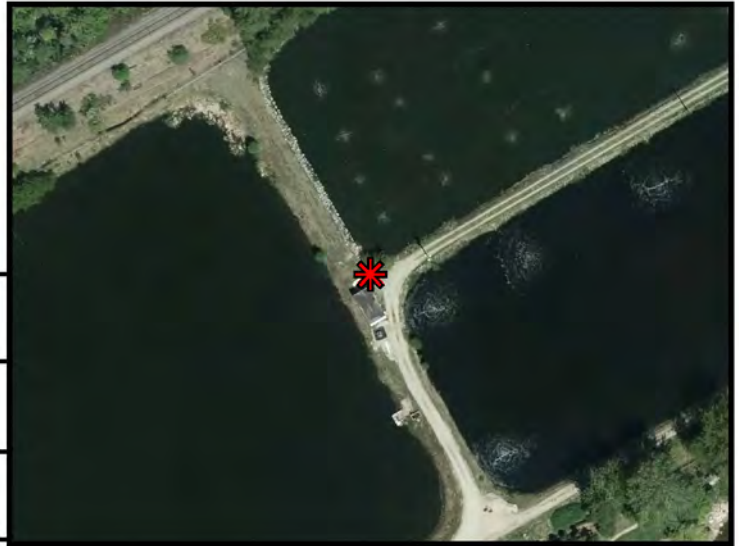
Major Equipment	Install Year	Condition	Remaining Life	Replace		Upgrade	
				Year	Cost	Year	Cost
2-Flygt 23 HP	2008	Good	21	2038	\$55000		\$
Standby Generator	2008	Good	41	2058	\$46000		\$
Minor Equipment							
Valves / Fittings	2008	Good	21	2038	\$28000		\$
Flowmeter	2008	Good	21	2038	\$6000		\$
Structures							
	2008	Good	41	2058	\$40000		\$
Electrical/Mechanical							
	2008	Good	21	2038	\$115000		\$

Comments:

Components in good condition;
Intermediate platform required



CASTLEGAR



Project Title: AMIP - Facilities Assessment

System Type: Sanitary System

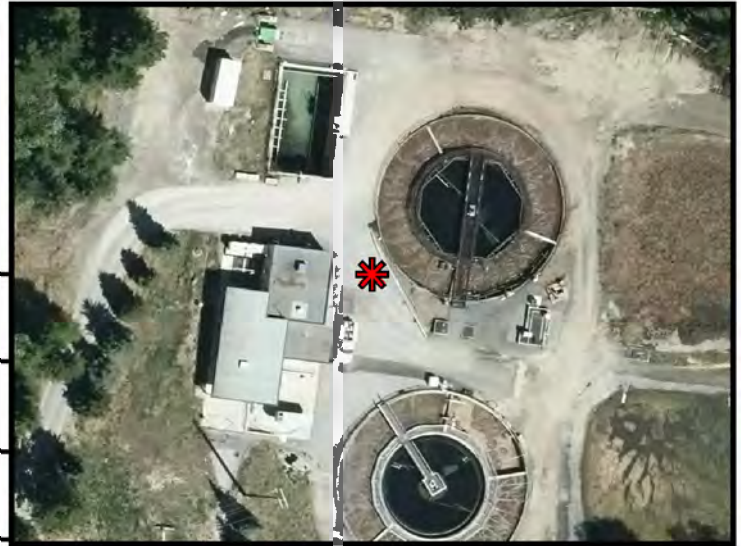
Facility Name: North WWTP

Asset ID: STP0001

Major Equipment	Install Year	Condition	Remaining Life	Replace		Upgrade	
				Year	Cost	Year	Cost
Blowers	1975	Fair	0	2018	\$		\$
Diffusers	1975	Poor	0	2018	\$		\$
Minor Equipment							
Chlorination	1975	Poor	0		\$		\$
					\$		\$
Structures							
	1975	Fair	8	2025	\$		\$
Electrical/Mechanical							
	1975	Poor	0	2018	\$		\$

Comments:

All aeration equipment very old; Many diffusers not operating; Island of sludge evident - Lagoons needed de-sludging; High ammonia present; Dechlorination required; Sani-dump creates sludge build-up; Outfall may need to be relocated



Project Title: AMIP - Facilities Assessment

System Type: Sanitary System

Facility Name: South WWTP

Asset ID: STP0002

Major Equipment	Install Year	Condition	Remaining Life	Replace		Upgrade	
				Year	Cost	Year	Cost
Bio-Reactors	1974-2006	Fair/Good	0-19	2036	\$		\$
Clarifiers	1974-2006	Fair/Good	0-19	2036	\$		\$
UV Disinfection	2006	Good	19	2036	\$		\$
Digesters	1974-2006	Fair/Good	0-19	2036	\$		\$
Headworks	2006	Good	19	2036	\$		\$
Minor Equipment							
Valves/Fittings	1974/2006	Fair	0-19	2036	\$		
Instruments	2006	Good	19	2036	\$		\$
Structures							
	1974-2006	Fair	7-29	2024-2056	\$		\$
Electrical/Mechanical							
	1974-2006	Fair/Good	0-19	2036	\$		\$

Comments:

Bio-reactors added in 2006; New scada system; Sludge ponds repaired; caustic dosing used for ph control; New degritter and screen auger; New blowers; Diffusers replaced in 2006; UV lamps not covered; Algae growth on new clarifier

Appendix C

*REP Assess North Lagoons WWT
Facility DRAFT*



CITY OF CASTLEGAR

Assessment of North Lagoons Wastewater Treatment Facility

Draft Report



December, 2017

URBAN
systems

Suite 204 – 625 Front Street,
Nelson, BC, V1L 4B6

Contact: Dr. Joanne Quarmby, R.P.Bio.
T: | 250.374.8311
jqarmby@urbansystems.ca

File: 0841.0103.01

urbansystems.ca

December 19, 2017

File: 0841.0103.01

City of Castlegar
460 Columbia Avenue
CASTLEGAR, BC V1N 1G7

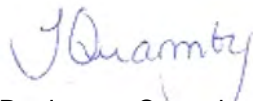
Attention: Chris Barlow, Chief Administrative Officer

RE: ASSESSMENT OF NORTH LAGOONS – DRAFT REPORT

Please find attached the draft report for the North Lagoons assessment. This study was completed to provide direction regarding process modifications and upgrades for the lagoons. We look forward to discussing this report with you and will be pleased to finalise the report once your comments have been received.

Sincerely,

URBAN SYSTEMS LTD.



Dr. Joanne Quarmby (Harkness), R.P.Bio.
Water and Wastewater Specialist



Peter Gigliotti, P.Eng.
Senior Environmental Engineer

/jq

Attachment

cc: Anthony Comazzetto, Urban Systems Ltd.

\\usl.urban-systems.com\projects\Projects_KAM084110103101R-Reports-Studies-Documents\R1-Reports\2017-12-19-LET-draft report cover.docx

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Appendices

- Appendix A Remedial Approach
- Appendix B Capacity Increase
- Appendix C Nutrient Removal

EXECUTIVE SUMMARY

This report presents an assessment of the City of Castlegar North Lagoons. The lagoons have been operating since 1963 and were last upgraded in 1975, with the addition of submerged aeration diffusers. The assessment summarises historical records of flow and effluent water quality as well as analysis from previous studies such as the discharge outfall study completed in 2011.

The report also examines historical population growth and relates serviced population in the Castlegar north sector to wastewater flows to arrive at per capita flows. Population projections are made for a 20-year horizon with a corresponding projection of the average daily flow (ADF) and maximum daily flow (MDF).

The lagoon assessment utilizes three fundamental parameters: Capacity, Condition and Compliance. A brief summary of these parameters follows:

- **Capacity:** the treatment capacity of the aerated lagoon cells is adequate for ADF, but is periodically exceeded by high flows resulting from inflow and infiltration within the north service area. Treatment capacity is also compromised by non-functioning air diffusers.
- **Condition:** A number of submerged air diffusers are not functioning. The blowers were upsized in 1997 with new larger blowers. Their condition should be assessed in more detail by maintenance staff because they have completed 20 years of service.
- **Compliance:** two elements of the facility are identified as having compliance issues. The dechlorination system utilizing sodium thiosulphate pucks is difficult to control and can result in higher than acceptable chlorine residual in the effluent. The outfall pipe discharges in a location where there is poor mixing and has the potential to direct the effluent towards an embayed area. This has been the subject of concern by Ministry of Environment for a number of years.

Several approaches are discussed to address these parameters. These approaches are classified as:

- **Remedial:** to repair non-functioning elements and correct deficiencies.
- **Capacity Increase:** to modify and improve the treatment components in order to accommodate for the projected future flows
- **Nutrient Removal:** to add process components for the removal of nitrogen and phosphorus should it be found from an environmental impact study that these nutrients need to be removed prior to discharge.

The suggested budgets for these approaches are approximated as follows:

1. Investigative work to determine the scope of remedial projects: approximately \$220,000.
2. Approximate value of remedial works based on assumed results of the investigations: approximately \$2.4 million.

3. Approximate value of capacity expansion for the 20-year horizon (without nutrient removal): approximately \$3.3 million
4. Approximate value of process additions for nutrient removal: approximately \$3.6 million.

The value of remedial work and capacity increase for the 20-year horizon is approximately \$5.9 million. These improvements are not expected to increase the annual maintenance and operational staffing costs. However, the annual power cost will increase by approximately 30% with the capacity increase. The addition of nutrient removal, if required, will add a further \$3.6 million expenditure and would increase operational complexity and cost.

1.0 INTRODUCTION

1.1 Subject

This report provides a functional assessment of the City of Castlegar North Lagoons. The North Lagoons receive domestic wastewater from the City's north end residential and commercial areas, including the downtown area. The wastewater is processed by a conventional partially mixed lagoon process using submerged air diffusers, and discharged to the Columbia River upstream of the confluence with the Kootenay River.

1.2 Purpose of Report

The North Lagoons have been operating since 1963 under a BC Ministry of Environment Permit (#PE-80). The original facultative lagoons were expanded and upgraded in 1975 with the installation of subsurface air diffusers. Flows to these lagoons have steadily increased, while water quality parameters for discharges to surface waters have become more stringent.

The purpose of this report is to:

1. Identify the treatment capacity of the existing process,
2. Identify poorly functional or non-functional components,
3. Examine the records to determine the severity of permit exceedances and when they occur,
4. Project the anticipated flows over the next 20-year horizon (to 2037), and
5. Develop concepts for upgrading the facility to process the projected flows and achieve the required discharge water quality.

The City of Castlegar submitted a funding application to undertake this study January, 2017. Notification that the funding application had been successful was received in the spring of 2017.

1.3 Scope

The scope of the study is limited to the North Lagoons. The City also operates an extended aeration wastewater treatment plant (WWTP) at the south end of the City. The South WWTP has been recently upgraded and expanded, and is not included in this assessment. The North Lagoons outfall was reviewed and assessed in 2011, the results of the outfall assessment are provided in a report entitled North Lagoons Upgrade Strategy, by Urban Systems Ltd., dated June 2011. That report is referenced in this assessment.

The assessment is conducted using operating data provided by City staff. No additional field work was undertaken for this study other than a brief site reconnaissance and discussion with the operator.

Concepts for upgrades are developed to address:

- capacity concerns,
- condition concerns, and
- compliance concerns.

The concepts are compared on the basis of cost effectiveness and making maximum use of existing process components.

1.4 Methodology

The methodology for conducting the study includes an examination of historical operating data on flows and effluent water quality. The lagoon performance is evaluated on the basis of air requirements and detention time. The effluent quality parameters are compared on the basis of:

- The current Permit (PE-80) parameters
- The BC Municipal Wastewater Regulation (MWR) deposited April 19, 2012.
- The Canada Wastewater Systems Effluent Regulations (2012)

Growth projections are made on the basis of historical growth patterns in Castlegar.

2.0 NORTH LAGOONS HISTORICAL PERFORMANCE

2.1 Process Description

The North Castlegar lagoons were originally constructed in 1963 as two facultative (non-aerated) ponds. The conversion to aerated ponds occurred in 1975 with the division of one of the facultative ponds into two aerated cells. The other cell remains as a facultative pond. A further upgrade was undertaken in 1996 with an upsized aeration system, desludging and the addition of chlorination. An overview to the lagoons can be found in Figure 2.1.

The process utilizes three cells; two cells are aerated with submerged air diffusers and are referred to as partial mix cells. The third cell is not aerated and, because of its shallow depth of 1.5 metres, relies on wind and wave action to maintain aerobic conditions. The aeration system uses two 40 HP blowers.

The air diffusers in the first two cells are not intended to maintain all solids in suspension, but rather provide sufficient oxygen to satisfy the biochemical oxygen demand (BOD). The existing cells have liquid volumes as follows:

- Cell #1: 33,000 m³
- Cell #2: 33,000 m³
- Cell #3: 24,000 m³

The effectiveness of the partial mix lagoon process is measured by reduction in carbonaceous BOD₅ (5-day carbonaceous biochemical oxygen demand) and reduction in TSS (total suspended solids). These reductions typically relate to the detention time in the lagoon cells and a reaction rate constant (**k**). The reaction rate constant varies with the water temperature. Summer water temperature between 15 and 20 °C demonstrate a k value between 0.2 and 0.3. Winter water temperatures between 5 and 10 °C will typically exhibit a k value between 0.08 to 0.12.

The chlorination facility uses chlorine gas (68 kg cylinders) with a chlorine contact tank of approximately 120,000 L volume located downstream of the outlet manhole. This provides approximately 1 hour contact time at the permit maximum flow rate of 2,724,000 L/d.

The facility also contains a septage disposal area, where trucked waste is discharged to a settling tank, which overflows into Cell #1.

Field observations at the lagoon site include:

- Many of the subsurface diffusers (Helixors static tube diffusers) in Cell #1 and Cell #2 are not functioning properly; some are plugged and some are broken.
- Islands of floating sludge are evident throughout.



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City of Castlegar
 North Lagoons
 Assessment
Site Overview

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



Scale: 1:5,000
 Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
 Data Sources: Imagery provided by ESRI

Project #: 0841.010301.01
 Author: AK
 Checked: JQ
 Status:
 Revision: A
 Date: 2017 / 12 / 19


FIGURE 2.1

- The trucked waste volumes could impair the lagoons' treatment capacity.
- A berm failure occurred in 2014; this was repaired with rip-rap armouring in 2015.

2.2 Existing Discharge Permit

The existing discharge permit (PE-0080) was originally issued in 1963 and was last amended in 1993, although these amendments related to operator certification with no changes to the type of treatment process or the effluent quality/release. The provisions of the Permit include the following effluent parameters:

- Maximum discharge rate is 600,000 Imperial gallons/day (2,724 m³/d)
- Maximum 5-day BOD concentration: 45 mg/L
- Maximum TSS concentration: 60 mg/L
- The permit makes reference to chlorination facilities but there is no indication of a chlorine residual concentration.

2.3 Recorded North Lagoons flows

The flow records provided by the City are plotted graphically on Figures 2.2 and 2.3. These records run from January 2015 to July 2017. Figure 2.2 plots the influent flows and Figure 2.3 plots the effluent flows. Minimum daily flows, average daily flows and maximum daily flows are plotted on each graph.

The flow data are summarised in the following Table 2.1:

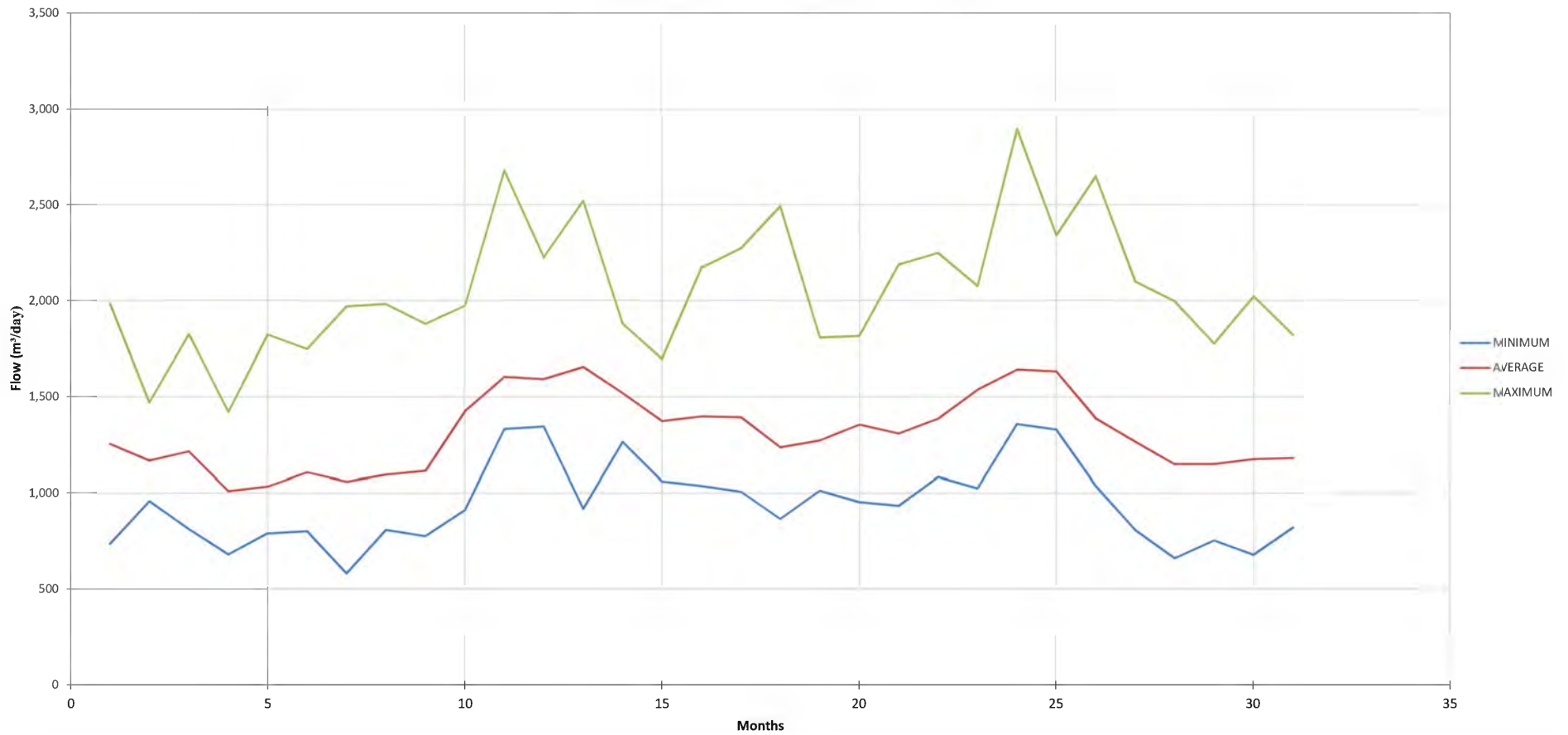
Table 2.1 – Flow Data

Event	Daily Flow (m ³ /d)
Influent (overall average)	1,588
Influent (typical high daily)	2,500
Effluent (overall average)	1,118
Effluent (typical high daily)	3,300

The highest single day of effluent flow at 4,500 m³/d is a notable excursion and could be a faulty reading. The typical effluent high day flows are approximately 3,300 m³/d. The effluent average flow is somewhat lower than the influent average flow. That is to be expected since the lagoons provide some dampening of flow rates. However, the typical effluent high days are unexpectedly higher than the influent high days.

For the purpose of estimating the BOD reduction capability, a round figure of 2,500 m³/d as a typical influent high flow day can be adopted.

Influent Summary from January 2015 - July 2017

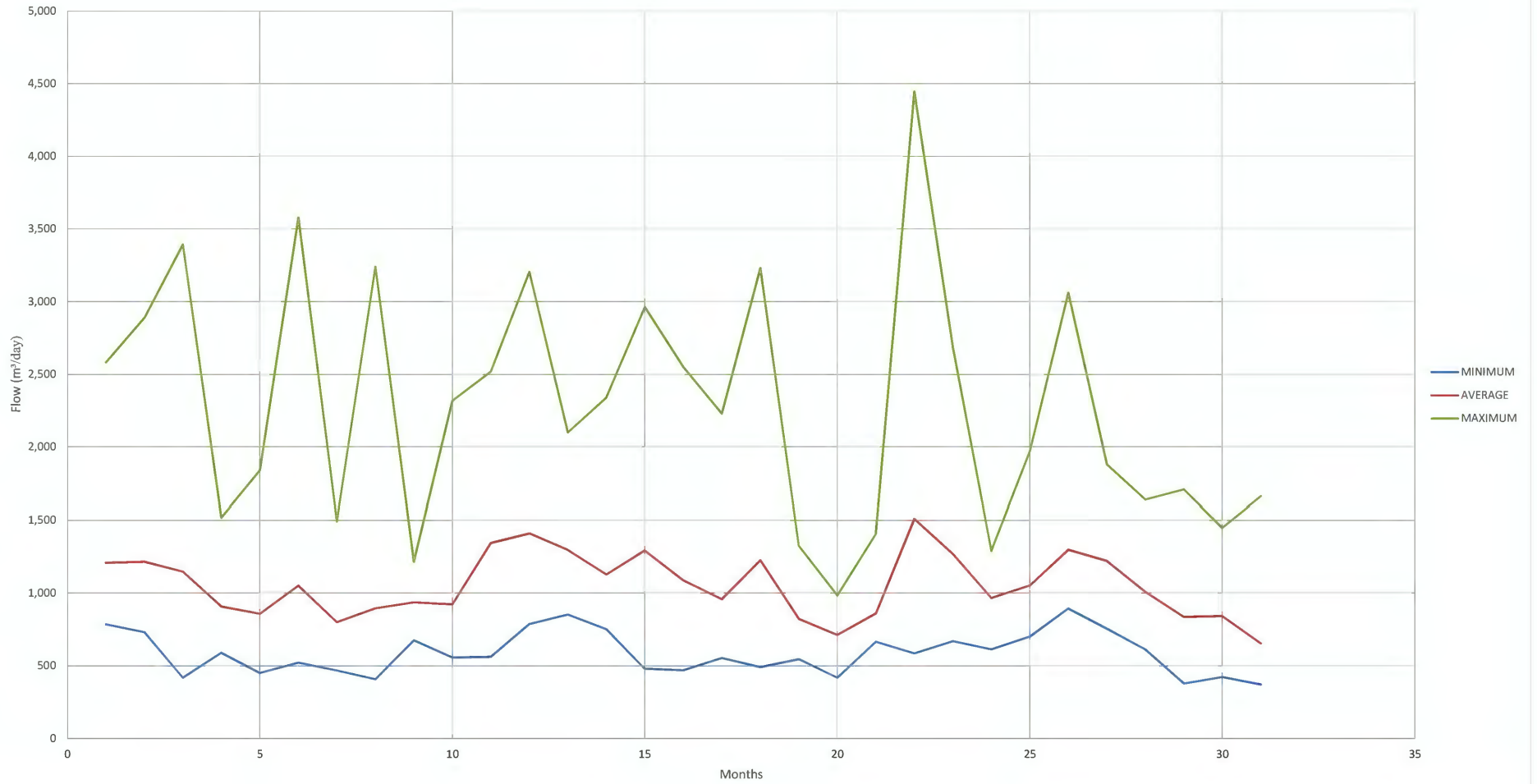


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City of Castlegar NORTH LAGOONS ASSESSMENT		
Scale	Revision Date	Figure
nts	----	FIG 2.2
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INFLUENT FLOW DATA		

Effluent Summary from January 2015 - July 2017



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City of Castlegar NORTH LAGOONS ASSESSMENT		
Scale	Revision Date	Figure
nts	----	FIG 2.3
0841.0103.01		Title
EFFLUENT FLOW DATA		

2.4 Available Treatment Capacity

The BOD removal capacity can be estimated from the calculation of detention time in the partial mix cells using typical values for the reaction rate constant (k) in summer and winter conditions. The equation is as follows:

$$BOD \text{ (effluent)} = BOD \text{ (influent)} / (1+kt)$$

Where k is the reaction rate constant and t is the detention time in days. The influent BOD has not been recorded but can be assumed to average approximately 250 mg/L (a literature average for domestic wastewater).

The reaction rate constant ranges from 0.10 at low temperatures (5 °C) to 0.25 at higher temperatures (20 °C). The recorded temperatures at the North Lagoons do not change significantly during winter and summer seasons. The lowest recorded is 17 °C and the highest recorded is 26 °C. Therefore a k factor of 0.2 was adopted for reaction rate estimates. However, a minimum temperature of 17 °C is high for a lagoon system, as this type of treatment process is highly affected by the ambient air temperature. It is more reasonable for the temperature to be in the 5 to 8 °C over the winter months. Therefore, the reaction rate (k) was also calculated for a temperature of 5 to 6 °C, and the outcome indicates that there is sufficient detention time for treatment with the current incoming flows.

Cell #1 and Cell #2 each have a detention time of $33,000/2,500 = 13$ days per cell. The calculated BOD values using this detention time and a k factor of 0.2 are:

- BOD exiting Cell 1: 69 mg/L
- BOD exiting Cell 2: 19 mg/L

2.5 Recorded Treatment Performance

Effluent sample records were provided for the period January 2013 to July 2017. The sampling includes ammonia (total and un-ionised), nitrate, BOD₅ (carbonaceous and total), TSS, pH, temperature, phosphate, total phosphorus and total and faecal coliforms. There are 60 samples over the period; the recorded minimum, maximum and average values are summarised in Table 2.2

Table 2.2 Effluent Quality Parameters Summary

Parameters (Units)	Minimum	Maximum	Average
Ammonia Total (mg/L)	0.756	34.8	20.7
Ammonia Un-ionised (mg/L)	0.005	1.227	0.327
Nitrate (mg/L)	0.05	2.43	0.37
CBOD ₅ (mg/L)	< 5	28	10
Total BOD ₅ (mg/L) (Note 1)	< 5	34	17
TSS (mg/L)	1	33	8
Orthophosphate (mg/L)	0.6	6.6	2.8
Total Phosphorus (mg/L)	0.7	11.0	5.0
pH	6.9	8.4	7.7
Temperature (°C)	17	26	21
Total Coliforms (MPN/100 mL)	< 3	> 110,000	7,502
Faecal Coliforms (CFU/100 mL)	< 3	56	2,200

Note 1: Assumed to be total BOD₅, based on duplicate data for the same sample dates.

Figure 2.4 provides a plot of the effluent carbonaceous BOD₅ concentration over the period from January 2013 to July 2017. The long term average is approximately 10 mg/L. There are several spikes over the period ranging from 2 to 25 mg/L, with a maximum recorded concentration of 28 mg/L. The average total BOD₅ is 17 mg/L, which correlates well with the calculated value based on the reaction rate constant and the detention time.

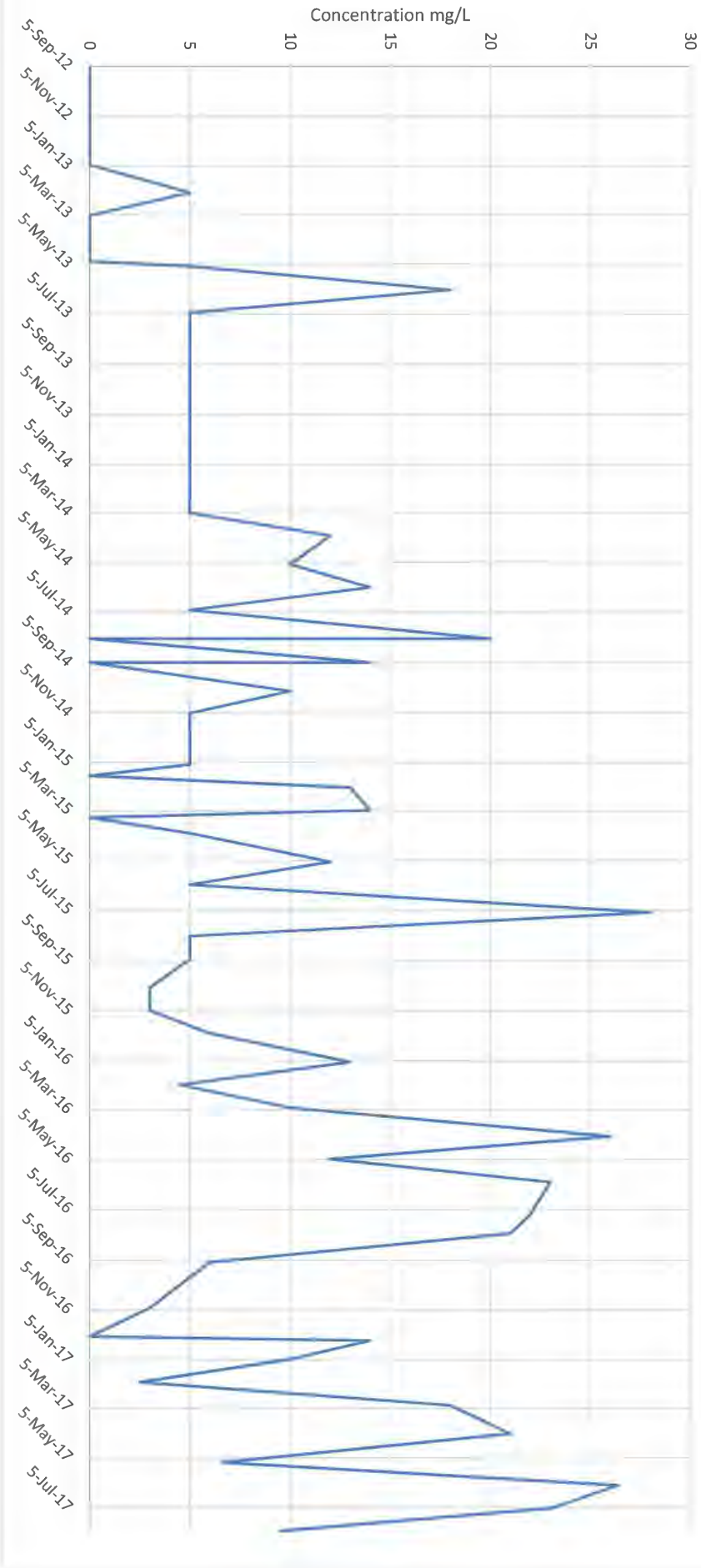
Figure 2.5 plots the effluent TSS concentration over the period. The average concentration is 8 mg/L with a maximum recorded at 33 mg/L on July 5, 2016. The high BOD recording also occurred on July 5, 2016. The spike for both of these parameters appear to occur every July and it is possible that they may be due to a summer algae bloom.

Figure 2.6 plots the concentrations of total phosphorus over the period and demonstrates a low value of 0.7 mg/L, averaging 5.0 mg/L, with a maximum reading of 11 mg/L.

Figure 2.7 plots the readings of un-ionised ammonia showing a low value of 0.005 mg/L, a maximum of 1.227 mg/L and an average over the period of 0.327 mg/L. The un-ionised ammonia concentration was calculated using the measured total ammonia concentration, laboratory measured pH and a standard temperature of 15 °C, as per the methodology outlined in the Federal wastewater regulation.



NORTH LAGOONS ASSESSMENT



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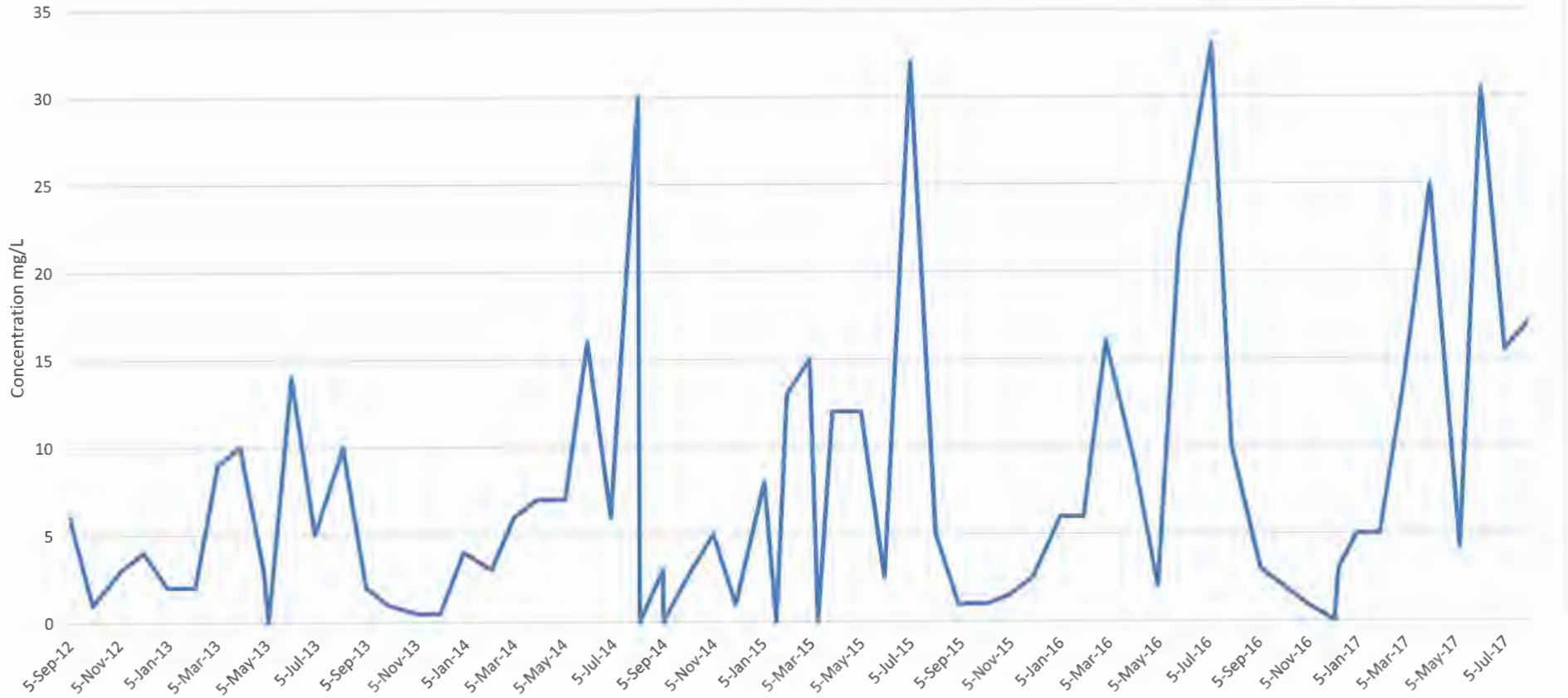
City of Castlegar
NORTH LAGOONS ASSESSMENT

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FIG 2.4

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EFFLUENT CBOD5

NORTH LAGOONS ASSESSMENT



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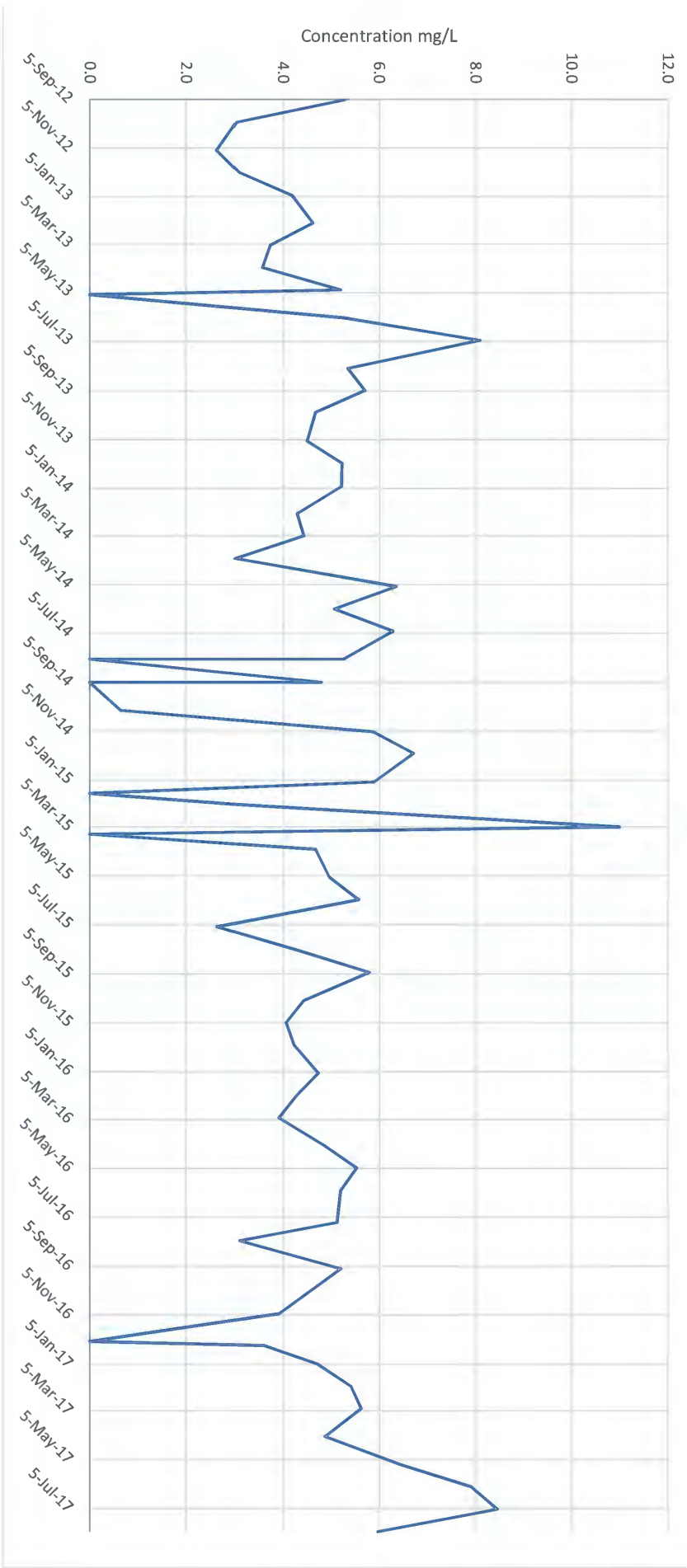


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City of Castlegar NORTH LAGOONS ASSESSMENT		
Scale	Revision Date	Figure
nts	----	FIG 2.5
0841.0103.01		Title

EFFLUENT TSS DATA



NORTH LAGOONS ASSESSMENT



Client/Project

City of Castlegar
NORTH LAGOONS ASSESSMENT

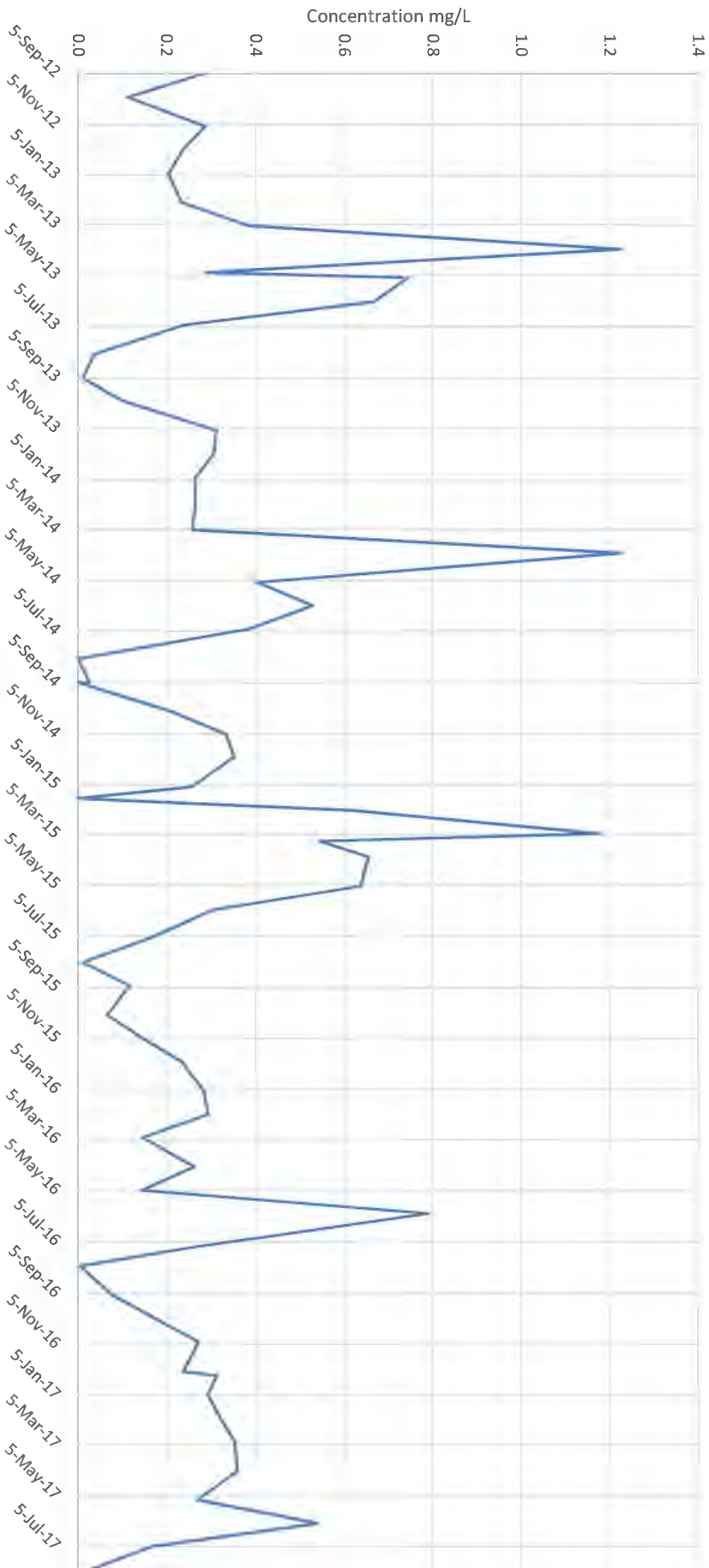
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EFFLUENT TOTAL PHOSPHORUS DATA



NORTH LAGOONS ASSESSMENT



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City of Castlegar
NORTH LAGOONS ASSESSMENT

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Revision Date

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FIG 2.7

EFFLUENT UN-IONISED AMMONIA DATA

The sampling results indicate that the effluent is consistently meeting the BC discharge permit requirements with respect to BOD₅ and TSS maximum levels.

The discharge flow rates exceeded the permit maximum of 2,724 m³/d 22 times over the 30-month period of record.

3.0 APPLICABLE LEGISLATION

3.1 Provincial and Federal Regulations

Modifications to the facility and/or discharge location, flows and quality parameters are governed by the BC Environmental Management Act. If changes are considered to be major, e.g., a greater than 10% increase in flows, then the facility will need to register under the MWR. If changes are considered to be minor, it is possible that the site changes may fall into a “Minor Permit Amendment” category and the site could continue to discharge under an amended permit.

There is federal legislation which may also apply to surface water discharges, known as the Wastewater Systems Effluent Regulations (WSER). This regulation applies to all sites that have an average influent flow rate of > 100 m³/d and discharge to a fisheries water. Therefore, this regulation applies to the North Lagoons. Discussions to harmonize the MWR and the WSER are ongoing but have not been concluded to date.

Table 3.1 summarises the relevant effluent quality parameters under the BC MWR and the Canadian WSER:

Table 3.1 – Relevant Effluent Quality Parameters under the BC MWR and the Canadian WSER

Parameter	BC MWR	WSER
CBOD ₅ (mg/L)	45 (max)	25 (avg)
TSS (mg/L)	45 (max)	25 (avg)
Total Residual Chlorine (mg/L)	0.02	0.02
Total Ammonia (mg/L)	IDZ calculation	n/a
Un-ionised Ammonia (mg/L)	n/a	1.25 (max)
Total Phosphorus (mg/L)	1.0 (max)	n/a
Orthophosphate (mg/L)	0.5 (max)	n/a

The parameters for CBOD₅ and TSS are given as maximum values under the MWR and average values under the WSER.

Ammonia can be present in two forms – ionised and un-ionised ammonia. It is the un-ionised form of ammonia which is toxic to fish. The proportion of these two forms of ammonia is dependent on temperature and pH, with the un-ionised form predominating as the pH increases. The ammonia concentration under the MWR focuses on total ammonia (i.e. both the ionised and un-ionised forms

of ammonia) and is to be determined from the initial dilution zone (IDZ) calculations and pH values. The IDZ is an area immediately around the point of discharge where it is acceptable for degradation in water quality to occur. The WSER requires a maximum concentration of 1.25 mg/L as un-ionised ammonia, prior to effluent release. However, if the effluent un-ionised ammonia concentration of 1.25 mg/L cannot be met before effluent release, then there is no need to upgrade for ammonia treatment as long as an un-ionised ammonia concentration of 0.016 mg/L is met in the receiving environment, 100 m away from the point of release. To achieve this mixing in the environment, it is essential that the outfall is appropriately designed and located to achieve maximum dispersion in the receiving environment.

The MWR requirement for total phosphorus is 1.0 mg/L and 0.5 mg/L for orthophosphate. The WSER does not address any phosphorus limits. The MWR also makes the following provision:

The total and orthophosphate criteria may be waived if it can be shown from an environmental impact study that receiving waters would not be subject to an undesirable degree of increased biological activity because of phosphorus addition.

It is also possible that an environmental impact study could indicate that there is the need for a more stringent effluent phosphorus concentration. Concerns relating to nutrient deficiency and the impacts on the fisheries resources has led to the addition of fertilizers to Arrow Lake and Kootenay Lake, both of which are upstream of the Columbia River at Castlegar. It is possible that the river is nutrient deficient and there would be no detrimental impacts as a result of nutrients being released in the effluent from the North Lagoons.

The receiving water conditions warrant an environmental impact study before any decision can be made on the effluent requirements for ammonia, phosphorus and disinfection.

4.0 SERVICED POPULATION AND FLOW PROJECTIONS

4.1 Historical Population

The City is serviced with two wastewater treatment plants. The South Castlegar plant services approximately 58% of the population and the North Lagoons service approximately 42% of the population. The recorded population from the Canada Census data is summarised in Table 4.1 as follows:

Table 4.1 – Historical Population Data

Year	Canada Census Population	North Sector Population (42%)
1991	6,579	2,763
1996	7,027	2,951
2001	7,585	3,186
2006	7,259	3,049
2011	7,816	3,283
2016	8,039	3,376

4.2 Historical Flow Data

The available flow records for the last two corresponding census years are provided in Table 4.2

Table 4.2 – Flow Records for the Last Two Corresponding Census Years

Year	ADF (m ³ /d)	MDF (m ³ /d)	Serviced Pop	ADF/Cap (L/d)	MDF/Cap (L/d)
2011	1,980	2,620	3,283	603	798
2016	1,700	2,700	3,376	504	800

The North sector service area includes the downtown commercial, so per capita rates are expected to be higher than strictly residential areas. Residential per capita rates are typically in the 400 L to 500 L per capita range. The North sector sewers are also subject to groundwater infiltration and stormwater inflow. A brief study of the North Trunk Sanitary Sewer was undertaken by Kerr Wood Leidal and Associates Ltd., and reported in a Technical Memorandum dated September 13, 2006. The report estimates a base groundwater infiltration rate of 7.1 L/s (613 m³/d) and periodic storm inflow of 6.3 L/s.

The commercial flows and the groundwater infiltration have an impact on the flows arriving at the North Lagoons. For the purpose of this overall assessment relating flows to census population on the basis of the north/south population split will provide a reasonably accurate representation of per capita contribution. A per capita rate of 550 L/c/d can be adopted for average daily flow and 800 L/c/d adopted for maximum daily flow.

4.3 Population Projection

The Census population data indicate a growth of 1,460 people over a 25 year period, or approximately 22% over 25 years. Expressed as an annual growth factor, this is the equivalent of approximately 0.8% per year. A conservative growth rate of 1% per year would be appropriate for a long- term projection. The City's Official Community Plan also suggests a growth rate of 1% per year.

The use of a 1% per year growth rate for 20 years uses a Compound Amount Factor of 1.22, resulting in a 2037 (2017 + 20) population of 9,800. The North sector population would be approximately 4,120.

4.4 Flow Projection

The flow projections to the North Lagoons for the year 2037 are as follows:

- Maximum Daily Flow: $4,120 \times 800 \text{ L/c/d} = 3,300 \text{ m}^3/\text{d}$
- Average Daily Flow: $4,120 \times 550 \text{ L/c/d} = 2,270 \text{ m}^3/\text{d}$

It is evident that projected the maximum daily flow of 3,300 m³/d represents a greater than a 10% increase over the current permit value of 2,724 m³/d. It can therefore be expected that the permit will need to be cancelled and that the site would need to register under the MWR for the treatment strategy that would take the site to the 20-year horizon. A 10% increase, under a minor permit amendment, to 3,000 m³/d would be approximately equivalent to a maximum day flow for 3,750 people. At a growth rate of 1% per annum, a service population of 3,750 would be reached in approximately ten years.

5.0 UPGRADE APPROACHES

The discharge quality from the North Lagoons is currently in compliance with the provisions of the BC discharge permit, although there have been occasions when the flow exceeded the permit maximum. There are also a number of concerns that have been identified by the Ministry of Environment, and observation of the process functionality. Chief among these are:

- The lack of a formal dechlorination process and the inability to control the effluent chlorine residual.
- The location of the discharge at the shore of an embayed area. This may be having a deleterious impact on the receiving water and the fish in that reach of the Columbia River. This concern was put forward in a letter from the Ministry of Environment in 1999, where both environmental concerns and public health concerns were highlighted.
- There is visible evidence that many of the sub-surface diffusers are plugged and not functional.
- Some floating “islands” of sludge are visible in Cell #1 and Cell #2.

The following sections provide a discussion of several potential approaches, ranging from:

- “Do nothing”.
- Remedial approach: a remedial strategy to correct deficiencies and repair inoperable elements.
- Increase capacity approach: increase processing capacity to accommodate growth.
- Improve treatment approach: modify the process to include nutrient removal.

5.1 Do Nothing Approach

The North Lagoons system generally meets the current discharge permit requirements with the exception of periodic peak flows which exceed the allowable maximum daily flow of 2,724 m³/d. In addition, taking data from 2012, there are also low concerns with respect to meeting the requirements of the WSER for effluent CBOD₅, TSS and un-ionised ammonia. However, it should be noted that lagoon systems are vulnerable to periodic increases in pH as a result of natural algal growth. This can cause the un-ionised ammonia concentration to increase significantly, and the resulting concentration could exceed the 1.25 mg/L acutely toxic threshold. Reliance on the ability to meet an un-ionised concentration of 0.016 mg/L at a location 100 m away from the outfall could be challenging for this site, given the location of the outfall.

However, from the aeration pattern at the surface, there is evidence that the diffusers in both Cell #1 and Cell #2 need replacement. It can also be anticipated that the blowers will require replacement or overhaul after more than 20 years of service.

The location of the discharge outfall into the Columbia River was the subject of a study undertaken in 2011. The concern is the poor mixing available with the end of the outfall in a location which is not conducive to mixing and could result in the effluent being directed towards an embayed area with both fisheries and recreational uses. While there is a designed gas chlorination system, the dechlorination system is a temporary makeshift system using sodium thiosulphate pucks in a plastic tube located in the outfall chamber. The puck dissolve rate is not easily controllable and pucks are replaced daily. The effectiveness of this system is undetermined and it could be, at times, over-dosing or under-dosing. While there is no requirement in the current permit for dechlorination, there is a requirement in the WSER, with the clauses in coming into effect on January 1st, 2021.

The 2011 study explores two potential new discharge points which could provide adequate mixing and recommends further analysis including an environmental impact study, IDZ modelling and river bottom profiling.

The exterior berms were suffering from erosion and this issue has been corrected with the installation of rip-rap armouring along the exterior of the berms.

Sludge accumulation is anticipated in Cell #1 and possibly Cell #2. Both cells should be probed and the bottom surveyed to establish the depth of sludge and the requirement for desludging.

Given the concerns with aging equipment, the lack of a formal dechlorination system, and the location of the outfall, the “do nothing” approach is not recommended.

5.2 Remedial Approach

The remedial approach is directed at correcting or repairing items that are either not functioning properly, need replacement due to age or condition, or have been identified as potential risks by the Ministry of Environment.

The major items identified include:

- Desludging of Cell #1.
- Replacing the diffuser grid in Cell #1.
- Overhauling the blowers.
- Installing flow-paced dechlorination, although a possible alternative of UV disinfection may also be considered, depending on the UV transmittance of the effluent.
- Extending the outfall.

Implementation of the foregoing will require some investigative activities, including:

- A sludge depth survey in all three cells to assess the extent of desludging.
- A performance specification and solicitation for air diffusion equipment.
- An inspection and performance testing of the blowers.
- Investigation of optional forms of dechlorination (sulphur dioxide gas and sodium thiosulphate powder).
- Sampling and recording of effluent UV transmittance. If UV transmittance is sufficiently high, UV disinfection may be a preferable method of disinfection.
- Further analysis of outfall extension options.

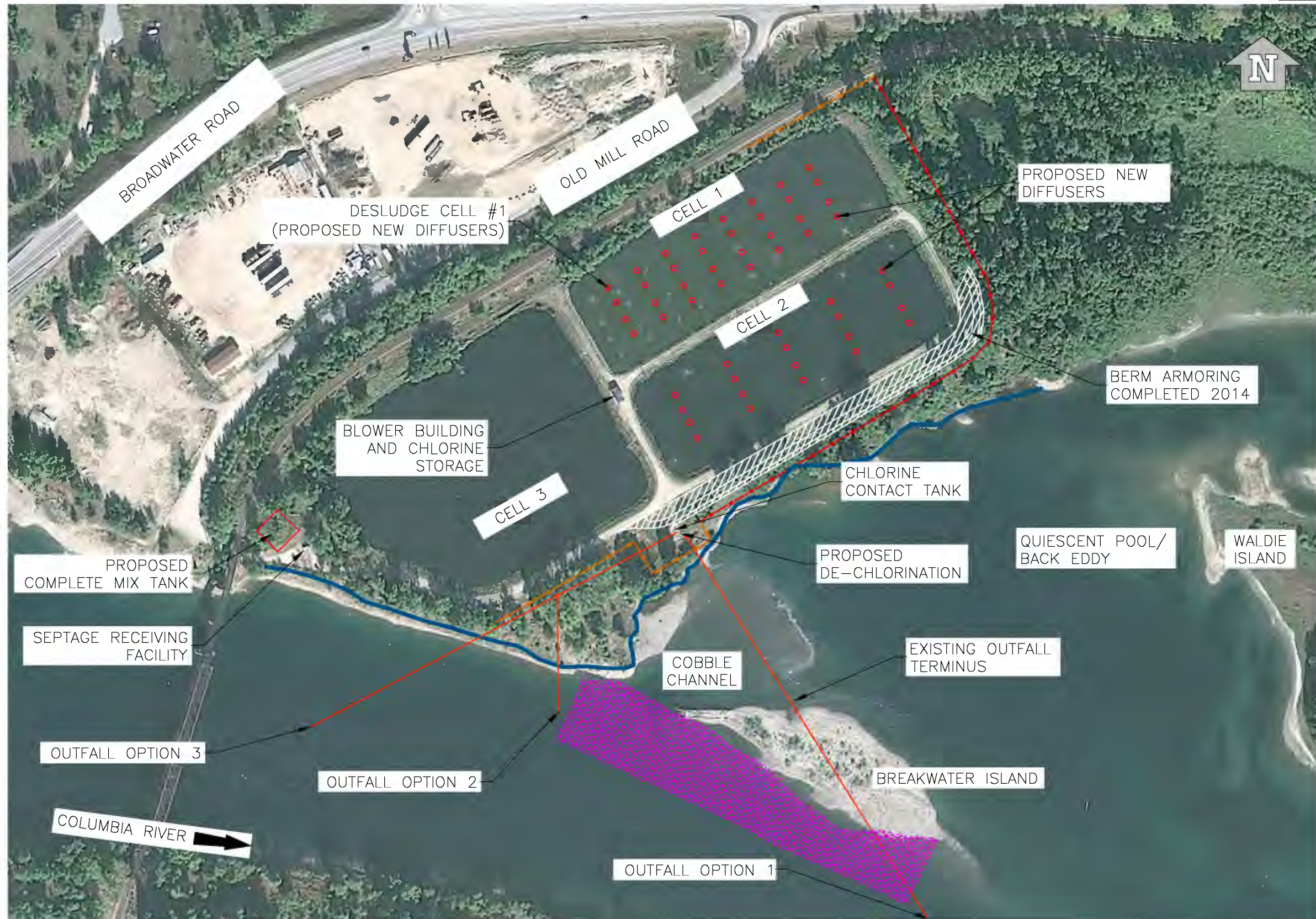
The previous outfall analysis work in 2011 recommended Option 2. Option 2 re-routes the outfall pipe west and upstream of Breakwater Island. However, the study also indicates that there is an area of mountain whitefish egg-laying habitat adjacent to the Breakwater Island west shoreline. The Option 2 alignment is proposed to run approximately 25 m from the riverbank. A potential third option is to extend the outfall line in a south westerly direction and out to the middle of the river channel. The risk of effluent reaching the mountain whitefish egg-laying area could be reduced with an outfall terminus in the middle of the river channel. Figure 5.1 provides a depiction of the three outfall alignment options.



This approach will not increase the processing capacity of the North Lagoons facility, so it is not anticipated that an MWR Registration would be required. However, if a new dechlorination system is installed and the outfall is extended, and amendment to the existing Permit would very likely be required. Discussions with the Ministry of Environment should be undertaken to determine if this would be classed as a “minor” amendment.

The decision-making process for treatment levels, dechlorination and discharge location will require an environmental impact study. The requirements of an environmental impact study are outlined in the BC MWR and generally include the following:

- Summary of the characteristics of the receiving environment.
- Summary of existing uses and fisheries values associated with the receiving environment.
- Calculation of dilution ratios and statistical evaluation of river flows (in this case these are controlled by the Hugh Keenlyside Dam and the Columbia River Treaty).
- Determination of effluent quality criteria for the protection of the environment and human health.

Appendix A provides a breakdown of the capital cost estimates for this approach.



- LEGEND:
-  AVERAGE ANNUAL HIGH WATERMARK
 -  HIGHEST USE MOUNTAIN WHITEFISH EGG MAT MONITORING AREAS

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Client/Project		
City of Castlegar		
NORTH LAGOONS ASSESSMENT		
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OUTFALL OPTIONS

5.3 Capacity Increase Approach

The flows to the North Lagoons are expected to increase with increasing serviced population. The 20 year design horizon flows will see the detention time in each cell reduced to 10 days. The reduced detention time will compromise the lagoons' ability to reduce BOD. The site does not have sufficient room to expand the partial mix lagoons or to add another cell.

There are several approaches to increasing processing capacity without constructing more lagoon cells. These include:

1. Deepening Cell #3 to allow for the installation of submerged air diffusers and providing additional partial mix lagoon capacity
2. Add a complete mix reactor at the front end of the lagoons. The effect of a complete mix reactor is to reduce soluble BOD prior to the partial mix lagoons. A complete mix reactor can significantly reduce soluble BOD with a detention time of less than 1 day. While TSS is not reduced in the complete mix tank, the organic loading is significantly reduced, resulting in an increased processing capacity. The complete mix tank will require additional blower capacity and would be sized to process the projected 20-year horizon flow.

Appendix B provides a cost estimate for this approach.

5.4 Nutrient Removal Approach

The Provincial Regulation (MWR) and Federal Regulations (WSER) both list nutrients on their effluent discharge parameters. The MWR lists phosphorus and total ammonia, while the WSER lists nitrogen (in the form of un-ionised ammonia). The MWR requires an environmental impact study of the receiving water to establish acceptable concentrations of ammonia and phosphorus in the discharge, as well as the disinfection levels.

This approach is based on the assumption that the environmental impact study will show that nutrient removal for both nitrogen and phosphorus will be required and the options for adding nutrient removal processes should be considered.

Nitrogen in wastewater treatment processes is typically removed by nitrification (which converts ammonia to nitrate, followed by denitrification (which converts nitrate to nitrogen gas). The nitrification/denitrification process can be achieved with an attached growth reactor. That is, some form of media is used to promote the growth of nitrifying bacteria. Post denitrification would require carbon source addition and this approach is generally only pursued where very low effluent total nitrogen concentrations are required. If denitrification is required in this case, the preferred approach would likely be an alternative such as pre-denitrification.

Phosphorus reduction can be achieved biologically through a process referred to as BNR (Biological Nutrient Removal). This process is somewhat complex and requires significant operator attention. In smaller plants such as the North Lagoons, phosphorus is more readily reduced by precipitation through the use of a coagulating agent such as alum. Precipitation can be achieved in a coagulation/flocculation tank. However, the floc formed by the chemical addition contains the phosphorus and must be removed from the flow through a filter or clarifier. The process units therefore include:

- chemical dosing, coagulation/flocculation, and filtration/clarification.
- The filtration will also require backwashing to clear the filter media of accumulated floc, and this backwash water is returned to the head of the lagoons.
- The filtration process will also result in significant removal of TSS, making UV disinfection a preferable replacement for chlorination/dechlorination.

Appendix C provides capital cost estimates for this approach.

Appendix A

Remedial Approach

Appendix A – Remedial Approach

Table 1 – Investigative Budget

Item	Total
1. Sludge Survey Probing (all Cells)	\$ 28,000
2. Assessment of sludge management options	\$ 40,000
3. New air diffuser specification & solicitation	\$ 9,000
4. Blower inspection & overhaul assessment	\$ 4,000
5. Effluent UVT sampling & disinfection options comparison	\$ 14,000
6. Flow metering assessment and upgrade strategy	\$ 3,000
7. Outfall field work, analysis and pre-design	\$ 60,000
8. Environmental impact study	\$ 45,000
Sub-Total	\$ 203,000
Contingency (10%)	\$ 20,300
Total (rounded)	\$ 220,000

Notes:

Table 1 presents an estimate of the investigations required to confirm the scope of remedial works that would update poorly functioning process components and acknowledge the need to move towards ultimately registering the facility under the MWR. This scope includes an assessment to determine the preferred approach for desludging, the ultimate destination of the sludge and the costs associated with the available sludge management options.

Table 2 – Approximate Budget for Remedial Works

Item	Total
1. Desludging of Cell #1	\$ 400,000
2. Replacement of diffusers in Cells #1 and #2	\$ 560,000
3. Blower overhaul	\$ 50,000
4. Dechlorination	\$ 150,000
5. Outfall extension	\$ 420,000
Sub-Total	\$ 1,580,000
Contingency & Engineering (50%)	\$ 790,000
Total (rounded)	\$ 2,370,000

Notes:

Table 2 is an approximate estimate of the capital cost of remedial works. The scope of these works is based on assumed results of the investigative phase. There is no provision for an increase in processing capacity. For desludging, this assumes that the sludge will be stored on-site in geotubes and that there is sufficient room on-site to accommodate geotubes. There is no allowance for removing the solids off-site for either disposal or reuse. These costs will need to be determined through a study, as outlined in Table 1.

Appendix B

Capacity Increase

Appendix B – Capacity Increase

Item	Total
1. Complete Mix Tank	\$ 1,200,000
2. Diffusers for Complete Mix Tank	\$ 320,000
3. Yard Piping	\$ 280,000
4. New Larger Blowers (3)	\$ 380,000
Sub-Total	\$ 2,180,000
Engineering & Contingency (50%)	\$ 1,090,000
Total (rounded)	\$ 3,270,000

Notes:

The capital cost estimate above is for increasing the processing capacity of the facility by adding a complete mix tank ahead of the lagoons. The design maximum daily flow capacity is 3,300 m³/d. The estimate assumes that the remedial works for air diffusers in the lagoons, dechlorination and outfall extension, as listed in Appendix A, would have been completed.

Appendix C

Nutrient Removal

Appendix C – Nutrient Removal

Item	Total
1. SBR or MBBR addition for nitrogen removal	\$ 650,000
2. Chemical addition and filtration for phosphorus removal	\$ 1,200,000
3. UV Disinfection	\$ 540,000
Sub-Total	\$ 2,390,000
Engineering & Contingency (50%)	\$ 1,195,000
Total (rounded)	\$ 3,585,000

Notes:

The above estimate is based on the assumption that the environmental impact study will show that nutrient removal is required for discharge into the Columbia River. This result is not anticipated from a general knowledge of the receiving water environment. The approximate cost estimate is intended to provide a sense of the magnitude of investment should the environmental impact study find that nutrient removal is required.