ABBOTSFORD

plan FOR 200K

ENGINEERING & REGIONAL UTILITIES

DRAINAGE MASTER PLAN

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Executive Summary

Introduction

The City of Abbotsford (City) adopted the new Official Community Plan (OCP) in June 2016. The City retained Kerr Wood Leidal Associates Ltd. (KWL) to prepare a Drainage Master Plan (DMP) for the entire City. The DMP allows the City to determine the required drainage infrastructure upgrades for the next 25 years (Year 2019-2043) to meet the expected demands of the projected population growth to 200,000 people and land use changes as per the 2016 OCP.

The City's drainage assets include approximately 500 km of gravity storm sewer and over 31,000 associated structures (manholes, headwalls, catch basins, etc.), 381 detention facilities, 526 km of ditches, 173 km of creeks, 1,296 culverts, 33 km of dykes, and 5 drainage pump stations.

Key Drainage Issues

The key drainage issues known to City staff include:

- localized flooding in the lowlands of Matsqui and Sumas Prairies,
- undersized drainage infrastructure in the urban and rural upland areas,
- periodic road closures caused by flooding,
- active erosion and instability within creek ravines and along river banks,
- sediment deposition and debris accumulation in lower reaches of channels, and
- lack of resilience for climate change and seismic events for the pump stations and dikes.

Capital Project List for Studied Areas

The City has completed many Integrated Stormwater Management Plans (ISMP), lowland drainage studies, as well as erosion, sedimentation, detention, and pump station studies. The recommendations from historical studies were reviewed and consolidated into a capital project list. The upgrading projects were updated to consistent criteria and cost estimates were updated to 2017 dollars. The capital project list was prioritized using a decision matrix and sorted into short, medium, and long term projects.

Dike Assessment

The dike upgrading assessment includes the City's three dikes, namely Matsqui Dike (Fraser River), Vedder Dike (Vedder Canal and Fraser River), and Sumas Dike (Sumas River, Saar Creek, and Arnold Slough). An indicative upgrading cost was estimated based on seismic and geometric upgrades to meet the Provincial "high consequence" performance criteria and 1 m sea level rise under climate change conditions, respectively.

Municipal Programs

The DMP also included the review of and recommendations for the following municipal programs:

- A Stormwater Management Policy and Criteria – the review recommended that the City establish a City-wide Stormwater Source Control bylaw, additions to the Development Bylaw, and review, amendment and/or enforcement of other existing bylaws.
- Regional Facilities Management – completed a City-wide detention facility inventory and creation of a GIS database, and a desktop assessment of potential new detention pond locations in areas downstream of proposed development was undertaken. A map of potential infiltration areas was also developed based on available soils data to guide the selection of source control measures and centralized stormwater management facilities for future development.
- River Management Programs – details on the Nooksack River overflow, asbestos cement issue in the Sumas River and Vedder River sediment management programs are summarized for future reference.

- Stormwater Fees and Charges – a review of best practices of stormwater fees and charges in Canada and the US was provided and identified two commonly used fee structures, including a flat rate and a variable rate for the City's future consideration.

Drainage Capital Expenditures

The total capital expenditures are estimated to be $447M for the next 25 years, with an average annual cost of approximately $18M. An additional $72M will be required for dike improvement beyond the 25 year study timeline (from 2044-2050). Section 11 provides a summary of the proposed drainage capital plan annual expenditures.

Approximately 77% of the total $447M capital expenditure is attributed to dike improvement. Without dike improvement costs, the total capital expenditures are $104M, with an average annual cost of $4.2M. Many high-cost, lower priority projects (such as pump station upgrades, new detention ponds and storm diversion construction) were scheduled near the end of the master planning period (Years 2041-2043).

Recommendations

Based on the findings in the DMP, it is recommended that the City:

1. **Periodically Update DMP** – Update the DMP once every 5 years as additional floodplain and drainage studies are completed. Update the cost estimates for the currently unstudied areas as these areas are assessed. Conduct a back-up power study for the McLennan Creek, Matsqui Slough, DeJong, and Vanderloos pump stations. Consider developing a Dike Master Plan to refine the dike upgrading cost and to develop a feasible phased approach for dike upgrades.
2. **Update Policies -** Develop an enforceable City-wide Stormwater Source Control Bylaw for new development and redevelopment. Add requirements to incorporate climate change and fish friendly approaches in the Development Bylaw.
3. **DMP Implementation -** Adjust the annual capital budget to accommodate the capital costs of the drainage system upgrades. Incorporate growth-related upgrades and their costs in the City's Development-Cost-Charge program. Conduct feasibility and predesign phases for each project prior to design and construction. Conduct 19 future studies recommended in the DMP, including a feasibility study on Stormwater Fees and Charges to explore an appropriate rate structure and implementation strategy for the City.

1. Introduction

The City of Abbotsford (City) adopted the new Official Community Plan (OCP) in June 2016. The retained Kerr Wood Leidal Associates Ltd. (KWL) to prepare a Drainage Master Plan (DMP) for the entire City area. Figure 1-1 presents a map indicating the extents of the study area, major watershed boundaries and the existing land use as shown in the 2016 orthophoto. The DMP will allow the City to determine the required infrastructure upgrades for the next 25 years to meet the expected demands of the projected population growth to 200,000 people and land use changes as per the 2016 OCP.

1.1 City-wide Drainage

The City covers an area of 39,000 hectares and includes over 10 watersheds. The Downes Creek, Willband Creek, and Clayburn Creek watersheds drain north to the Fraser River through the Matsqui Prairie lowlands by pumping or gravity. The Marshall Creek watershed drains south into the Sumas River which drains northeast to the Fraser River through the Sumas Prairie. The Fishtrap Creek watershed drains south to the United States. The remaining rural watersheds, including the Bertrand Creek, Salmon River, Nathan Creek, Mt. Lehman Creek, and McLennan Creek watersheds, are contained within the rural drainage boundary. These watersheds drain west to the Township of Langley, or north to the Fraser River by gravity.

The City maintains approximately:

- 500 km of gravity storm sewer,
- over 31,000 associated structures (manholes, headwalls, catch basins, etc.),
- 381 detention facilities,
- 526 km of ditches,
- 173 km of creeks,
- 1,296 culverts,
- 33 km of dykes, and
- 5 major drainage pump stations.

The total value of the drainage system is in the range of $700M, excluding roadside ditches and culverts in the rural upland drainage area, which are considered a part of road infrastructure.

Known Drainage Issues

The key drainage issues known to City staff include:

- localized flooding in the lowlands of Matsqui and Sumas Prairies and Rural Upland Area,
- undersized drainage infrastructure in the urban and rural upland areas,
- periodic road closures caused by flooding,
- active erosion and instability within creek ravines and along river banks,
- sediment deposition and debris accumulation in lower reaches of channels, and
- lack of resilience for climate change and seismic events (pump stations and dikes).

1.2 Scope of Work

The scope of this project is summarized below:

- Review and consolidate recommendations of previous Integrated Stormwater Management Plans (ISMPs) and lowland drainage studies. Review criteria / assumptions in each study and adjust to make consistent. Update the infrastructure sizing for adjusted criteria / assumptions and land use plan of 2016 OCP. Update cost estimates provided in these studies to 2017 dollars;

- Estimate potential project cost for drainage upgrades in the unstudied areas (areas not covered by previous drainage studies);
- Estimate long-term dike upgrading cost;
- Estimate pump station upgrading and backup power cost;
- Review options for stormwater fees and charges;
- Conduct a bylaw and policy review and recommend updates;
- Develop a prioritization matrix and establish a prioritized project list;
- Review and recommend updates to current DCC and capital programs; and
- Group prioritized projects into short, medium, and long term projects.

1.3 Previous Drainage Studies

The City provided background studies and reports as listed in Table A1 in Appendix A. The historical studies were categorized and are discussed in the following sections.

ISMPs

Since 2006, the City has completed three Integrated Stormwater Management Plans (ISMPs):

- Marshall Creek,
- Downes Creek, and
- Clayburn Creek.

The Willband Creek ISMP is underway. The Fishtrap Creek ISMP is scheduled to start in 2018/2019.

Lowland Drainage Studies

Phase 1 Lowland Drainage studies for Matsqui Prairie (completed 2013) and Sumas Prairie (completed 2017) have been undertaken. Phase 2 Drainage Study of Matsqui Prairie is scheduled to start in 2019.

The remaining rural watersheds will be studied in the future with reduced levels of effort due to limited land use change and development pressure.

Erosion, Sedimentation, Dike, Pump Stations, Detention Studies

The City has also completed many other studies including:

- Erosion and sedimentation studies for urban creeks and the Fraser River bank;
- Dike assessment and upgrades;
- Pump station studies to increase pumping capacity and resiliency, and
- Detention pond studies to increase storage volume to meet development needs.

Recommendations from environmental, flow monitoring and irrigation related studies were not included in the DMP proposed project list.

Recommendations from each study were extracted and compiled into a list of proposed projects as summarized in Section 2.

1.4 Report Outline

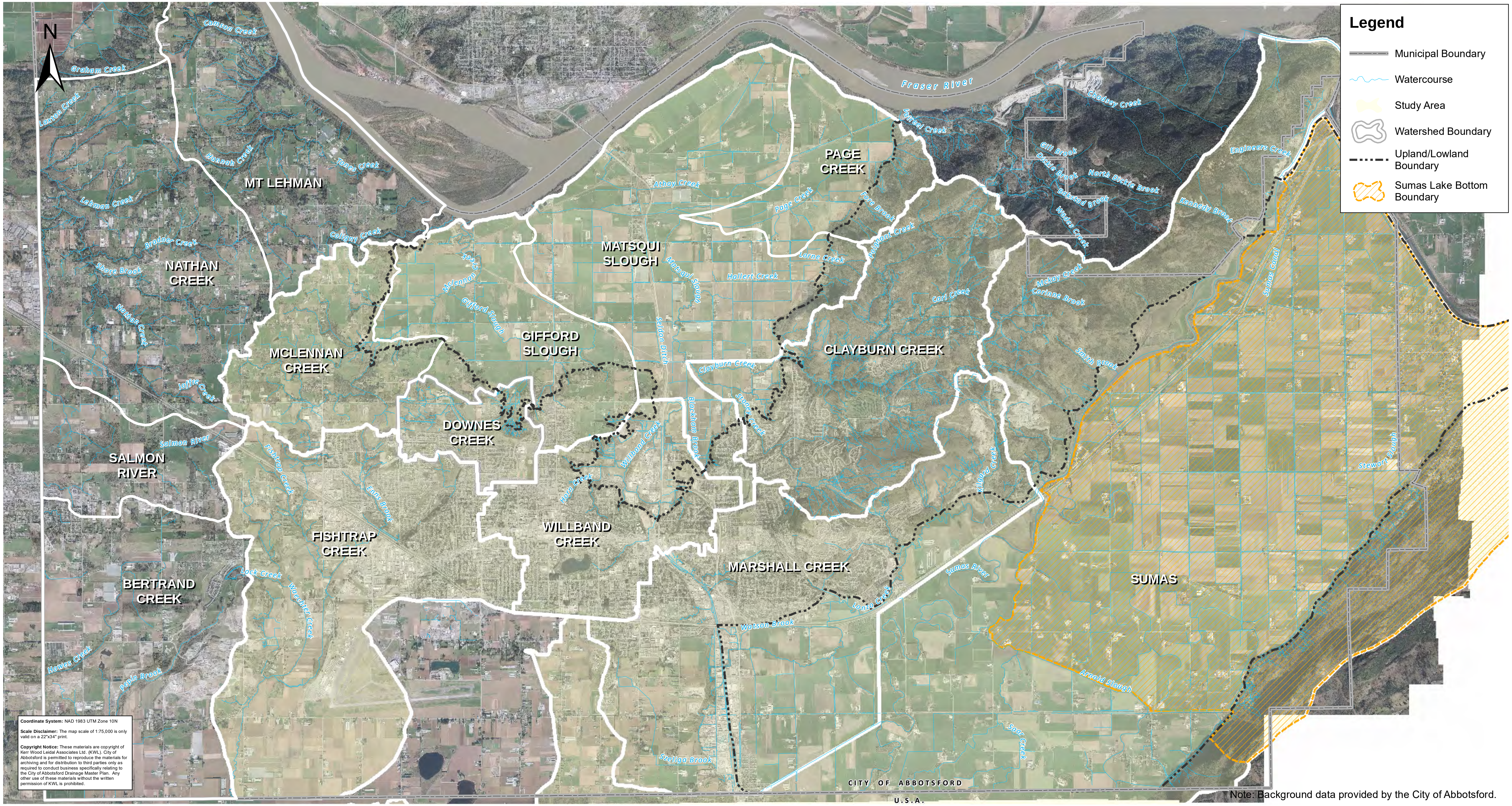
The outline of the DMP report is summarized in Table 1-1. It provides a road map of the report structure.

Table 1-1: Outline of the DMP Report

<table>
<tr><th colspan="2">Section #</th><th>Section Title</th><th>Project Team</th></tr>
<tr><td></td><td>1.</td><td>Introduction</td><td rowspan="6">Crystal Campbell, David Zabil, Eva Li, and Bryce Whitehouse</td></tr>
<tr><td rowspan="6">Construction Project Related</td><td>2.</td><td>Compilation of Drainage Projects</td></tr>
<tr><td>3.</td><td>Estimation of Project Cost for Studied Areas</td></tr>
<tr><td>4.</td><td>Estimation of Project Cost for Unstudied Areas</td></tr>
<tr><td>5.</td><td>Project Prioritization</td></tr>
<tr><td>6.</td><td>Estimation of Pump Station Upgrading Cost</td></tr>
<tr><td>7.</td><td>Estimation of Dike Upgrading Cost</td><td>Mike Currie, Amir Taleghani, and Allison Matfin</td></tr>
<tr><td rowspan="3">Municipal Program Related</td><td>8.</td><td>Stormwater Management Policy and Criteria</td><td>Colwyn Sunderland, Robin Hawker, and Michael Gregory</td></tr>
<tr><td>9.</td><td>Regional Facilities Management</td><td>David Zabil, and Bryce Whitehouse</td></tr>
<tr><td>10.</td><td>River Management Programs</td><td>City of Abbotsford</td></tr>
<tr><td rowspan="3">Drainage Master Plan</td><td>11.</td><td>Proposed Capital Expenditures</td><td rowspan="3">Crystal Campbell, David Zabil, and Eva Li</td></tr>
<tr><td>12.</td><td>Stormwater Drainage Fee Options</td></tr>
<tr><td>13.</td><td>Summary of Findings and Recommendations</td></tr>
</table>

City of Abbotsford
Drainage Master Plan

KERR WOOD LEIDAL
consulting engineers



Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:75,000 is only valid on a 22"x34" print.

Project No.	510.152
Date	June 2018
Scale	1:75,000

Study Area and 2016 Air Photo

Figure 1-1

2. Compilation of Drainage Projects

2.1 Proposed Projects from Previous Studies

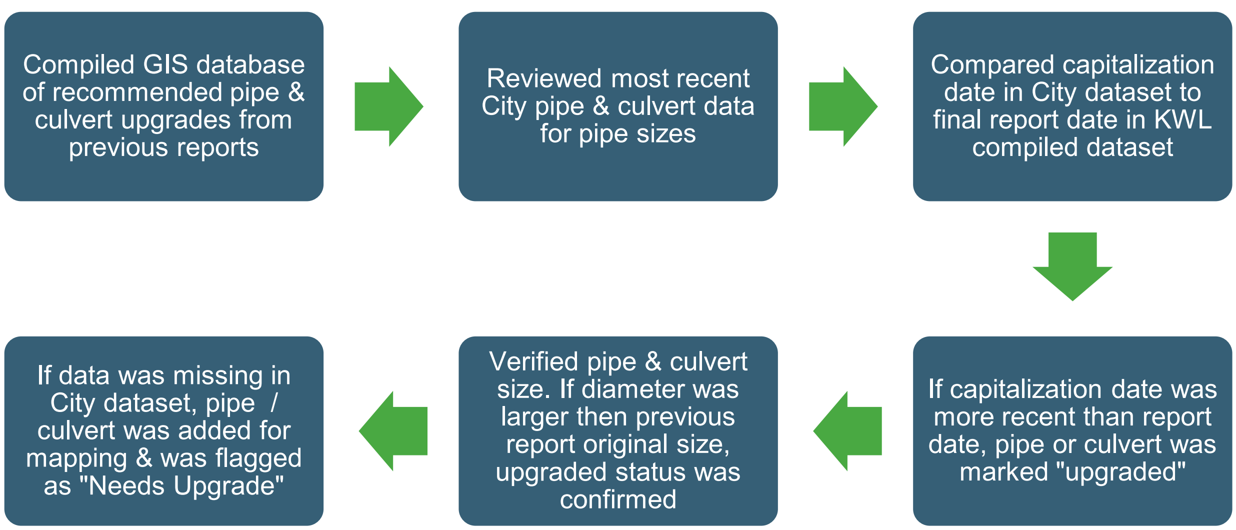
Proposed upgrades and their associated costs were extracted from the previous studies. Table B1 in Appendix B provides a list of all the proposed projects with comment on the project locations and status. Figure 2-1 shows the location of all the proposed projects from existing studies. The proposed upgrading projects can be broadly categorized as:

- Hydraulic Upgrades: storm sewer and culvert renewal;
- Creek Upgrades: berms, flood boxes, creek widening, and sediment management;
- Detention Facility Upgrades;
- Urban Creek Stabilization;
- Pump Station Improvements; and
- Studies.

Diking projects are listed separately under Section 7.

Exclusion of Projects Already Constructed

The City's GIS data was reviewed to identify culverts and storm sewers that have been upgraded since the completion of the previous studies. These projects were noted as completed from the proposed project list. The following methodology, as shown in flowchart below, was used to identify completed pipe projects:



Flowchart Methodology to Identify Completed Pipe Projects

Non-pipe completed and/or constructed projects were identified by City staff, and removed from the project list.

2.2 Proposed Projects from Additional City Known Drainage Issues

The City Departments also provided anecdotal information about additional known drainage issues as shown on Figure 2-2. If these issues were not covered under the existing studies, additional infrastructure upgrading projects or a follow-up study were added to the project list and costs estimated based on similar projects. Table B1 in Appendix B indicates the added projects/studies.

2.3 Proposed Projects in the City's Approved Drainage Capital Plan

The City provided copies of the approved *Drainage Capital Plan, namely 2017-2021 Drainage Capital Plan and 2018-2022 Project Summary Renewal & Replacement (RR) and Strategic Initiatives & Opportunities (SIO)*. They included a list of proposed projects, studies and their approved funding under the capital plan for the next five years. Studies that were not already in the complied proposed project list were added.

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City of Abbotsford

Drainage Master Plan

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Project No.	510.152
Date	June 2018
Scale	1:35,000

Proposed Projects from Previous Studies

Figure 2-1

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Project No. 510.152
Date June 2018
Scale 1:35,000

Known Drainage Issues

Figure 2-2

3. Estimation of Project Cost for Studied Areas

The existing studies were conducted from the 1980's to present. During this time, the drainage criteria, rainfall data and land use has evolved, and inflation has occurred. The base assumptions in each study were reviewed and standardized to bring the projects to a consistent criterion.

Project costs were updated to reflect a 2017-dollar value. Some studies identified proposed improvements but did not provide cost estimates. For these, KWL estimated order of magnitude costs based on similar project types.

The following sections describe the adjustments made.

3.1 Update for 2016 OCP Land Use Total Impervious Area (TIA) Increase

New 2016 OCP

Abbotsford's new OCP (bylaw 2600-2016), was adopted in June 2016. It plans for a future population of 200,000 people and focuses 75% of new growth in existing neighbourhoods. This will be achieved by supporting a 'city of centres', including a City Centre, Urban Centres, and Neighbourhood Centres, and promoting growth in areas where it is financially sustainable by using existing infrastructure and amenities. The 2016 OCP map showing future land use is provided in Figure 3-1. To meet the infrastructure requirements of the planned growth, the DMP outlines projects to meet the demands.

Comparison with Previous OCPs

Based on the previous drainage studies used, three versions of OCP land use maps were obtained representing 1980, 1996 and 2005 conditions. All the drainage studies and ISMPs were based on the 2005 OCP land use, except for the Fishtrap Creek Master Drainage Plan (1987) which used the 1980 OCP. GIS analysis was performed to identify land use change areas between the 2005 OCP and 2016 OCP.

For simplicity, the study areas were divided into the sub-catchments shown in Table 3-1 and average total impervious area (TIA) values were calculated for each using the area-weighted method. The computed TIAs for both the 2005 and 2016 OCPs are compared in Table 3-1. The Fishtrap Creek Master Drainage Plan was completed 30 years ago and was considered an unstudied area for the purposes of this DMP due to the outdated recommendations.

As shown in Table 3-1, the largest increases in TIA are expected in the lowland and rural areas (D2, M1, S2, S4, Mat1 and Mat2 located in the Sumas and Matsqui Prairies). The urban areas experience relatively smaller TIA changes, with some reductions estimated. The 2005 and 2016 land use categories and TIA values assumed for each type of land use were reviewed by the City and are included in Table C1 in the Appendix C.

The 2016 and 2005 OCP land use comparison is presented in Figure 3-2. In a few cases, TIA decreases in the 2016 OCP land use due to a more detailed land use categorization system used for the 2016 OCP. For example, Urban Large Lot in 2016 has a lower percentage impervious (40%) than Urban Residential (60%) in 2005. This may not reflect actual decrease in impervious coverage in the 2016 OCP. The conservative approach taken was to not reduce flows or infrastructure sizes in areas where the TIA was estimated to decrease.

Table 3-1: 2005 and 2016 OCP TIA Comparison

Watershed	Sub-Catchment[1]	OCP Avg TIA (%)		Average TIA Change (%)
		2005	2016	
Clayburn	C1	44	44	0
	C2	37	31	-6
	C3	24	15	-9
	C4	15	6	-9
Downes	D1	40	39	-1
	D2	16	30	13
Marshall	M1	18	32	14
	M2	60	59	-1
	M3	40	35	-5
Sumas	S1	17	8	-9
	S2	5	20	15
	S3	1	9	8
	S4	5	20	15
Matsqui	Mat1	8	26	18
	Mat2	17	30	13
	Mat3	6	8	2

1. Refer to Figure 3-2 for sub-catchment boundary.

Peak Flow Adjustment for Increased TIA

The proposed hydraulic upgrade projects located within the TIA increase areas (D2, M1, S2, S3, S4, Mat1, Mat2 and Mat3) may require upsizing to account for the increased peak flow estimates. The *Matsqui Prairie Drainage Study* did not provide any hydraulic upgrade recommendations, therefore only the pipes (storm sewer and culverts) in the Downes Creek, Clayburn Creek and Marshall Creek watersheds, and two culverts in the Sumas watershed were included in the land-use-based upgrading.

A trend of unit area 10-year and 100-year return period runoff associated with varying impervious coverages was developed by randomly sampling storm sewers in the 2012 Clayburn ISMP XP-SWMM model. Catchments with similar TIA values were grouped, and their peak flows averaged to provide a data point. This process was repeated for various TIAs, and the results for the 10-year return period are shown in Table 3-2. The relationship between peak unit flow and TIA is plotted in Figure 3-3.

Table 3-2: Average Unit Flow versus TIA Relationship

Average TIA %	Average Unit Runoff ($m^3/s/ha$)
2.0%	0.021
23.0%	0.081
50.0%	0.093
80.2%	0.097
96.7%	0.101

Based on the change in the percentage impervious from the date of the study to the new 2016 OCP land use, the adjustment factor for peak flow was estimated using the relationship in Figure 3-3. The resulting factors are summarized in Table 3-3. The land use factor was only applied to the pipes that were identified as undersized in previously completed studies and only in sub-catchments indicating a TIA increase (see Table 3-1). The adjustment factor shown in the table below also includes a 10% increase for climate change as discussed in the next section. This 10% climate change factor was also applied to projects located in areas with no expected increase in TIA.

Table 3-3: Land Use Adjustment Factor for Peak Flow Estimates

Exiting % TIA	Expected Future % TIA	% Impervious Change	Adjustment Factor[1]	
			10-Year	100-Year
5	20	15%	2.57	2.01
16	30	14%	1.48	1.42
18	32	14%	1.37	1.34
40	40	0%	1.10	1.10
1. Adjustment Factor includes land use change and climate change components.				

3.2 Update for Climate Data

Design Rainfall Used

The design storms used in the previous studies were reviewed and summarized in Table 3-4. The previous design rainfall intensities and volumes are higher than the volumes and intensities in the most-up-to-date version of the Abbotsford IDF curve created in 2014, and uses rainfall data from 1977 - 2001. Therefore, no adjustments were made to account for difference in design storms in this project.

Climate Change

The 2016 Metro Vancouver *Climate Projections for Metro Vancouver* report predicted a 10% increase in rainfall volume by 2050 and a 20% increase by 2080. To account for the effect of climate change on the proposed infrastructure upgrades, the City selected the 10% climate change factor for this study. This factor will be reviewed in the future when more information becomes available.

In areas with increasing TIA, the climate change increase was added on to the land use change factor as noted in Section 3.1, and if the there was no change in TIA, the 10% climate change factor alone was used. For simplicity, this rainfall increase factor was applied to the peak flows. In reality, a 10% change in rainfall may result in a peak flow change of less than, or in certain unique instances more than, 10% depending on factors such as initial moisture condition, depression storage, infiltration rate, etc. In general, increasing the peak flow by 10% likely results in flows that are slightly higher than if the rainfall change was applied to the hydrologic/hydraulic model and peak flows recalculated.

Table 3-4: 10-Year and 100-Year Design Storm Summary from Previous Studies

Duration	Willband MDP			Marshall Creek ISMP			Fishtrap MDP**			Clayburn ISMP			Downes ISMP***		
	Volume (mm)	Average Intensity (mm/hr)	% Diff*	Volume (mm)	Average Intensity (mm/hr)	% Diff*	Volume (mm)	Average Intensity (mm/hr)	% Diff*	Volume (mm)	Average Intensity (mm/hr)	% Diff*	Volume (mm)	Average Intensity (mm/hr)	% Diff*
10-Year Design Storm															
1-hr.							19.0	19.00	-7.9%	20.5	20.50	-0.6%			
2-hr.				27.5	13.75	0.1%	30.0	15.00	9.2%	28.2	14.10	2.7%			
6-hr.	45.8	7.63	3.4%	44.6	7.43	0.7%	46.8	7.80	5.1%	45.7	7.62	3.2%			
12-hr.	65.3	5.44	1.9%	67.1	5.59	4.7%	67.2	5.60	4.9%	67.6	5.63	5.4%			
24-hr.				92.4	3.85	5.2%	88.8	3.70	1.1%	95.5	3.98	8.7%			
100-Year Design Storm															
1-hr.							27.5	27.50	-7.2%	29.5	29.50	-0.4%			
2-hr.				39.0	19.50	-0.3%	38.0	19.00	-2.8%	39.6	19.80	1.3%			
6-hr.	58.4	9.73	2.7%	57.9	9.65	1.8%	64.8	10.80	14.0%	59.3	9.88	4.2%			
12-hr.	84.2	7.02	0.9%	88.6	7.38	6.2%	87.6	7.30	5.0%	88.1	7.34	5.5%			
24-hr.				123.1	5.13	5.2%	144.0	6.00	23.0%	126.2	5.26	7.8%			
Gauge Used	Avg of Abbotsford Airport & Mission West Abby (1977 & 1963 – 1983)			Abbotsford Airport (1977 – 2001)			Abbotsford Airport (1977 – 1983)			Avg of Abbotsford Airport & Mission West Abby (1977 & 1963 – 2001)			Abbotsford Airport (1977 - 2001)		

* % Difference between design storm volume used in project and current 2014 Abbotsford Airport IDF (1977 - 2001)
** Average Intensity was interpreted from IDF curve graph, a slight interpretation difference could lead a high difference in intensity
*** Downes ISMP mentioned in text that the 2014 Abbotsford A IDF curve was used but no table was provided with numbers. Therefore there would be no change or difference and is excluded from this analysis

3.3 Update for Change in Drainage Criteria

The drainage criteria used in the previous studies was compared with the current design criteria (2011). All the previous projects used the 10-year design event to size minor storm sewer upgrades and the 100-year design event to size major storm sewer upgrades. The same design criteria govern today; therefore, no adjustment factors were required for the reassessment of pipe sizes or costs.

3.4 Update Capital Costs

Inflation

To update the project cost estimates to the 2017-dollar value, the Engineering News Record (ENR)[1] Construction Cost Indexes (CCI) were used. ENR evaluates cost indexes for 20 cities across the US and Canada (Toronto and Montreal). Toronto indexes were used for 1990 – 2013, and Seattle, WA used for 2015 – 2017. Inflation for each year is summarized in Table C2 in Appendix C.

The building and construction cost indices for ENR's individual cities use the same components and weighting as those for the 20-city national indices. The city indices use local prices for Portland cement and 2 x 4 lumber and the national average price for structural steel. It uses local union wages, plus fringes, for carpenters, bricklayers, iron workers, and laborers.

Construction Cost Factors

A consistent construction cost factor was applied to all the proposed projects. The factor adds 68% to the project construction cost and includes the following components:

- Mobilization / Demobilization and Bonding 8%,
- Construction Engineering 20%, and
- Contingency 40%.

For project costs that already included a factor that was more or less than 68%, the factor was stripped from the total cost, and then 68% was added. For existing projects without construction factors, 68% was directly added to the original cost.

Project Costs to 2017 Dollar Value

Project costs from previous reports were brought up to a 2017 dollar value by applying inflation rates and adjusting the construction cost factors.

For proposed non-pipe type of projects, including erosion protection, sediment management, channel widening, detention ponds, berm construction, etc., the inflation factor and contingency cost were applied to adjust the original cost to the 2017 value.

For pipe upgrade projects, including storm sewers and culverts, the additional upgrading factors such as land use change, design rainfall and criteria change, were applied. In the case of the scaled peak flow estimates requiring a storm sewer or culvert to be larger than the original recommended upgrade size, the storm sewer project was costed as a "Class D" estimate with 2017 unit rates. The updated project cost to a 2017 value is presented in Table C3 in Appendix C. The table also includes the conduit length and the proposed conduit size for the 2016 OCP conditions. Project costs from the City's Approved 2017 and 2018 Capital Project list were kept the same as before.

[1] http://www.enr.com/economics/historical_indices

Class 'D' Cost Estimate and Assumptions

The cost estimates provided are Class 'D' accuracy. This means that the general requirements for upgrading including size and approximate depth of excavation, as well as some general site conditions are known. The projects identified have not considered the following factors affecting construction:

- relocation of adjacent services (gas, hydro, telephone, etc.);
- special permitting requirements (fisheries windows, contaminated site, etc.);
- geotechnical issues requiring special construction such as pile-supported piping, buoyancy problems or rock blasting; and
- critical market shortages of materials.

As the above factors have not been allowed for in estimating construction unit rates or project design, the contingency amount of 68% were applied to all projects.

GST has not been included in the estimated project costs. The unit prices, including 6% of contractor mark-up/overhead, reflect KWL's recent experience with similar work, and therefore represent the best prediction of actual (2017) costs as of the date prepared. Actual tendered costs would depend on such things as market conditions generally, remoteness factor, the time of year, contractors' workloads, any perceived risk exposure associated with the work, and unknown conditions.

3.5 Summary of Drainage Projects for Studies Areas

The proposed projects from studied area have been compiled in Table 3-5 by project type. Timelines and costs were also provided.

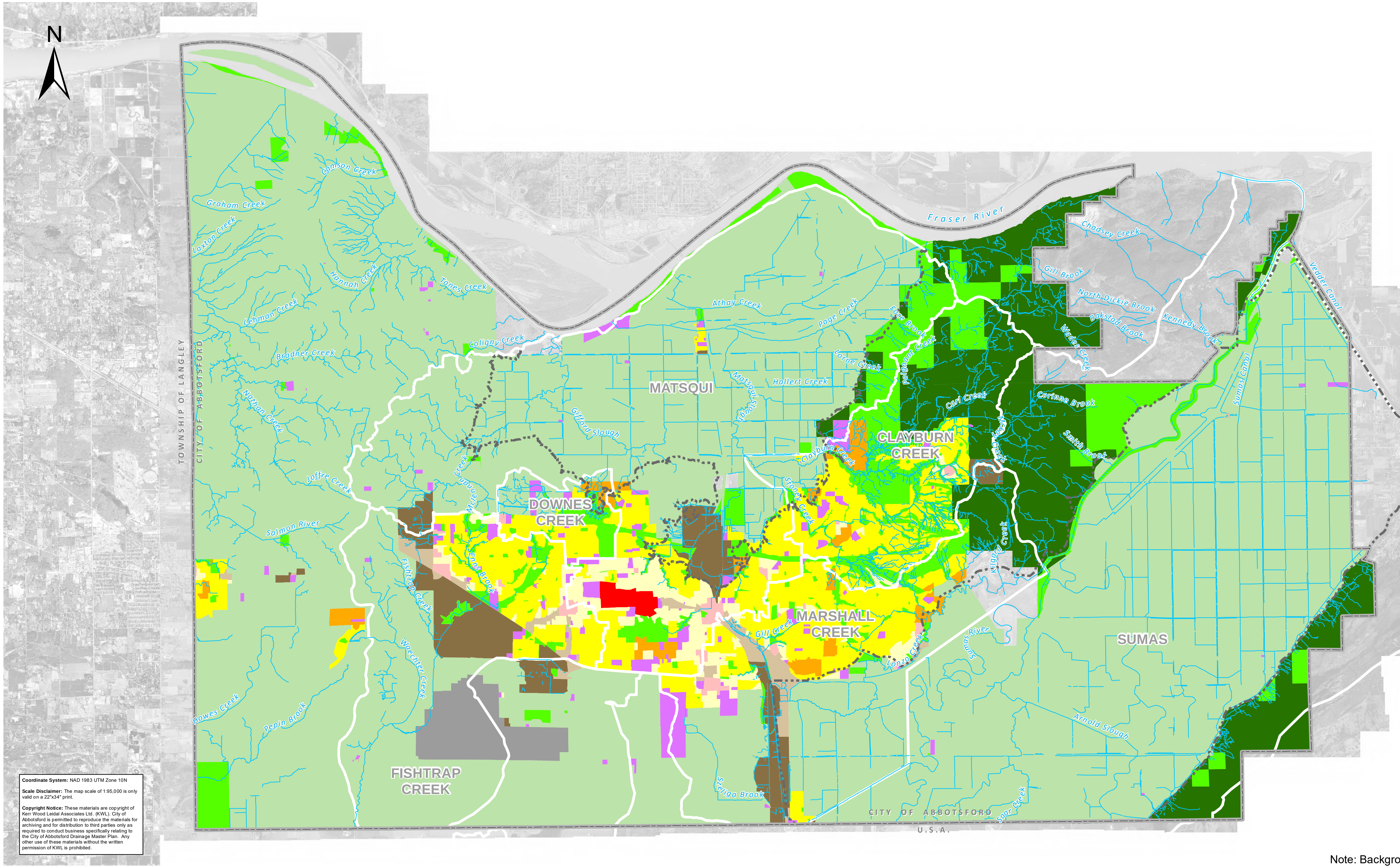
Table 3-5: Estimated Project Costs for Studied Areas

Project Type	Time Frame		Capital Cost		DCC Cost		Total Cost	
	From	To	Total	Annual	Total	Annual	Total	Annual
Storm Sewer and Culvert Renewal								
Short Term	2019	2023	$4,800,000	$960,000	$1,526,000	$305,200	$6,326,000	$1,265,200
Medium Term	2024	2028	$4,800,000	$960,000	$834,000	$167,000	$5,634,000	$1,127,000
Long Term	2029	2043	$13,218,000	$881,000	$1,332,000	$89,000	$14,661,000	$977,000
At Time of Development	2019	2043	$0	$0	$15,953,000	$638,000	$15,953,000	$638,000
Clayburn Creek Lowland Works								
Short Term	2019	2023	$0	$0	$1,592,000	$1,592,000	$1,592,000	$1,592,000
Medium Term	2024	2028	$0	$0	$572,000	$572,000	$572,000	$572,000
Long Term	2029	2043	$0	$0	$225,000	$225,000	$225,000	$225,000
Detention Facility Upgrades								
Short Term	2019	2023	$571,847	$114,369	$0	$0	$571,847	$114,369
Medium Term	2024	2028	$786,761	$157,352	$0	$0	$786,761	$157,352
Long Term	2029	2043	$85,965	$5,731	$0	$0	$85,965	$5,731
Long Term - New Ponds	2040	2043	$0	$0	$6,066,621	$1,516,655	$6,066,621	$1,516,655
Urban Creek Stabilization								
Short Term	2019	2023	$0	$0	$1,405,000	$281,000	$1,405,000	$281,000
Medium Term	2024	2028	$0	$0	$1,405,000	$281,000	$1,405,000	$281,000
Long Term	2029	2043	$0	$0	$922,497	$61,500	$922,497	$61,500
Miscellaneous								
Short Term*	2019	2023	$685,000	$137,000	$0	$0	$685,000	$137,000
Long Term*	2041	2043	$0	$0	$5,531,924	$1,843,975	$5,531,924	$1,843,975

Note: Miscellaneous short term – Gill Creek Culvert Headwall Rehabilitation; Miscellaneous Long term* – Horn Creek Storm Diversion.*

City of Abbotsford
Drainage Master Plan

KERR WOOD LEIDAL
consulting engineers



Legend

- Municipal Boundary
- Watercourse
- Watershed Boundary
- Upland/Lowland Boundary

2016 OCP Land Use

- Agriculture
- Airport
- City Centre
- Country / Rural
- Industrial
- Institutional
- Commercial
- Neighbourhood / Urban Centre
- Open Space
- Urban 1 and 2
- Urban 3 and 4
- Suburban / Urban Large Lot

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:95,000 is only valid on a 22"x34" print.

Note: Background data provided by the City of Abbotsford.

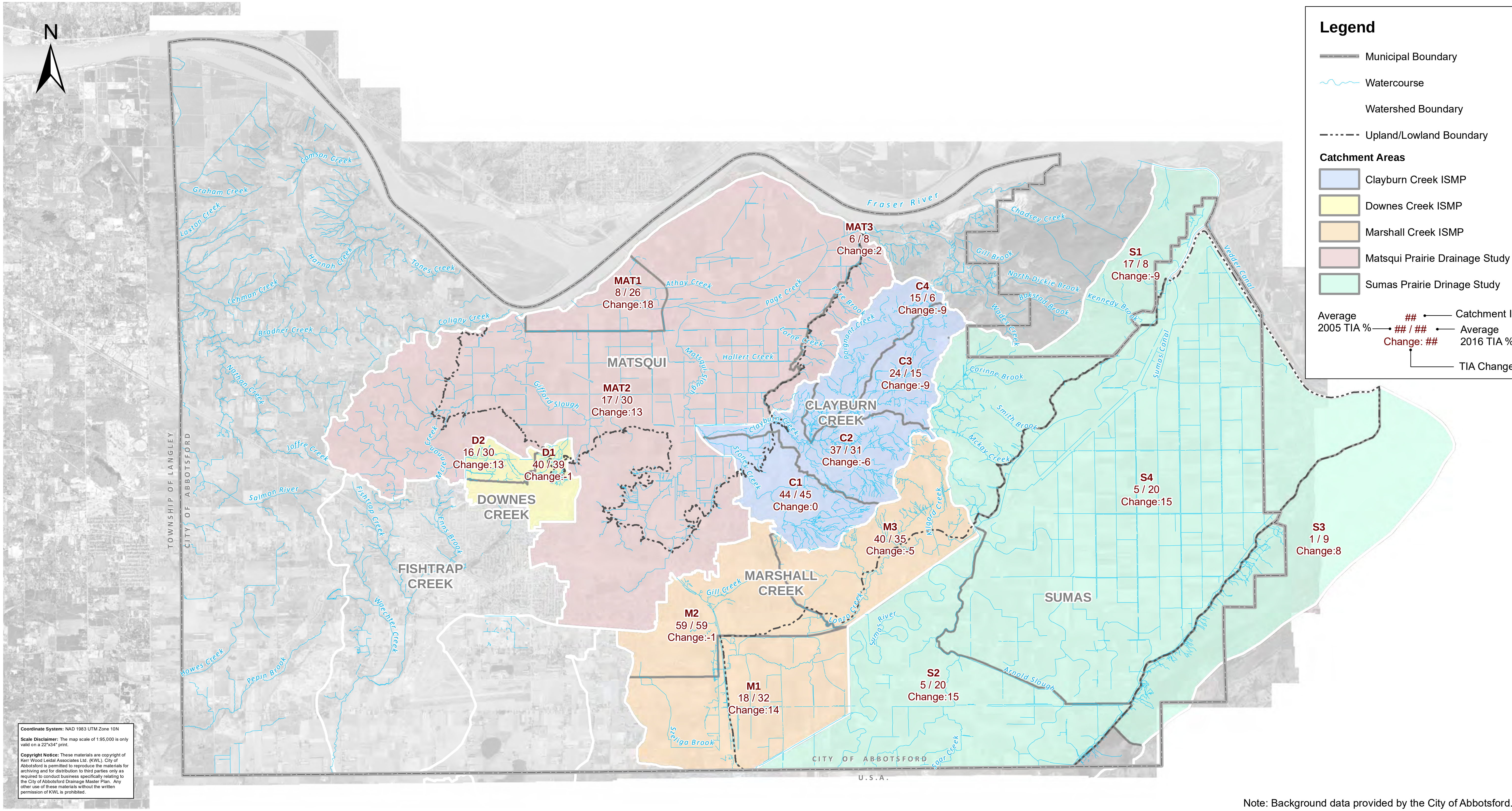
Project No. 510.152
Date June 2018
Scale 1:95,000

2016 OCP Land Use

Figure 3-1

City of Abbotsford
Drainage Master Plan

KERR WOOD LEIDAL
consulting engineers



Note: Background data provided by the City of Abbotsford.

Project No.	510.152
Date	June 2018
Scale	1:95,000

2016 and 2005 OCP Land Use Comparison

Figure 3-2

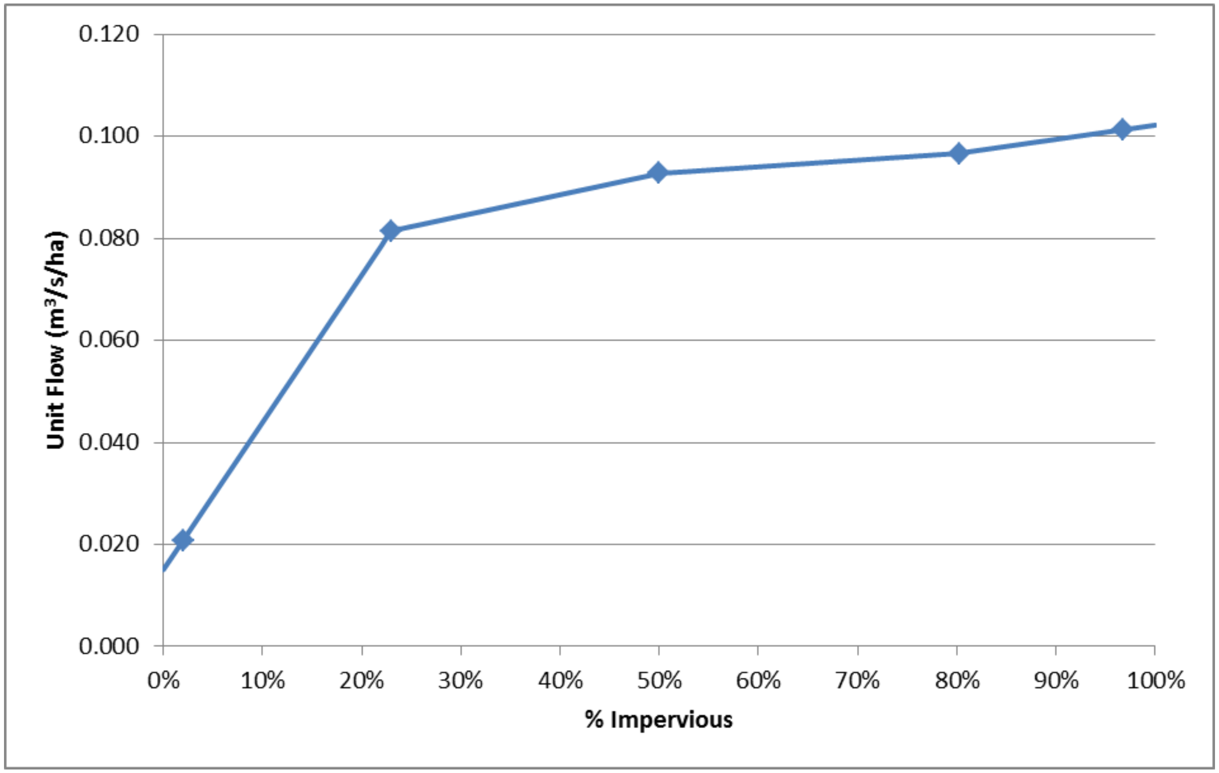


Figure 3-3: Linear Interpolation of Average Unit Flow to Catchment TIA

4. Estimation of Project Cost for Unstudied Areas

Approximately 19,530 ha of the City area has not been studied in the past, see Figure 4-1. This accounts for 50% of the City area and presents a data gap in preparing a comprehensive City-wide DMP. The City has future plans for assessing these areas, however placeholder costs are required at this time to include in the City-wide DMP. The methodology for estimating costs for these areas is discussed in this section. The estimated projects and costs will be updated once future studies are completed.

4.1 Representative Land Use Areas

Representative land use sub-catchment areas were selected from the 2005 OCP to represent typical land use within the studied areas. Land use in the 2005 OCP was the base for all the drainage studies completed over the past decade. A normalized upgrading cost ($/unit) for each type of land use was developed by examining the projects within these representative sub-catchments. The review led to the selection of eleven sample land use areas with reasonable catchment size and distinct land use type, as shown in Table 4-1 and Figure D1 in Appendix D.

Drainage projects within the selected areas were categorized into four types:

- storm sewer;
- culvert;
- detention pond; and
- stream (used for vegetation removal, erosion protection and sediment management type projects).

The total upgrading costs (2017 $ value) for each type were calculated using GIS.

Table 4-1: Representative Studied Land Use Areas Summary

Sub-Catchment	Selected Land Use Area (2005 OCP)	Area (ha)	TIA	Upgrading Cost Summary			
				Storm Sewer	Stream	Detention	Culvert
Clayburn Creek	Mixed Urban Residential Area	341	50%	$6,634,000	$0	$193,400	$1,022,300
	Conservation Area	323	1%	$0	$0	$0	$0
Marshall Creek	Rural Residential	334	10%	$0	$0	$0	$0
	Industrial / Commercial / Institutional	555	85%	$1,071,800	$0	$0	$2,286,300
	Mixed Residential	106	20%	$0	$0	$0	$0
	Upland Agriculture	489	50%	$34,200	$0	$0	$1,569,600
Downes Creek	Upland Agriculture	73	20%	$0	$0	$0	$0
	Mixed Urban Residential Area	139	50%	$3,421,900	$0	$0	$0
	Commercial / Institutional	7	85%	$0	$0	$0	$0
	Conservation Area	105	1%	$864,500	$151,400	$189,200	$0
Sumas Prairie	Lowland Agricultural	2846	20%	$269,100	$0	$0	$1,138,400

The unstudied area was divided into five land use areas, as shown in Figure 4-1. Similarly, typical land use areas were identified, and TIAs were calculated based on 2016 OCP for each sub-catchment, as listed in Table 4-2.

Table 4-2: Unstudied Land Use Areas Summary

Sub-Catchment	Land Use (2016 OCP)	Area (ha)	TIA
Bertrand/Salmon/Nathan/ Mt. Lehman Creek	Mixed Residential	147	50%
	Upland Agricultural	7879	20%
	Conservation	245	1%
	Industrial /Institutional	35	80%
Clearbrook Rd	Upland Agricultural	1012	20%
	Mixed Residential	2	50%
	Conservation	19	1%
	Commercial/Industrial/Institutional	269	85%
Fishtrap Creek	Mixed Residential	588	60%
	Upland Agricultural	1523	20%
	Conservation	130	1%
	Industrial /Institutional	791	85%
Vaireel Creek	Rural Residential	483	10%
	Mixed Residential	129	50%
	Upland Agricultural	1	20%
	Conservation Area	105	1%
Sumas Lake Bottom Area	Lowland Agricultural	5490	20%
	Lowland Residential	565	10%
	Conservation	107	1%
	Institutional/Choice of Use	9	90%

4.2 Drainage Infrastructure Density Analysis

For both studied and unstudied areas, drainage densities were estimated to facilitate the cost calculation. They include:

- storm sewer density (m/ha);
- culvert density (unit/ha);
- detention pond density (unit/ha);
- ditch density (m/ha); and
- stream density (m/ha).

The linear length of the drainage channel and pipe, and the unit number of the culvert and detention pond were calculated for each studied typical land use area and for the unstudied areas using GIS. The total length and total unit number were divided by the drainage area and the calculated densities are provided in Table D1 in Appendix D.

4.3 Cost Estimate for Unstudied Areas

For unstudied areas, costs were estimated based on a selected studied area with the same land use and the most-similar drainage density. The costs from Table 4-1 were adjusted to estimate the unstudied area costs using the following factors:

- Area adjustment factor: to account for the area difference between the studied and unstudied areas.
- Density adjustment factor: to account for the density difference between the studied and unstudied areas.

The final cost estimates for the unstudied area are provided in Table 4-3.

Table 4-3: Estimated Costs for Unstudied Sub-Catchments

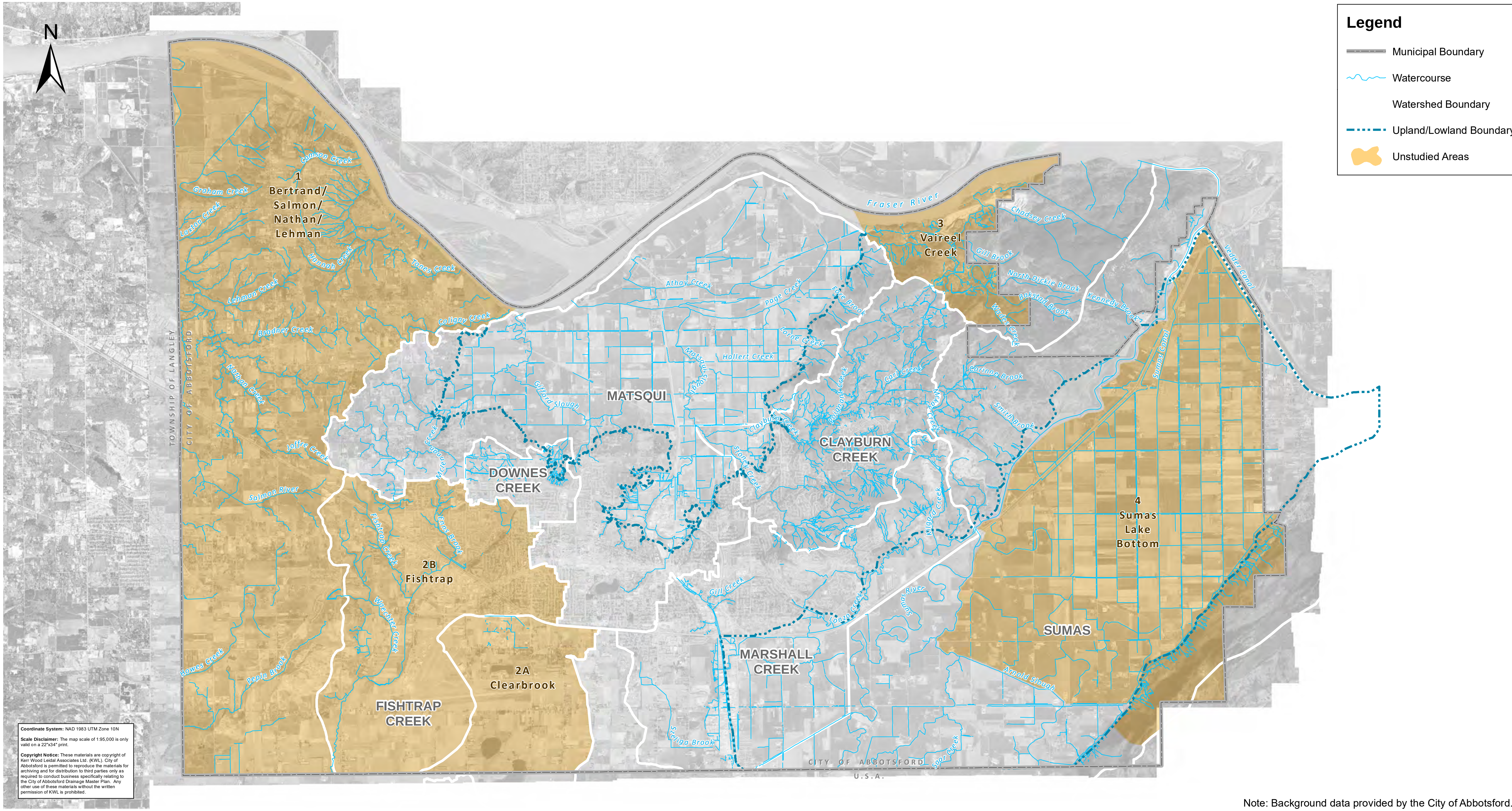
Sub-Catchment	Area (ha)	Land Use	Upgrading Cost	Total Cost
Bertrand / Salmon / Nathan / Mt. Lehman Creek	147	Mixed Residential	$2,229,000	$2,989,000
	7879	Upland Agricultural	$298,000	
	245	Conservation	$417,000	
	35	Industrial /Institutional	$45,000	
Clearbrook Rd	1012	Upland Agricultural	$942,000	$1,292,000
	2	Mixed Residential	$42,000	
	19	Conservation	$113,000	
	269	Commercial/Industrial/Institutional	$195,000	
Fish Trap Creek	588	Mixed Residential	$11,183,000	$22,900,000
	1523	Upland Agricultural	$7,521,000	
	130	Conservation	$2,766,000	
	791	Industrial /Institutional	$1,430,000	
Vaireel Creek	483	Rural Residential	$0	$148,000
	129	Mixed Residential	$13,000	
	1	Upland Agricultural	$58,000	
	105	Conservation Area	$77,000	
Sumas Lake Bottom Area	5490	Lowland Agricultural	$3,867,000	$4,004,000
	565	Lowland Residential	$0	
	107	Conservation	$72,000	
	9	Institutional/Choice of Use	$65,000	

The costs in Table 4-3 are placeholder estimates for use in long term planning and budgeting and should be updated once the unstudied areas are analyzed in detail. The total estimated costs for the unstudied areas represents approximately a third of the total (studied plus unstudied) costs for these project types.

Path: O:\0500-0599\510-152\430-GIS\MXD-Rp\Final\510152_Phase1_Fig4-1_Unstudied_Areas.mxd Date Saved: 6/4/2018 2:21:46 PM | Author: JLau

City of Abbotsford
Drainage Master Plan

KERR WOOD LEIDAL
consulting engineers



Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:95,000 is only valid on a 22"x34" print.

Note: Background data provided by the City of Abbotsford.

Project No.	510.152
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Scale	1:95,000

Unstudied Areas

Figure 4-1

5. Project Prioritization

The consolidated capital project list was analyzed to determine the priority of the projects from studied areas. The rationale of the prioritization matrix and recommended short to long-term upgrades are discussed in the following sections.

5.1 Prioritization Matrix

A decision matrix was developed as a systematic way of prioritizing drainage projects for the studied areas within the City of Abbotsford. A majority of the proposed projects (excluding studies, dike improvements, new detention facilities, and pump station upgrades) were ranked as short-term, mid-term and long-term based on the following criteria:

- technical rating,
- urgency,
- risk/consequence,
- location: urban containment boundary,
- community impact,
- economic impact, and
- agricultural impact.

For each of the criteria, a score of 1 to 5 (where 5 represents highest urgency) was assigned to each project. Criteria considered to be more important than others were given higher weighting (e.g. higher maximum scores) than others. These scores were then multiplied together to determine an overall priority score for each project. With all the projects compiled for studied areas, prioritization criteria were developed for each project type (storm sewers, culverts, detention facilities, channels). The prioritization matrix and weight system are presented in Table 5-1.

5.2 Prioritization Results

Applying the prioritization matrix to the projects resulted in the prioritization of Project Initiation Time shown in Table C3 in Appendix C. The application of the criteria is summarized in Table E1 in Appendix E which shows the score (from 1 to 5) for each project.

Table 5-1: Project Prioritization Criteria and Weighing System

Criteria	Weighting (1- least important, 5 – most important)									
Projects	**Storm Sewer Upgrades**		**Culvert Upgrades**		**Detention Facilities**		**Erosion and Sedimentation**		**Channel Upgrades**	
Technical Rating	30%		30%		30%		30%		20%	
	1 - Minor drainage, DCC; 2 - Major drainage, DCC; 3 – Minor drainage, 1 pipe size up; 4 - Minor drainage, 2 or more pipe sizes up; 5 – Major drainage pipe.					1 – long term project; 3 – mid term project; 5 – short term project (defined in historical studies)				
Urgency	20%		15%		15%		10%		20%	
	1 - q/Q = 1 or < 1; 2 - q/Q = 1 - 1.2; 3 - q/Q = 1.2 - 1.5; 4 - q/Q = 1.5 - 2; 5 - q/Q > 2.					1 – new pond; 3– inlet/outlet modification to meet different criteria; 5 – inlet/outlet modification to meet same criteria.	1 - outside future land use change area; 3 - immediately d/s of future land use change area; 5 - inside of future land use change area.		1 – little benefit until other works completed; 3– increase level of protection; 5 – provide protection to currently unprotected developed area.	
Risk / Consequence	20%		15%		15%		20%		20%	
	1 - Priority 5; 2 - Priority 4; 3 - Priority 3; 4 - Priority 2; 5 - Priority 1 (as defined in ISMP).					1 – drain to lowlands; 5 – drain to steep creeks.	1 - No threat to public or private properties; 3 - Indirect threat to public or private properties; 5 - Threat to public or private properties.			
Urban Containment Boundary	10%		10%		10%		10%		10%	
	1 – outside of UCB; 5 – inside of UCB.									
Community Impacts	10%		10%		10%		10%		10%	
	1 - 0% or <0% Average TIA Change; 2 - 1% to 5% Average TIA Change; 3 - 6% or <10% Average TIA Change; 4 - 11% or <15% Average TIA Change; 5 - >15% Average TIA Change.					1 -not a known issue; 5 - known issue (based on 2017 issue map from City).			1 -little to no impact; 3 - terrestrial habitat disruption (mitigated); 5 - instream habitat disruption (mitigated over time).	
Economic Impacts	10%		10%		10%		10%		10%	
	1 - < 400mm Pipe Size; 2 - 400 - 600mm Pipe Size; 3 - 600 - 700mm Pipe Size; 4 - 700 - 1200mm Pipe Size; 5 >1200mm Pipe Size.					1 - high cost to construct; 3 - medium cost to construct; 5 - low cost to construct.				
Environmental/ Agricultural Impact	0%		10%	1 - Lowlands 5 - Uplands	10%	1 - without erosion issues; 5 – with erosion issues.	10%	1 - no negative impact to aquatic life & habitat; 3 - indirect impact to aquatic life & habitat; 5 – negative impact to aquatic life & habitat.	10%	1 - no benefit to agriculture; 5 – improves agriculture.
Total	**100%**		**100%**		**100%**		**100%**		**100%**	

Note: Downes Creek Pipes were manually assigned a Priority to match the KWL format by comparing future & existing results, & New pipes used same Urgency Rating as existing pipes in the project
q/Q = design flow/pipe capacity

6. Estimation of Pump Station Upgrading Cost

6.1 Pump Station and Floodbox Capacity Review

The current pump station capacities were reviewed as part of the Matsqui and Sumas Drainage studies and the required capacities to meet the Agriculture and Rural Development Subsidiary Agreement (ARDSA) criteria. The Matsqui Slough, McLellan Creek & Barrowtown Pump Stations capacities and additional required capacities to meet various criteria are summarized in Table 6-1 below.

Table 6-1: Pump Station Capacities

Winter, 10-Year, 5-Day			Summer, 10-Year, 2-Day		
Current Pump Capacity (m^3/s)	Additional Required Pumping Capacity (m^3/s)	Current Floodbox Capacity (m^3/s)	Current Pump Capacity (m^3/s)	Additional Required Pumping Capacity (m^3/s)	Current Floodbox Capacity (m^3/s)
Combined Matsqui Slough & McLellan Creek Pump Stations					
16.55	Very Little	N/A	16.55	40	N/A
Barrowtown Pump Station					
39.8	29	226.5[1] 81[2]	39.8	125	226.5[1] 0[3]

Notes:
1. Based on a 0.3m head differential.
2. Peak flow modelled during 10-year 5-day winter ARDSA storm.
3. Assumes closed floodboxes during Fraser River Freshet.

Additional capacities based on meeting the ARDSA criteria.

The City recommended that upgrades to pump stations to achieve the 10-year 2-day summer ARDSA criterion will not be pursued at this time as flooding issues are currently experienced only in the winter months. Therefore, it is recommended that the upgrade to the Barrowtown Pump Station to meet the 10-year 5-day ARDSA criterion be considered. The required additional capacity for pumping the Sumas River at the Barrowtown Dam is 29 m^3/s.

6.2 Pump Station Discharge Head Upgrade

The Barrowtown Pump Station was mainly designed to pump Lake Bottom Area. It uses Pump 1 and 2 to pump water from the Sumas River to the Fraser River during freshet. The Barrowtown pumps are able to run at their full capacities, in high speed mode, only when the pumping head is sufficiently high (>3m). During times when the water levels on the upstream and downstream sides of the pump station are nearly equal, the pumps are run in low speed mode to prevent cavitation which would result if the pumps were run in high speed mode (KCB, 2011). Static and dynamic methods were proposed to increase the system head requirement. The estimated construction cost is $1,750,000 in 2017 dollars. A cost benefit/risk analysis is recommended to determine whether either is an economically viable option.

6.3 Pump Station Resilience Review

For the Barrowtown pump station and the other four pump stations along the Matsqui Dike (McLennan Creek, Matsqui Slough, DeJong and Vanderloos), there is no backup (standby) power system in place to maintain pumping operations in the event of a utility power failure. In 2013, a preliminary back-up power study was completed for the Barrowtown pump station. The probable cost of backup power was estimated to be $4,131,000 in 2017 dollars. To increase resiliency along the Matsqui Dike, high level backup power costs were estimated for the other four pump stations. The estimated costs for the four Mastsqui Dike pump stations total $3,100,000 based on the electrical replacement cost in the Pump Station PSAB 3150 Study (Earth Tech, 2008) and the backup power cost for the Barrowtown pump station. The summary of the backup power cost estimate is provided in Table 6-2. A detailed study is recommended to update these high-level cost estimates for these stations.

Table 6-2: Pump Station Backup Power Cost

Pump Station	Backup Power Cost Estimate (2017 dollar with contingency)
Barrowtown	$4,131,000
McLennan Creek	$1,000,000
Matsqui Slough	$1,900,000
DeJong	$100,000
Vanderloos	$100,000

These projects and costs are added into the overall DMP.

7. Estimation of Dike Upgrading Cost

The dike upgrading assessment includes three distinct dikes: Matsqui Dike (Fraser River), Vedder Dike (Vedder Canal and Fraser River), and Sumas Dike (Sumas River, Saar Creek, and Arnold Slough). The City requires an indicative cost estimate for determining an appropriate approach to long-term funding of such activities. This section summarizes the relevant background, methodology, assumptions, and resultant dike upgrading cost estimate. Supporting geotechnical engineering advice was provided by exp Services (EXP). Figure 7-1 shows the study area and each of the subject dikes.

The content of this section reflects the final technical memorandum for Dike Upgrading Cost Estimate dated June 6, 2018.

7.1 Background

Lower Mainland Flood Management Strategy

The Lower Mainland Flood Management Strategy (LMFMS) is a collaborative initiative that has the participation of 50 governmental and non-governmental agencies working together to better protect Lower Mainland communities from major Fraser River and coastal flooding (Fraser Basin Council, 2017). The Fraser Basin Council (FBC) serves as project manager. Phase 1 of the LMFMS was completed in 2016. The key outcome was an analysis of Fraser River and coastal flood scenarios, both present day and year 2100, taking into account sea level rise and other projected impacts of climate change. Phase 2 is now underway and is aimed at developing a regional flood strategy report and recommendations for action, including cost-sharing options.

Matsqui Dike

The Matsqui Dike parallels the Fraser River along Matsqui Prairie from Upper Sumas Mountain Road at the east end to the railway near Harris Road at the west end (approximately 11.5 km total length). The dike was originally constructed between 1920 and 1922 and was last upgraded in 2007 in advance of an expected high peak freshet on the Fraser River (Golder Associates, 2007). The 2015 and 2016 dike inspection reports note that the dike is in excellent shape, with regular vegetation maintenance being completed, and no items requiring immediate attention (City of Abbotsford, 2016) (City of Abbotsford, 2015).

The dike has four pump stations: McClennan Creek, Matsqui Slough, Dejong, and Vanderloo. The railway crosses the dike in two locations that are lower than the design crest elevation (Golder Associates, 2007). The dike is generally set back from the Fraser River except for the lock-block wall section which runs along the river-side (north) of the JAMES Wastewater Treatment Plant (WWTP). A secondary dike runs along the land-side (south) of the JAMES WWTP and as such does not protect the plant from Fraser River flooding.

The reach of the Fraser River adjacent to the Matsqui Dike has historically been prone to channel shifting and bank erosion. Some sections were riprapped in the 1970s and 1980s. Since 1997, there has been a tendency for erosion arcs to form along the upstream half of the dike (between Sumas Mountain and the northerly tip of Matsqui Prairie (arcs A-G). Mitigation work was completed on arc E in 2014 (Golder Associates, 2014). Six mitigation options were identified for arcs A-D, and the preferred option, “submerged rock spurs” (Northwest Hydraulic Consultants, 2015), is to be confirmed through consultation with First Nations and is subject to environmental approval. Arcs F and G were assessed for relative to risk to the dike and mitigation work was completed in 2017 on Arc F.

Vedder Dike

The Vedder River/Canal conveys flow for a length of approximately 13 km from the Chilliwack River to the Sumas River downstream of the Trans Canada Highway. The Vedder River/Canal system was built between 1920 and 1922 for two primary purposes:

1. redirect Chilliwack River flow away from the Chilliwack area to the north (to mitigate frequent flood occurrences); and
2. support the reclamation of Sumas Lake (which would become Sumas Prairie).

Following a major flood in 1975, the dike works along the Vedder River/Canal were significantly upgraded. The City of Abbotsford portion of the dike was further upgraded in 2007 in advance of an expected high peak freshet on the Fraser River. The design dike elevation for this portion of the dike is based on the Fraser River flood, as the Vedder Canal flood level is lower than that of the Fraser (Golder Associates, 2007).

The Vedder River Management Area (VRMA) is the active river channel and floodplain area between the setback dikes. The VRMA (325 ha) is owned by the Province and is considered a public use area. The Vedder River Management Area Plan (VRMAP) was prepared in 1983 and updated in 2015 (Vedder River Management Committee, 1983) (Tetra Tech EBA, 2015). The VRMAP identifies river reaches that may require sediment removals to maintain flood capacity and monitors erosion of the river banks. The Vedder River Management Area Committee (VRMAC) manages sediment removals.

Most of the Vedder dike system is owned and operated by the City of Chilliwack. The City of Abbotsford portion of the Vedder Dike parallels the Vedder Canal on the southwest side from Keith Wilson Road to the confluence with the Sumas River. The dike then follows the Sumas River upstream to the Barrowtown Dam and Pump Station. The total length of the City of Abbotsford portion of the Vedder Dike is approximately 4.5 km. The 2015 and 2016 dike inspection reports noted the dike is in excellent shape, with regular vegetation maintenance being completed, and no items requiring immediate attention (City of Abbotsford, 2016) (City of Abbotsford, 2015).

The Barrowtown Dam portion of the dike is considered part of both the Vedder Dike and the Sumas Dike, and the dike crest elevation on the dam is achieved by a 300 mm high curb (Golder Associates, 2007). North Parallel Road adjacent to the dam was widened in 2016 (WSP, 2017).

In 2008, geotechnical investigations and analysis was completed for the Vedder Dike to assess the impacts of the emergency raise of the dike in 2007, and this assessment recommended that a toe berm be constructed north of Highway 1 to address stability concerns (Golder Associates, 2008).

Sumas Dike

The Sumas Dike begins at Vye Road to the south and winds along Sumas Prairie to the Barrowtown Dam and Pump Station (approximately 16.7 km total length), with the purpose of protecting the reclaimed Sumas Lake bottom from flooding. The dike alignment parallels Arnold Creek, interceptor ditch, and Spree Creek before reaching the Sumas River. Marshall Creek, Arnold Slough, and Saar Creek flow into the Sumas River, and the Sumas River drains into the Fraser River. Most of the year, the Sumas River flows by gravity through floodboxes at the Barrowtown Pump Station. During the Fraser River freshet, the Sumas River flow can be pumped using two of the four pumps at the Barrowtown Pump Station. All four pumps can be used to drain the Sumas Lake bottom area.

In addition, the Nooksack River, located in Washington State in the United States of America, can contribute to the Sumas River flood hazard. During large floods, the Nooksack River may overflow its banks, with a portion of the floodwater flowing across the Washington State – British Columbia border and into the Sumas River. However, it is understood that the Sumas Dike was not originally designed for, and is not currently designed for, the additional hazard from the Nooksack River overflow scenario.

It is understood that asbestos-laden sediment is a concern in the Sumas River due to upstream sources (Swift Creek landslide) in the United States of America (BC Ministry of Water, Land, and Air Protection, 2004). This concern can complicate vegetation management and sediment removal.

The Sumas Dike was originally designed and constructed to agricultural standards in 1919-1923, with reduced requirements compared to standard dikes (Klohn Leonoff, 1989). The most recent upgrade for the Sumas Dike was completed in 1983-1984 (Crippen Consultants, 1988). The 2015 and 2016 dike inspection reports noted the dike is in excellent shape, with regular vegetation maintenance being completed, and no items requiring immediate attention (City of Abbotsford, 2016) (City of Abbotsford, 2015).

Though the Sumas Dike protects the Sumas Lake Bottom area from flooding, it exacerbates flooding in Sumas Prairie West. Raising the Sumas Dike would further protect the Sumas Lake bottom, but would cause increased flooding to the west (UMA Engineering Ltd., 2003). Previous reports and studies have analyzed this intertwined system and proposed a variety of options for consideration (Kerr Wood Leidal, 2014) (Kerr Wood Leidal, 2017) (UMA Engineering, 2004). Summarized below are the options developed as part of the 2004 Sumas Prairie Flood Hazard Investigation (UMA Engineering, 2004):

- construct a floodway for the Marshall sump to convey water to Barrowtown more quickly;
- build a new large pump station at Barrowtown to pump the Sumas River - $80 million capital, $0.5 million O&M;
- deepen and enlarge the Sumas River - $51 million capital, $0.6 million O&M – this cost estimate does not include an allowance for removal and disposal of the asbestos laden sediment in the Sumas River;
- construct separate Sumas and Vedder River channels to the Fraser River - $68 million capital, $0.1 million O&M; and
- construct a tunnel through Sumas Mountain from Barrowtown to the Fraser River - $155 million capital, $0.1 million O&M.

Glen Valley Dike

The Glen Valley Diking District is a private dike authority that is located in both the Township of Langley and the City of Abbotsford along the Fraser River floodplain. The Glen Valley Diking works are not included in the long-term dike upgrade assessment.

The Glen Valley works consist of two wing-dikes and a pump station on Nathan Creek. The west-wing dike is located in the Township of Langley and the east wing-dike is located in the City of Abbotsford. The wing-dikes act in conjunction with a river-side CN rail embankment to protect the primarily agricultural floodplain area. It is important to note that the rail embankment was not designed as a dike, and it is understood that CN does not view it as providing flood protection. CN has previously indicated that it does not intend to upgrade the embankment for flood protection purposes.

7.2 Survey of Nearby Jurisdictions

Phone and email surveys/interviews were completed with nearby jurisdictions on the Fraser River to improve understanding of how other municipalities and regional districts are planning for their dike systems. This included the City of Surrey, City of Chilliwack, District of Kent, and District of Mission. Table 7-1 summarizes the jurisdictions contacted and responses to the set survey questions. The survey questions focused on:

- awareness of flood levels considering sea level rise and climate change;
- current and future dike crest design elevations;
- seismic design guidelines and upgrades;
- funding plans for long-term dike upgrades; and
- agricultural standard dikes.

All jurisdictions were familiar with the most recent studies and modelled flood levels considering sea level rise and climate change, though none of the regions have adopted new dike crest elevations considering sea level rise or climate change. Generally, participants are looking to guidance from the province and the Fraser Basin Council regarding design requirements for future upgrades. None of the jurisdictions surveyed currently have plans to upgrade dikes to meet seismic requirements. Larger jurisdictions (City of Chilliwack and City of Surrey) have funding plans in place for long-term dike upgrades, assuming that two-thirds of the cost will be funded by the provincial and federal governments.

Table 7-1: Nearby Jurisdictions Survey Summary

Question	City of Chilliwack	City of Surrey	District of Kent	District of Mission
Contact	Frank Van Nynatten vanny@chilliwack.com 604-793-2720	Carrie Baron CABaron@surrey.ca 604-591-4278	Matthew Connolly mconnolly@district.Kent.bc.ca 604-796-2235	Matt Dunham mdunham@mission.ca 604-820-3765
Are you aware of the most recent flood levels developed for the Fraser River considering sea level rise and climate change[1]?	Yes	Yes	Yes	Yes
What is the current design event for your Fraser River dike system?	The 1894 Flood of Record, designated as the 500-year event. Flood profile from the MFLNRO March 2014 Report[2]	The 1894 Flood of Record, designated as the 500-year event. Surrey is still working to achieve this level in some locations. Flood profile from the 2008 MOE & NHC Report[3]	The District has not specified a design flood level. The dikes do not meet the provincially designated 1894 Flood of Record (500-year event), as there is not sufficient freeboard or below flood level. It is a challenge to meet current flood levels & obtain property needed for ROW with small region & tax base.	The Silverdale dike (4 km) is built to an agricultural standard with a current design event of 100 years. The Mission dike is in 2 portions, 1 km to the west that is constructed to a 100 to 200-year event & the remaining 2km to a 50-year event.
Have you formally adopted a new design event for your dike system considering sea level rise and/or climate change for future upgrades?	No, Chilliwack is coordinating with the Fraser Basin Council to consider the implications & determine what the new design will be.	No, MFLNRO has not set out which condition in the 2014 report[1] governs, & more detailed works & regional study are underway at Fraser Basin Council. Future upgrades & higher elevations are considered when doing the designs &/or acquiring the ROWS for recent upgrades.	No.	No.
Are you familiar with the provincial *Seismic Design Guidelines for Dikes, &* do you have plans to upgrade dikes to meet the standards moving forwards?	Yes. There are no specific plans to upgrade the dikes to meet seismic standards unless other upgrades are being completed.	Surrey has completed geotechnical assessments along the Fraser River, which show the provincial guidelines cannot be met. An exemption has been sought & received from the Inspector of Dikes in the past & is being sought again. New funding for upgrades is not considering seismic upgrades. The FBC is setting up a new committee to revisit the guidelines. There is concern regarding the ability to fund seismic upgrades in significant residential/industrial areas without filling the whole land base (super dike).	Yes. No plans to meet the seismic guidelines at present & expect that that cost would be a large concern for the District.	Yes. No plans have been made for upgrades, general concern & attention has been related to the design elevation.
Do you have a funding plan or diking utility to complete future upgrades to the diking system?	Yes, Chilliwack has an annual dike improvement capital budget to fund 1/3 of the expected cost for upgrades, with the assumption that the federal & provincial governments would each fund 1/3 of the total cost. $600,000 is the 2017 budget, which rolls over to eventually fund large-scale dike upgrades. The annual improvement budget is reviewed annually & has gone up over the last few years.	At present, Surrey has only included dike upgrade funding in the drainage utility 10-year plan for existing conditions (500-year event), assuming 2/3 of the funding would be from the provincial & federal governments. Surrey's Coastal Flood Adaptation strategy looks at future requirements along the coast. The regional FBC strategy is being looked at to help with funding for future climate change conditions. Surrey has a drainage utility & parcel tax ($351 for industrial/commercial & $221 for residential currently)[4].	Grants are applied for dike upgrades when available (Hammersley Pump Station currently being upgraded). The District has a diking account some properties pay into that funds all dike activities (O&M & capital), which is not sufficient for large upgrades. Provincial or federal grants are viewed as the only sufficient source of funding to complete large upgrades.	There is no funding plan or diking utility to complete future upgrades.
Does your region treat agricultural dikes differently than standard dikes?	No, the dikes protect all land uses. Chilliwack was not aware of the historic difference in standards for agricultural & standard dikes.	Many dikes in Surrey are non-standard (Agricultural or other). The province transferred responsibility for the Colebrook diking district to Surrey several years ago with funding to upgrade to current standards & acquire land, with the dikes designated as low-risk & thus without seismic requirements. When upgrading non-standard dikes, the Surrey aims to achieve the current provincial standards when possible.	All dikes in the District of Kent are standard dikes.	The Silverdale dike was constructed to agricultural standards with steeper slopes & narrower crest. The dike was raised in 2007 to a 100-year design event & large sections have been filled on both sides by local farm operators & a logging contractor. Most of the work was monitored by FLNRO & Mission, with the belief that they are providing further stabilization.

1. Ministry of Forests, Lands, & Natural Resource Operations, May 2014. "Simulating the Effects of Sea Level Rise & Climate Change on Fraser River Flood Scenarios". http://www.env.gov.bc.ca/wsd/public_safety/flood/pdfs_word/Simulating_Effects_of_Sea_Level_Rise_and_Climate_Change_on_Fraser_Flood_Scenarios_Final_Report_May-2014.pdf
2. Ministry of Forests, Lands, & Natural Resource Operations, March 2014. "Fraser River Design Flood Level Update – Hope to Mission". https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/integrated-flood-hazard-mgmt/fraser_river_design_flood_level_update-hope_to_mission_final_report.pdf
3. Northwest Hydraulics Consultants (NHC) for the Ministry of Environment (MOE), March 2008. "Fraser River Hydraulic Model Update – Final Report". https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/integrated-flood-hazard-mgmt/fraser_update_full_report_2008.pdf
4. Surrey Drainage Parcel Tax: http://www.surrey.ca/city-services/4690.aspx

7.3 Dike Upgrade Methodology

Field Review

A one-day field review of the dike systems was completed by KWL and exp with the City on October 25, 2017. The goal of the field review was to generally review the alignment and condition of the dike, major utilities, confirm the findings in dike inspection reports, and to discuss upgrade methodology. The dikes are in good condition and site observations generally confirmed the results of the most recent dike inspections (2015 and 2016).

Flood Profiles

Table 7-2 presents the proposed criteria for long-term upgrading that will be used in developing the cost estimates. For the purpose of this cost assessment, the dikes are assumed to be upgraded to meet the below flood profiles with 0.6 m freeboard.

Table 7-2: Proposed Long-term Dike Upgrading Criteria

<table>
<tr><th>Criteria</th><th>Matsqui Dike</th><th>Vedder Dike</th><th>Sumas Dike</th></tr>
<tr><td>Design Flood Scenario[1]</td><td colspan="2">500-year return period flood[2]
• “Moderate” climate change impact to flow
• 1 m of sea level rise</td><td>200-year return period flood[3]
• Nooksack River overflow into Sumas River
• 0.3 m addition to flood profile as an allowance for climate change impacts (discharge, sea level rise)</td></tr>
<tr><td>Seismic Performance</td><td colspan="3">Provincial “high-consequence” dike seismic performance criteria[4]</td></tr>
<tr><td colspan="4">Notes:
1. The flood profiles selected are used to assess the approximate cost of long-term dike upgrades. Selection of a design flood profile for each dike should be assessed in the future for conceptual design and analysis.
2. Selected from scenarios provided in: Ministry of Forests, Lands, and Natural Resource Operations, 2014. Simulating the Effects of Sea Level Rise and Climate Change on Fraser River Flood Scenarios”. The 500-year return period flood has an annual exceedance probability of 0.2%.
3. An estimate of the 200-year return period flood, with Nooksack River overflow, is provided in: UMA, 2003. “Sumas Prairie Flood Hazard Investigation Interim Report”. The 2003 study did not analyze climate change impacts including discharge changes and downstream sea level rise impacts to the flood profile. The flood profile was increased by 0.3 m as an allowance for climate change.
4. Presented in: Golder Associates, 2014. “Seismic Design Guidelines for Dike (2nd Edition)”. Prepared for the Ministry of Forests, Lands, and Natural Resource Operations.</td></tr>
</table>

Sumas Dike and the Nooksack River Overflow Hazard

The long-term dike upgrading cost estimate for the Sumas Dike has been prepared based on the assumption that the future upgrades will also address the Nooksack River overflow hazard.

The cost of upgrading the Sumas Dike without addressing the Nooksack River overflow hazard has not been addressed in detail.

It is understood that the breakdown between costs for upgrading with and without considering the Nooksack River overflow hazard would be useful for the City in planning for securing funding future upgrades.

In lieu of a more detailed analysis of the cost breakdown, the points below can be used to inform the City.

- In general, the existing Sumas Dike appears to have sufficient freeboard above the existing 200-year return period flood profile without considering climate change impacts.

- With a 0.3 m allowance for climate change impacts (but without the Nooksack River overflow hazard), the existing Sumas Dike would require minor raising (up to 0.3 m) to have sufficient freeboard.
- Long-term upgrading to account for the Nooksack River and climate change impacts would generally require a dike raise of up to about 1 m.
- Dike raising is a general indicator of upgrading costs, and as such, the cost of upgrading the Sumas Dike without considering the Nooksack River overflow hazard can be approximated to be on the order of one-third of the cost of upgrading with considering the Nooksack River overflow hazard.
- Climate change impacts for the Sumas River and Nooksack River have not been studied, and a 0.3 m addition to flood profiles may not be sufficient. An updated study of the Sumas River flood hazard which considers climate change impacts to both the Sumas River and Nooksack River would better inform the costs of future upgrading.

Dike Upgrade Assumptions

Table 7-3 presents the assumptions for dike upgrading used in developing the cost estimates. Assessment of the existing condition and selection of design criteria would be required for dike upgrade design.

Table 7-3: Dike Upgrade Assumptions

Item	Assumption
Existing condition	The existing dike fill is in good condition and work is not required to repair the dike core prior to raising.
Crest height	The crest height will be the selected flood profile plus 0.6 m freeboard.
Crest width [a]	The minimum crest width will be 4 m.
Crest surfacing	The crest will be maintained in accordance with existing surfacing material (primarily gravel with some paved sections where the dike is a road).
Side slopes [a]	The landside slopes will be 3H:1V. The waterside slopes will be 2H:1V where erosion protection is installed or 3H:1V where erosion protection is not installed.
Seepage mitigation	If the dike crest elevation is more than 4 m greater than the landside toe elevation, a gravel toe berm will be constructed to reduce seepage. In areas with known seepage within 50 m of the dike, the land will be locally filled for an additional 1 m height.
Access [a]	Access to the dike will be provided every 2 km. Turnouts will be provided at intervals of 300 to 500 m on the landside of the dike, provided there are no access ramps within this interval. Turnouts will have an extra 6 m width and extend for 20 m with 15 m taper sections on both sides.
Road crossings	Road crossings of the dike will be raised and paved, with the road grade no greater than 5%. This includes the Highway 1 and Sumas dike intersection, where the Highway is below the future dike crest elevation approximately 0.3 m[b].
Rail crossings	Rail crossings of the dike below the design elevation will have manual flood gates installed.
Alignment	The dike will retain the existing alignment, with the exception of the section along the WWTP where the secondary setback dike alignment is proposed to become the primary dike.
Drainage	All drainage ditches will be located a minimum of 7.5 m from the toe; ditches will be relocated where required.

Item	Assumption
Utilities	Utilities located in the dike footprint will be relocated or raised.
Habitat compensation	Habitat compensation will be required to offset dike upgrading impacts. Compensation will be accounted for as a percentage of the construction cost.
Bank protection	River banks will be protected by riprap if the dike is within 10 m of the top of bank (Fraser River, Vedder Canal, Sumas River only). Along the Matsqui dike where erosion arcs have formed (station 9+300 to 11+600), the erosion arcs will be addressed in accordance with current design and cost estimates (Northwest Hydraulic Consultants, 2015).
Seismic [c, d]	The dikes will be upgraded to meet the current provincial seismic dike design guidelines. Upgrades will include 10 m wide strips of densification on either side of the dike extending 10 to 15 m below the existing ground.
Land acquisition	Land will be purchased at market value to ensure that the dike footprint plus 5 m on either side is controlled by the City to allow for maintenance, access, and potential future upgrades.
Pump stations	Pump station upgrades will include replacement of the entire pump station (structural, mechanical, electrical, and instrumentation) based on the 2008 pump station replacement study[e] by Earthtec-AECOM. The Barrowtown pump station is included in the Vedder dike estimate. Pump station costs have been scaled to 2017 dollars using an inflation price index. The costs in the Earthtec-AECOM assessment do not include a premium for fish-friendly pumps and facilities.

a) Dike Design and Construction Guide – Best Management Practices for British Columbia, 2003.
b) Highway elevation from UMA, 2003. "Sumas Prairie Flood Hazard Investigation Interim Report".
c) Seismic Design Guidelines for Dikes, 2nd edition. Ministry of Forests and Natural Resource Operations, 2014.
d) Seismic design could include alternative options such as stone column drains where space is limited.
e) Earthtec-AECOM, 2008. The City of Abbotsford: Drainage Pump Station PSAB 3150 Study.

7.4 Dike Upgrading Cost Estimate

Dike Condition Summary

Record drawings, design reports, and previous assessments were reviewed to assess the existing dike geometry, crest elevation, erosion protection, and other key features. The dikes were divided into reaches based on dike characteristics and major infrastructure crossings. A summary of key dike characteristics by reach is shown in Table 7-4.

Table 7-4: Summary of Abbotsford Dike Conditions

Reach	Length (m)[a]			Crest Width [a]	Crest Elevation [a] (m)			Approx. Upgrade Flood Level - Without Freeboard (m) [b]		Raise Req'd for 0.6 m FB	Slopes (H:1V)		Erosion / Setback			Pump Stations / Floodboxes [a]	Seepage [d]	Additional Info
	Start Sta.	End Sta.	Length	Width (m)	Up-stream	Down-stream	Low Point	Up-stream	Down-stream	Avg. (m)	Land	Water	River Setback (m)	History	Erosion Protection [c]			
Matsqui Dike - Last Upgrade 2007. 1+000 to 12+544 (11.544 km)																		
Reach 1	1000	2040	1040	3.6	9.23	9.187	7.9 at 1+550 to 1+590	9.64	9.64	1.03	2.8	2.5	30-500 avg. 180	No history noted	River riprap	McClennen Creek Pump Station at 1+820		
Reach 2	2040	2910	870	3.6	9.187	9.29		9.61	9.61	0.97	2.7	2.5	15-40 avg. 20	No history noted	Riprap at WWTP		History of seepage	
Reach 3	2910	5000	2090	3.6	9.29	9.402	9.1 in some locations at JAMES WWTP	9.86	9.61	0.99	2.8	2.5	10-170 avg. 40	No history noted	River riprap	Matsqui Slough Pump Station at 3+400	History of seepage	Lock block wall primary dike and secondary dike (both 9.1 to 9.3 m elevation) at James Bay WWTP to Masqui Slough Pump Station
Reach 4	5000	6000	1000	3.6	9.402	9.718		9.84	10.14	1.03	2.7	2.5	20-100 avg. 50	No history noted	River riprap	Dejong Pump Station at 5+820	History of seepage & boils	Mission Bridge and CN Rail Bridge
Reach 5	6000	7230	1230	3.6	9.718	9.83		10.22	10.15	1.01	2.8	2.5	20-100 avg. 40	No history noted	River riprap	Vanderloo Pump Station at 6+510	History of seepage & boils	
Reach 6	7230	9870	2640	3.6	9.83	10.03	9.2 at 5+540	10.69	10.27	1.15	3	2.5	100-430 avg: 150	Erosion arcs A, B, and C West of Beharrel Rd	River riprap		History of seepage & boils	
Reach 7	9870	12544	2674	3.6	10.03	9.936	9.4 for 40 m	10.93	10.72	1.44	3	2.5	30-250 avg: 70	Erosion arc E (10+080) repaired 2014. Erosion arc D/G (11+200). Erosion arc F (10+960) repaired 2016, expanded downstream.	River riprap		History of seepage	
Sumas Dike - Last Upgrade 1985. South portion 0+100 to 7+460 and North Section 0+100 to 9+484 (16.744 km total)																		
Reach 1	100	3980	3880	6.6	7.08	7.26	6.3 at 2+830 to 2+860	7.53	7.51	0.95	2-2.5	2	<10m, often no setback	No history noted	Little to none	2 CMPs with flapgates at 2+840 and 2+400		Along Intercepting Canal. Includes 0.3 m climate change allowance for flood level.
Reach 2	3980	6100	2120	3.6	7.26	7.13		7.51	7.24	0.78	2-2.5	2	<10m, often no setback	No history noted	Little to none	Pipe with flapgate at 4+620		Along Intercepting Canal and Spree Creek. Includes 0.3 m climate change allowance for flood level.
Reach 3	6100	7460	1360	3.6	7.13	7.272		7.24	7.13	0.58	2-2.5	2	<10m, often no setback	No history noted	Little to none	900 mm CMP with screw gate at 7+090		Includes 0.3 m climate change allowance for flood level.
Reach 4	100	2660	2560	3.6	7.062	6.998		7.13	6.87	0.57	2-2.5	2	<10m, often no setback	No history noted	Little to none			Includes 0.3 m climate change allowance for flood level.
Reach 5	2660	5540	2880	3.6	6.998	6.76		6.87	6.83	0.57	2-2.5	2	<10m, often no setback	No history noted	Little to none	600 mm CMP with screw gate at 2+690		Includes 0.3 m climate change allowance for flood level.
Reach 6	5540	9210	3670	3.6-10	6.76	6.458		6.83	6.78	0.80	2-2.5	2	<10m, often no setback	No history noted	Little to none	900 mm CSP with screw gate at 6+800		Dike is North Parallel Road from 9+210 to 8+220 (10m wide). Includes 0.3 m climate change allowance for flood level.
Reach 7	9210	9484	274	6.6	6.458	10.95	Barrowtown Dam	6.76	6.76	Reach 3 Vedder			No setback, dam	No history noted	Little to none	Barrowtown Dam and Pump Station		Includes 0.3 m climate change allowance for flood level.

Reach	Length (m)[a]			Crest Width [a]	Crest Elevation [a] (m)			Approx. Upgrade Flood Level - Without Freeboard (m) [b]		Raise Req'd for 0.6 m FB	Slopes (H:1V)		Erosion / Setback			Pump Stations / Floodboxes [a]	Seepage [d]	Additional Info
	Start Sta.	End Sta.	Length	Width (m)	Up-stream	Down-stream	Low Point	Up-stream	Down-stream	Avg. (m)	Land	Water	River Setback (m)	History	Erosion Protection [c]			
Vedder Dike - Last Upgrade 2007. 3+740 to 8+484 (4.744 km)																		
Reach 1	3750	6370	2620	3.6-4.5	10.6	11.035		11.78	11.76	1.55	3-2.5	2.5	2200-4500 (Fraser) None on canal	No history noted	None			
Reach 2	6370	8110	1740	3.6-4.8	10.95	10.6		11.74	11.67	1.53	3-2.5	2.5	2200-2700 (Fraser) None on canal	No history noted	None		Geotech. investigation recommended seepage berm	
Reach 3	8110	8484	374	6.6	10.726	10.95		11.68	11.68	1.44			2800 (Fraser) None on canal	No history noted	None	Barrowtown Pump Station and Dam		300 mm curb at dam for current crest elevation

a. Dike Record Drawings (Matsqui and Vedder 2007, Sumas 1985). Sumas pipes not confirmed in the field.
b. Simulating Effects of sea level rise and climate change on fraser flood scenarios (May 2014)
c. Lower Mainland Dike Assessment (NHC, 2015)
d. City of Abbotsford Seepage Maps and *Geotechnical Investigation and Analysis: Emergency Dike Raising Vedder Canal and Sumas River* (Golder, 2008).

Unit Costs

Unit costs for upgrade components were developed based on previous dike construction projects in the Lower Mainland region. The table below summarizes the unit costs and their basis.

Table 7-5: Unit Costs for Dike Upgrading

Item	Unit Rate	Assumption / Basis
Dike Fill	$1500 per m raise per lineal m	Includes construction cost of dike fill, topsoil surfacing, re-seeding, and granular dike surfacing.
Buried Utility Pipe	$400 each	Includes removal and replacement of utilities within the dike corridor.
Utility Pole Replacement	$10,000 each	Includes replacement of existing utility pole.
Water Main River Crossings (through dike)	$200,000 each	Includes allowance for potential replacement of a portion of the water main or the construction of a non-standard dike to reduce impact to existing water main (e.g. lightweight fill, concrete cap, etc.).
Seepage Mitigation – Toe Berm	$70/m^3	Includes supply, placement, and compaction of a landside gravel seepage toe berm in locations where the dike height is greater than 4 m.
Seepage Mitigation – Landside Filling	$40/m^3	Includes placement and compaction of dike fill type material in low-lying areas where seepage has been observed based on City of Abbotsford records.
Paved Access Roads	$100/m^2	Includes supply, placement, and compaction of granular bases and asphalt paving.
Rail Crossings	$200,000 each	Includes the cost of a manual floodgate.
Turnouts	$60/m^3	Includes placement and compaction of dike fill for landside dike turnouts as per provincial design guidelines.
Drainage	Varies	Drainage costs include replacement of small floodboxes and culverts on the Sumas Dike.
Bank Protection	$70/m^3	Includes the supply and placement of riprap bank protection and granular or fabric filter.
Seismic	$15/m^3 densified soil	Includes densification of the ground adjacent to the dike for 10 metres on either side. In areas where 10 m is not available, alternatives such as stone column drains could be considered (not included in cost estimate).
Land Acquisition	$2/m^2	Based on assessed land value July 1, 2016 for a sampling of rural properties in Abbotsford.
Pump Stations	Varies	Includes full replacement of pump station (structural, mechanical, electrical, and instrumentation) with a 20% allowance for additional unaccounted items (decommissioning, fish-friendly pump station, water control).

Class D Cost Estimates

The cost estimates provide for long term upgrading of each of the City's dikes are high-level lump sum estimates in 2018 dollars. These costs are considered indicative for planning purposes only and planning, conceptual design, and investigation would be required to more accurately determine costs.

Table 7-6 summarizes the dike upgrade costs for each dike without seismic performance improvements. Table 7-7 summarizes the dike upgrade costs including seismic performance improvements. Additional details are provided in Tables F1 to F3 on Appendix F.

Estimates have been prepared with little or no site information and as such indicate the approximate magnitude of the cost of the capital tasks, for project planning purposes only. The estimate has been derived from unit costs for similar projects.

Table 7-6: Class D Cost Estimate Summary Excluding Seismic Performance Improvements

Dike	Geometric [a]	Bank Protection [b]	Land Acquisition	Pump Stations	Totals
Matsqui Dike	$31,860,000	$18,267,000	$29,000	$11,387,000	$61,543,000
Vedder Dike	$10,855,000	$2,466,000	N/A	$27,352,000	$40,673,000
Sumas Dike [c]	$27,416,000	$8,512,000	$299,000	N/A	$36,227,000
Subtotal	$70,131,000	$29,245,000	$328,000	$38,739,000	$138,443,000
Contingency (50%)	$35,065,500	$14,622,500	$164,000	$19,369,500	$69,221,500
Total Construction	$105,196,500	$43,867,500	$492,000	$58,108,500	$207,664,500
Professional Services (10% of construction)					$20,766,000
TOTAL (ROUNDED)					**$228,000,000**

a) Includes crest elevation, surfacing, width, side slopes, access, seepage mitigation, crossings, drainage, and utilities.
b) Includes bank protection as well as habitat mitigation and compensation allowance for bank protection and geometric dike components.
c) Cost estimate assumes long-term upgrades will also address the Nooksack River overflow hazard. A detailed review of the cost breakdown between upgrading the Sumas Dike with and without addressing the Nooksack River overflow hazard has not been conducted. However, based on estimated dike raising heights, the cost of upgrading the Sumas Dike without addressing the Nooksack River overflow hazard is estimated as approximately 1/3 of the cost of upgrading the dike with addressing the Nooksack River overflow hazard.

Table 7-7: Class D Cost Estimate Summary Including Seismic Performance Improvements

Dike	Base Cost Excluding Seismic [a]	Seismic	Totals
Matsqui Dike	$61,543,000	$33,303,000	$94,846,000
Vedder Dike	$40,673,000	$17,175,000	$57,848,000
Sumas Dike [b]	$36,227,000	$62,213,000	$98,440,000
Subtotal	$138,443,000	$112,691,000	$251,134,000
Contingency (50%)	$69,221,500	$56,345,500	$125,567,000
Total Construction	$207,664,500	$169,036,500	$376,701,000
Professional Services (10% of construction)			$37,670,000
TOTAL (ROUNDED)			**$414,000,000**

a) Refer to Table 7-6.
b) Cost estimate assumes long-term upgrades will also address the Nooksack River overflow hazard. A detailed review of the cost breakdown between upgrading the Sumas Dike with and without addressing the Nooksack River overflow hazard has not been conducted. However, based on estimated dike raising heights, the cost of upgrading the Sumas Dike without addressing the Nooksack River overflow hazard is estimated as approximately 1/3 of the cost of upgrading the dike with addressing the Nooksack River overflow hazard.

7.5 Phasing

The City has suggested the phasing approach outlined below to incorporate the dike upgrading cost into the drainage master plan.

- Medium-term (5-15 year): Full seismic performance upgrading and partial dike raising. The partial raise is estimated by a consistent 0.5 m raise.
- Long-term (16-32 year): complete the rest of the dike raising and other construction components including utilities, seepage, access and roads, turnouts, rail crossings, drainage, bank protection, land acquisition and pump stations.

This phasing approach will allow the City to roughly distribute the estimated dike upgrading cost for long-term planning and budgeting purposes. On a practical basis, it is not likely that the dike upgrading program will be implemented exactly in this way. Some items included in the long-term cost may need to be at least partially implemented earlier (i.e. land acquisition and bank protection).

Medium-term Implementation Indicative Cost

A simplified cost estimating approach was used to estimate the cost of the medium-term partial dike raising. This approach only includes the geometric portion of the dike raising (i.e. the earthwork needed to raise the dike crest). As a crude approximation, it is assumed that the unit cost would be two-thirds of the total unit cost for the full dike raising.

This approach does not include other construction components including utilities, seepage, access and roads, turnouts, rail crossings, drainage, bank protection, land acquisition and pump stations. Each of these would be long-term items, and would require further consideration on a reach-by-reach basis. Whereas the other cost estimates in this technical memorandum are indicated as “Class D”, the phased cost estimate provided herein is unclassified (much less certain than a Class D cost estimate). This cost estimate is in 2018 dollars.

Table 7-8: Indicative Cost Estimate for Medium-term Dike Upgrading

Dike	Partial Dike Raising[a] (0.5 m)	Seismic	Totals
Matsqui Dike	$11,500,000	$33,303,000	$44,803,000
Vedder Dike	$4,700,000	$17,175,000	$21,875,000
Sumas Dike	$16,700,000	$62,213,000	$78,913,000
Subtotal	$32,900,000	$112,691,000	$145,591,000
Habitat Compensation (5%)			$7,280,000
Contingency (50%)			$72,796,000
Subtotal			**$225,667,000**
Professional Services (10% of construction)			$22,567,000
TOTAL (ROUNDED)			**$248,000,000**

a) Partial dike raising represented by a 0.5 m raise. Only includes the geometric portion of the dike raising (i.e. the earthwork needed to raise the dike crest by 0.5 m). Does not include other construction components including utilities, seepage, access and roads, turnouts, rail crossings, drainage, bank protection, land acquisition and pump stations.

Long-term Implementation Indicative Cost

The long-term implementation cost is estimated to be $166,000,000 by subtracting the medium-term implementation cost presented in Table 7-8 from the total upgrading cost estimate presented in Table 7-7.

Limitations

The cost estimates provide an indication of anticipated long-term dike upgrading costs to meet the stated dike standards. The estimates reflect typical dike upgrading work based on general principles, and are not based on any site-specific design work. Design concepts were not investigated thoroughly for feasibility and it is possible that alternative concepts may be preferred. Actual costs for any given area or component may vary significantly based on the actual concept that is selected, and the design that is undertaken. Some component cost items are based on previous work by others, as noted, and are subject to the pertinent limitations of the source (no work has been done to verify such costs).

As noted herein, the most recent available Sumas Dike flood profiles do not consider how climate change may impact the Sumas River and the Nooksack River. An updated flood hazard study would better inform the potential costs of future upgrading, including the cost breakdown with and without considering the Nooksack River overflow hazard.

The City should exercise caution in using these indicative cost estimates for program planning. In particular, the City should recognize that approach taken to distribute costs between medium-term and long-term is very simplistic, and not likely fully representative of how the dike upgrading work will actually occur. The cost estimating approach for seismic performance improvement is also simplistic, and does not reflect actual site conditions.

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City of Abbotsford

Drainage Master Plan - Long-term Dike Upgrading Cost Assessment

KERR WOOD LEIDAL
consulting engineers

Legend

- Municipal Boundary
- Pump Station
- Matsqui Dike
- Sumas Dike
- Vedder Dike

Project No. 510.152

Date June 2018

Scale 1:70,000

1,000 500 0 1,000 m

Long-term Dike Upgrading Cost Assessment Study Area

Figure 7-1

8. Stormwater Management Policy and Criteria

Over the years, the City has developed stormwater management policies on a City-wide scale through bylaws and a watershed scale through ISMPs. This section summarizes the City's existing policy and criteria related to stormwater management and compares them with those from other municipalities. To guide future development, recommendations were made to update criteria and work toward consistency across watersheds and City-wide depending on site-specific issues, incorporate climate change considerations, and address stakeholder concerns.

8.1 City's Existing Policy and Criteria

City-wide Stormwater Management Criteria

Stormwater management criteria within the City is summarized in bylaws and supplemented with DFO and ARDSA guidelines. The major sources are listed below with criteria summarized in Table 8-1:

City Bylaws:

- City of Abbotsford Consolidated Development Bylaw No. 2070-2011
- Stormwater Source Control Bylaw for CICP Industrial lands, No. 2045-2011
- City of Abbotsford Erosion & Sediment Control Bylaw, 2010
- City of Abbotsford Streamside Protection Bylaw, Bylaw No.1465-2005

Guidelines:

- Rainwater Management Measures for Clayburn Watershed – Draft, 2013
- DFO: Urban Stormwater Guidelines and Best Management Practices for Protection of Fish and Fish Habitat, Draft Discussion Document – 2001. http://www.dfo-mpo.gc.ca/Library/277967.pdf
- ARDSA: Agriculture and Rural Development Subsidiary Agreement

Table 8-1: Summary of Existing Stormwater Criteria

Application	Criteria/Methodology
Flood and Erosion Protection	
Minor Drainage System	10-year return period design event. [1]
Major Drainage System	100-year return period design event. [1]
Agricultural Lowland Flooding – ARDSA[2]	Limit flooding to 5 days during a 10-year 5-day winter storm & to 2 days during a 10-year 2-day growing season storm. Provide 1.2 m of freeboard during baseflows between storm events.
Environmental Protection	
Volume Reduction Source Controls	On-site rainfall capture (runoff volume reduction) for 6-month 24-hour storm (72% of the 2-year 24-hour storm). [3, 4, 5]
Water Quality Treatment	Remove 80% of Total Suspended Solid from 6-month 24-hour storm (72% of the 2-year 24-hour storm). [3] Limit construction discharge water quality to < 25 NTU turbidity or total suspended solids of 25 mg/L at all times except in the 24-hour period following significant rainfall events (≥25 mm/day) at which time the turbidity can be up to 100 NTU. [6] (or 75 mg/L [3])
Rate Control Detention / Diversion	Detain 10-year (100-year upstream of Clayburn Village) peak flows to 5 L/s/ha. [1] Control post-development flows in creeks to pre-development levels for 6-month, 2-year and 5-year 24-hour event. [3]

1. City of Abbotsford Development Bylaw No. 2070-2011.
2. ARDSA = Agriculture and Rural Development Subsidiary Agreement.
3. DFO Urban Stormwater Guidelines and BMPs for the Protection of Fish and Fish Habitat, 2001.
4. Stormwater Source Control Bylaw for CICP Industrial lands, No. 2045-2011
5. Rainwater Management Measures for Clayburn Watershed – Draft, 2013
6. City of Abbotsford Erosion & Sediment Control Bylaw, 2010

The City *Streamside Protection Bylaw* is consistent with the Provincial Riparian Areas Regulation to protect fish habitat from adverse effects of land development (see Table 8-2).

Table 8-2: Existing Streamside Protection and Enhancement Area Widths

<table>
<tr><th rowspan="3">Watercourse Type</th><th rowspan="3">Existing or potential[2] streamside vegetation conditions</th><th colspan="3">Streamside Protection and Enhancement Area width[1]</th></tr>
<tr><th rowspan="2">Fish Bearing</th><th colspan="2">Non Fish Bearing</th></tr>
<tr><th>Permanent</th><th>Non-Permanent</th></tr>
<tr><td rowspan="3">Wetlands and all other watercourses</td><td>Category 1. Continuous areas ≥ 30 m or discontinuous but occasionally > 30 m to 50 m</td><td colspan="2">At least 30 m</td><td>At least 15 m</td></tr>
<tr><td>Category 2. Narrow but continuous areas = 15 m, or discontinuous but occasionally > 15 m to 30 m</td><td rowspan="2">Greater of:
-existing width, or
-potential width, or
-15 m</td><td colspan="2">15 m</td></tr>
<tr><td>Category 3. Very narrow but continuous areas up to 5 m, or discontinuous but occasionally > 5 m to 15 m</td><td colspan="2">At least 5 m & up to 1 5m</td></tr>
</table>

Watercourse Type	Existing or potential[2] streamside vegetation conditions	Streamside Protection and Enhancement Area width[1]		
		Fish Bearing	Non Fish Bearing	
			Permanent	Non-Permanent
Ravines >60 m in width[3]	N/A	10 m		
Ditches	N/A	2 times channel width[4] (max. 10 m, min 5 m)	2 m	

[1]Measured from the Top of Ditch Bank for Ditches and from the Top of Bank for Streams and Wetlands.
[2]Potential vegetation is considered to exist if there is a reasonable ability for regeneration either naturally or with assistance through enhancement, and is considered to not exist on part of an area covered by a permanent structure.
[3]Measured from Left Top of Bank to Right Top of Bank, excluding the stream channel.
[4]Channel Width is determined by the width of the ditch at the midpoint between the ditch invert and the top of the ditch bank.

Watershed-Scale Criteria

In addition to the City-wide design criteria and policies, the City has developed and implemented ISMPs on a watershed basis, which provides watershed specific guidelines. The Clayburn Creek ISMP is the only one adopted by the City to date.

Table 8-3: Summary of Policies Recommendations from ISMPs

Clayburn Creek ISMP
• **Volume Reduction/LID:** Add volume reduction target (6-month 24-hour event) • Develop green road standards for stormwater treatment & volume reduction • Develop examples & standards for Stormwater Source Controls to aid with implementation • Enhance **Tree Protection Bylaw** to require compensation for <20 cm diameter trees. • Enforce the **Streamside Protection Bylaw** with no-net-loss variances except for creek crossings • Enforce the **Erosion & Sediment Control Bylaw**
Downes Creek ISMP
• Review existing City development standards to ensure compatibility with LID application • Revise the development standards to require LID measures to achieve rainfall capture targets • Require annual monitoring & maintenance, with documentation, for “hot-spot” water quality BMP facilities • Require minimal removal & compaction of surficial soil during construction & development • Identify & maintain any areas with reasonable infiltration capacity for siting of BMP/LID facilities • Develop & implement a watershed monitoring & adaptive management • Amend to require tree removal permits for tree felling within the City, maintain maximum existing/native vegetation during development, including mature trees, & protect high-value “habitat” trees

Marshall Creek ISMP
• Maximizing source controls such as disconnected roof leaders, infiltration facilities and swales, rain gardens, absorbent soil layers, lot terracing, and green roofs to capture the 6-month return period rainfall. • Constructing regional detention and/or infiltration facilities, and diversions to reduce post-development flows to pre-development levels for the 6-month, 2-year and 5-year events. • Incorporate references to the ISMP and the summary in the development bylaw. • Establish riparian setbacks along all watercourses • Review development application designs to check that they meet the requirements of the plan. • Inspect during construction to ensure that BMPs/facilities are being constructed as designed. • Collect Development Cost Charges (DCCs) and construct regional detention/infiltration facilities. • Enhance riparian areas along the Marshall Creek Mainstem to offset any increases in effective impervious area that have not been addressed with onsite source controls and regional facilities.

8.2 Existing Source Control Bylaw Enforcement Challenges

Development Services have had some developers submit drawings for infrastructure in accordance to the *Stormwater Source Control Bylaw* to meet zoning requirements, but did not construct the measures once zoning was approved and at time of construction.

The *Stormwater Source Control Bylaw* is a compliance bylaw, but is not enforceable after the zoning without the City going to court. An enforceable bylaw must be included in the City's *"Consolidated Bylaw Notice Enforcement Bylaw, 2007 Bylaw No. 1703 – 2007*. This makes the *Stormwater Source Control Bylaw* a regulatory bylaw allowing the Bylaw Department to enforce it.

8.3 Stormwater Criteria from Other Jurisdictions

Each individual jurisdiction has its own accepted design practices and evolving requirements regarding storm drainage and stormwater management. Five municipalities in the Fraser Valley and Lower Mainland were selected and their drainage criteria and policies are summarized in Table G1 in Appendix G.

The following are key findings of the City's existing policy review and comparison with other local municipalities:

- The City's drainage design criteria, including minor and major system, detention, and agricultural lowland, are generally in agreement with those from other municipalities.
- The City's *Streamside Protection Bylaw* is consistent with the Provincial *Riparian Areas Regulation* to protect fish habitat from adverse effects of land development.
- The City needs to develop an enforceable *City-wide Source Control Bylaw* outlining acceptable measures, and capture targets and volume reduction criteria, with reference to the existing ISMPs as needed. Information from both the Draft *Clayburn Creek Rainwater Management Measures* and *CICP Stormwater Source Control Bylaw* could be used to develop this bylaw.
- Need to continue to develop and adopt ISMPs for major watersheds.

8.4 Recommendations

Based on the stormwater policy review, it is recommended that the City:

Stormwater Source Controls

1. Develop an enforceable City-wide Stormwater Source Control Bylaw for new development and redevelopment. Combine information from the Clayburn Creek rainwater management Bylaw and the CICP Stormwater Source Control Bylaw (No. 2045-2011) to create this document. This will supplement the provisions of the City's Development Bylaw.
    a. Include this bylaw within the City's "Consolidated Bylaw Notice Enforcement Bylaw, 2007 Bylaw No. 1703 – 2007" to ensure it can enforced by the Bylaw Department, and is a regulatory, not a compliance, bylaw.
    b. Include specific criteria for ISMP watersheds, CICP specific requirements, and for unstudied areas, if needed or adopt consistent criteria throughout the City that will meet or exceed the individual watershed criteria.
    c. Add high level information for guidance such as the Infiltration Map, source control prescriptions (e.g. Clayburn ISMP Table and Map), clear capture targets (6-month 24-hour event Volume Reduction), etc.
2. Develop Stormwater Source Controls Examples and Standards to aid with education and implementation. Refer to the Clayburn Creek Rainwater Management Measures for the green road standards for stormwater treatment and volume reduction.
3. Incorporate O&M procedures (source controls, detention, and BMPs) into the City's regular O&M activities.

Development Bylaw, 2011 (Bylaw No. 2070-2011)

1. Under Rainwater Management Principles (Section No. 4, Item 2), add reference to new City-wide Stormwater Source Control Bylaw.
2. Add requirement to incorporate climate change into analysis and design. Provide sources for climate change information to be used.
3. Require fish friendly design for new drainage infrastructure installation or upgrades (culverts, flood boxes and pump stations).
4. Require minimal removal and compaction of surficial soil during construction and development.

Other Bylaws:

1. Enforce the *Streamside Protection Bylaw No. 1465-2005* with no-net-loss variances except for creek crossings. Establish riparian setbacks along all watercourses to comply with bylaw.
2. Enforce the *Erosion and Sediment Control Bylaw* for protect water quality and minimize sedimentation in waterways.
3. Amend the existing *Tree Protection Bylaw (No. 1831-2009)* as necessary to require tree removal permits for tree felling within the City, maintain maximum existing/native vegetation during development, including mature trees, and protect high-value "habitat" trees. Require compensation for loss of "<20 cm diameter trees.
4. Add a requirement to the Building Permit process to adhere to the Stormwater Source Control Bylaw.
5. Amend the Building Bylaw (No. 2597-2016) to include adding impervious paving as a change on a lot that would trigger the Building Permit process. .

9. Regional Facilities Management

9.1 Detention Facilities

Database

A detention facility database was complied to summarize all facilities included in recently completed projects as well as larger facilities currently proposed. The database includes physical characteristics of each facility such as storage volume, area, invert elevations, design water levels, high water level, outflow release rate, etc. A total of 108 facilities are summarized in the database (shown in Table H1 in Appendix H. Of those 108 facilities, 11 have not had performance studies completed as of 2017. These 11 are listed at the bottom of the table.

Facilities without Detailed Assessments

To condense the City's large database of ponds that have not had performance studies completed, the following 5 filters where applied to reduce the list down to the 11 flagged in Table H1:

1. municipal ownership,
2. facility type is pond, tank or infiltration,
3. must have a control structure
4. have more than 1000 m^3 of storage and;
5. as of 2017, have not been studied.

To add these unstudied ponds to the database, as-built drawings of each one were obtained from the City and all relevant data was transcribed.

Detention Facility Assessment

All assessments and recommended upgrades completed in past studies have been included in Table H1 in Appendix H.

To assess facilities that have not been assessed as of 2017, a unit release rate was calculated and compared to the 5 l/s/ha maximum allowable release rate set by the City in the Development Bylaw. For the 11 facilities with sufficient information in the unstudied category, the calculated orifice release rate on the as-built drawing was divided by the contributing drainage area to estimate the unit release rate. Of these 11 facilities, the as-built drawings did not include contributing drainage area for 5 facilities. To determine the missing drainage area, existing drainage models were used where available, and where not available, a combination of storm sewer system mapping and contours were used to approximate the drainage area. All facilities assessed in this study are listed under the "Pond Without Detailed Studies" heading in Table H1 in Appendix H.

Community & Regional Facilities

Potential locations to be investigated further for large detention facilities have been identified as shown in Figure 9-1. These facility locations could mitigate downstream erosion and prevent the need for long term downstream storm sewer upgrades. Figure 9-2 and 9-3 provide a closer view of the facilities with the highest potential to reduce flooding. The proposed locations are municipally-owned parkland or open space with no existing detention or infiltration facility within. Once the municipally-owned open spaces were identified, those spaces were prioritized by reported downstream issues and the density land use change exercise that was undertaken in Section 4.

The areas identified in Figures 9-1 to 9-3 are areas that may be suitable for detention facilities and require detailed examination. The sites shown in these figures were selected by applying the following filters or criteria to the mapping data:

1) lot owned by the City
2) lot zoned park or open space
3) lot larger than 1000 m^2 (excluding riparian setback areas)
4) lot contains slopes flatter than 5%

Parks located adjacent to watercourses are ideal locations for these detention facilities due to their available space and their location between the upslope development and the downslope watercourse.

The areas identified for detention facility consideration, were qualitatively assessed for their potential to reduce existing downstream flooding and the potential to mitigate the impact of runoff from future development. Figures 9-1 to 9-3 show the classification of each location's potential as described in Table 9-1.

Table 9-1: Prioritization Criteria of Potential Regional Facility Areas

Location Potential	Change in Density	Downstream Issues	Detention Facility Impacts
High	Increase	Reported Downstream Flooding	Detain and reduce peak runoff from existing impervious runoff and increased impervious runoff due to future densification, which would mitigate the potential compounding of local downstream flooding
Medium	No Change	Reported Downstream Flooding	Reduce the contribution to local downstream flooding from existing impervious runoff
Low	Increase	None Reported	Mitigate future downstream flooding potential by reducing peak flow from an expected increase in impervious runoff due to densification
Future Considerations	No Change or Decreasing	None Reported	To be determined at time of development

9.2 Infiltration Assessment

Infiltration potential was assessed in GIS by using the current BC surficial geology layer (Soils), the provided floodplain layers received from the City, and any special consideration layers from completed past projects. Any soils that contained sand, gravels or a combination of both was estimated to be well draining soils where 100-year infiltration may be possible. Soils that did not contain sand or gravel were assumed to be poorly draining soils and only able to infiltrate the 6-month storm. Figure 9-4 shows the resulting infiltration assessment. The infiltration map should be incorporated in the recommended Stormwater Source Control Bylaw to guide selection of source control measures. Approximately 57% of the area within the Urban Drainage Boundary has good infiltration potential.

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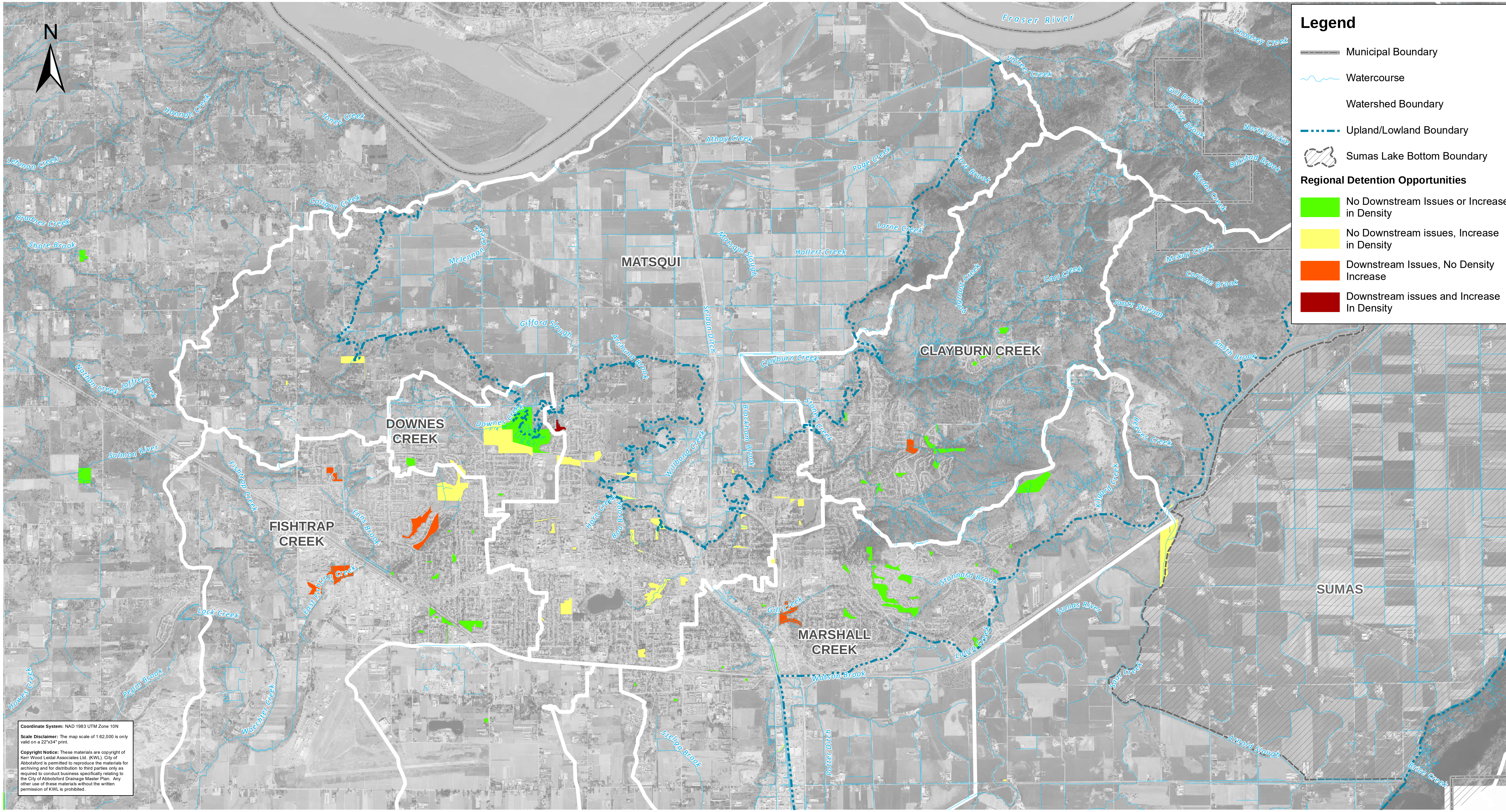
City of Abbotsford

Drainage Master Plan

KERR WOOD LEIDAL consulting engineers



Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:62,000 is only valid on a 22"x34" print.

Project No. 510.152

Date June 2018

Scale 1:62,000

Detention Facilities Overview

Figure 9-1

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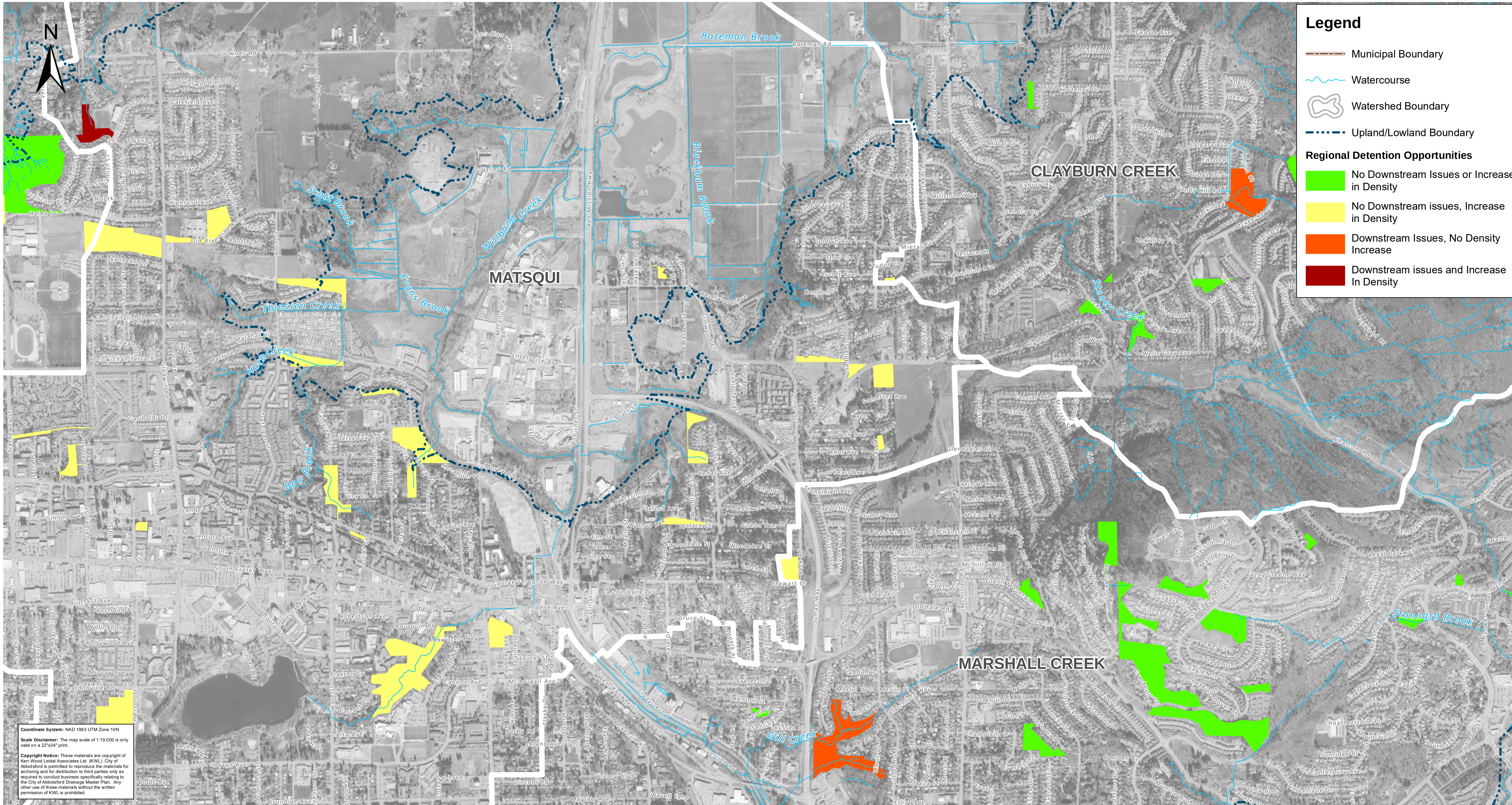
City of Abbotsford

Drainage Master Plan

KERR WOOD LEIDAL
consulting engineers



Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:19,000 is only valid on a 22"x34" print.

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Date June 2018

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Detention Facilities City Core

Figure 9-2

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Drainage Master Plan

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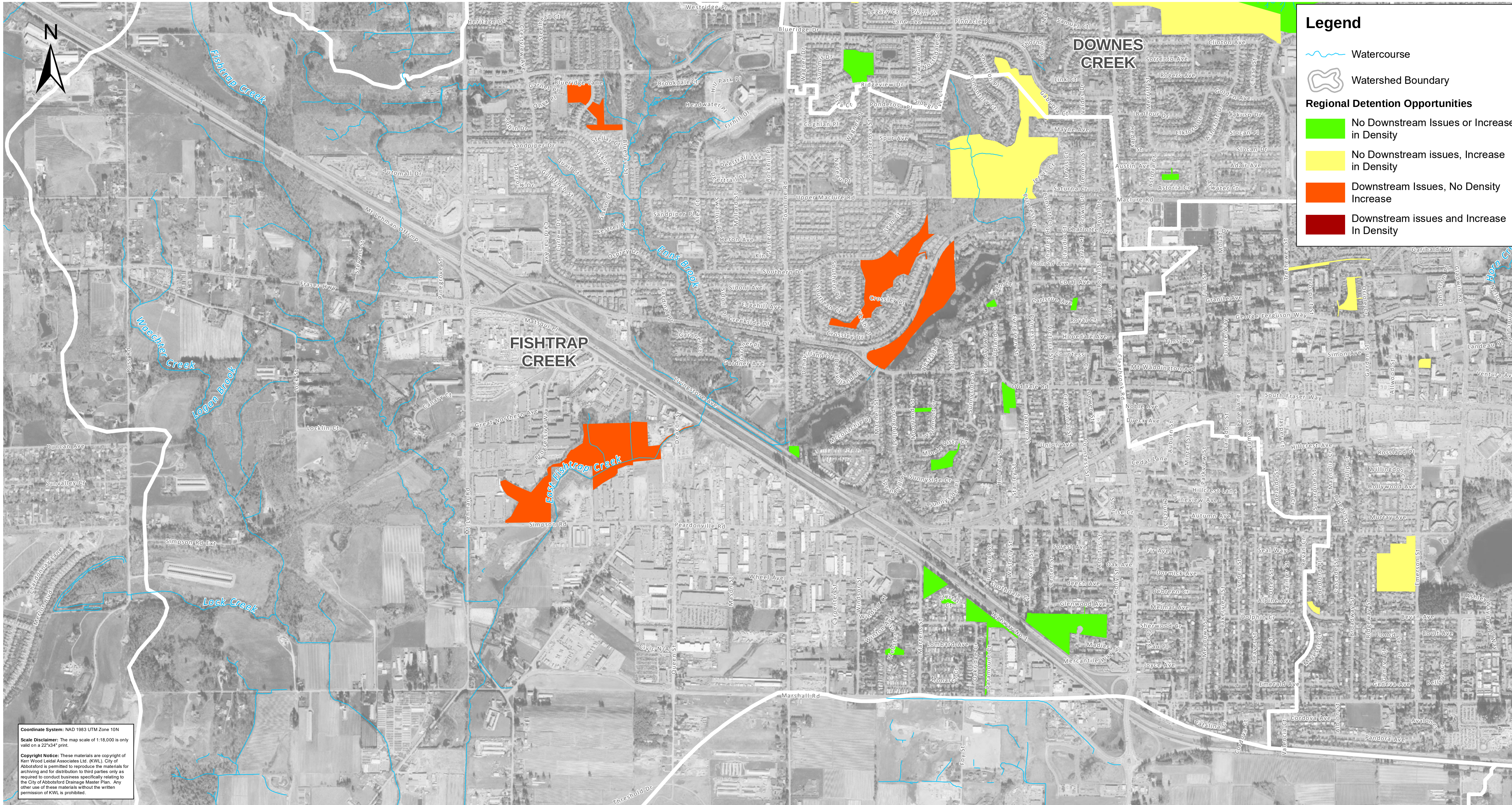

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:18,000 is only valid on a 22"x34" print.

Project No. 510.152
Date June 2018
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Detention Facilties Fishtrap Watershed

Figure 9-3

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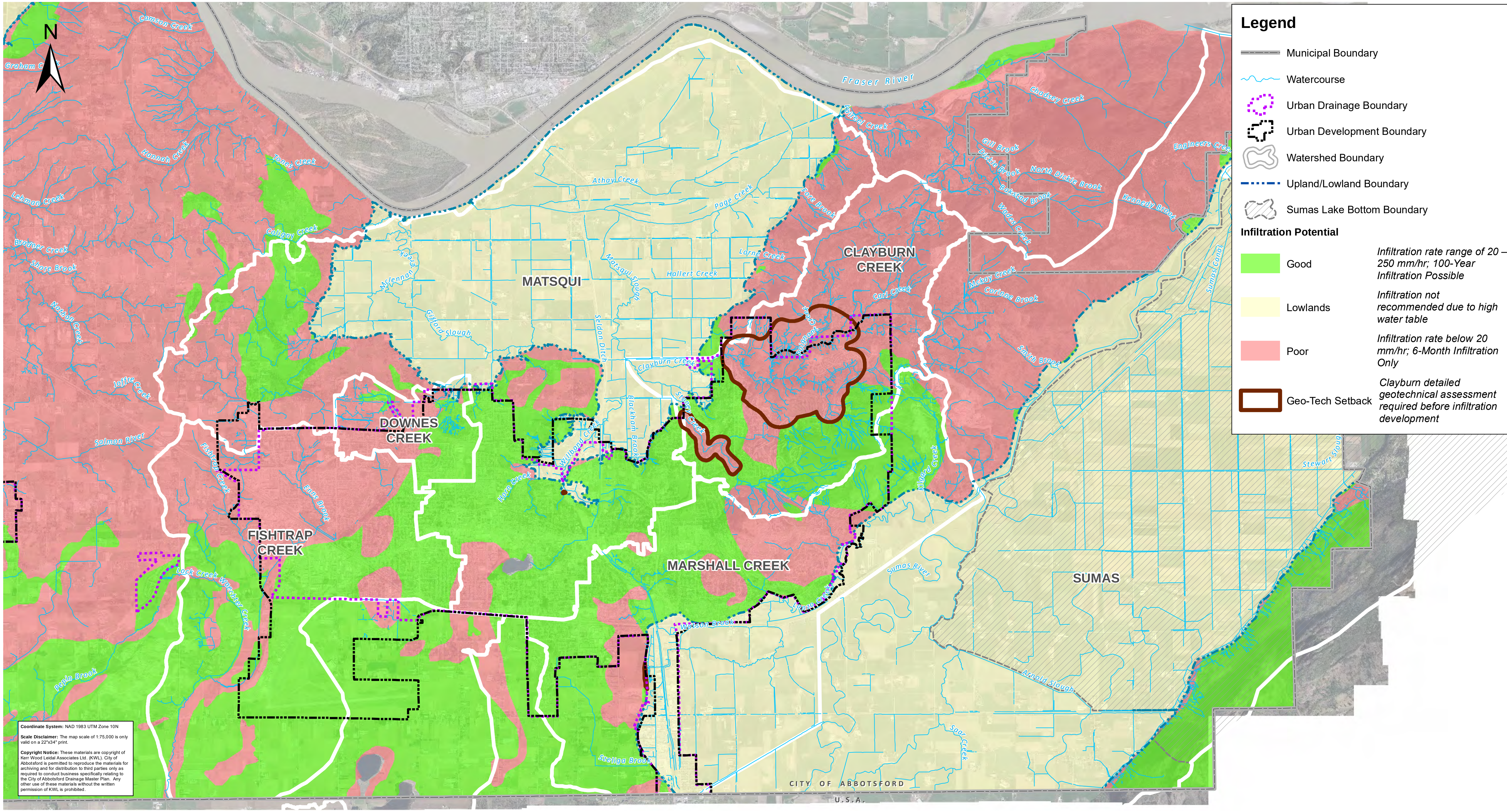

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Infiltration Opportunities

Figure 9-4

10. River Management Programs

10.1 Nooksack River Overflow

Major flooding of West Sumas Prairie and the Washington State cities of Everson, Sumas and the unincorporated areas of Whatcom, occurred in November 1990 when the overflow from the Nooksack River flooded into the Sumas River basin.

The Nooksack River International Task Force (NRITF) was established comprising members from both Canada and the United States, in response to the November 1990 flooding. Canadian members are from Federal, Provincial and the City of Abbotsford. Its focus is on the following four strategies:

1. Improving emergency response to Trans-Boundary flooding;
2. Improving floodplain management;
3. Restoring the early 1970's Nooksack River flow capacity; and
4. Developing a comprehensive Flood Damage Reduction Plan.

Focus since 2011 has been on Strategy #4. Work done to date included:

- Conversion of 1D model to a calibrated 2D MIKE FLOOD model for Sumas Prairie in Canada. Three 100-year flood scenarios were developed:
  1. Nooksack River overflow with embankment breaches (Southern Railway & Whatcom Road),
  2. Nooksack River overflow with embankment overtopping (no breaches), and
  3. No overflow.
- Creation of a Flood Emergency Response Model for Sumas Prairie covering both Abbotsford and Washington state lowlands (requires further calibration).
- Installation of a gauge at Everson, WA which is the location where the Nooksack overflow would occur.
- Development of a methodology to estimate potential flooding extents in West Sumas Prairie given recorded water levels at the gauge.

The last NRITF meeting was in February 2011 and the last NRITF Technical Meeting occurred in November 2012. In November 2017, the City met with the Province and their consultants KWL to discuss work completed to date. Potential next steps include creation of a HAZUS model to estimate flood damage under a 100-year flood event on the Canada side, and a NRITF meeting to be set up by the Province and their US counterparts to reconnect on this issue. This has not been included in the DMP now.

10.2 Asbestos Cement Issue in the Sumas River

Naturally-occurring asbestos is present in Swift Creek in the State of Washington, USA, resulting from a historical landslide in the 1920s. Swift Creek is a tributary of the Sumas River, which runs through Abbotsford and eventually drains into the Fraser River. The Sumas River carries sediment from the USA and deposits it in the Sumas Prairie. To date, the landslide remains active and continues to contribute sediments to Swift Creek and Sumas River.

In 2009, the City of Abbotsford along with Federal and Provincial environment and health agencies, was notified by the US Environmental Protection Agency (USEPA) in Washington State of renewed concerns regarding potentially elevated naturally occurring asbestos levels in the Sumas River sediments.

To maintain the productivity of farmland in Sumas Prairie, sediment deposited in the bed of Sumas River needs to be removed on a regular basis to provide good drainage and prevent flooding. With asbestos in the sediment, the excavated material is deemed a health hazard as there is a risk of the asbestos drying out and becoming air-borne. Removing the excavated material safely requires trucking it to a safe disposal site, keeping it wet, covering it with a 0.5m thick blanket of clay, and retaining a host of environmental and geotechnical specialists to monitor all aspects of the excavation. To remove the sediment and provide drainage in Sumas River, the Sumas Prairie Dyking, Drainage and Irrigation District incurred a clean-up cost of $125K in 2010 and $52K in 2011.

In 2015, Whatcom County presented the Swift Creek Sediment Management Action Plan (SCSMAP) at the Swift Creek Science Symposium. One of the elements of the action plan is the design and construction of sediment basins at the toe of the landslide (Goodwin Reach sediment basins). The implementation of the action plan (estimated $15M dollars) is pending financial support from Washington State. Regardless whether the SCSMAP goes ahead or not, the asbestos-laden sediment deposited in the Swift Creek/Sumas River will still need to continue to be periodically removed to maintain an acceptable drainage level of service. The clean-up costs could be significant. The City continues to work with Provincial and Federal Government on the asbestos issue and clean-up costs, as water and sediment is a Provincial responsibility, and the transboundary nature of the flow of sediment is a Federal issue.

10.3 Vedder River Sediment Management Program

The Vedder River / Canal system conveys water from Chilliwack Lake and its headwaters to the Fraser River. The Vedder River flows west and north from Chilliwack to join the Sumas River (downstream of Barrowtown Pump Station in Abbotsford) via Vedder Canal, before its confluence with the Fraser River. The system from Vedder Crossing to the Highway 1 bridge (near Barrowtown Pump Station) is approximately 12 km. A map of the Vedder River and Canal system is showing in Figure 10-1.

Flood control dykes are located along both sides of the Vedder River and Canal. These dykes are essential for protecting properties in the cities of Abbotsford and Chilliwack. Natural fluvial processes carry sand and sediment from Chilliwack River basin upstream into the Vedder River and Canal. Historically the annual sediment deposits averages 50,000 to 60,000 m^3/year. The sediment reduces the channel capacity and increases the flood threat to the surrounding communities. Removal of sediments is necessary to maintain the level of flood protection.

The Vedder River Management Committee (VRMC) was established in 1983 to manage this ongoing flood threat. The Management Committee includes representatives from the City of Abbotsford, City of Chilliwack, Ministry of Forests, Lands, Natural Resource Operations and Rural Development (MFLNRORD), and Department of Fisheries and Oceans (DFO). It is supported by a Technical Committee. The Technical Committee is responsible for making recommendations to the Management Committee for a sediment removal plan every second year on the even number years. The timing was selected to avoid disrupting Pink Salmon spawning.

The sediment removal work is typically carried out in two phases: (a) Planning Phase and (b) Removal/Assessment Phase.

a. Planning Phase

The need for sediment removal is established by carrying out repeat surveys of permanently established cross sections to calculate sediment volumes. A hydraulic model is used to calculate the water surface profile and evaluate the change in the dyke freeboard. (A minimum freeboard of 0.75m is to be maintained at a 200-year design flood of 1,470 m^3/s, with starting water level elevation of 7.4m at the Highway 1 Bridge.) Sites for sediment removal are selected in consultation with a registered biologist and to provide improvement in the channel capacity where it is most required.

The Planning Phase for the sediment removal cycle typically begins early in the even number years. The following planning studies are typically completed:

- Survey of the Vedder River and Canal Profile,
- Hydraulic Modelling, and
- Sediment Removal Environmental Planning.

Once the planning process is complete and potential sediment removal sites are identified, the following approvals are typically applied by the end of May:

- Water Sustainability Act,
- Fisheries Act,
- Navigable Waters Protection Act, and
- Canadian Environmental Assessment Act.

The sale of sediment is tendered jointly with the three agencies (City of Abbotsford, City of Chilliwack, and MFLNRO) according to the jurisdiction of the sediment removal sites. The tender process typically takes place in June. Sediment removal by the Contractor is permitted within the Fisheries window. The Contractor is typically allowed to stockpile the removed sediment on a designated location and will have approximately 2 years to remove it.

b. Removal/Assessment Phase

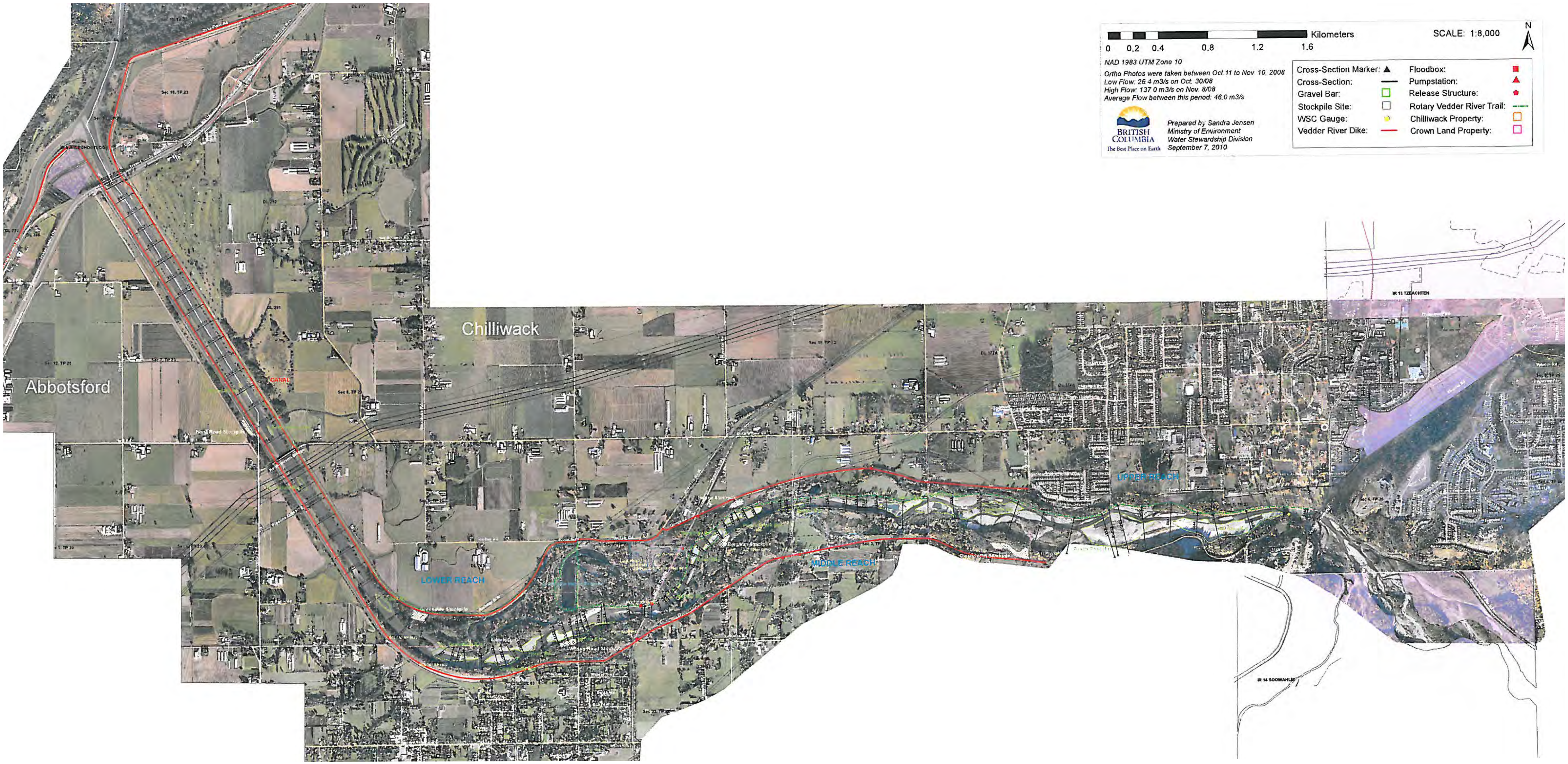
Consultants are retained for environmental monitoring during removals, and post-removal surveying.

c. Cost Sharing

A cost sharing agreement was established in February 2010 to share cost between the three agencies. There is a different cost-sharing arrangement for the planning and removal/assessment phases of the program. In the planning stages, the actual removal volumes are unknown and yet to be determined. A historically agreed to formula is applied as below for the costs incurred in the Planning Phase:

- City of Abbotsford - 15%
- City of Chilliwack - 33%
- Province - 52%

For the removal/assessment phase, consultant fees are cost shared based on the actual volume of sediment removed. Typically, the sale of sediment would subsidize these costs, if positive bids are received.



Project No. 510-152
Date June 2018
Scale Not to Scale

Vedder River and Canal System

Figure 10-1

11. Proposed Capital Expenditures

11.1 Drainage Upgrades in Studied Areas

Storm sewer and culvert projects include existing infrastructure with a reported capacity deficiency. To establish Capital Costs for storm sewer and culvert upgrade projects, the infrastructure undersized for flows under existing land use conditions without climate change were sized for the existing land use flows and a construction cost estimated. Engineering and contingency costs were added. The DCC Costs were then estimated by resizing the pipes for future land use with climate change flows, re-costing the larger upgrades, and subtracting the above Capital Costs. All costs are in 2017 dollars.

Flood protection works projects, existing detention facility upgrade projects, and studies were considered Capital Cost projects. Urban Creek Stabilization projects were included as DCC Cost projects as is currently the practice in the City's existing budgeting documents.

The prioritization criteria presented in Table 5-1 were applied and all projects were sorted by descending priority with the highest priority projects scheduled for initiation in 2019.

The City's 2017 *Engineering Budget Book* showed annual budgets for Storm Sewer and Culvert Renewal projects ($616,000/yr) and for Urban Creek Stabilization projects ($281,000/yr). The other project types did not have a set annual budget. During the project prioritization task, it was found that using $616,000 per year for storm sewer and culvert renewal projects would mean that these projects would be completed in 37 years, by 2056. Furthermore, the highest priority 'short term' projects could not be completed within the first 5 years. It is proposed that the annual funding be increased to $960,000 per year to expedite the 'short term' projects and complete all projects within 25 years, by 2043. The $281,000 per year budget for Urban Creek Stabilization appeared to be adequate. Each project in the other project types was assigned a construction timeline (year) based on available information and engineering judgement. The timelines for these projects can be adjusted to suit funding levels.

Table 11-1 summarizes the various project types, the construction timelines, and Capital and DCC Costs. Individual projects are listed in Table C3 in Appendix C.

Table 11-1: Summary of Drainage Projects, Timelines, and Costs for Studied Areas (by Project Type)

Project Type	Time Frame		Capital Cost		DCC Cost		Total Cost	
	From	To	Total	Annual	Total	Annual	Total	Annual
Storm Sewer and Culvert Renewal								
Short Term	2019	2023	$4,800,000	$960,000	$1,526,000	$305,200	$6,326,000	$1,265,200
Medium Term	2024	2028	$4,800,000	$960,000	$834,000	$167,000	$5,634,000	$1,127,000
Long Term	2029	2043	$13,218,000	$881,000	$1,332,000	$89,000	$14,661,000	$977,000
At Time of Development	2019	2043	$0	$0	$15,953,000	$638,000	$15,953,000	$638,000
Clayburn Creek Lowland Works								
Short Term	2019	2023	$0	$0	$1,292,000	$258,000	$1,292,000	$258,000
Medium Term	2024	2028	$0	$0	$572,000	$114,000	$572,000	$114,000
Long Term	2029	2043	$0	$0	$225,000	$15,000	$225,000	$15,000
Detention Facility Upgrades								
Short Term	2019	2023	$572,000	$114,000	$0	$0	$572,000	$114,000
Medium Term	2024	2028	$215,000	$43,000	$0	$0	$215,000	$43,000
Long Term	2029	2043	$86,000	$6,000	$0	$0	$86,000	$6,000
Long Term – New Ponds	2040	2043	$0	$0	$6,067,000	$1,517,000	$6,067,000	$1,517,000
Urban Creek Stabilization								
Short Term	2019	2023	$0	$0	$1,405,000	$281,000	$1,405,000	$281,000
Medium Term	2024	2028	$0	$0	$1,405,000	$281,000	$1,405,000	$281,000
Long Term	2029	2043	$0	$0	$1,223,000	$82,000	$1,223,000	$82,000
Miscellaneous								
Short Term*	2019	2023	$685,000	$137,000	$0	$0	$685,000	$137,000
Long Term*	2041	2043	$0	$0	$5,532,000	$1,844,000	$5,532,000	$1,844,000
Total Studied Areas								
25-Years	**2019**	**2043**	**$24,376,000**	**$975,000**	**37,366,000**	**$1,495,000**	**$61,852,000**	**$2,474,000**

Note: Miscellaneous short term – Gill Creek Culvert Headwall Rehabilitation; Miscellaneous Long term* – Horn Creek Storm Diversion.*

11.2 Drainage Upgrades in Unstudied Areas

The unstudied area costs were separated into short, medium, and long-term projects based on the distribution within the reference studied areas (see Section 4 for discussion). The costs were then split between Capital and DCC based on the ratio of Capital vs DCC of the storm sewer, culvert, creek, and detention projects in the reference studied areas. The unstudied area project cost estimates are summarized in Table 11-2.

Table 11-2: Summary of Drainage Projects, Timelines and Costs for Unstudied Areas

Project Type	Time Frame		Capital Cost		DCC Cost		Total Cost	
	From	To	Total	Annual	Total	Annual	Total	Annual
Short Term	2019	2023	$2,446,000	$489,200	$1,772,000	$354,400	$4,217,000	$843,400
Medium term	2024	2028	$6,706,000	$1,341,200	$4,856,000	$971,200	$11,561,000	$2,312,200
Long Term	2028	2043	$9,023,000	$602,000	$6,534,000	$436,000	$15,556,000	$1,038,000
Total Unstudied Areas								
25-Years	**2019**	**2043**	**$18,175,000**	**$727,000**	**$13,162,000**	**$526,480**	**$31,334,000**	**$1,253,360**

11.3 Planning Studies

A total of 19 planning studies are proposed in this DMP. A list of studies is provided in Table B1 in Appendix B. They include:

- Approved studies starting from year 2019, as listed in the 2018-2022 Project Summary Renewal and Replacement (RR) and Strategic Initiatives & Opportunities (SIO), and 2017-2021 Drainage Capital Plan (Approved);
- Recommended Bylaw updates, including Subdivision Development Bylaw, Stormwater Source Control Bylaw Updates, Infill Development Strategy, etc.;
- Stormwater Fees and Charges Feasibility Study;
- ISMPs and Drainage Master Plan Update;
- Proposed studies to investigate reported local flooding issues; and
- Proposed dike and pump station upgrade and back-up power studies.

The planning studies cost breakdown is provided in Table 11-3.

Table 11-3: Summary of Timelines, and Costs for Planning Studies

Project Type	Time Frame		Capital Cost	
	From	To	Total	Annual
Short Term	2019	2023	$1,707,000	$341,000
Medium Term	2024	2028	$230,000	$46,000
Long Term	2029	2043	$150,000	$10,000
Total Planning Studies				
25-Years	**2019**	**2043**	**$2,087,000**	**$83,480**

11.4 Pump Station Upgrades

There are four pump stations, namely McLennan Creek, Matsqui Slough, DeJong and Vanderloos, located along the Matsqui dike. The Barrowtown pump station is located at the northeast end of the Sumas dike. Full pump station replacement cost has been included in the dike upgrading costs, as noted in Section 11.5. However, costs of additional pump station upgrading that is not included in the pump station replacement cost in Section 11.5, is provided in Table 11-4 .. It includes expenditures to provide back-up power for all the pump stations and to improve pumping head for the Barrowtown pump station. Pump station upgrading cost is considered 100% capital cost.

Table 11-4: Summary of Timelines, and Costs for Pump Station Upgrade Projects

Project Type	Time Frame		Capital Cost	
	From	To	Total	Annual
Barrowtown Pump Head Upgrade				
Long Term	2041	2043	$1,750,000	$583,000
Barrowtown Back-up Power Construction				
Long Term	2041	2043	$4,131,000	$1,377,000
Back-up Power Construction (other pump stations)				
Long Term	2041	2043	$3,079,000	$1,026,000
Total Pump Station Upgrade Projects				
Long Term	**2041**	**2043**	**$8,960,000**	**$2,987,000**

11.5 Dike Upgrading Cost

The total improvement cost for the Matsqui, Vedder and Sumas dikes is estimated to be to meet the latest requirement for sea level rise, climate change and seismic standards. As the timing and amount of funding is unknown, dike upgrades are considered medium to long term projects to be completed by year 2050. Assumptions used in the cost distribution are provided below:

- Medium term (5-15 year): raise all three dikes by 0.5 m and provide full seismic upgrade to meet the Provincial high-consequence performance criteria.
- Long term (16-32 year): complete the remaining dike raising and other construction components including utilities, seepage, access and roads, turnouts, rail crossings, drainage, bank protection, land acquisition and pump station replacements.

The cost breakdown is provided in Table 11-5.

Table 11-5: Summary of Timelines, and Costs for Dike Upgrade Projects

Project Type	Time Frame		Capital Cost	
	From	To	Total	Annual
Matsqui Dike Upgrade				
Medium Term	2024	2033	$73,924,000	$7,392,000
Long Term	2034	2050	$82,571,000	$4,857,000
Vedder Dike Upgrade				
Medium Term	2024	2033	$36,094,000	$3,609,000
Long Term	2034	2050	$59,355,000	$3,491,000

Project Type	Time Frame		Capital Cost	
	From	To	Total	Annual
Sumas Dike Upgrade				
Medium Term	2024	2033	$130,206,000	$13,021,000
Long Term	2034	2050	$32,220,000	$1,895,000
Total Dike Upgrade				
27-Years	**2024**	**2050**	**$414,370,000**	**$15,347,000**

11.6 Summary of Total Drainage Capital Expenditures

Figure 11-1 and Table 11-6 provide a summary of the proposed drainage capital plan annual expenditures, which is the sum of all the costs listed in Sections 11.1 to 11.5. The total capital expenditures are estimated to be $447M for the next 25 years (2019-2043), with an average annual cost approximately $18M. It is assumed that dike improvements will go beyond the 25 year plan and be completed by year 2050. An additional $72M will be required for dike improvement from 2044-2050.

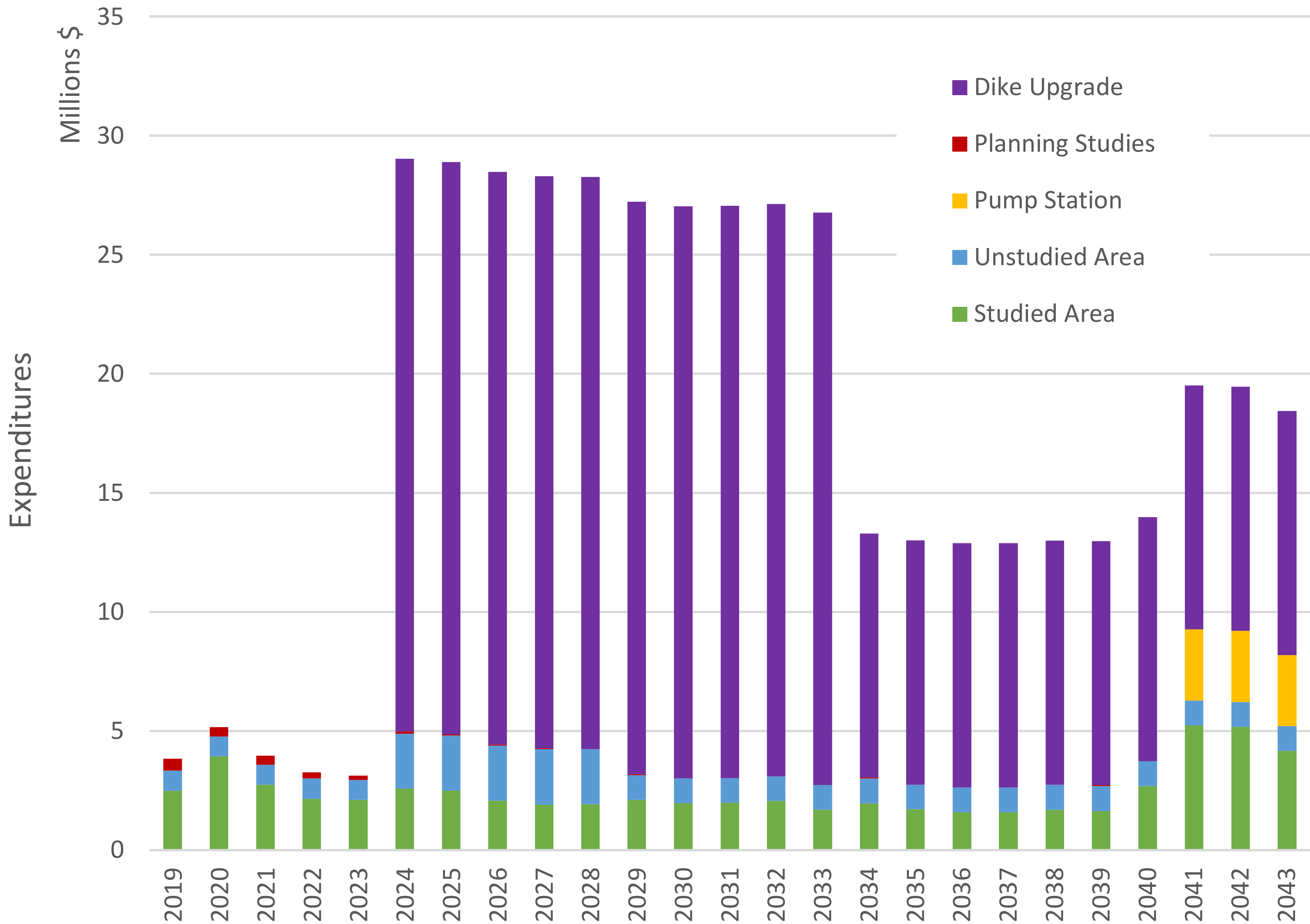
Approximately 77% of the total $447M capital expenditure is attributed to dike improvement. Without dike improvement cost, the total capital expenditures are $104M, with an average annual cost of $4.2M. The 2041-2043 non-dike related capital expenditures are higher because many high-cost, low-priority projects (such as pump station upgrades, new detention ponds and storm diversion construction) are allocated to the end the master planning period.

11.7 Capital Spending and Reserve Balance

The City provides drainage upgrades through many funding sources:

- grants,
- Community Works Fund,
- DCC,
- Reserves, and
- Debt (if required).

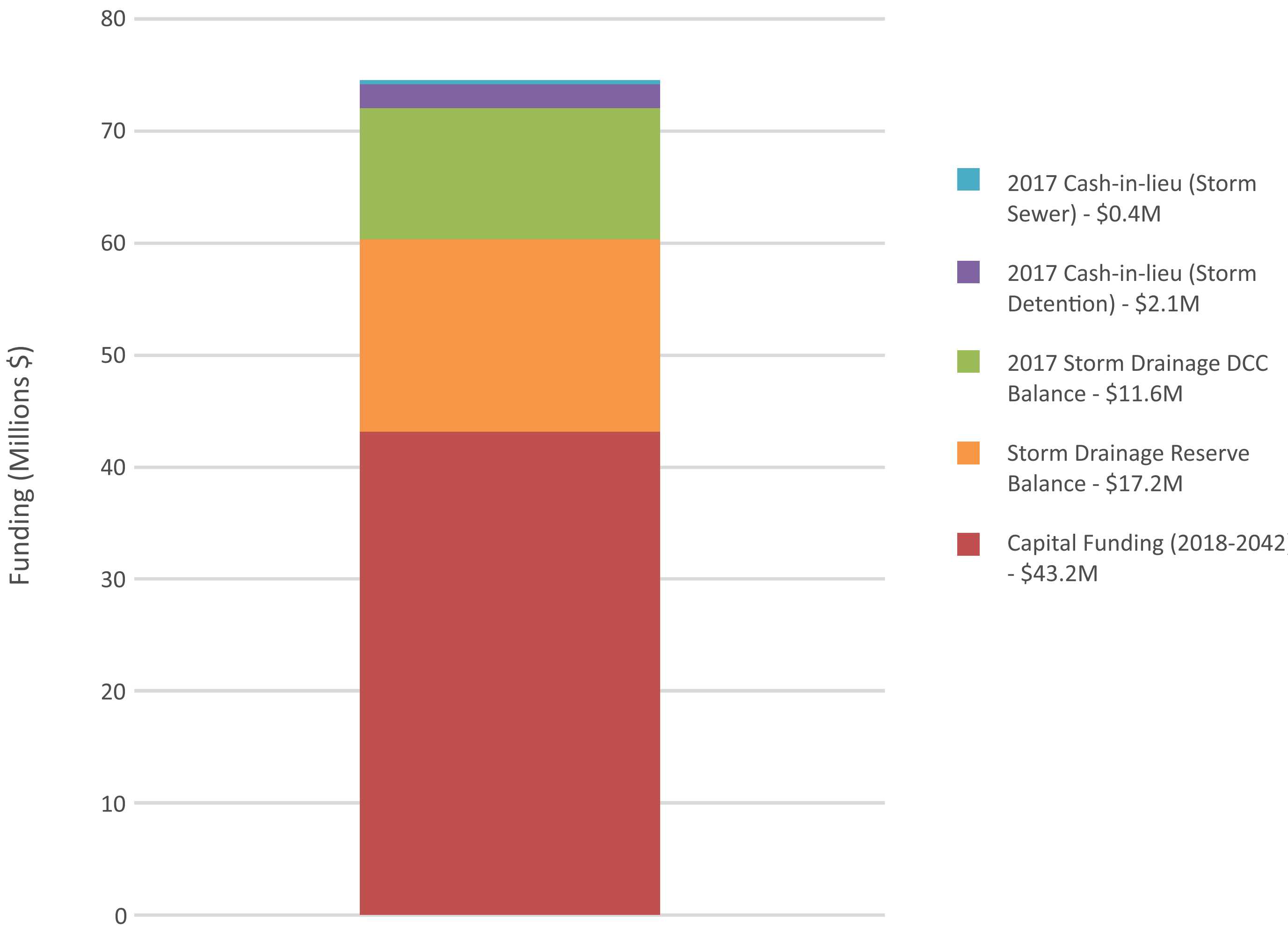
A total of $74.5M funding is currently available through capital spending budget and reserve balance on drainage upgrades until 2042. Figure 11-2 shows the break down of funding amount from various sources.



Project No.	510-152
Date	June 2018
Scale	-------

Total Drainage Capital Expenditures

Figure 11-1



Project No.	510-152
Date	June 2018
Scale	-------

Capital Spending and Reserve Balance

Figure 11-2

12. Stormwater Drainage Fee Options

Based on the drainage capital expenditures summarized in Section 11.0, stormwater drainage fee options are explored to finance the DMP.

12.1 Background

The City of Abbotsford covers a drainage area over 37,000 ha, which includes Urban Development Area, Matsqui Prairie, Sumas Prairie, Upland Rural Area, and Glen Valley. The City currently finances drainage infrastructure through a combination of property taxes, urban storm drainage user fees and local service area charges, Development Cost Charges (DCCs), grants and other recoveries. Users within Urban Development Boundary, Matsqui and Sumas Prairie are paying drainage fee through property tax to fund drainage system improvement and maintenance programs. Upland Rural Area is not paying for any fee for drainage, and the services is limited to clean roadside ditches and replacing major culverts under road in emergency situations. Glen Valley is managed by a private diking district, and the City collects annual fee on their behalf through property tax. Through the data collection phase of the DMP, the total cost for the short-term, mid-term and long-term drainage projects was estimated. For each project, the cost was distributed between DCC eligible capital and other capital revenue sources based on site specific information.

In each calendar year, the City allocates a capital drainage budget to address existing drainage deficiencies with the highest priority. The capital budget is partially funded by annual charges on the property tax bill. For new development and re-development that require drainage upgrades and expansion, the drainage budgets are financed through DCCs based on the Development Cost Charge Bylaw. DCCs also fund bank stabilization and community detention projects. The Bylaw, outlines the charges that new developers are required to pay for roads, drainage, sewer, water, and parks services. The charges vary by property land use type, with different rates set for residential, commercial, industrial, and institutional users.

A drainage fee structure has been adopted by many municipalities in BC and across Canada for recovering costs of stormwater service. The City is interested in exploring options for amending its current stormwater revenue structure, which includes a combination of drainage fees and taxation. Drainage fees may be established based on the estimated annual drainage capital and operating costs. Typically, a drainage fee model does not change the current local service area charges or DCCs. It only changes the potion of the program that is funded through the general tax levy. With a drainage fee, the charge basis is correlated to a property's impact on the stormwater system directly, offering increased fairness and equity in allocating program costs among all users, regardless of taxation status.

12.2 Drainage Fee Model

There are around 30 municipalities across Canada that have implemented a stormwater user fee and there are an estimated 1,500 stormwater municipalities across the US that have adopted drainage fee structures. A review of best practices of stormwater fees and charges in US and Canada identified two commonly used fee structures:1) Fixed Fee, and 2) Variable Rates.

Details on the typical design and examples of each model are outlined in this section.

Fixed Fee

A fixed fee model involves user charges that are allocated to customers based on property size, property type, or some other indicator such as the number and size of water meters. Fixed fees can be designed as either a “flat fee”, with the same fee or rate applied to all properties, or a “tiered flat fee”, in which the fee varies according to property zoning and land use.

Fixed fee models provide small advantages over the traditional general fund taxation model by shifting revenues off the tax bill to a “user charge” and improving transparency in the relationship between costs and levels of service for stormwater management. A primary benefit of flat rate models is that they are simple, and relatively easy to implement.

Example – City of Mississauga, Ontario

The City of Mississauga administers a drainage fee with a tiered flat fee for residential properties and a variable rate for industrial, commercial, and institutional customers. Residential properties are grouped into one of five fee classes according to three property characteristics:

- property size;
- property type (e.g. single family residential, multi-family residential); and
- rooftop area (m^2).

A graphic showing the thresholds associated with each of the five fee classes is shown in Figure 12-1.

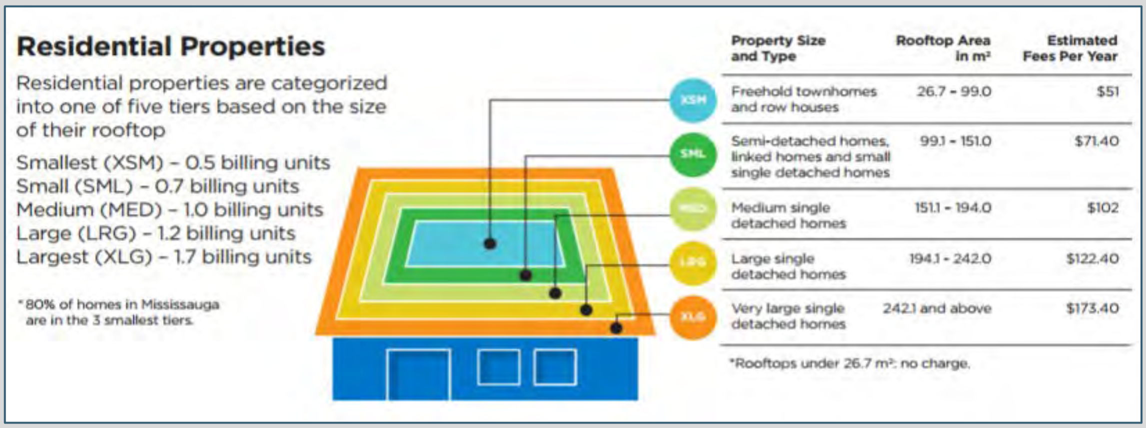


Figure 12-1: Mississauga Residential Drainage Fee

The tiered model simplifies the rate calculation but may be considered slightly less equitable for customers that only marginally fit into a fee class (e.g., users with a rooftop area just below or above the category threshold). While the model considers the impacts of impervious rooftop area, it does not consider other factors such as pavement area, which also have a significant impact on loads to the stormwater system. This means that a property with a large roof could pay more than a property with a small roof but large parking surface such as an apartment building.

Variable Rate

A variable rate model involves user charges that are assigned as a unique charge for each customer, based on the total footprint area of impervious (or “hard”) surface on their property (e.g., roof covering and pavement materials). For example, a property with a large proportion of hard surface (e.g., retail shopping plaza) would pay a higher rate than an equally sized property with less impervious area (e.g. a single-family detached home).

The total impervious area is strongly correlated to the amount of stormwater runoff and pollutant loading each customer discharges into the stormwater system. Legal precedents and case law in the U.S. affirms the use of impervious area as a key variable to allocate stormwater program costs to individual properties.

Variable rate models are considered more equitable by allocating drainage costs to users based on their load on the stormwater system. However, they require a much higher cost and administrative effort to design, implement, and manage these systems on an ongoing basis. For a city the size of Abbotsford, implementing a variable rate could require a new full-time employee with specialized technical and economic/financial expertise in design and implementation.

Example – The City of Victoria

The City of Victoria's drainage fee is authorized under the Sanitary Sewer and Stormwater Utilities Bylaw No. 14-071 (2015). Users pay an annual variable charge according to the following factors:

- impervious area (roof, pavement), measured through building plans, aerial photos, and GIS mapping;
- intensity code base fee according to property type (e.g. low density residential, industrial);
- street frontage area (m^2) multiplied by a standard rate by street class (e.g. $1.67/$m^2$ for local streets - $4.09/$m^2$ for arterial streets). This measure serves as an indicator of the level of effort for street cleaning services provided by the City;
- Codes of Practice status, whereby certain high-interest properties pay an additional annual rate to participate in a program to install onsite pre-treatment components; and
- rainwater management credits for properties that install sustainable rainwater management features (e.g. rain gardens) in alignment with the City's Rainwater Rewards Program.

The key features of the City of Victoria's drainage fee program are illustrated in Figure 12-2.

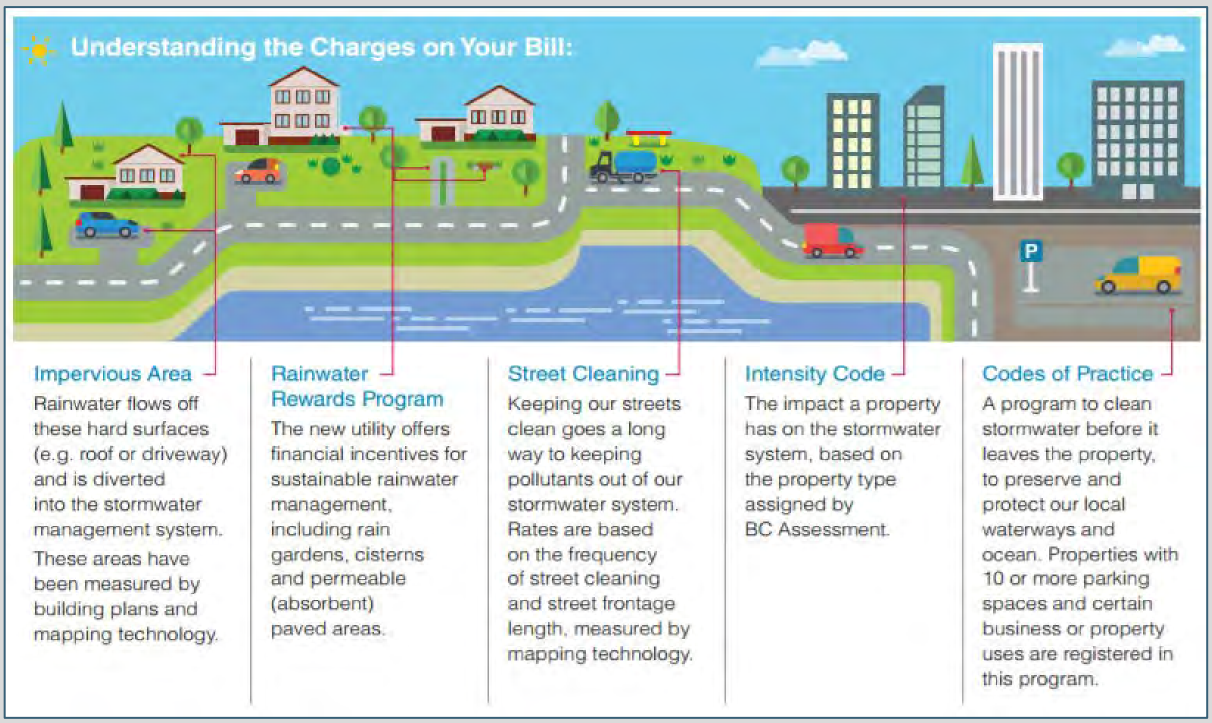


Figure 12-2: City of Victoria Drainage Fee

12.3 Considerations on Cross Border Inflow

For areas that receive cross border inflow, the inter-jurisdictional issues vary on a city-vs-city or city-vs-country basis. The drainage fee may be defined by a water/sewer servicing agreement, if there is one in place. Pipe discharges from the upstream municipality (City A) to the downstream municipality (City B) are usually easy to quantify. The impacts to City B's stormwater program and consequently to City's user-fee revenue determines the base charge to feepayers. On the other hand, watercourse drainage from City A to City B is more complicated. The options are:

- Option 1 - the incremental costs of external drainage could be billed separately to the upstream municipality. This requires the City B to quantify its own capital cost on stream restoration, flow and sediment management, and ongoing maintenance that are attributable to City A. This incremental cost is not included in City B's overall stormwater user-fee revenue requirement for its feepayers); or
- Option 2 - the total costs comprise the overall stormwater user-fee revenue requirement and are shared among downstream municipality's feepayers (i.e., which lets City A off the hook at the expense of City B feepayers).
- Option 2B - it reflects an accounting adjustment to Option 2 in that City B would pay City A's charge so that City B feepayers would have the lower base charge of Option 1. (for example, City A's charge can be subsidized using tax funds rather than a fee exemption).

For cross border cost charges, an overarching caution is that whenever a city initiates a new fee/charge to an adjacent community, it can expect that a new fee/charge to charged back in return. In practice, it is common that cities negotiate and modify existing inter-jurisdictional transfers, shared services agreements., or as an example City B gives “super-credits” on City A's drainage fee (when City A owns property in City B) in exchange for in-lieu services provided by City A to City B (e.g., bridge/culvert/road maintenance, street sweeping).

12.4 Recommendations

There will likely be a high level of effort and long timeline involved in the implementation of the stormwater fees and charges. Given the political and socio-economic uncertainties involved in adopting a new funding mechanism under these circumstances, it is suggested that a future feasibility study be conducted to explore and to investigate, analyze, and formulate an appropriate rate structure and ultimately develop a recommended implementation strategy for Council to decide how to proceed with the implementation phase.

The level of effort, time, and cost required to complete a feasibility study varies widely. A budget in the range of $150,000 to $200,000 is recommended for this purpose.

13. Summary of Findings and Recommendations

13.1 Master Plan Key Components

A full range of drainage upgrade projects have been identified within the 2043 OCP planning horizon and costed in 2017 dollars, with a total value of approximately **$447M**. It is assumed that dike improvements will go beyond the 25 year plan and be completed by year 2050. An additional $72M will be required for dike improvement from 2044-2050.

The following projects are key to the 2043 OCP capital plan:

1. **Storm Sewer and Culvert Renewal** – a total of 168 storm sewers, 42 culverts and 2 bridges will require capacity upgrades to accommodate the existing flood conveyance needs and the increased flows from the anticipated growth in the City.
2. **Clayburn Village Berms and Channel Widening and Pump Station** – Lowland flood protection works including berms with floodboxes, channel widening, and pump station will be required to address the existing flooding in the lowland Clayburn Village. Some of the protection works, such as berm construction is underway.
3. **Detention Facility Upgrades** – Downes Creek and Clayburn Creek ISMP studies identified 34 detention facilities that require inlet/outlet modification and/or storage expansion to meet volume control goals. This accounts for about 10% of the City's total 380 detention facilities. One new detention pond was proposed within the Marshall Creek watershed as a short term project and two new detention ponds were proposed in the Downes Creek watershed as long term projects.
4. **Urban Creek Stabilization** - Erosion protection projects include bank armouring and construction and expansion of sediment traps. Sediment removal is considered a maintenance program and is excluded from the project list.
5. **Unstudied Areas** - Approximately 50% of the City area has not been assessed by drainage studies and presents a data gap in preparing a comprehensive City-wide DMP. High level drainage upgrading costs were estimated for the unstudied areas using unit costs from studied areas with similar land use type. The estimated projects and costs will be updated once future studies are completed.
6. **Planning Studies** – Planning studies were compiled from the City's approved capital project list, flooding issues to be addressed and recommendations from historical studies and this DMP.
7. **Pump Station Upgrades** – All five pump stations, including Barrowtown, McLennan Creek, Matsqui Slough, DeJong and Vanderloos, will need backup power to increase resiliency in the event of power failure. The Barrowtown pump station also needs upgrade to increase system head to allow high speed operation, increasing pump flow.
8. **Dike Upgrades** – The dike upgrading assessment includes three dikes, including the Matsqui Dike (Fraser River), Vedder Dike (Vedder Canal and Fraser River), and Sumas Dike (Sumas River, Saar Creek, and Arnold Slough). A conceptual upgrading cost was estimated for seismic upgrade and geometric upgrade to meet the Provincial "high consequence" performance criteria and the 1 m sea level rise under climate change conditions, respectively.
9. **Stormwater Fees and Charges** – A review of stormwater fees and charges best practices in Canada and US identified two commonly used fee structures: flat rate and variable rate. A future feasibility study is recommended to explore an appropriate rate structure and develop a recommended implementation strategy for the City.
10. **Stormwater Policy and Criteria** – Stormwater policy review led to recommendations on establishing City-wide Stormwater Source Control bylaw, additions to the Development Bylaw and enforcement of other existing bylaws.

13.2 Total Drainage Capital Expenditures

The total capital expenditures are estimated to be $447M for the next 25 years (2019-2043), with an average annual cost approximately $18M. An additional $72M will be required for dike improvement beyond the 25 year study timeline (from 2044-2050).

Approximately 77% of the total $447M capital expenditure is attributed to dike improvement. Without dike improvement cost, the total capital expenditures are $104M, with an average annual cost of $4.2M. Many high-cost, lower priority projects (such as pump station upgrades, new detention ponds and storm diversion construction) were scheduled near the end the master planning period (2041-2043).

A summary of drainage projects by project type, timelines and costs is provided in Table 13-1. Table B1 in Appendix B and Table C3 in Appendix C provide additional details on individual projects. The DMP does not include system operation & maintenance and asset condition replacement.

13.3 Recommendations

Based on the findings in the DMP, it is recommended that the City:

Periodically Update DMP

1. Update the DMP as additional drainage studies and floodplain mapping (Willband and Fishtrap Creek ISMPs and additional floodplain modelling), are completed.
2. Update projects and costs for the unstudied areas as these areas are assessed. Estimated costs in this DMP for these unstudied areas are placeholder values for long term planning and budgeting only.
3. Conduct a back-up power study for the McLennan Creek, Matsqui Slough, DeJong, and Vanderloos pump stations.
4. Consider developing a Dike Master Plan to refine the dike upgrading cost and to develop a feasible phased approach for dike upgrades.

Update Policies

5. Develop an enforceable City-wide Stormwater Source Control Bylaw for new development and redevelopment.
6. Add requirements to incorporate climate change and fish friendly approaches in the Development Bylaw and require minimal removal and compaction of surficial soil during construction and development.

DMP Implementation

7. Adjust the annual capital budget to accommodate the capital costs of the drainage system upgrades. It is proposed that the annual funding be increased from $616,000 to $960,000 per year to expedite the ‘short term’ storm sewer and culvert renewal projects and complete all projects within 25 years, by 2043.
8. Incorporate growth-related upgrades and their costs in the City’s Development-Cost-Charge program.
9. Conduct feasibility and predesign phases for each project prior to design and construction. Capital plan projects were identified and costed with limited site information.
10. Conduct a feasibility study on Stormwater Fees and Charges to explore an appropriate rate structure and implementation strategy for the City.

Table 13-1: Summary of Drainage Projects, Timelines, and Costs

Project Type	Time Frame		Capital Cost		DCC Cost		Total Cost	
	From	To	Total	Annual	Total	Annual	Total	Annual
Storm Sewer and Culvert Renewal								
Short Term	2019	2023	$4,800,000	$960,000	$1,526,000	$305,200	$6,326,000	$1,265,200
Medium Term	2024	2028	$4,800,000	$960,000	$834,000	$167,000	$5,634,000	$1,127,000
Long Term	2029	2043	$13,218,000	$881,000	$1,332,000	$89,000	$14,661,000	$977,000
At Time of Development	2019	2043	$0	$0	$15,953,000	$638,000	$15,953,000	$638,000
Clayburn Creek Lowland Works								
Short Term	2019	2023	$0	$0	$1,292,000	$258,000	$1,292,000	$258,000
Medium Term	2024	2028	$0	$0	$572,000	$114,000	$572,000	$114,000
Long Term	2029	2043	$0	$0	$225,000	$15,000	$225,000	$15,000
Detention Facility Upgrades								
Short Term	2019	2023	$572,000	$114,000	$0	$0	$572,000	$114,000
Medium Term	2024	2028	$215,000	$43,000	$0	$0	$215,000	$43,000
Long Term	2029	2043	$86,000	$6,000	$0	$0	$86,000	$6,000
Long Term - New Ponds	2040	2043	$0	$0	$6,067,000	$1,517,000	$6,067,000	$1,517,000
Urban Creek Stabilization								
Short Term	2019	2023	$0	$0	$1,405,000	$281,000	$1,405,000	$281,000
Medium Term	2024	2028	$0	$0	$1,405,000	$281,000	$1,405,000	$281,000
Long Term	2029	2043	$0	$0	$1,223,000	$82,000	$1,223,000	$82,000
Miscellaneous								
Short Term	2019	2023	$685,000	$137,000	$0	$0	$685,000	$137,000
Long Term	2041	2043	$0	$0	$5,532,000	$1,844,000	$5,532,000	$1,844,000

Project Type	Time Frame		Capital Cost		DCC Cost		Total Cost	
	From	To	Total	Annual	Total	Annual	Total	Annual
Unstudied Areas								
Short Term	2019	2023	$2,446,000	$489,000	$1,772,000	$354,000	$4,217,000	$843,000
Medium Term	2024	2028	$6,706,000	$1,341,000	$4,856,000	$971,000	$11,561,000	$2,312,000
Long Term	2029	2043	$9,023,000	$602,000	$6,534,000	$436,000	$15,556,000	$1,038,000
Planning Studies								
Short Term	2019	2023	$1,707,000	$341,000	$0	$0	$1,707,000	$341,000
Medium Term	2024	2028	$230,000	$46,000	$0	$0	$230,000	$46,000
Long Term	2029	2043	$150,000	$10,000	$0	$0	$150,000	$10,000
Pump Station Upgrades								
Long Term	2041	2043	$8,960,000	$2,987,000	$0	$0	$8,960,000	$2,987,000
Dike Improvements								
Medium Term	2024	2033	$240,224,000	$24,022,000	$0	$0	$240,224,000	$24,022,000
Long Term	2034	2050	$174,146,000	$10,244,000	$0	$0	$174,146,000	$10,244,000
Total Capital Work (25-Year)	**2019**	**2043**	**$396,000,000**	**$16,000,000**	**$51,000,000**	**$2,000,000**	**$447,000,000**	**$18,000,200**
Total Capital Work (Dike Upgrades)	**2044**	**2050**	**$72,000,000**	**$10,244,000**	**$0**	**$0**	**$72,000,000**	**$10,244,000**

An annual break down of the total capital expenditures is provided in Table 13-2.

Table 13-2: Summary of Annual Drainage Capital Expenditure

Year	Capital Cost	DCC Cost	Total Cost
2019	$1,948,000	$1,893,000	$3,841,000
2020	$2,216,000	$2,958,000	$5,174,000
2021	$2,396,000	$1,569,000	$3,965,000
2022	$1,713,000	$1,559,000	$3,272,000
2023	$1,619,000	$1,506,000	$3,125,000
2024	$26,424,000	$2,590,000	$29,014,000
2025	$26,589,000	$2,302,000	$28,891,000
2026	$26,374,000	$2,093,000	$28,467,000
2027	$26,353,000	$1,935,000	$28,288,000
2028	$26,324,000	$1,937,000	$28,261,000
2029	$25,634,000	$1,585,000	$27,219,000
2030	$25,584,000	$1,453,000	$27,037,000
2031	$25,584,000	$1,467,000	$27,051,000
2032	$25,585,000	$1,543,000	$27,128,000
2033	$25,584,000	$1,173,000	$26,757,000
2034	$11,856,000	$1,441,000	$13,297,000
2035	$11,891,000	$1,109,000	$13,000,000
2036	$11,806,000	$1,074,000	$12,880,000
2037	$11,806,000	$1,074,000	$12,880,000
2038	$11,806,000	$1,186,000	$12,992,000
2039	$11,855,000	$1,125,000	$12,980,000
2040	$11,806,000	$2,170,000	$13,976,000
2041	$14,793,000	$4,715,000	$19,508,000
2042	$14,681,000	$4,770,000	$19,451,000
2043	$13,833,000	$4,605,000	$18,438,000
Total	**$396,000,000**	**$51,000,000**	**$447,000,000**

Report Submission

Prepared by:

KERR WOOD LEIDAL ASSOCIATES LTD.

PROFESSIONAL PROVINCE OF T. LI # 35082 BRITISH COLUMBIA ENGINEER 2018-JUN-07

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Project Engineer

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Reviewed by:

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Technical Reviewer

This document is a copy of the sealed and signed hard copy original retained on file. The content of the electronically transmitted document can be confirmed by referring to the filed original.

Statement of Limitations

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

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Revision History

Revision #	Date	Status	Revision	Author
0	June 6, 2018	Final	Issued as final	EL/DZ
A	May 11, 2018	Draft		EL/DZ

OQM CERTIFIED

KWL File No. 0510.152-300

Appendix A

List of Background Reports

Table A1: List of Available Reports

Year	Item No.	Title	Received
Upland Drainage Modelling Related			
2017	N/A	Willband Creek ISMP_Part 1&2 Report (Draft)	✓
2012	12-05	Clayburn Creek ISMP	✓
2011	11-04	City Wide Drainage Modelling and Capital Planning	✓
2010	10-01	Downes Creek ISMP	✓
2007	07-03	Review of 100-Year Demining & Cross-border Flows Provided by US in 2007	✓
2006	06-01	Marshall Creek ISMP	✓
2006	06-02	King Road Drainage Study	
1996		Infrastructure Study of Old Abbotsford Downtown Area (Vol1)	
1996		Infrastructure Study of Old Abbotsford Downtown Area (Vol2)	
1987	87-01	Fishtrap Creek - Master Drainage Plan	✓
Lowland Drainage/Flood Modelling Related			
2015		Sumas Prairie Drainage Study Part I	✓
2014	14-01	Sumas Mike Flood Model Refinement	✓
2014	14-05	Sumas Prairie Design Flood Simulation & Impact Mitigation (Ph 1 Project Summary)	✓
2014	14-09	Fraser River Design Flood Level Update - Hope to Mission	✓
2014	14-10	Lower Mainland Flood Management Strategy - Phase 1 - Project 1: Simulating the Effects of Sea Level Rise & Climate Change on Fraser River Flood Scenarios	✓
2013	13-04	Matsqui Prairie Drainage Study - Phase 1	✓
2012	12-08	Prairie Street Flood Prevention Works Compensation Planning and Assessment	✓
2012	12-10	Flood Emergency Model Preparation for Sumas Prairie	✓
2005	05-03	Sumas Prairie Flood Hazard Investigation, 1990 Flood Calibration (2005)	✓
2003	03-01	Sumas Prairie Flood Hazard Investigation Interim Report 2003	✓
2001	01-02	Sumas River Flood Study - Farm Survey	✓
2001	01-03	Flood and erosion Assessment of Horn Creek / Boa Brook	✓
2001	01-04	Comprehensive Management for Flood Protection Works	✓
1998	98-02A	The Sumas River Flood Routing Study - Interim Report (Vol 1)	✓
1998	98-02B	The Sumas River Flood Routing Study - Interim Report (Vol 2)	✓
1998	98-02C	The Sumas River Flood Routing Study - Interim Report (Vol 3)	✓
1996	96-01	Flood Protection Dykes and Environmental Concerns	✓
1993	93-01	Matsqui Slough Drainage Study	✓
1989	89-02	Engineering Studies for Floodplain Management Plan	✓
1988	88-01	ARDSA 22007 - Matsqui Prairie Drainage and Irrigation Feasibility Study	✓
1988	88-02	Matsqui Prairie Drainage and Irrigation District Economic Analysis	✓
Pump Station Related			
2011	11-01	Barrowtown Pump Station End Use Assessment	✓
2011	11-05	Barrowtown PS - Preliminary Pumping Study: Throttling to Increase Capacity when Pumping from Sumas River	✓
2010	10-03	Matsqui Slough & McLennan Creek Drainage PSs - End Use Assessment Rpt	✓
2009	09-04	Proposed Road - Barrowtown Pump Station	✓
2008	08-05	Drainage Pump Station PSAB 3150 Study	✓
1993	Misc01	A Guide to the Barrowtown Pump Station and Sumas Prairie Floodplain	✓
1992	92-01	Matsqui Slough and Mclennan Creek Drainage Pump Stations Operating and Maintenance Manual	✓
1991	91-02	Matsqui Prairie Drainage and Irrigation Project - Drainage System Maintenance and Operation Manual	✓
Drainage Improvement Related			
2015	15-04	Waechter Creek at Simpson Rd Extension Culvert Replacement Completion Report	✓
1985		Sumas River Improvements	
Erosion, Bank Protection & Sediment Traps Related			
2016	16-02	Risk of Erosion at Matsqui Dyke from Erosion Arcs F and G	✓
2016	16-06	No. 4 Road Ditch Erosional Assessment	✓
2016	16-12	Proposed Bank Protection: Erosion Arc F(b) Completion	✓
2015	15-02	Prairie Street Creek - Watercourse and Erosional Source Assessment	✓
2015	15-05	Fraser River at Matsqui - Erosion Study and Development of Mitigation Concepts	✓
2014	14-02	Ridgedale Erosion Arc (Contract No. 2014-02)	✓
2014	14-08	Gill Creek Watercourse and Erosional Source Assessment	✓
2013	13-10	Beharrel Bank Stabilization - Design Brief	✓
2012	12-09	Shamrock Creek Scour Mitigation	✓
2010	10-05A	Fraser River Bank Erosion - Matsqui Trail Regional Park (Final Report)	✓
2010	10-05B	Fraser River Bank Erosion - Matsqui Trail Regional Park (Final Report - Addendum)	✓
2009	09-02	Bank Stabilization Marshall Creek and Horn Creek Erosion Sites - Phase II and III	✓
2007	07-01	Bank Stabilization Marshall Creek and Horn Creek Erosion Sites - Phase I	✓
1987	87-02	Lonzo Creek Erosion between Beck Rd. & Cyril St.	✓
2009	09-06	Sumas River Sediment Trap at International Boundary	✓

Year	Item No.	Title	Received
Infiltration/Detention Related			
2014	14-04	CICP Infiltration Gallery - Well Monitoring and Infiltration Testing (2014)	✓
2013	13-08	Broadway St from Bevan Ave to 200 m North Abbotsford, Infiltration Assessment Report	✓
2013	13-11	CICP Infiltration Gallery - Well Monitoring and Infiltration Testing (2013)	✓
2012	12-13	Clearbrook & Marshall Infiltration Gallery - Final Design Report	
2011	11-02	Design and Modelling for the Walnut Avenue Detention Facility Expansion	✓
2011	11-03	2010 Underground Concrete Stormwater Detention Tank Inspections	✓
2011	11-06	Willband Creek Detention Expansion	✓
2011	11-08	Underground Concrete Stormwater Detention Tank Inspections	✓
2009	09-03	Underground Concrete Stormwater Tank Inspections (2009)	✓
2008	08-03	Vicarro Ranch Community Detention Ponds - Assessment of Downstream Impacts	✓
2005	05-02	Feasibility Evaluation of SW Source Control Strategies for Vicarro Ranch Dev. Area	✓
Land Use Related			
2015	15-06	Abbotsford OCP Update Stormwater Assessment	✓
Municipal SW Program Related			
2013	13-06	Clayburn Creek Watershed - Rainwater Management Measures	✓
2013	13-09	Fishtrap Creek Hwy 1 Storm Detention Structure (Standard Operating Procedures)	✓
2009	09-05	CICP Lands Stormwater Source Control Bylaw	✓
1998	98-01	Surrey/Abbotsford/Kamloops Assessing Applicability of Stormwater Utility to Local	✓
1990	90-02	Involvement of Public Works Dpmt in Flood of West Sumas Prairie Nov 10-13, 1990	✓

Appendix B

Proposed Drainage Projects

Table B1: Summary of Proposed Projects from Previous Studies

Project Description	Project ID *	Project Location	2017 Final Costs	Project Timeline / Comments
Sumas Prairie Drainage Study - Phase 1, 2017				
Vegetation Removal				
Marshall Crk	SUMAS_1	36000 BLOCK & NORTH PARALLEL RD		Not Included. Operational Program
Saar Crk	SUMAS_2	1300 BLOCK & WHATCOM RD		
Sumas River	SUMAS_3	LAMSON RD		
Arnold Slough	SUMAS_4	1300 BLOCK & COLE RD		
Hydraulic Upgrades				
Culvert at Vye Rd on Saar Crk	SUMAS_5	VYE RD	$845,600	2025
Culvert at Old Yale Rd on Arnold Slough	SUMAS_6	38000 BLOCK & OLD YALE RD	$432,500	2041
Risk of Erosion at Matsqui Dyke from Erosion Arcs F & G, 2016				
Erosion Stabilization Emergency Works				
Design, Permitting, and Assisting with Tendering	FRASER_2		$88,932	2025-2032
Construction Monitoring and Supervision	FRASER_2		$120,558	
Construction Costs	FRASER_2		$1,619,251	
Freshet Monitoring	FRASER_2		$41,011	
Prairie Street Creek Watercourse & Erosional Source Assessment, 2015				
Flow Reduction				
Stabilize Erosion Bank & Widen Channel				
Area 1, Waypoint 2	PRAIRIE_1	32000 BLOCK & DOWNES RD		City does not want to pursue at this time
Area 2, Waypoint 6	PRAIRIE_2	32000 BLOCK & DOWNES RD		
Area 3, Waypoint 7	PRAIRIE_3	32000 BLOCK & DOWNES RD		
Area 4, Waypoint 11 & 12	PRAIRIE_4	32000 BLOCK & CHILCOTIN DR		
Area 5, Waypoint 13	PRAIRIE_5	32000 BLOCK & CHILCOTIN DR		
Area 6, Waypoint 19	PRAIRIE_6	4000 BLOCK & PRAIRIE ST		
Construct Weirs & Step Pools d/s of Pedestrian Bridge				
Sediment Management				
Create Trap @ Prairie Street Culvert	PRAIRIE_11	32000 BLOCK & DOWNES RD	$36,000	2018
Increase Size - Downes Rd Sediment Trap	PRAIRIE_9	32000 BLOCK & DOWNES RD		
Remove Sediment Reach 2	PRAIRIE_10	4000 BLOCK & PRAIRIE ST		Not Included. Operational Program
Remove Debris Jams				
Reach 1 Waypoint 3 & 8	PRAIRIE_7	32000 BLOCK & DOWNES RD		Not Included. Operational Program
Reach 2, Waypoint 23	PRAIRIE_8	4000 BLOCK & PRAIRIE ST		
Fraser River at Matsqui - Erosion Study & Development of Mitigation Concepts, 2015				
Erosion Stabilization				
Erosion Stabilization	FRASER_3			2018-2022 10M received from the Province
Gill Creek Watercourse and Erosional Source Assessment, 2014				
Construct Sediment Trap & Diversion @ Waypoint 1	GILL_1	2100 BLOCK & SUMAS WAY	$750,000	2019-2021
Construct Detention Facility @ Waypoint 5	GILL_2	MIRUS DR		
Widen Watercourse & armour bank @ Waypoint 6 & 8	GILL_3	MIRUS DR		
Extend Pipes down bank to watercourse @ Waypoint 7	GILL_4	MIRUS DR		
Construct Bank Stabilization @ Waypoint 10, 11	GILL_5	MIRUS DR		
Pipe watercourse through Erosive Section @ Waypoint 13	GILL_6	MIRUS DR		
Remove Debris Jam / Modify Weir @ Waypoint 14	GILL_7	MIRUS DR		
Beharrel Bank Stabilization - Design Brief, 2013				
Beharrel Bank (no costing)				Completed

Project Description	Project ID *	Project Location	2017 Final Costs	Project Timeline / Comments
Matsqui Prairie Drainage Study, 2013				
Clayburn Village Flood Protection				
Clayburn Village Drainage				
Install Floodboxes	MATSQUI_1	4200 BLOCK & WRIGHT ST	$162,510	2020
Install Flap gates	MATSQUI_2	4300 BLOCK & WRIGHT ST		
Construct 100L/s Pump Station	MATSQUI_3	4300 BLOCK & WRIGHT ST	$572,455	2024
Clayburn Creek Berms				
Construct North Berm Ch. 12036-12629	MATSQUI_6	4200 BLOCK & WRIGHT ST	$300,000	2020
Construct North Berm Ch. 12710-12930, 0.5 m High Berms	MATSQUI_6	4200 BLOCK & WRIGHT ST		
Construct South Berm Ch. 12036-12200	MATSQUI_7	4200 BLOCK & WRIGHT ST	$248,483	completed
Upgrade Existing Temporary Berms (North and South)	MATSQUI_7	4200 BLOCK & WRIGHT ST		
Matsqui Prairie Drainage Study, 2013				
Clayburn Creek Conveyance Upgrades				
Channel Enlargement / Deepening - Backwatered Section			$365,910	onging - 2020
Ch. 14284-14212	MATSQUI_8	CLAYBURN RD		
Ch. 14202-13825	MATSQUI_8	CLAYBURN RD		
Ch. 13815-13333	MATSQUI_8	CLAYBURN RD		
Channel Enlargement / Deepening - Non-Backwatered Section			$707,705	2022
Ch. 13323-13300	MATSQUI_9	CLAYBURN RD		
Ch. 13282-13086	MATSQUI_9	CLAYBURN RD		
Ch. 13076-12727	MATSQUI_9	CLAYBURN RD		
Ch. 12710-12574	MATSQUI_9	CLAYBURN RD		
Bridge Upgrades			$225,417	2029
Farm Bridge Upgrade	MATSQUI_4	CLAYBURN RD		
Wright St Bridge Raising	MATSQUI_5	4200 BLOCK & WRIGHT ST		Completed
Wright St Raising	MATSQUI_5	4200 BLOCK & WRIGHT ST		
Driveway Raising	MATSQUI_5	4200 BLOCK & WRIGHT ST		
Signage, moving pipes, railing	MATSQUI_5	4200 BLOCK & WRIGHT ST		
Matsqui Slough Conveyance Upgrades				
Matsqui Upgrades			$55,568	2020
Deepen Under Clayburn Bridge	MATSQUI_10	34000 BLOCK & CLAYBURN RD		
Ch. 14284-14884	MATSQUI_10	34000 BLOCK & CLAYBURN RD		
Sediment Management				
Sediment Management				Addressed in Clayburn ISMP List
Expand and Improve Existing Sediment Traps				
Clayburn ISMP, 2012				
PRIORITY 1 - Upgrade to Provide Major Drainage Route				
Culvert	K_CV140	4600 BLOCK & SUMAS MOUNTAIN RD	$254,700	2019
	K_CV193	WILLET RD	$387,600	2021
	K_CV221	4700 BLOCK & WILLET RD	$413,600	2021
	K_CV2	35000 BLOCK & CASSIAR AVE	$564,200	2022
	K_CV48	35000 BLOCK & MCKEE RD	$136,300	2023
	K_CV52	MCKEE RD	$604,300	2024
	K_CV211	4600 BLOCK & SUMAS MOUNTAIN RD	$202,300	2024
	K_CV116	4300 BLOCK & BLAUSON BLVD	$315,400	2025
	K_CV224	3500 BLOCK & OLD CLAYBURN RD	$264,000	2025
	K_CV46	35000 BLOCK & MCKEE RD	$329,300	2026
	K_CV133	4700 BLOCK & WILLET RD	$158,500	2026
	K_CV135	4700 BLOCK & WILLET RD	$199,600	2030
Bridge	K_CV76	35000 BLOCK & STRAITON RD	$851,100	2019

Project Description	Project ID *	Project Location	2017 Final Costs	Project Timeline / Comments
Clayburn ISMP, 2012				
PRIORITY 1 - Upgrade to Provide Major Drainage Route				
Storm Sewer	K_860E11	3500 BLOCK & BASSANO TERRACE	$67,800	2019
	K_527E11	35000 BLOCK & SANDY HILL RD	$96,700	2020
	K_525E11	35000 BLOCK & SANDY HILL RD	$68,100	2025
	K_517E11	35000 BLOCK & SANDY HILL RD	$248,700	2026
	K_526E11	35000 BLOCK & SANDY HILL RD	$4,900	2026
PRIORITY 2 - Minor Flow Capacity - Multi-Diameter Upgrade				
Culvert	K_CV89	34000 BLOCK & BATEMAN RD	$303,000	2030
Bridge	K_CV42	34000 BLOCK & BATEMAN RD	$130,200	2026
	K_CV60	34000 BLOCK & BATEMAN RD	$457,500	2034
Storm Sewers	K_517E10	3900 BLOCK & COACHSTONE WAY	$204,800	2027
	K_943E10	34000 BLOCK & LABURNUM AVE	$119,000	2028
	K_945E10	34000 BLOCK & LABURNUM AVE	$35,000	2028
	K_947E10	34000 BLOCK & LABURNUM AVE	$196,600	2028
	K_948E10	3400 BLOCK & WRIGHT ST	$112,200	2028
	K_959E10	34000 BLOCK & LABURNUM AVE	$155,000	2028
	K_967E10	34000 BLOCK & LABURNUM AVE	$90,600	2028
	K_1407E10	3500 BLOCK & MONASHEE ST	$91,100	2028
	K_1884E10	35000 BLOCK & EXBURY AVE	$98,900	2028
Storm Sewers	K_420E11	35000 BLOCK & MCKEE RD	$133,400	2029
	K_908E11	3500 BLOCK & MCKINLEY DR	$41,300	2029
	K_1095E10	35000 BLOCK & HIGH DR	$152,700	2029
	K_1100E10	35000 BLOCK & HIGH DR	$64,500	2029
	K_1309E11	3800 BLOCK & OLD CLAYBURN RD	$43,200	2029
	K_1772E10	34000 BLOCK & HIGH DR	$166,900	2029
	K_1938E10	35000 BLOCK & LABURNUM AVE	$63,900	2029
	K_1941E10	35000 BLOCK & LABURNUM AVE	$69,700	2029
	K_518E10	3900 BLOCK & COACHSTONE WAY	$206,700	2030
	K_5F12	36000 BLOCK & STEPHEN LEACOCK DR	$60,400	2031
	K_6F12	36000 BLOCK & STEPHEN LEACOCK DR	$94,200	2031
	K_111E12	36000 BLOCK & MCKEE RD	$34,200	2031
	K_370F12	4400 BLOCK & BLAUSON BLVD	$22,700	2031
	K_386F12	4400 BLOCK & BLAUSON BLVD	$32,600	2031
	K_388F12	4400 BLOCK & BLAUSON BLVD	$97,300	2031
	K_511E10	3900 BLOCK & COACHSTONE WAY	$149,800	2031
	K_1262F10	4000 BLOCK & OLD CLAYBURN RD	$97,700	2031
	K_1408E10	35000 BLOCK & SKEENA AVE	$66,400	2031
	K_1416E10	3500 BLOCK & MONASHEE ST	$66,300	2031
	K_1710E11	3400 BLOCK & WHATCOM RD	$80,800	2031
	K_1713E11	3400 BLOCK & WHATCOM RD	$25,400	2031
	K_1885E10	35000 BLOCK & EXBURY AVE	$84,900	2031
	K_2342F10	35000 BLOCK & STRAITON RD	$66,000	2031
	K_2358F10	35000 BLOCK & STRAITON RD	$46,800	2031
	K_374F12	4400 BLOCK & BLAUSON BLVD	$46,500	2032
	K_927E10	34000 BLOCK & ASCOTT AVE	$108,000	2032
	K_929E10	3400 BLOCK & SUSSEX ST	$96,000	2032
	K_930E10	34000 BLOCK & LABURNUM AVE	$81,600	2032
	K_940E10	34000 BLOCK & IMMEL ST	$103,900	2032
	K_1141F11	4300 BLOCK & SHEARWATER DR	$61,200	2032
	K_519E10	3900 BLOCK & COACHSTONE WAY	$196,200	2033
	K_1102E10	34000 BLOCK & HIGH DR	$33,400	2033

Project Description	Project ID *	Project Location	2017 Final Costs	Project Timeline / Comments
Clayburn ISMP, 2012				
PRIORITY 2 - Minor Flow Capacity - Multi-Diameter Upgrade				
Storm sewers	K_1648E11	35000 BLOCK & ANGUS CR	$59,100	2033
	K_946E10	34000 BLOCK & LABURNUM AVE	$64,600	2034
	K_1312E11	3800 BLOCK & OLD CLAYBURN RD	$164,500	2034
	K_4F12	36000 BLOCK & STEPHEN LEACOCK DR	$32,200	2034
	K_2351F10	35000 BLOCK & STRAITON RD	$50,300	2034
	K_2349F10	35000 BLOCK & STRAITON RD	$52,900	2034
	K_2350F10	35000 BLOCK & STRAITON RD	$100,400	2034
	K_520E10	3900 BLOCK & COACHSTONE WAY	$165,300	2035
	K_901E11	35000 BLOCK & MCKEE RD	$100,100	2035
	K_975E10	34000 BLOCK & TERRACE CT	$109,900	2035
	K_980E10	34000 BLOCK & TERRACE CT	$96,600	2035
	K_1266F10	34000 BLOCK & CLAYBURN RD	$61,400	2035
	K_1267F10	34000 BLOCK & CLAYBURN RD	$64,200	2035
	K_1269F10	34000 BLOCK & CLAYBURN RD	$69,300	2035
	K_1271F10	34000 BLOCK & CLAYBURN RD	$127,200	2035
	K_400E11	3200 BLOCK & MCKINLEY DR	$58,200	2037
	K_1010F10	34000 BLOCK & BATEMAN RD	$186,200	2037
	K_1306E11	3800 BLOCK & OLD CLAYBURN RD	$27,700	2037
	K_514E10	3900 BLOCK & COACHSTONE WAY	$81,600	2038
	K_1709E11	3400 BLOCK & WHATCOM RD	$123,600	2038
	K_1270F10	34000 BLOCK & CLAYBURN RD	$62,300	2038
	K_72F12	4400 BLOCK & BLAUSON BLVD	$31,300	2039
	K_371F12	4400 BLOCK & BLAUSON BLVD	$71,700	2039
	K_684F12	4400 BLOCK & BLAUSON BLVD	$19,900	2039
	K_907E11	35000 BLOCK & MCKEE RD	$35,300	2039
	K_1036F10	34000 BLOCK & CLAYBURN RD	$63,100	2039
	K_1092E10	34000 BLOCK & HIGH DR	$55,700	2039
	K_1140F11	4300 BLOCK & SHEARWATER DR	$55,900	2039
	K_1268F10	4300 BLOCK & WRIGHT ST	$36,200	2039
	K_1272F10	34000 BLOCK & CLAYBURN RD	$96,000	2039
	K_1307E11	3800 BLOCK & OLD CLAYBURN RD	$112,900	2039
	K_1775E10	35000 BLOCK & HIGH DR	$45,100	2039
	K_2347F10	35000 BLOCK & STRAITON RD	$15,800	2039
	K_480E10	34000 BLOCK & BATEMAN RD	$141,000	2040
PRIORITY 3 - Minor Flow Capacity - One Pipe Diameter Upgrade				
Storm Sewers	K_1246E11	3300 BLOCK & MCKINLEY DR	$32,600	2038
	K_199E11	35000 BLOCK & TWEEDSMUIR DR	$62,700	2040
	K_387E11	3200 BLOCK & PURCELL AVE	$89,300	2040
	K_453E11	3400 BLOCK & MCKINLEY DR	$77,100	2040
	K_1352E11	35000 BLOCK & NAKISKA CT	$27,900	2040
	K_1068E10	35000 BLOCK & MORGAN WAY	$167,400	2041
	K_1235F11	4000 BLOCK & CHANNEL ST	$52,600	2041
	K_1361E11	3200 BLOCK & BOXWOOD CT	$55,800	2041
	K_1843E10	35000 BLOCK & CHRISTINA PL	$198,000	2041
	K_109E12	36000 BLOCK & MCKEE RD	$34,800	2042
	K_446E11	35000 BLOCK & MCKINLEY PL	$77,700	2042
	K_454E11	3400 BLOCK & MCKINLEY DR	$66,600	2042
	K_745E11	3900 BLOCK & OLD CLAYBURN RD	$27,900	2042
	K_1060F11	35000 BLOCK & BELANGER DR	$124,900	2042

Project Description	Project ID *	Project Location	2017 Final Costs	Project Timeline / Comments
Clayburn ISMP, 2012				
PRIORITY 3 - Minor Flow Capacity - One Pipe Diameter Upgrade				
Storm sewers	K_1353E11	3200 BLOCK & BOXWOOD CT	$72,900	2042
	K_1357E11	3300 BLOCK & BOXWOOD CT	$77,000	2042
	K_1358E11	3200 BLOCK & BOXWOOD CT	$117,200	2042
	K_1359E11	3200 BLOCK & BOXWOOD CT	$107,600	2042
	K_1360E11	3200 BLOCK & BOXWOOD CT	$42,500	2042
	K_1362E11	3300 BLOCK & BOXWOOD CT	$45,300	2042
PRIORITY 4 - DCC Upgrades				
Storm Sewers	K_11E11	3600 BLOCK & FOREST OAKS CT	$101,700	Time of development
	K_13E11	3600 BLOCK & FOREST OAKS CT	$83,500	
	K_19E11	3700 BLOCK & CASTLE PINES CT	$40,200	
	K_33E11	3700 BLOCK & CASTLE PINES CT	$78,600	
	K_869E11	3400 BLOCK & WHATCOM RD	$45,000	
	K_1711E11	3400 BLOCK & WHATCOM RD	$46,900	
	K_1009F10	34000 BLOCK & BATEMAN RD	$123,200	
	K_7F12	36000 BLOCK & AUGUSTON PARKWAY SOUTH	$61,100	
	K_8F12	36000 BLOCK & AUGUSTON PARKWAY SOUTH	$99,400	
	K_989E10	34000 BLOCK & TERRACE CT	$33,600	
	K_1340E10	3300 BLOCK & MCKEE DR	$46,600	
	K_1370E10	3500 BLOCK & MONASHEE ST	$146,600	
	K_1418E10	3600 BLOCK & BULKLEY ST	$58,800	
	K_1903E10	3700 BLOCK & BULKLEY ST	$37,500	
	K_1904E10	34000 BLOCK & MIERAU ST	$23,400	
	K_1448E10	3700 BLOCK & OLD CLAYBURN RD	$55,400	
	K_21E12	36000 BLOCK & BUCKINGHAM DR	$98,800	
	K_27E12	36000 BLOCK & BUCKINGHAM DR	$67,400	
	K_51E12	36000 BLOCK & WESTMINSTER DR	$82,600	
	K_70E12	36000 BLOCK & WESTMINSTER DR	$81,500	
	K_37E12	36000 BLOCK & WESTMINSTER DR	$73,600	
	K_38E12	36000 BLOCK & WESTMINSTER DR	$73,200	
	K_36E12	36000 BLOCK & WESTMINSTER DR	$122,300	
	K_131E12	36000 BLOCK & BUCKINGHAM DR	$46,600	
	K_133E12	36000 BLOCK & BUCKINGHAM DR	$102,200	
	K_137E12	36000 BLOCK & BUCKINGHAM DR	$38,800	
EROSION MANAGEMENT				
Existing Detention Facility Modification for Erosion Management	CLAYBURN_DET1	Stoney Creek and Clayburn Creek Watershed	$193,422	2021
			$214,914	2025
			$85,965	2035
Rehabilitate Existing Erosion Sites & Mitigate Erosive Flows			$53,728	2033
SEDIMENT MANAGEMENT				
Expand & Improve existing Dutra sediment trap	CLAYBURN_SED1	35000 BLOCK & STRAITON RD	$80,000	2025
Remove sediment under Wright St & Construct weir	CLAYBURN_SED2	4200 BLOCK & WRIGHT ST		Completed
Barrowtown PS - Preliminary Pumping Study, 2011				
Option 1 Static Method - Head pond construction				
Option 2 Dynamic Method - Introduction of adjustable flow restriction in discharge piping of Pump 1 & 2				
Pump Works Sub-total (for budgeting only)	BARROW_1	40000 BLOCK & QUADLING RD	$1,750,000	2041-2043

Project Description	Project ID *	Project Location	2017 Final Costs	Project Timeline / Comments
Barrowtown PS - Backup Power Study, 2013				
Option A				
Option B				
Option C				
Pump Works Sub-total (for budgeting only)	BARROW_2		$4,131,300	2041-2043
Other PS - Backup Power Construction				
McLennan PS - Backup Power	MCLENNAN_1		$988,800	2041-2043
Matsqui PS - Backup Power	MATSQUI_1		$1,898,100	2041-2043
DeJong PS - Backup Power	DEJONG_1		$103,600	2041-2043
Vanderloo PS - Backup Power	VANDERLOO_1		$88,800	2041-2043
Downes Creek ISMP, 2010Existing Land Use - 2006Future Land Use - 2015				
Pipe Works - Replacement				
In catchment D2	DOWNES_PIPE_6C	3900 BLOCK & CLEARBROOK RD	$142,000	2022
In catchment D2	DOWNES_PIPE_6A	3900 BLOCK & CLEARBROOK RD	$217,800	2023
In catchment D2	DOWNES_PIPE_6B	31000 BLOCK & DOWNES RD	$112,300	2023-2024
In catchment D1	DOWNES_PIPE_1	DOWNES RD	$600,800	2027
In catchment D1	DOWNES_PIPE_3B	32000 BLOCK & CLINTON AVE	$549,900	2032-2033
In catchment D1	DOWNES_PIPE_7B	31000 BLOCK & BLUERIDGE DR	$233,400	2034
In catchment D1	DOWNES_PIPE_3C	32000 BLOCK & CLINTON AVE	$1,099,756	2036-2037
In catchment D1	DOWNES_PIPE_2A	32000 BLOCK & HAIDA DR	$229,800	2037
In catchment D1	DOWNES_PIPE_4	3300 BLOCK & SLOCAN DR	$385,200	2037
In catchment D2	DOWNES_PIPE_7A	31000 BLOCK & DOWNES RD	$29,300	2038
In catchment D1	DOWNES_PIPE_3A	32000 BLOCK & SORRENTO AVE	$432,500	2038
In catchment D1	DOWNES_PIPE_5	32000 BLOCK & ASTORIA CR	$630,600	2038-2039
In catchment D1	DOWNES_PIPE_7C	31000 BLOCK & PINNACLE PL	$90,500	2040
In catchment D1	DOWNES_PIPE_2B	32000 BLOCK & HAIDA DR	$634,700	2040-2041
Construct New Ponds				
Pond Y				
Detention Pond	DOWNES_POND_1	4000 BLOCK & CLEARBROOK RD	$804,153	2041
25% Environmental Enhancement	DOWNES_POND_1	4000 BLOCK & CLEARBROOK RD	$201,038	2041
Pond Z				
Detention Pond	DOWNES_POND_2	32000 BLOCK & CLINTON AVE	$3,973,460	2042-2043
25% Environmental Enhancement	DOWNES_POND_2	32000 BLOCK & CLINTON AVE	$993,365	2042-2043
Modify 2x manhole for flow diversion	DOWNES_POND_2	32000 BLOCK & CLINTON AVE	$94,606	2042-2043
Pond Inlet and Outlet Adjustments				
Pond A				
Inlet Control w/ emergency bypass	DOWNES_POND_3	32000 BLOCK & HAIDA DR	$47,303	2021
Outlet Control w/ emergency overflow	DOWNES_POND_3	32000 BLOCK & HAIDA DR	$47,303	2021
Pond C				
Inlet Control w/ emergency bypass	DOWNES_POND_4	3600 BLOCK & CLEARBROOK RD	$47,303	2021
Outlet Control w/ emergency overflow	DOWNES_POND_4	3600 BLOCK & CLEARBROOK RD	$47,303	2021
Pond G				
Modify 2x manhole for flow diversion	DOWNES_POND_5	31000 BLOCK & DOWNES RD	$94,606	2021
Inlet Control w/ emergency bypass	DOWNES_POND_5	31000 BLOCK & DOWNES RD	$47,303	2021
Outlet Control w/ emergency overflow	DOWNES_POND_5	31000 BLOCK & DOWNES RD	$47,303	2021
Erosion Stabilization				
Stabilize bank erosion (8 sites)	DOWNES_ERO_6	4000 BLOCK & VERDON WAY	$151,370	2032-2033

Project Description	Project ID *	Project Location	2017 Final Costs	Project Timeline / Comments
Fraser River Bank Erosion - Matsqui Trail Regional Park Final Report Addendum, 2010				
Remove hard points & regrade banks (2H:1V).	FRASER_1			Completed
Remove hard points & regrade banks (6H:1V).	FRASER_1			
Leave existing bank-line as is & construct rock-filled trench.	FRASER_1			
Place continuous Riprap protection along existing bank-line.	FRASER_1			
Upgrade hard-points at end of each erosion arc.	FRASER_1			
Dredging Sand/Gravel Bar on north side of river (annual)	FRASER_1			
Upgrade existing Riprap upstream Beharrel Rd. Access	FRASER_1			
Create Riparian Barrier & Place Log Booms in erosion arcs	FRASER_1			
Bank Stabilization Marshall Creek and Horn Creek Erosion Sites Phase II and III, 2009				
Horn Creek Bank Stabilization (Direct Costs)				
Site A	HORN_A_1	NELSON PL	$299,767	on-going
Site B	HORN_B_2	TRAFALGAR ST	$495,402	
Site D	HORN_D_7	TRAFALGAR ST	$752,071	
Site H	HORN_H_5	TRAFALGAR ST	$465,338	2021-2024
Site I	HORN_I_6	MACLURE RD	$81,772	2021-2024
Site E	HORN_E_4	TRAFALGAR ST	$358,890	2021-2024
Site F	N/A			monitoring site
Site G	N/A			monitoring site
Horn Creek Stormwater Diversion				
General (Mobilisation, Demobilisation)	HORN_1	32000 BLOCK & MACLURE RD	$96,543	2043
Site Works	HORN_1	32000 BLOCK & MACLURE RD	$5,435,381	2043
Sumas River Sediment Trap at International Boundary, 2009				
Sediment Trap (3:1 slope)				Not Pursued
Design and Modelling for the Walnut Ave Detention Facility Expansion, 2011				
Aquatic Marsh - Proposed Design (not costed)	WALNUT_1	34000 BLOCK & WALNUT AVE		Completed
Willband Creek Detention Expansion, 2011				
Excavating the existing ponds (mainly sides) with 1:5 side slope, placing the spoil earth on the banks with 1:5 side slopes and maximum fill height elevation of + 5.0 m.	WILLBAND_1			Completed
Grass seeding of the newly exposed daylight areas of the ponds and over the spoil earth piles.				
Landscaping				
Marshall Creek ISMP, 2006				
Proposed Storm Sewer Improvements				
5-Year Capital Plan - Major Drainage System Improvements				
Delair Rd at Walker Cr	MARSHALL_1	34000 BLOCK & DELAIR RD	$106,500	2023
Delair Rd at Sumas Way	MARSHALL_2	1900 BLOCK & SUMAS WAY	$228,700	2032
5-Year Capital Plan - Minor Drainage System Improvements				
Rona parking lot	MARSHALL_4	1200 BLOCK & SUMAS WAY	$226,100	2027
Industrial Ave at Riverside Rd	MARSHALL_3	34000 BLOCK & INDUSTRIAL WAY	$93,300	2028
Keats St & Keats Cr to Shelley Ave & Highview St	MARSHALL_5	33000 BLOCK & SHELLEY AVE	$393,400	2030
Highview St: Shelley Ave to King Rd	MARSHALL_6	1600 BLOCK & HIGHVIEW ST	$212,500	2030
King Rd: Highview St to Kempley Cr	MARSHALL_7	33000 BLOCK & KING RD	$177,100	2033
King Rd: Kempley Ct to Franklin Ave	MARSHALL_8	33000 BLOCK & KING RD	$140,100	2034
5-Year + Minor Drainage System Improvements				
South of McClary Ave	MARSHALL_9	34000 BLOCK & MCCLARY AVE	$82,700	2038
East side of CNR R/W north of Vye Rd	MARSHALL_10	800 BLOCK & RIVERSIDE RD	$74,300	2038
East side of CNR R/W north of Vye Rd	MARSHALL_11	1000 BLOCK & RIVERSIDE RD	$106,500	2040

Project Description	Project ID *	Project Location	2017 Final Costs	Project Timeline / Comments
Marshall Creek ISMP, 2006				
Proposed Storm Sewer Improvements				
DCC Major Drainage System Improvements				
McCallum Rd south of McConnell Rd	MARSHALL_12	1000 BLOCK & MCCALLUM RD	$34,200	Time of development
East of McCallum Rd south of McConnell Rd	MARSHALL_13	1000 BLOCK & MCCALLUM RD		Completed
Old Yale Rd east of Delair Rd	MARSHALL_14	35000 BLOCK & OLD YALE RD	$397,800	Time of development
Old Yale Rd at Delair Park	MARSHALL_15	35000 BLOCK & OLD YALE RD	$311,300	
Old Yale Rd at Delair Rd	MARSHALL_16	35000 BLOCK & OLD YALE RD	$71,400	
DCC Minor Drainage System Improvements				
North side of Industrial Ave	MARSHALL_17	34000 BLOCK & INDUSTRIAL WAY	$153,700	Time of development
Easement between 7th Ave and Farmer Rd	MARSHALL_18	4TH AVE	$269,100	
King Rd east of Kempley Ct	MARSHALL_19	33000 BLOCK & KING RD	$100,900	
King Rd east of Kempley Ct	MARSHALL_20	33000 BLOCK & KING RD	$116,000	
Old Yale Rd at Delair Rd	MARSHALL_21	35000 BLOCK & OLD YALE RD	$81,400	
Eagle Mountain Dr near Doneagle Pl	MARSHALL_22	35000 BLOCK & EAGLE MTN DR	$58,700	
Proposed Culvert Improvements				
5-Year Capital Plan - Major Culvert Improvements				
East side of CNR R/W at S. Fraser Way	MARSHALL_C7	34000 BLOCK & GLADYS AVE	$322,600	2019
Riverside Rd south of Vye Rd	MARSHALL_C9	700 BLOCK & RIVERSIDE RD	$419,400	2019
34300 blk. Farmer Rd	MARSHALL_C1	300 BLOCK & RIVERSIDE RD	$133,400	2020
300 blk. Sumas Way (West Side)	MARSHALL_C2	300 BLOCK & SUMAS WAY	$213,100	2020
300 blk. Sumas Way (West Side)	MARSHALL_C3	200 BLOCK & SUMAS WAY	$216,100	2020
Private property on 800 blk. McCallum Rd	MARSHALL_C4	800 BLOCK & MCCALLUM RD	$178,000	2020
Vye Rd at CNR R/W (West Side)	MARSHALL_C5	34000 BLOCK & VYE RD	$222,100	2021
1200 blk. Riverside Rd	MARSHALL_C11	34000 BLOCK & VYE RD	$189,400	2021
SRY R/W north of S. Fraser Way	MARSHALL_C6	34000 BLOCK & GLADYS AVE	$470,100	2022
1100 blk. Riverside Rd	MARSHALL_C12	34000 BLOCK & VYE RD	$121,800	2023
Dahl Park near Forrest Cr	MARSHALL_C8	FORREST TERRACE	$440,700	2024
1300 blk. Riverside Rd	MARSHALL_C10	RIVERSIDE RD	$179,300	2026
DCC Culvert Improvement Projects				
East side of SRY R/W at Hwy 1	MARSHALL_C13	SUMAS WAY	$786,800	Time of development
200 blk. Walnut Ave	MARSHALL_C14	200 BLOCK & WALNUT ST	$339,600	
800 blk. Riverside Rd	MARSHALL_C15	34000 BLOCK & VYE RD	$360,600	
1000 blk. Riverside Rd	MARSHALL_C16	34000 BLOCK & VYE RD	$380,200	
East side of CNR R/W at Riverside Rd	MARSHALL_C17	WEST RAILWAY ST	$116,100	
High Priority Erosion Sites Rehabilitation				
Marshall Site 1	MARSHALL_T11_208	MIRUS DR	$48,272	2024
Marshall Site 2	MARSHALL_T11_212	2200 BLOCK & LUMAR PL	$24,136	2025
Marshall Site 4	MARSHALL_T7_185	36000 BLOCK & LOWER SUMAS MTN RD	$24,136	2025
Marshall Site 3	MARSHALL_T7_183	36000 BLOCK & CARRINGTON LANE	$36,204	2032
Flood and Erosion Assessment of Horn Creek/Boa Brook, 2001 - Alternatives				
As is				Completed
Raise Yards of Kinsmen Area				Completed
Initiate Bioengineering Upstream Stabilization / Planting			$11,121	2032
Debris Trash Rack				Completed
Sediment Trap / Basin	HORN_BOA_1	MACLURE RD	$77,848	2032
Widen and Re-grade Channel				Completed
Flood Protection Berm / Dike				Completed
Channel Armouring				Completed
Channelized Side-Stream				Completed
Wattle Bundle Armouring				Completed
Protect Stormwater Outfalls				Completed

Project Description	Project ID *	Project Location	2017 Final Costs	Project Timeline / Comments
Fishtrap Master Drainage Plan, 1987				
Hwy 401 Detention Storage and Culvert Improvements				Do not undertake until Fishtrap ISMP is completed
Excavation				
Cultivate, lime, seed				
Control Structure				
Hwy 401 culvert upgrade				
Area 3 repiping				
Livingston, Old Yale and Towline protective work				
Paving at control structure				
Fencing and signing				
Rock work				
TOTAL	**FISH_1**		**$1,076,159**	
Simpson Road Detention Storage and Culvert Improvement				Do not undertake until Fishtrap ISMP is completed
Control Structure				
Box culver and end well				
Rock work				
Simpson Road drain reconstruction				
Fencing and signing				
TOTAL	**FISH_2**		**$223,957**	
Mt. Lehman and Marshall Culvert Improvement				
Marshall Road Culvert Headwall improvements				
Culvert Installation	FISH_3	1900 BLOCK & MT LEHMAN RD	$84,348	
Creek Clearing	FISH_4	1700 BLOCK & PEARDONVILLE RD	$113,433	
Known Drainage Issues				
Gill Creek Culvert Headwall Rehabilitation			$685,000	2019
Mill Lake Flooding (Willband Creek Watershed)				Willband ISMP to address
Storm Sewers Surcharge/Basement Flooding due to High Lake Level				
Bank Erosion at Ravine Park (Willband Creek Watershed)				
Steep Eroding Bank adjacent to Trail				
End of Life Culvert at Arbour Park (Willband Creek Watershed)				
1800 mm CSP Culvert Coming to End of Useful Life				
Poor Condition Critical Storm Infrastructure under Railway (Willband Creek Watershed)				
near the east end of Pine St.				
Potential Detention (Willband Creek Watershed)				
Low lying farm land too wet SE of Valley Rd				
Willband Creek Flooding at Willband Creek Park (Willband Creek Watershed)				
Trail Flooding 100 m east of Abbotsford Mission Hwy, weir need repair				
Willband Creek Park wetland area (Willband Creek Watershed)				
Sized for smaller event in isolation of MP flood event				
Rockpit Drain Well Replacement (Willband Creek Watershed)				
at Old Clayburn Neighbourhood (Hurst Crescent)				
Runoff Erosion on Trail (Willband Creek Watershed)				
Thiessen Creek at Old Riverside Park				
Lack of Detailed Design + Requirements in Development Bylaw. Need a Plan for Infill Development (Curb/gutter, on-site drainage) (Marshall Creek Watershed)				Source control bylaw to address
bylaw additions				
Waechter Creek Flooding in the Past (Fishtrap Creek Watershed)				Fishtrap ISMP to address
at Marshall Road Extension				
East Fishtrap Creek Culvert Not Functioning Property (Fishtrap Creek Watershed)				Fishtrap ISMP to address
1800 mm culvert near Old Yale Rd and Mitchell St crossing				
East Fishtrap Creek Flooding Issue due to High Pond Level (Fishtrap Creek Watershed)				
near Charlotte Ave and Princess St				

Project Description	Project ID *	Project Location	2017 Final Costs	Project Timeline / Comments
Known Drainage Issues				
Low Land Flooding (Marshall Creek Watershed)				S/S by Sumas Prairie Drainage Study Phase 1
Ditch at Angus Campbell Road				
Low Land Flooding (Willband Creek Watershed)				Willband ISMP to address
Hwy property at Hwy 11 and Gladys Ave crossing				
Tweedsmuir Detention Pond Not Functioning Well (Clayburn Watershed)				Addressed in Clayburn ISMP
casing wet back yard near Westview Blvd				
Culvert Failure lead to Road Closure and Bank Failure (Sumas Watershed)				Completed
Kilgard Creek tributary near (lower) Suman Mountain Rd				
Willband Creek Culvert at Abbotsford Mission Hwy Crossing Floated (Willband Creek Watershed)				Willband ISMP to address
after Hwy widening on the east side of the why				
Trail and Old Transfer Station Flooding (Willband Creek Watershed)				
near Willband Creek north of Valley Rd				
Townshipline Rd East of Bates Road flooding (Mastsqui Watershed)				Matsqui Phase 2 study to address
Partial road flooding in the past in the ditch/tributary of McLennan Creek				
Past Flooding at Olund Road (Mastsqui Watershed)				
Flooding in the past in the tributary/ditch of Hawkins Brook				
Study Project List				
DCC Bylaw Update - Storm Drainage			$30,000	2017/2018
Subdivision Development Bylaw Update - Phase 1			$25,000	2017/2018
City Centre Servicing Study			$50,000	2017/2018
Historical Downtown Servicing Study - Drainage			$50,000	2017/2018
Auguston Servicing Study - Drainage			$50,000	2017/2018
Ledgeview Servicing Study - Drainage			$12,500	2017/2018
McKee Peak Servicing Study - Drainage			$50,000	2017/2018
Fishtrap Creek ISMP			$383,000	2017/2018
Subdivision Development Bylaw Update - Phase 2			$20,000	2019
Infill Development Stragety			$20,000	2019
Matsqui Phase 2 Study			$458,000	2019
Sumas Prairie Drainage Study Phase 2			$200,000	2020
Stormwater Fee and Charges Feasibility Study			$200,000	2020
Pepin Brook Flooding (Bertrand Creek Watershed)			$20,000	2020
Howes Creek tributary flooding (Bertrand Creek Watershed)			$20,000	2020
Downes Creek Tributary Lowland Flooding			$20,000	2020
Storm main full near Blueridge Dr (Downes Creek and Fishtrap Creek border)			$20,000	2020
Potential Community Detention U/S of Horn Creek and Boa Brook erosion sites			$20,000	2020
Stormwater Source Control Bylaw Update			$30,000	2021
Fishtrap Creek Detention, Simpson Ave			$135,000	2021
Fishtrap Creek Drainage			$27,000	2021
Delair Park Community Detention Study			$167,000	2021
Nathan Creek ISMP Study			$350,000	2022
Pump Stations Resiliency Study			$100,000	2024
DMP Updates (once every 5 years)			$200,000	2024, 2029,2034,2039
Barrowtown Pump Station Upgrade Cost Benefit Study			$50,000	2026
Dike Upgrade Detailed Cost by Phase			$30,000	2027

Appendix C

Estimation of Project Cost for Studied Areas

Table C1: Percentage TIA Assumed for Each Land Use Type

2005			2016	
TIA%	**Land Use Code**	**OCP Land Type**	**TIA%**	**OCP Land Type**
5	A	Agriculture	**20**	Agriculture
90	C	Commercial	**90**	Regional Commercial
			90	Neighborhood Centre
90	CC	City Centre	**90**	City Centre
			90	Urban Centre
80	CR	City Residential	**80**	Urban 1 – Midrise
			80	Urban 2 - Ground
90	CU	Choice of Use	**90**	Secondary Commercial
90	I	Institutional	**90**	Hospital
			90	Institutional
			90	Institutional Complex
75	IB	Industrial Business	**90**	High Impact Industrial
75	IB_CICP	IB on CICP Land	**90**	General Industrial
			75	Airport
75	IR	Industrial Land Reserve	**75**	Special Study Area
40	LDR	Low Density Residential	**60**	Urban 4 - Detached
10	R	Rural Residential	**10**	Rural
1	RC	Resource Conservation	**1**	Open Space
50	SR	Suburban Residential Zone	**40**	Suburban
			10	Country
60	UR	Urban Residential	**60**	Urban 3 – Infill
			40	Urban Large Lot

Final approved June 22, 2017

Table C2: Construction Cost Index Inflation Recommendations

Year	Construction Cost Index	Annual % CCI Change	Inflation Cost Increase
2017	10698.72	0.7	0%
2016	10622.73	2.2	1%
2015	10398.13	0.1	3%
2014	10384.58	1.8	3%
2013	10204.3	2.5	5%
2012	9956.3	0.1	7%
2011	9951.55	4.8	8%
2010	9499.3	0.5	13%
2009	9452.8	-0.7	13%
2008	9519.3	1.6	12%
2007	9366.16	0.6	14%
2006	9308.71	1.4	15%
2005	9182.39	3.7	17%
2004	8855.14	0.6	21%
2003	8798.54	8.6	22%
2002	8103.32	0.3	32%
2001	8080.93	1.5	32%
2000	7963.21	-3.3	34%
1999	8237.51	4.2	30%
1998	7909.45	-0.4	35%
1997	7940.84	-1	35%
1996	8020.55	4.1	33%
1995	7702.64	-0.4	39%
1994	7732.17	4.7	38%
1993	7387.77	5.3	45%
1992	7017.93	7.4	52%
1991	6537.05	2.1	64%
1990	6401.54	6.3	67%

Notes:

1. 1990-2013 Construction Cost Index from Toronto, ON.
2. 2014-2017 Construction Cost Index from Seattle, WA. (Toronto CCI is not available for this period).

Table C3: Updated Project Cost and Initiation Time

Project List	Project Cost	Capital Cost	DCC Cost	Initiation Time	Conduit Size (2016 OCP)	Conduit Length	Catchment
Short Term 2019-2023							
Storm Sewers							
K_860E11	$67,800	$57,100	$10,700	2019	900	19.8	Clayburn
K_527E11	$96,700	$89,000	$7,700	2020	1050	28.8	Clayburn
DOWNES_PIPE_6C	$142,000	$128,600	$13,400	2022	1350	5.0	Downes
DOWNES_PIPE_6A	$217,800	$191,500	$26,300	2023	1050	27.0	Downes
DOWNES_PIPE_6B	$112,300	$101,500	$10,800	2023	750	9.0	Downes
MARSHALL_1	$106,500	$106,500	$0	2023	525	63.5	Marshall
Culverts/Bridges							
K_CV76	$851,100	$401,800	$449,300	2019	3600x2400	19.2	Clayburn
K_CV140	$254,700	$213,500	$41,200	2019	1800	12.0	Clayburn
MARSHALL_C7	$322,600	$298,000	$24,600	2019	1650	23.6	Marshall
MARSHALL_C9	$419,400	$325,400	$94,000	2019	2100	24	Marshall
MARSHALL_C1	$133,400	$133,400	$0	2020	1350	20	Marshall
MARSHALL_C2	$213,100	$192,100	$21,000	2020	1200	20.8	Marshall
MARSHALL_C3	$216,100	$171,500	$44,600	2020	1350	16	Marshall
MARSHALL_C4	$178,000	$158,200	$19,800	2020	1050	17.5	Marshall
MARSHALL_C5	$222,100	$175,800	$46,300	2021	1350	17	Marshall
MARSHALL_C11	$189,400	$171,500	$17,900	2021	1200	16	Marshall
K_CV193	$387,600	$270,600	$117,000	2021	2100	13.6	Clayburn
K_CV221	$413,600	$299,600	$114,000	2021	2400	11.9	Clayburn
K_CV2	$564,200	$315,800	$248,400	2022	3050	13.6	Clayburn
MARSHALL_C6	$470,100	$446,400	$23,700	2022	1650	44.1	Marshall
K_CV44	$491,800	$304,300	$187,500	2023	2700	12.4	Clayburn
K_CV48	$136,300	$128,500	$7,800	2023	500	26.0	Clayburn
MARSHALL_C12	$121,800	$121,800	$0	2023	1050	25.1	Marshall
Channel Upgrades							
Install Floodboxes	$162,510	$0	$162,510	2020	N/A	N/A	Clayburn Village
Install Flap gates					N/A	N/A	Clayburn Village
Construct North Berm Ch. 12710-12930	$300,000	$0	$300,000	2020	N/A	N/A	Clayburn Village
Deepen Under Clayburn Bridge	$55,568	$0	$55,568	2020	N/A	N/A	Matsqui SI
Ch. 14284-13884					N/A	N/A	Clayburn Creek
Ch. 14284-14212	$365,910	$0	$365,910	2020	N/A	N/A	Clayburn Creek
Ch. 14202-13825					N/A	N/A	Clayburn Creek
Ch. 13815-13333					N/A	N/A	Clayburn Creek
Ch. 13323-13300	$707,705	$0	$707,705	2022	N/A	N/A	Clayburn Creek
Ch. 13282-13086					N/A	N/A	Clayburn Creek
Ch. 13076-12727					N/A	N/A	Clayburn Creek
Ch. 12710-12574					N/A	N/A	Clayburn Creek

Table C3: Updated Project Cost and Initiation Time

Project List	Project Cost	Capital Cost	DCC Cost	Initiation Time	Conduit Size (2016 OCP)	Conduit Length	Catchment
Short Term 2019-2023							
Detention Pond							
P13	$193,422	$193,422	$0	2021	N/A	N/A	Clayburn (Stoney)
P14					N/A	N/A	Clayburn (Stoney)
P21					N/A	N/A	Clayburn (Stoney)
P40					N/A	N/A	Clayburn (Stoney)
P49					N/A	N/A	Clayburn (Stoney)
P50					N/A	N/A	Clayburn (Stoney)
P52 and P53					N/A	N/A	Clayburn (Stoney)
P20-1 and P20-2					N/A	N/A	Clayburn (Stoney)
P51					N/A	N/A	Clayburn (Stoney)
Pond A	$94,606	$94,606	$0	2021	N/A	N/A	Downes
Pond C	$94,606	$94,606	$0	2021	N/A	N/A	Downes
Pond G	$189,212	$189,212	$0	2021	N/A	N/A	Downes
Urban Creek Stabilization							
Gill Creek Erosion Sites	$750,000	$0	$750,000	2019	N/A	N/A	Marshall
Horn Creek Bank Stabilization	$906,000	$0	$906,000	2021	N/A	N/A	Willband
Study Project List							
Subdivision Development Bylaw Update - Phase 2	$20,000	$20,000	$0	2019	N/A	N/A	City wide
Stormwater Source Control Bylaw Update	$30,000	$30,000	$0	2019	N/A	N/A	City wide
Infill Development Strategy	$20,000	$20,000	$0	2019	N/A	N/A	City wide
Matsqui Phase 2 Study	$458,000	$458,000	$0	2019	N/A	N/A	Matsqui
Stormwater Fee and Charges Feasibility Study	$200,000	$200,000	$0	2020	N/A	N/A	City wide
Pepin Brook Flooding (Bertrand Creek Watershed)	$20,000	$20,000	$0	2020	N/A	N/A	Betrand
Howes Creek tributary flooding (Bertrand Creek Watershed	$20,000	$20,000	$0	2020	N/A	N/A	Betrand
Downes Creek Tributary Lowland Flooding	$20,000	$20,000	$0	2020	N/A	N/A	Downes
Storm main full near Blueridge Dr (Downes Creek and Fish	$20,000	$20,000	$0	2020	N/A	N/A	Downes/Fishtrap border
Potential Community Detention U/S of Horn Creek and Bo	$20,000	$20,000	$0	2020	N/A	N/A	Willband
Sumas Prairie Drainage Study Phase 2 in 2018	$200,000	$200,000	$0	2020	N/A	N/A	Sumas
Fishtrap Creek Detention, Simpson Ave	$135,000	$135,000	$0	2021	N/A	N/A	Fishtrap
Fishtrap Creek Drainage	$27,000	$27,000	$0	2021	N/A	N/A	Fishtrap
Delair Park Community Detention Study	$167,000	$167,000	$0	2021	N/A	N/A	
Nathan Creek ISMP Study	$350,000	$350,000	$0	2022	N/A	N/A	Nathan
Miscellaneous							
Gill Creek Culvert Headwall Rehabilitation	$685,000	$685,000	$0	2019	N/A	N/A	Marshall

Table C3: Updated Project Cost and Initiation Time

Project List	Project Cost	Capital Cost	DCC Cost	Initiation Time	Conduit Size (2016 OCP)	Conduit Length	Catchment
Medium Term 2024-2028							
Storm Sewers							
K_525E11	$68,100	$68,100	$0	2025	525	38.0	Clayburn
K_517E11	$248,700	$248,700	$0	2026	675	118.3	Clayburn
K_526E11	$4,900	$4,900	$0	2026	450	4.0	Clayburn
MARSHALL_4	$226,100	$226,100	$0	2027	750	29.5	Marshall
DOWNES_PIPE_1	$600,800	$556,600	$44,200	2027	1800	17.4x2	Downes
K_268E11	$48,700	$48,700	$0	2027	525	22.2	Clayburn
K_517E10	$204,800	$204,800	$0	2028	900	80.7	Clayburn
K_959E10	$155,000	$155,000	$0	2028	525	112.1	Clayburn
K_943E10	$119,000	$119,000	$0	2028	675	50.2	Clayburn
K_945E10	$35,000	$35,000	$0	2028	600	9.5	Clayburn
K_948E10	$112,200	$112,200	$0	2028	675	52.4	Clayburn
K_947E10	$196,600	$196,600	$0	2028	750	99.3	Clayburn
K_967E10	$90,600	$90,600	$0	2029	750	40.4	Clayburn
K_1407E10	$91,100	$91,100	$0	2028	675	18.7	Clayburn
K_1884E10	$98,900	$82,700	$16,200	2028	900	30.0	Clayburn
MARSHALL_3	$93,300	$62,600	$30,700	2028	900	27.6	Marshall
Culverts/Bridges							
K_CV52	$604,300	$476,800	$127,500	2024	1800	58.5	Clayburn
K_CV211	$202,300	$202,300	$0	2024	600	42.8	Clayburn
MARSHALL_C8	$440,700	$440,700	$0	2024	1200	78.3	Marshall
K_CV116	$315,400	$180,300	$135,100	2025	900	34.5	Clayburn
K_CV224	$264,000	$164,800	$99,200	2025	1200	25.3	Clayburn
Culvert at Vye Rd on Saar Crk	$845,600	$668,024	$177,576	2025	3600x4100	22.2	Sumas
K_CV42	$130,200	$117,900	$12,300	2026	N/A	N/A	Clayburn
K_CV46	$329,300	$183,600	$145,700	2026	750	46.5	Clayburn
K_CV133	$158,500	$113,400	$45,100	2026	1200	6.5	Clayburn
MARSHALL_C10	$179,300	$179,300	$0	2026	1200	23.4	Marshall
Channel Upgrades							
Construct 100L/s Pump Station	$572,455	$0	$572,455	2024	N/A	N/A	Clayburn Village
Urban Creek Stabilization							
T11_208	$48,272	$0	$48,272	2024	N/A	N/A	Marshall
T11_212	$24,136	$0	$24,136	2025	N/A	N/A	Marshall
T7_185	$24,136	$0	$24,136	2025	N/A	N/A	Marshall
Clayburn Expand & Improve existing Dutra sediment trap	$80,000	$0	$80,000	2025	N/A	N/A	Clayburn
Erosion at Matsqui Dyke from Erosion Arcs F & G	$1,869,752	$0	$1,869,752	2025	N/A	N/A	Matsqui dike
Detention Pond							
P47	$214,914	$214,914	$0	2025	N/A	N/A	Clayburn
P12					N/A	N/A	Clayburn (Stoney)
P18					N/A	N/A	Clayburn (Stoney)
P19-1, P19-2, P19-3					N/A	N/A	Clayburn (Stoney)
P24-1,P24-2, P24-3, P24-4					N/A	N/A	Clayburn (Stoney)
P26-1, P26-2					N/A	N/A	Clayburn (Stoney)
P36					N/A	N/A	Clayburn (Stoney)
P39-1, P39-2					N/A	N/A	Clayburn (Stoney)
P1					N/A	N/A	Clayburn

Table C3: Updated Project Cost and Initiation Time

Project List	Project Cost	Capital Cost	DCC Cost	Initiation Time	Conduit Size (2016 OCP)	Conduit Length	Catchment
Medium Term 2024-2028							
Study Project List							
DMP Update (every 5 years) 2024, 2029, 2034, 2039	$200,000	$200,000	$0	2024	N/A	N/A	City wide
Dike Updates Detailed Cost by Phase	$30,000	$30,000	$0	2027	N/A	N/A	City wide
Pump Stations Resiliency Study (Back-up Power)	$100,000	$100,000	$0	2024	N/A	N/A	Matsqui dike
Barrowtown Pump Station Upgrade Cost Benefit Study	$50,000	$50,000	$0	2026	N/A	N/A	Barrowtown PS
Long Term 2029-2043							
Storm Sewers							
K_420E11	$133,400	$133,400	$0	2029	525	91.4	Clayburn
K_1938E10	$63,900	$63,900	$0	2029	450	39.0	Clayburn
K_1941E10	$69,700	$69,700	$0	2029	900	17.5	Clayburn
K_908E11	$41,300	$37,300	$4,000	2029	600	7.0	Clayburn
K_1309E11	$43,200	$43,200	$0	2029	450	26.5	Clayburn
K_1772E10	$166,900	$166,900	$0	2029	450	127.7	Clayburn
K_1095E10	$152,700	$152,700	$0	2029	450	116.1	Clayburn
K_1100E10	$64,500	$64,500	$0	2029	450	43.9	Clayburn
MARSHALL_5	$393,400	$393,400	$0	2030	675	102.9	Marshall
MARSHALL_6	$212,500	$212,500	$0	2030	675	102.2	Marshall
K_518E10	$206,700	$162,700	$44,000	2031	900	81.5	Clayburn
K_1262F10	$97,700	$81,800	$15,900	2031	900	29.5	Clayburn
K_511E10	$149,800	$119,000	$30,800	2031	900	57.2	Clayburn
K_111E12	$34,200	$34,200	$0	2031	675	3.0	Clayburn
K_388F12	$97,300	$97,300	$0	2031	375	70.7	Clayburn
K_386F12	$32,600	$32,600	$0	2031	450	9.0	Clayburn
K_370F12	$22,700	$22,700	$0	2031	600	3.0	Clayburn
K_2342F10	$66,000	$66,000	$0	2031	375	27.5	Clayburn
K_2358F10	$46,800	$46,800	$0	2031	375	25.0	Clayburn
K_1710E11	$80,800	$80,800	$0	2031	675	28.9	Clayburn
K_1713E11	$25,400	$25,400	$0	2031	675	2.1	Clayburn
K_6F12	$94,200	$73,300	$20,900	2031	600	36.4	Clayburn
K_5F12	$60,400	$60,400	$0	2031	525	33.6	Clayburn
K_1416E10	$66,300	$66,300	$0	2031	675	26.2	Clayburn
K_1408E10	$66,400	$66,400	$0	2032	675	26.2	Clayburn
K_1885E10	$84,900	$84,900	$0	2032	750	35.2	Clayburn
K_1141F11	$61,200	$61,200	$0	2032	525	26.5	Clayburn
MARSHALL_2	$228,700	$164,800	$63,900	2032	675	111.2	Marshall
K_481E10	$415,100	$290,800	$124,300	2032	1500	100.5	Clayburn
K_374F12	$46,500	$46,500	$0	2032	600	16.2	Clayburn
K_930E10	$81,600	$81,600	$0	2032	375	57.9	Clayburn
K_940E10	$103,900	$103,900	$0	2032	525	61.4	Clayburn
K_927E10	$108,000	$108,000	$0	2033	450	79.5	Clayburn
K_929E10	$96,000	$96,000	$0	2033	525	54.9	Clayburn
K_1648E11	$59,100	$59,100	$0	2033	600	16.8	Clayburn
K_1102E10	$33,400	$33,400	$0	2033	450	18.5	Clayburn
MARSHALL_7	$177,100	$177,100	$0	2033	750	82.5	Marshall
DOWNES_PIPE_3B	$549,900	$549,900	$0	2033	1050	217.0	Downes
K_519E10	$196,200	$154,600	$41,600	2034	900	77.0	Clayburn

Table C3: Updated Project Cost and Initiation Time

Project List	Project Cost	Capital Cost	DCC Cost	Initiation Time	Conduit Size (2016 OCP)	Conduit Length	Catchment
Long Term 2029-2043							
Storm Sewers							
K_2351F10	$50,300	$34,800	$15,500	2034	600	11.9	Clayburn
K_2350F10	$100,400	$48,900	$51,500	2034	600	39.9	Clayburn
K_2349F10	$52,900	$52,900	$0	2034	525	37.3	Clayburn
K_4F12	$32,200	$32,200	$0	2034	525	10.6	Clayburn
K_1312E11	$164,500	$121,200	$43,300	2034	600	75.5	Clayburn
DOWNES_PIPE_7B	$233,400	$218,800	$14,600	2034	600	138.0	Downes
MARSHALL_8	$140,100	$140,100	$0	2034	525	91.0	Marshall
K_946E10	$64,600	$64,600	$0	2035	450	44.0	Clayburn
K_975E10	$109,900	$109,900	$0	2035	525	75.1	Clayburn
K_980E10	$96,600	$96,600	$0	2035	525	64.3	Clayburn
K_901E11	$100,100	$100,100	$0	2035	375	68.6	Clayburn
K_1271F10	$127,200	$127,200	$0	2035	525	80.5	Clayburn
K_1269F10	$69,300	$69,300	$0	2035	525	33.1	Clayburn
K_1267F10	$64,200	$64,200	$0	2035	375	42.6	Clayburn
K_1266F10	$61,400	$61,400	$0	2035	375	40.3	Clayburn
K_520E10	$165,300	$130,900	$34,400	2035	900	63.8	Clayburn
DOWNES_PIPE_3C	$1,099,756	$1,099,756	$0	2036	1500	125.0	Downes
DOWNES_PIPE_2A	$229,800	$229,800	$0	2037	600	116.0	Downes
DOWNES_PIPE_4	$385,200	$385,200	$0	2037	600	95.6	Downes
K_1010F10	$186,200	$186,200	$0	2037	375	134.6	Clayburn
MARSHALL_9	$82,700	$65,500	$17,200	2038	600	30.0	Marshall
K_400E11	$58,200	$58,200	$0	2038	375	29.9	Clayburn
K_1306E11	$27,700	$27,700	$0	2038	300	5.0	Clayburn
DOWNES_PIPE_7A	$29,300	$29,300	$0	2038	200	15.3	Downes
K_514E10	$81,600	$50,500	$31,100	2038	900	28.0	Clayburn
K_1709E11	$123,600	$91,000	$32,600	2038	600	56.7	Clayburn
K_1246E11	$32,600	$32,600	$0	2038	600	2.1	Clayburn
K_1270F10	$62,300	$62,300	$0	2038	375	41.0	Clayburn
MARSHALL_10	$74,300	$74,300	$0	2038	525	37.2	Marshall
DOWNES_PIPE_3A	$432,500	$401,200	$31,300	2038	600	54.5	Downes
DOWNES_PIPE_5	$630,600	$630,600	$0	2038	675	48.8	Downes
K_371F12	$71,700	$54,300	$17,400	2039	600	30.2	Clayburn
K_684F12	$19,900	$19,100	$800	2039	600	1.4	Clayburn
K_72F12	$31,300	$26,900	$4,400	2039	600	7.8	Clayburn
K_907E11	$35,300	$35,300	$0	2039	375	15.6	Clayburn
K_1307E11	$112,900	$112,900	$0	2039	450	83.5	Clayburn
K_1092E10	$55,700	$55,700	$0	2039	450	36.7	Clayburn
K_1775E10	$45,100	$45,100	$0	2039	450	28.0	Clayburn
K_2347F10	$15,800	$10,800	$5,000	2039	525	7.0	Clayburn
K_1140F11	$55,900	$32,600	$23,300	2039	375	32.5	Clayburn
K_1272F10	$96,000	$96,000	$0	2040	300	68.6	Clayburn
K_1268F10	$36,200	$36,200	$0	2040	375	19.7	Clayburn
K_1036F10	$63,100	$63,100	$0	2040	375	41.7	Clayburn
K_480E10	$141,000	$112,200	$28,800	2040	900	53.4	Clayburn
K_1352E11	$27,900	$27,900	$0	2040	450	5.1	Clayburn

Table C3: Updated Project Cost and Initiation Time

Project List	Project Cost	Capital Cost	DCC Cost	Initiation Time	Conduit Size (2016 OCP)	Conduit Length	Catchment
Long Term 2029-2043							
Storm Sewers							
MARSHALL_11	$106,500	$106,500	$0	2040	525	63.5	Marshall
K_387E11	$89,300	$89,300	$0	2040	525	49.5	Clayburn
K_453E11	$77,100	$50,800	$26,300	2040	200	36.6	Clayburn
DOWNES_PIPE_7C	$90,500	$90,500	$0	2040	600	35.0	Downes
K_199E11	$62,700	$62,700	$0	2040	450	33.6	Clayburn
DOWNES_PIPE_2B	$634,700	$598,700	$36,000	2040	525	100.7	Downes
K_1361E11	$55,800	$36,400	$19,400	2041	600	15.0	Clayburn
K_1843E10	$198,000	$198,000	$0	2041	900	72.4	Clayburn
K_1235F11	$52,600	$52,600	$0	2041	675	13.2	Clayburn
K_1068E10	$167,400	$167,400	$0	2041	450	119.2	Clayburn
K_446E11	$77,700	$77,700	$0	2042	300	45.9	Clayburn
K_745E11	$27,900	$27,900	$0	2042	450	14.0	Clayburn
K_454E11	$66,600	$37,000	$29,600	2042	250	41.2	Clayburn
K_109E12	$34,800	$34,800	$0	2042	600	3.3	Clayburn
K_1060F11	$124,900	$124,900	$0	2042	525	78.6	Clayburn
K_1362E11	$45,300	$37,800	$7,500	2042	750	13.2	Clayburn
K_1353E11	$72,900	$36,000	$36,900	2042	600	28.5	Clayburn
K_1360E11	$42,500	$27,500	$15,000	2042	600	11.6	Clayburn
K_1359E11	$107,600	$80,100	$27,500	2042	675	47.8	Clayburn
K_1358E11	$117,200	$86,600	$30,600	2042	675	53.2	Clayburn
K_1357E11	$77,000	$59,300	$17,700	2042	750	30.8	Clayburn
Culverts/Bridges							
K_CV135	$199,600	$199,600	$0	2030	1800	15.6	Clayburn
K_CV89	$303,000	$205,400	$97,600	2030	3050x1500	8.4	Clayburn
K_CV60	$457,500	$256,800	$200,700	2034	3050x1500	14.3	Clayburn
Culvert at Old Yale Rd on Arnold Slough	$432,500	$341,675	$90,825	2041	3000x2700	13.1	Sumas
Channel Upgrades							
Farm Bridge Upgrade	$225,417	$0	$225,417	2029	N/A	N/A	Clayburn backwatered
Urban Creek Stabilization							
T7_183	$36,204	$0	$36,204	2032	N/A	N/A	Marshall
Horn_BOA_BioEngineering	$11,121	$0	$11,121	2032	N/A	N/A	Willband
Horn_BOA_Sediment Trap/Basin	$77,848	$0	$77,848	2032	N/A	N/A	Willband
Downes Erosion 8 sites	$151,370	$0	$151,370	2032	N/A	N/A	Downes
Clayburn Erosion Sites	$53,728	$0	$53,728	2033	N/A	N/A	Clayburn
Detention Pond							
P2	$85,965	$85,965	$0	2035	N/A	N/A	Clayburn
P3					N/A	N/A	Clayburn
P31					N/A	N/A	Clayburn (Stoney)
P32					N/A	N/A	Clayburn (Stoney)
Pond Y	$1,005,191	$0	$1,005,191	2041	N/A	N/A	Downes
Pond Z	$5,061,431	$0	$5,061,431	2042	N/A	N/A	Downes
Miscellaneous							
Barrowtown PS - Backup Power (construction)	$4,131,290	$4,131,290	$0	2040	N/A	N/A	Barrowtown PS
Barrowtown PS - Upgrades (pump head)	$1,750,000	$1,750,000	$0	2040	N/A	N/A	Barrowtown PS
OtherPS - Backup Powder (construction)	$3,079,120	$3,079,120	$0	2040	N/A	N/A	Matsqui Dike

Table C3: Updated Project Cost and Initiation Time

Project List	Project Cost	Capital Cost	DCC Cost	Initiation Time	Conduit Size (2016 OCP)	Conduit Length	Catchment
100% DCC Projects							
Storm Sewers							
MARSHALL_16	$71,400	$0	$71,400	time of development	1350	10.8	Marshall
MARSHALL_12	$34,200	$0	$34,200	time of development	750	3	Marshall
MARSHALL_14	$397,800	$0	$397,800	time of development	1200	140.8	Marshall
MARSHALL_15	$311,300	$0	$311,300	time of development	1200	107.8	Marshall
MARSHALL_18	$269,100	$0	$269,100	time of development	1200	91.7	Marshall
K_1370E10	$146,600	$0	$146,600	time of development	300	102.2	Clayburn
K_1418E10	$58,800	$0	$58,800	time of development	250	73.7	Clayburn
MARSHALL_17	$153,700	$0	$153,700	time of development	600	69.5	Marshall
MARSHALL_22	$58,700	$0	$58,700	time of development	1200	11.4	Marshall
MARSHALL_21	$81,400	$0	$81,400	time of development	900	22.5	Marshall
K_1009F10	$123,200	$0	$123,200	time of development	375	83.1	Clayburn
K_989E10	$33,600	$0	$33,600	time of development	200	23.8	Clayburn
K_1904E10	$23,400	$0	$23,400	time of development	200	3.6	Clayburn
MARSHALL_19	$100,900	$0	$100,900	time of development	750	40.1	Marshall
MARSHALL_20	$116,000	$0	$116,000	time of development	450	77.2	Marshall
K_13E11	$83,500	$0	$83,500	time of development	525	44.7	Clayburn
K_33E11	$78,600	$0	$78,600	time of development	600	27.7	Clayburn
K_11E11	$101,700	$0	$101,700	time of development	525	59.6	Clayburn
K_70E12	$81,500	$0	$81,500	time of development	375	49.0	Clayburn
K_131E12	$46,600	$0	$46,600	time of development	675	9.9	Clayburn
K_133E12	$102,200	$0	$102,200	time of development	600	40.8	Clayburn
K_137E12	$38,800	$0	$38,800	time of development	675	5.6	Clayburn
K_869E11	$45,000	$0	$45,000	time of development	450	19.1	Clayburn
K_1711E11	$46,900	$0	$46,900	time of development	450	20.7	Clayburn
K_1340E10	$46,600	$0	$46,600	time of development	300	20.4	Clayburn
K_1903E10	$37,500	$0	$37,500	time of development	250	31.5	Clayburn
K_1448E10	$55,400	$0	$55,400	time of development	375	27.6	Clayburn
K_21E12	$98,800	$0	$98,800	time of development	450	63.1	Clayburn
K_19E11	$40,200	$0	$40,200	time of development	250	36.8	Clayburn
K_7F12	$61,100	$0	$61,100	time of development	375	32.3	Clayburn
K_8F12	$99,400	$0	$99,400	time of development	375	63.6	Clayburn
K_27E12	$67,400	$0	$67,400	time of development	450	37.4	Clayburn
K_51E12	$82,600	$0	$82,600	time of development	375	49.9	Clayburn
K_37E12	$73,600	$0	$73,600	time of development	375	42.5	Clayburn
K_38E12	$73,200	$0	$73,200	time of development	375	42.1	Clayburn
K_36E12	$122,300	$0	$122,300	time of development	375	82.3	Clayburn
Culverts and Bridges							
MARSHALL_C13	$786,800	$0	$786,800	time of development	2100	16	Marshall
MARSHALL_C14	$339,600	$0	$339,600	time of development	1200	140.8	Marshall
MARSHALL_C15	$360,600	$0	$360,600	time of development	1200	107.8	Marshall
MARSHALL_C16	$380,200	$0	$380,200	time of development	1350	10.8	Marshall
MARSHALL_C17	$116,100	$0	$116,100	time of development	600	69.5	Marshall
K_CV45	$903,000	$0	$903,000	time of development	2100	60.9	Clayburn
K_CV49	$784,400	$0	$784,400	time of development	2400	51.2	Clayburn
K_CV50	$191,700	$0	$191,700	time of development	1200	16.5	Clayburn

Table C3: Updated Project Cost and Initiation Time

Project List	Project Cost	Capital Cost	DCC Cost	Initiation Time	Conduit Size (2016 OCP)	Conduit Length	Catchment
100% DCC Projects							
Culverts and Bridges							
K_CV37	$490,900	$0	$490,900	time of development	2400	25.5	Clayburn
K_CV117	$791,500	$0	$791,500	time of development	2100	61.4	Clayburn
K_CV84	$593,800	$0	$593,800	time of development	3400	17.6	Clayburn
K_VL57_BDG	$837,700	$0	$837,700	time of development	3400	31.3	Clayburn
K_CV83	$402,700	$0	$402,700	time of development	3600x2100	15.1	Clayburn
K_CV86	$291,400	$0	$291,400	time of development	2400x2100	10.0	Clayburn
K_VL51_BDG.1	$325,600	$0	$325,600	time of development	3600x1800	12.6	Clayburn
K_CV113	$634,200	$0	$634,200	time of development	2400	38.0	Clayburn
K_CV115	$567,700	$0	$567,700	time of development	1800	51.0	Clayburn

Note: Refer to Table C2 in the Appendix C for the construction cost index inflation factor.

Appendix D

Estimate of Project Costs for Unstudied Areas

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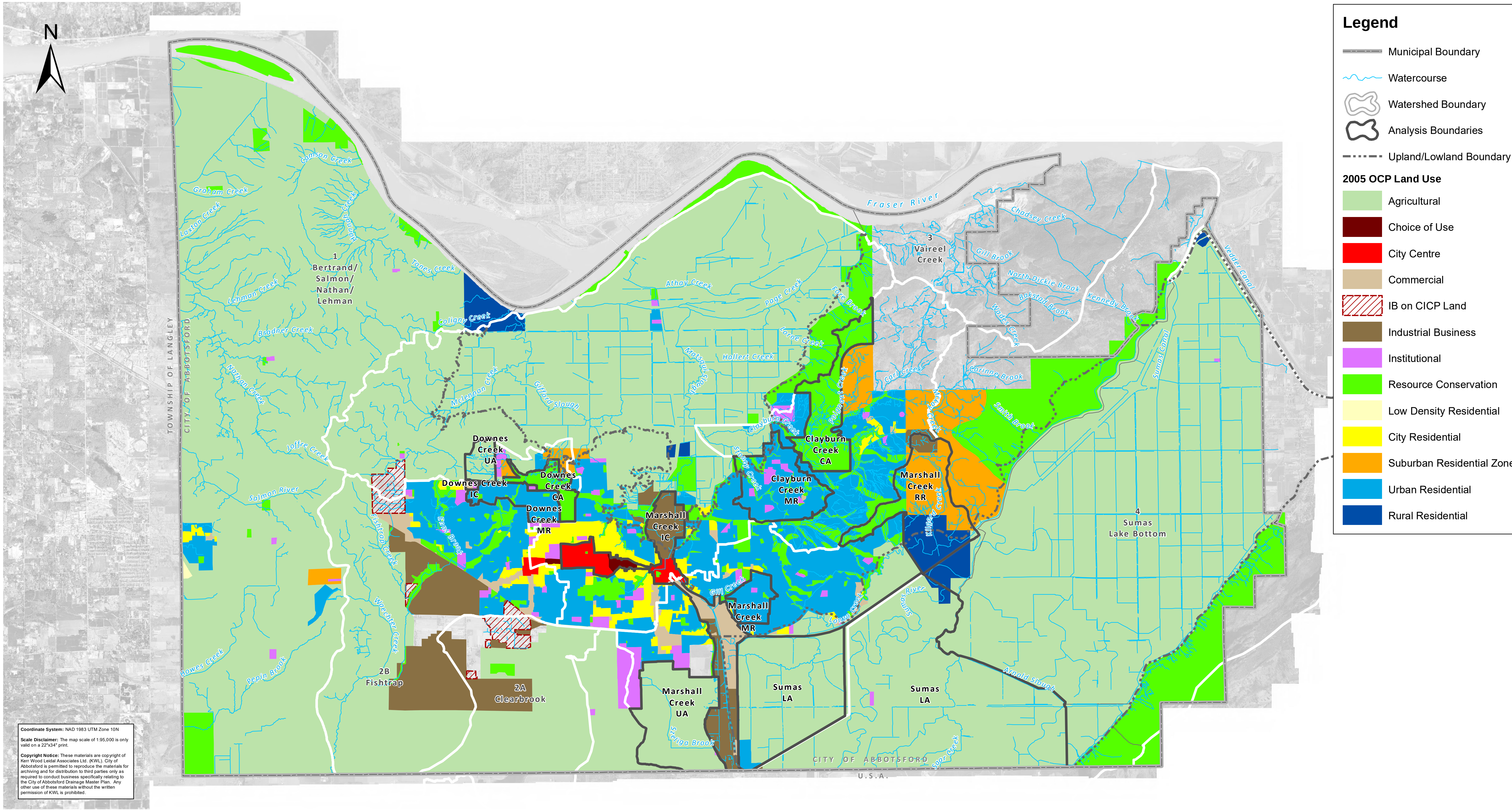
City of Abbotsford
Drainage Master Plan

KERR WOOD LEIDAL
consulting engineers



Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:95,000 is only valid on a 22"x34" print.

Project No. 510.152
Date June 2018
Scale 1:95,000

Studied/Unstudied Area Boundaries

Figure D1

Table D1: Drainage Density Calculation for Studied and Unstudied Areas

Sub-Catchment	Selected Land Use Area (2005 OCP)	Density				
		Storm Sewer (m/ha)	Ditch (m/ha)	Stream (m/ha)	Detention (unit/ha)	Culvert (unit/ha)
Studied Areas						
Clayburn Creek	Mixed Residential Area	121	2	19	0.17	0.05
	Conservation Area	3	6	76	0.02	0.06
Marshall Creek	Rural Residential	2	20	58	0.01	0.15
	Industrial /Commercial Area	93	7	41	0.30	0.19
	Mixed Residential Area	138	0	1	0.08	0.00
	Upland Agriculture	7	0	11	0.01	0.06
Downes Creek	Upland Agriculture	1	48	55	0.00	0.11
	Mixed Residential Area	158	0	1	0.04	0.01
	Institutional/Com	157	0	23	0.27	0.00
	Conservation Area	33	6	75	0.05	0.00
Sumas Prairie	Lowland Agricultural	2	15	12	0.00	0.07
Un-Studied Areas						
Bertrand / Salmon / Nathan / Mt. Lehman Creek	Mixed Residential	129	0	10	0.35	0.17
		30	0	15	0.05	0.62
		19	0	0	0.21	0.46
	Upland Agricultural	1	0	23	0.00	0.08
	Conservation	5	0	27	0.03	0.13
	Industrial / Institutional	27	0	0	0.11	0.74
		75	0	0	0.35	0.39

Sub-Catchment	Selected Land Use Area (2005 OCP)	Density				
		Storm Sewer (m/ha)	Ditch (m/ha)	Stream (m/ha)	Detention (unit/ha)	Culvert (unit/ha)
Un-Studied Areas						
Clearbrook Rd	Upland Agricultural	1	0	0	0.00	0.02
	Mixed Residential	428	0	0	0.00	0.00
		66	0	0	2.51	0.00
	Conservation	16	0	0	0.05	0.00
	Commercial / Industrial / Institutional	104	0	11	0.96	0.08
		15	0	0	0.00	0.19
		32	2	11	0.11	0.07
Fish Trap Creek	Mixed Residential	138	0	6	0.10	0.04
		97	0	0	0.10	0.04
		109	0	2	0.42	0.04
	Upland Agricultural	1	0	17	0.01	0.08
	Conservation	50	2	62	0.20	0.30
	Industrial / Institutional / Commercial	158	1	12	0.42	0.03
		82	2	7	0.29	0.08
		71	0	11	0.33	0.11
Vaireel Creek	Rural Residential	0	0	49	0.00	0.00
	Mixed Residential	1	0	103	0.01	0.00
	Upland Agricultural	0	0	51	0.00	1.45
	Conservation Area	0	0	38	0.00	0.04
Sumas Lake Bottom Area	Lowland Agricultural	0	27	6	0.00	0.12
	Lowland Residential	0	10	30	0.00	0.06
	Conservation	0	1	35	0.00	0.01
	Institutional/COU	7	32	0	0.00	0.33

Appendix E

Project Prioritization

Table E1: Project Rating and Prioritization Score (by Project)

Project Type / List	Pipe / Culvert ID	Catchment	Technical Rating	Urgency	Risk / Consequence	Urban Containment Boundary	Community Impacts	Economic Impacts	Environmental / Agricultrual Impact	Total Score
Storm Sewer Upgrades										
K_860E11		Clayburn	5	5	5	5	2	2	N/A	**4.4**
K_527E11		Clayburn	5	4	5	5	2	3	N/A	**4.3**
K_525E11		Clayburn	5	3	5	5	2	1	N/A	**3.9**
K_517E11		Clayburn	5	1	5	5	2	3	N/A	**3.7**
K_526E11		Clayburn	5	2	5	5	2	1	N/A	**3.7**
K_268E11		Clayburn	5	1	5	5	2	2	N/A	**3.6**
K_517E10		Clayburn	3	5	4	5	2	2	N/A	**3.6**
K_1407E10		Clayburn	3	5	4	5	2	2	N/A	**3.6**
K_1884E10		Clayburn	3	5	4	5	2	2	N/A	**3.6**
K_420E11		Clayburn	3	5	4	5	2	1	N/A	**3.5**
K_518E10		Clayburn	3	4	4	5	2	3	N/A	**3.5**
K_959E10		Clayburn	3	5	4	5	2	1	N/A	**3.5**
K_943E10		Clayburn	3	5	4	5	2	1	N/A	**3.5**
K_945E10		Clayburn	3	5	4	5	2	1	N/A	**3.5**
K_948E10		Clayburn	3	5	4	5	2	1	N/A	**3.5**
K_947E10		Clayburn	3	5	4	5	2	1	N/A	**3.5**
K_967E10		Clayburn	3	5	4	5	2	1	N/A	**3.5**
K_1262F10		Clayburn	3	4	4	5	2	3	N/A	**3.5**
K_1938E10		Clayburn	3	5	4	5	2	1	N/A	**3.5**
K_1941E10		Clayburn	3	5	4	5	2	1	N/A	**3.5**
K_1772E10		Clayburn	3	5	4	5	2	1	N/A	**3.5**
K_1095E10		Clayburn	3	5	4	5	2	1	N/A	**3.5**
K_1100E10		Clayburn	3	5	4	5	2	1	N/A	**3.5**
K_908E11		Clayburn	3	5	4	5	2	1	N/A	**3.5**
K_1309E11		Clayburn	3	5	4	5	2	1	N/A	**3.5**
K_111E12		Clayburn	3	5	4	5	1	1	N/A	**3.4**
K_388F12		Clayburn	3	5	4	5	1	1	N/A	**3.4**
K_386F12		Clayburn	3	5	4	5	1	1	N/A	**3.4**
K_370F12		Clayburn	3	5	4	5	1	1	N/A	**3.4**
K_511E10		Clayburn	3	4	4	5	2	2	N/A	**3.4**
K_2342F10		Clayburn	3	5	4	5	1	1	N/A	**3.4**
K_2358F10		Clayburn	3	5	4	5	1	1	N/A	**3.4**
K_1710E11		Clayburn	3	4	4	5	2	2	N/A	**3.4**
K_1713E11		Clayburn	3	4	4	5	2	2	N/A	**3.4**
K_6F12		Clayburn	3	5	4	5	1	1	N/A	**3.4**
K_5F12		Clayburn	3	5	4	5	1	1	N/A	**3.4**
K_1416E10		Clayburn	3	4	4	5	2	2	N/A	**3.4**
K_1408E10		Clayburn	3	4	4	5	2	2	N/A	**3.4**
K_1141F11		Clayburn	3	5	4	5	1	1	N/A	**3.4**
K_1885E10		Clayburn	3	4	4	5	2	2	N/A	**3.4**

Project Type / List	Pipe / Culvert ID	Catchment	Technical Rating	Urgency	Risk / Consequence	Urban Containment Boundary	Community Impacts	Economic Impacts	Environmental / Agricultrual Impact	Total Score
Storm Sewer Upgrades										
K_481E10		Clayburn	3	5	4	1	2	3	N/A	**3.3**
K_374F12		Clayburn	3	4	4	5	1	2	N/A	**3.3**
K_930E10		Clayburn	3	4	4	5	2	1	N/A	**3.3**
K_940E10		Clayburn	3	4	4	5	2	1	N/A	**3.3**
K_927E10		Clayburn	3	4	4	5	2	1	N/A	**3.3**
K_929E10		Clayburn	3	4	4	5	2	1	N/A	**3.3**
K_1102E10		Clayburn	3	4	4	5	2	1	N/A	**3.3**
K_1648E11		Clayburn	3	4	4	5	1	2	N/A	**3.3**
K_2351F10		Clayburn	3	4	4	5	1	1	N/A	**3.2**
K_2350F10		Clayburn	3	4	4	5	1	1	N/A	**3.2**
K_2349F10		Clayburn	3	4	4	5	1	1	N/A	**3.2**
K_519E10		Clayburn	3	3	4	5	2	2	N/A	**3.2**
K_4F12		Clayburn	3	4	4	5	1	1	N/A	**3.2**
K_1312E11		Clayburn	3	3	4	5	2	2	N/A	**3.2**
K_975E10		Clayburn	3	3	4	5	2	1	N/A	**3.1**
K_980E10		Clayburn	3	3	4	5	2	1	N/A	**3.1**
K_946E10		Clayburn	3	3	4	5	2	1	N/A	**3.1**
K_901E11		Clayburn	3	3	4	5	2	1	N/A	**3.1**
K_520E10		Clayburn	3	2	4	5	2	2	N/A	**3.0**
K_1267F10		Clayburn	3	5	4	1	1	1	N/A	**3.0**
K_1266F10		Clayburn	3	5	4	1	1	1	N/A	**3.0**
K_1271F10		Clayburn	3	5	4	1	1	1	N/A	**3.0**
K_1269F10		Clayburn	3	5	4	1	1	1	N/A	**3.0**
K_1306E11		Clayburn	3	2	4	5	2	1	N/A	**2.9**
K_1010F10		Clayburn	3	4	4	1	2	1	N/A	**2.9**
K_400E11		Clayburn	3	2	4	5	2	1	N/A	**2.9**
K_1709E11		Clayburn	3	1	4	5	2	2	N/A	**2.8**
K_514E10		Clayburn	3	1	4	5	2	2	N/A	**2.8**
K_1270F10		Clayburn	3	4	4	1	1	1	N/A	**2.8**
K_371F12		Clayburn	3	1	4	5	1	2	N/A	**2.7**
K_684F12		Clayburn	3	1	4	5	1	2	N/A	**2.7**
K_72F12		Clayburn	3	1	4	5	1	2	N/A	**2.7**
K_1307E11		Clayburn	3	1	4	5	2	1	N/A	**2.7**
K_907E11		Clayburn	3	1	4	5	2	1	N/A	**2.7**
K_1775E10		Clayburn	3	1	4	5	2	1	N/A	**2.7**
K_1092E10		Clayburn	3	1	4	5	2	1	N/A	**2.7**
K_1140F11		Clayburn	3	1	4	5	1	1	N/A	**2.6**
K_1272F10		Clayburn	3	3	4	1	1	1	N/A	**2.6**
K_1268F10		Clayburn	3	3	4	1	1	1	N/A	**2.6**
K_1036F10		Clayburn	3	3	4	1	1	1	N/A	**2.6**
K_2347F10		Clayburn	3	1	4	5	1	1	N/A	**2.6**

Project Type / List	Pipe / Culvert ID	Catchment	Technical Rating	Urgency	Risk / Consequence	Urban Containment Boundary	Community Impacts	Economic Impacts	Environmental / Agricultrual Impact	Total Score
Storm Sewer Upgrades										
K_480E10		Clayburn	3	1	4	1	2	3	N/A	**2.5**
K_1246E11		Clayburn	1	5	3	5	2	2	N/A	**2.8**
K_1352E11		Clayburn	1	4	3	5	2	1	N/A	**2.5**
K_387E11		Clayburn	1	4	3	5	2	1	N/A	**2.5**
K_453E11		Clayburn	1	4	3	5	2	1	N/A	**2.5**
K_1843E10		Clayburn	1	2	3	5	2	3	N/A	**2.3**
K_199E11		Clayburn	1	3	3	5	2	1	N/A	**2.3**
K_1361E11		Clayburn	1	3	3	5	2	1	N/A	**2.3**
K_1235F11		Clayburn	1	2	3	5	2	3	N/A	**2.3**
K_1068E10		Clayburn	1	3	3	5	2	1	N/A	**2.3**
K_745E11		Clayburn	1	2	3	5	2	1	N/A	**2.1**
K_454E11		Clayburn	1	2	3	5	2	1	N/A	**2.1**
K_446E11		Clayburn	1	2	3	5	2	1	N/A	**2.1**
K_1060F11		Clayburn	1	2	3	5	1	2	N/A	**2.1**
K_109E12		Clayburn	1	2	3	5	1	2	N/A	**2.1**
K_1362E11		Clayburn	1	1	3	5	2	2	N/A	**2.0**
K_1353E11		Clayburn	1	1	3	5	2	1	N/A	**1.9**
K_1360E11		Clayburn	1	1	3	5	2	1	N/A	**1.9**
K_1359E11		Clayburn	1	1	3	5	2	1	N/A	**1.9**
K_1358E11		Clayburn	1	1	3	5	2	1	N/A	**1.9**
K_1357E11		Clayburn	1	1	3	5	2	1	N/A	**1.9**
K_1370E10		Clayburn	1	4	1	1	2	1	N/A	**1.7**
K_1418E10		Clayburn	1	4	1	1	2	1	N/A	**1.7**
K_1009F10		Clayburn	1	3	1	1	2	1	N/A	**1.5**
K_989E10		Clayburn	1	3	1	1	2	1	N/A	**1.5**
K_1904E10		Clayburn	1	3	1	1	2	1	N/A	**1.5**
K_13E11		Clayburn	1	1	2	1	1	2	N/A	**1.3**
K_33E11		Clayburn	1	1	2	1	1	2	N/A	**1.3**
K_11E11		Clayburn	1	1	2	1	1	1	N/A	**1.2**
K_131E12		Clayburn	1	1	1	1	1	3	N/A	**1.2**
K_133E12		Clayburn	1	1	1	1	1	3	N/A	**1.2**
K_137E12		Clayburn	1	1	1	1	1	3	N/A	**1.2**
K_70E12		Clayburn	1	2	1	1	1	1	N/A	**1.2**
K_869E11		Clayburn	1	1	1	1	2	1	N/A	**1.1**
K_1711E11		Clayburn	1	1	1	1	2	1	N/A	**1.1**
K_1340E10		Clayburn	1	1	1	1	2	1	N/A	**1.1**
K_1903E10		Clayburn	1	1	1	1	2	1	N/A	**1.1**
K_1448E10		Clayburn	1	1	1	1	2	1	N/A	**1.1**
K_21E12		Clayburn	1	1	1	1	1	2	N/A	**1.1**
K_19E11		Clayburn	1	1	1	1	1	1	N/A	**1.0**
K_7F12		Clayburn	1	1	1	1	1	1	N/A	**1.0**

Project Type / List	Pipe / Culvert ID	Catchment	Technical Rating	Urgency	Risk / Consequence	Urban Containment Boundary	Community Impacts	Economic Impacts	Environmental / Agricultrual Impact	Total Score
Storm Sewer Upgrades										
K_8F12		Clayburn	1	1	1	1	1	1	N/A	**1.0**
K_27E12		Clayburn	1	1	1	1	1	1	N/A	**1.0**
K_51E12		Clayburn	1	1	1	1	1	1	N/A	**1.0**
K_37E12		Clayburn	1	1	1	1	1	1	N/A	**1.0**
K_38E12		Clayburn	1	1	1	1	1	1	N/A	**1.0**
K_36E12		Clayburn	1	1	1	1	1	1	N/A	**1.0**
DOWNES_PIPE_3B	904	Downes	3	5	4	1	1	3	N/A	**3.2**
DOWNES_PIPE_7B	38	Downes	3	3	4	5	1	3	N/A	**3.2**
DOWNES_PIPE_3C	NEW PIPE	Downes	3	5	0	5	1	5	N/A	**3.0**
DOWNES_PIPE_4	832	Downes	3	4	4	1	1	2	N/A	**2.9**
DOWNES_PIPE_7A	168	Downes	3	4	3	1	4	1	N/A	**2.9**
DOWNES_PIPE_2A	395	Downes	3	4	4	1	1	2	N/A	**2.9**
DOWNES_PIPE_5	1073	Downes	3	4	3	1	1	2	N/A	**2.7**
DOWNES_PIPE_3A	680	Downes	3	3	4	1	1	2	N/A	**2.7**
DOWNES_PIPE_7C	NEW PIPE	Downes	3	3	0	5	1	3	N/A	**2.4**
DOWNES_PIPE_2B	390	Downes	3	2	3	1	1	2	N/A	**2.3**
MARSHALL_1	32B10	Marshall	5	3	5	5	4	1	N/A	**4.1**
MARSHALL_16	951C11	Marshall	4	1	2	5	1	4	N/A	**2.8**
MARSHALL_12	75B8	Marshall	4	1	2	1	4	3	N/A	**2.6**
MARSHALL_14	953C11	Marshall	4	1	2	1	1	4	N/A	**2.4**
MARSHALL_15	960C11	Marshall	4	1	2	1	1	4	N/A	**2.4**
MARSHALL_4	131B10	Marshall	3	5	4	5	4	1	N/A	**3.7**
MARSHALL_3	1227A9	Marshall	3	4	4	5	4	2	N/A	**3.6**
MARSHALL_5	30C8	Marshall	3	5	4	5	1	2	N/A	**3.5**
MARSHALL_6	28C8	Marshall	3	5	4	5	1	2	N/A	**3.5**
MARSHALL_2	366C10	Marshall	3	5	4	5	1	1	N/A	**3.4**
MARSHALL_7	18C8	Marshall	3	4	4	5	1	2	N/A	**3.3**
MARSHALL_8	39C8	Marshall	3	4	4	5	1	1	N/A	**3.2**
MARSHALL_9	156B10	Marshall	2	3	3	5	4	2	N/A	**2.9**
MARSHALL_10	38B10	Marshall	2	3	3	5	4	1	N/A	**2.8**
MARSHALL_11	32B10	Marshall	1	3	3	5	4	1	N/A	**2.5**
MARSHALL_18	1107A10	Marshall	1	1	1	5	4	4	N/A	**2.0**
MARSHALL_17	1228A9	Marshall	1	1	1	5	4	1	N/A	**1.7**
MARSHALL_22	1558C11	Marshall	1	1	1	5	1	4	N/A	**1.7**
MARSHALL_21	959C11	Marshall	1	1	1	5	1	3	N/A	**1.6**
MARSHALL_19	37C8	Marshall	1	1	1	5	1	2	N/A	**1.5**
MARSHALL_20	12C8	Marshall	1	1	1	5	1	1	N/A	**1.4**

Project Type / List	Pipe / Culvert ID	Catchment	Technical Rating	Urgency	Risk / Consequence	Urban Containment Boundary	Community Impacts	Economic Impacts	Environmental / Agricultrual Impact	Total Score
Urban Culvert Upgrades										
K_CV140		Clayburn	5	5	5	5	1	4	5	**4.5**
K_CV76		Clayburn	5	3	5	5	1	5	5	**4.3**
K_CV2		Clayburn	5	5	5	5	2	1	5	**4.3**
K_CV221		Clayburn	5	5	5	1	1	5	5	**4.2**
K_CV193		Clayburn	5	5	5	1	1	5	5	**4.2**
K_CV48		Clayburn	5	4	5	5	2	1	5	**4.2**
K_CV44		Clayburn	5	1	5	5	2	5	5	**4.1**
K_CV116		Clayburn	5	2	5	5	1	3	5	**4.0**
K_CV211		Clayburn	5	1	5	5	1	5	5	**4.0**
K_CV52		Clayburn	5	1	5	5	1	5	5	**4.0**
K_CV224		Clayburn	5	1	5	5	2	3	5	**3.9**
K_CV133		Clayburn	5	4	5	1	1	3	5	**3.9**
K_CV46		Clayburn	5	1	5	5	1	3	5	**3.8**
K_CV135		Clayburn	5	1	5	1	1	4	5	**3.5**
K_CV45		Clayburn	4	1	2	5	2	5	5	**3.4**
K_CV49		Clayburn	4	1	2	5	2	5	5	**3.4**
K_CV50		Clayburn	4	1	2	5	2	5	5	**3.4**
K_CV37		Clayburn	4	1	2	5	2	5	5	**3.4**
K_CV117		Clayburn	4	1	2	5	1	5	5	**3.3**
K_CV84		Clayburn	4	1	2	5	1	5	5	**3.3**
K_VL57_BDG		Clayburn	4	1	2	5	1	5	5	**3.3**
K_CV83		Clayburn	4	1	2	5	1	5	5	**3.3**
K_CV86		Clayburn	4	1	2	5	1	5	5	**3.3**
K_VL51_BDG.1		Clayburn	4	1	2	5	1	5	5	**3.3**
K_CV113		Clayburn	4	1	2	1	1	5	5	**2.9**
K_CV115		Clayburn	4	1	2	1	1	5	5	**2.9**
K_CV42		Clayburn	3	5	4	5	2	3	5	**3.8**
Urban Culvert Upgrades										
K_CV89		Clayburn	3	2	4	5	2	5	5	**3.5**
K_CV60		Clayburn	3	2	4	1	2	5	5	**3.1**
MARSHALL_C7	CUL0152	Marshall	5	5	5	5	1	4	5	**4.5**
MARSHALL_C9	CUL0034.1	Marshall	5	5	5	5	4	4	1	**4.4**
MARSHALL_C5	CUL0108.1	Marshall	5	5	5	5	4	3	1	**4.3**
MARSHALL_C1	CUL0021.1	Marshall	5	5	5	5	4	3	1	**4.3**
MARSHALL_C2	CUL0053.1	Marshall	5	5	5	5	4	3	1	**4.3**
MARSHALL_C3	CUL0055.1	Marshall	5	5	5	5	4	3	1	**4.3**
MARSHALL_C4	CUL0090	Marshall	5	5	5	1	4	3	5	**4.3**
MARSHALL_C6	CUL0139	Marshall	5	2	5	5	1	5	5	**4.2**
MARSHALL_C11	CUL0088.1	Marshall	5	5	5	5	4	2	1	**4.2**
MARSHALL_C12	CUL0087.1	Marshall	5	4	5	5	4	3	1	**4.2**
MARSHALL_C8	CUL0162	Marshall	5	2	5	5	1	3	5	**4.0**

Project Type / List	Pipe / Culvert ID	Catchment	Technical Rating	Urgency	Risk / Consequence	Urban Containment Boundary	Community Impacts	Economic Impacts	Environmental / Agricultrual Impact	Total Score
Urban Culvert Upgrades										
MARSHALL_C10	CUL0077.1	Marshall	5	2	5	5	4	3	1	**3.9**
MARSHALL_C13	CUL0175.1	Marshall	4	5	2	5	1	3	1	**3.3**
MARSHALL_C14	CUL0024	Marshall	4	5	2	1	4	3	5	**3.6**
MARSHALL_C15	CUL0085.1	Marshall	4	5	2	5	4	5	1	**3.8**
MARSHALL_C16	CUL086.1	Marshall	4	5	2	5	4	5	1	**3.8**
MARSHALL_C17	CUL0150	Marshall	4	5	2	5	1	2	5	**3.6**
DOWNES_PIPE_6A	114998	Downes	5	4	5	1	4	3	5	**4.2**
DOWNES_PIPE_6C	893.1	Downes	5	5	5	1	4	2	5	**4.2**
DOWNES_PIPE_6B	902.1	Downes	5	5	5	1	4	1	5	**4.1**
DOWNES_PIPE_1	culv-1	Downes	5	5	5	1	1	4	1	**3.7**

Project Type / List	Pipe / Culvert ID	Catchment	Technical Rating	Urgency	Risk / Consequence	Urban Containment Boundary	Economic Consideration	Environmental Impact	Total Score
Detention Pond									
Pond A		Downes	5	3	5	5	5	5	**4.3**
Pond C		Downes	5	3	5	5	5	5	**4.3**
Pond G		Downes	5	3	5	1	3	5	**3.7**
Pond Y		Downes	1	1	5	1	1	1	**1.6**
Pond Z		Downes	1	1	1	5	1	1	**1.4**
P13		Clayburn (Stoney)	5	5	5	5	5	5	**4.6**
P14		Clayburn (Stoney)	5	5	5	5	5	5	**4.6**
P21		Clayburn (Stoney)	5	5	5	5	5	5	**4.6**
P40		Clayburn (Stoney)	5	5	5	5	5	5	**4.6**
P49		Clayburn (Stoney)	5	5	5	5	5	5	**4.6**
P50		Clayburn (Stoney)	5	5	5	5	5	5	**4.6**
P52 and P53		Clayburn (Stoney)	5	5	5	5	5	5	**4.6**
P20-1 and P20-2		Clayburn (Stoney)	5	5	5	5	5	5	**4.6**
P51		Clayburn (Stoney)	5	5	5	5	5	5	**4.6**
P47		Clayburn	3	3	5	5	5	5	**4.1**
P12		Clayburn (Stoney)	3	3	5	5	5	5	**3.7**
P18		Clayburn (Stoney)	3	3	5	5	5	5	**3.7**
P19-1, P19-2, P19-3		Clayburn (Stoney)	3	3	5	5	5	5	**3.7**
P24-1,P24-2, P24-3, P24-4		Clayburn (Stoney)	3	3	5	5	5	5	**3.7**
P26-1, P26-2		Clayburn (Stoney)	3	3	5	5	5	5	**3.7**
P36		Clayburn (Stoney)	3	3	5	5	5	5	**3.7**
P39-1, P39-2		Clayburn (Stoney)	3	3	5	5	5	5	**3.7**
P1		Clayburn	3	3	5	5	5	5	**3.7**
P2		Clayburn	1	3	5	5	5	1	**2.7**
P3		Clayburn	1	3	5	5	5	1	**2.7**
P31		Clayburn (Stoney)	1	3	5	5	5	1	**2.7**
P32		Clayburn (Stoney)	1	3	5	5	5	1	**2.7**

Project Type / List	Pipe / Culvert ID	Catchment	Technical Rating	Urgency	Risk / Consequence	Urban Containment Boundary	Economic Impacts	Agricultrual Impact	Total Score
Channel Upgrades									
Install Floodboxes	Clayburn Village	Matsqui/Clayburn Village	5	5	5	1	5	1	**3.7**
Install Flap gates	Clayburn Village	Matsqui/Clayburn Village	5	5	5	1	5	1	**3.7**
Construct North Berm Ch. 12710-12930, 0.5 m High Berms	Clayburn Village	Matsqui/Clayburn Village	5	5	5	1	3	1	**3.7**
Enlarge/Deepen Ch. 13323-13300	Clayburn Cr	Matsqui/Clayburn Creek	5	3	1	1	3	5	**3.1**
Enlarge/Deepen Ch. 13282-13086	Clayburn Cr	Matsqui/Clayburn Creek	5	3	1	1	3	5	**3.1**
Enlarge/Deepen Ch. 13076-12727	Clayburn Cr	Matsqui/Clayburn Creek	5	3	1	1	3	5	**3.1**
Enlarge/Deepen Ch. 12710-12574	Clayburn Cr	Matsqui/Clayburn Creek	5	3	1	1	3	5	**3.1**
Construct 100L/s Pump Station	Clayburn Village	Matsqui/Clayburn Village	5	3	3	1	3	1	**2.7**
Deepen Under Clayburn Bridge	Matsqui Sl	Matsqui Slough	5	3	1	1	5	5	**3.3**
Ch. 14284-14884	Matsqui Sl	Matsqui Slough	5	3	1	1	5	5	**3.3**
Enlarge/Deepen Ch. 14284-14212	Clayburn backwatered	Matsqui/Clayburn Creek	1	1	1	1	1	5	**1.7**
Enlarge/Deepen Ch. 14202-13825	Clayburn backwatered	Matsqui/Clayburn Creek	1	1	1	1	1	5	**1.7**
Enlarge/Deepen Ch. 13815-13333	Clayburn backwatered	Matsqui/Clayburn Creek	1	1	1	1	1	5	**1.7**
Farm Bridge Upgrade	Clayburn backwatered	Matsqui/Clayburn Creek	1	1	1	1	1	5	**1.7**
Rural Culvert Project List									
Culvert at Vye Rd on Saar Crk		Sumas	5	3	5	1	5	5	**3.9**
Culvert at Old Yale Rd on Arnold Slough		Sumas	1	1	3	1	3	5	**2.1**
Project Type / List	**Pipe / Culvert ID**	**Catchment**	**Technical Rating**	**Urgency**	**Risk / Consequence**	**Urban Containment Boundary**	**Economic Consideration**	**Environmental Impact**	**Total Score**
Bank Stabilization & Sediment Management									
Gill Creek Erosion Sites		Sumas Prairie	5	5	5	5	3	5	**4.8**
Fraser River at Matsqui		Fraser River	5	5	5	1	5	3	**4.4**
Horn Creek Bank Stabilization		Willband	5	3	5	5	1	5	**4.4**
T11_208		Marshall	5	5	3	5	5	3	**4.4**
T11_212		Marshall	5	5	3	5	5	3	**4.4**
T7_185		Marshall	5	5	3	5	5	5	**4.2**
T7_183		Marshall	5	3	3	5	5	5	**4.0**
Erosion at Matsqui Dyke from Erosion Arcs F & G		Matsqui	5	5	5	1	1	3	**4.0**
Clayburn Expand & Improve existing Dutra sediment trap		Clayburn	5	1	3	5	3	5	**4.0**
Prairie St Sediment Trap		Willband	5	1	3	5	5	3	**4.0**
Horn_BOA_BioEngineering		Willband	3	3	3	5	5	5	**3.4**
Horn_BOA_Sediment Trap/Basin		Willband	3	3	3	5	5	3	**3.2**
Horn Creek Storm Diversion		Willband	1	1	1	5	1	1	**1.4**
Clayburn Erosion Sites		Clayburn	1	1	1	3	5	3	**1.8**
Downes Erosion 8 sites		Downes	1	1	1	3	3	5	**1.8**
Project Type / List	**Pipe / Culvert ID**	**Catchment**	**Technical Rating**	**Urgency**	**Risk / Consequence**	**Urban Containment Boundary**	**Economic Impacts**	**Agricultrual Impact**	**Total Score**
Pump Station		**Catchment**							
Barrowtown PS - Upgrades		Sumas	1	1	1	1	1	5	**1.4**
Barrowtown PS - Backup Power		Sumas	1	1	1	1	1	5	**1.4**
Other Four PS - Backup Power		Matsqui	1	1	1	1	1	5	**1.4**

Appendix F

Dike Long Term Upgrades Cost Estimate

Table F1: Matsqui Dike Long-Term Upgrading Class D Cost Estimate

Item	Description	Unit	Unit Rate ($)	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Reach 7	Total	KWL Assumptions
				Cost ($)	Cost ($)	Cost ($)	Cost ($)	Cost ($)	Cost ($)	Cost ($)	Cost ($)	
Matsqui Dike												
General Dike Upgrade												
1.1	Dike Fill	lin.m	1,500	1,716,000	1,305,000	3,735,000	1,500,000	1,845,000	3,960,000	4,011,000	18,072,000	Unit rate is for 1 m dike raise based on previous dike upgrade projects along the Lower Fraser. The cost includes dike fill, crest surfacing, topsoil, and seeding. Cost increases in Reach 1 and Reach 3 to account for space limitations.
1.2	Utilities	L.S.	1	0	0	200,000	10,000	310,000	45,000	200,000	765,000	
1.3	Seepage Mitigation - Toe Berm	cu.m	70	728,000	0	0	0	861,000	0	1,871,800	3,460,800	Gravel toe berm where dike height >4m.
1.4	Seepage Mitigation - Fill	cu.m	40	0	1,052,000	944,000	1,260,000	1,080,000	2,424,000	1,808,000	8,568,000	1 m of fill in seepage and sand boil areas identified during freshet.
1.5	Access & Roads	sq.m	100	40,000	20,000	60,000	60,000	20,000	120,000	20,000	340,000	Includes 5% grade tie-ins to existing roads and assumes all roads paved.
1.6	Turnouts	cu.m	60	0	0	0	0	0	0	54,144	54,144	Turnout ramps (6m wide for 20 m with 15 m tapers on either side)
1.7	Rail Crossings	each	200,000	200,000	0	0	200,000	0	0	200,000	600,000	Manual flood gates at rail crossings.
1.8	Drainage	L.S.	1	0	0	0	0	0	0	0	-	Drainage includes ditch relocation if required and small floodboxes.
2.1	Bank Protection	lin.m	4,200	0	2,310,000	2,940,000	630,000	0	See reach 7	10,000,000	15,880,000	Reach 7 cost estimate is based on $10 million cost estimate the City is currently estimating for rock spur erosion mitigation as per NHC design (includes erosion arcs in Reach 6).
2.2	Habitat Mitigation and Compensation	L.S.	5% of above items	134,200	234,350	393,950	183,000	205,800	327,450	908,247	2,386,997	Estimated as 5% of total cost of items 1.1 to 1.8 and item 2.
3	Land Acquisition	sq.m	2	5,180	4,254	915	12,418	48	1,116	5,228	29,160	
4	Pump Stations	L.S.	NA	3,750,000	0	7,199,000	236,000	202,000	0	0	11,387,000	Pump station costs from Earthtec-AECOM 2008 *Drainage Pump Station PSAB 3150 Study* with 20% allowance for additional unaccounted items (decomissioning, fish-friendly pump station, water control).
SUBTOTAL CONSTRUCTION (ROUNDED)				6,573,380	4,925,604	15,472,865	4,091,418	4,523,848	6,877,566	19,078,419	61,543,000	
CONSTRUCTION CONTINGENCY 50%				3,286,690	2,462,802	7,736,433	2,045,709	2,261,924	3,438,783	9,539,210	30,771,500	
TOTAL CONSTRUCTION - EXCLUDING SEISMIC				**9,860,070**	**7,388,407**	**23,209,298**	**6,137,126**	**6,785,771**	**10,316,349**	**28,617,629**	**92,314,500**	
PROFESSIONAL SERVICES ALLOWANCE												
10% of Construction Cost				986,007	738,841	2,320,930	613,713	678,577	1,031,635	2,861,763	9,231,450	
TOTAL AMOUNT - EXCLUDING SEISMIC (excl. GST)				**10,846,077**	**8,127,247**	**25,530,228**	**6,750,839**	**7,464,349**	**11,347,984**	**31,479,392**	**101,545,950**	

Item	Description	Unit	Unit Rate ($)	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Reach 7	Total	KWL Assumptions
				Cost ($)	Cost ($)	Cost ($)	Cost ($)	Cost ($)	Cost ($)	Cost ($)	Cost ($)	
Seismic Performance Improvement												
Seismic Performance Improvement		cu.m	15	3,900,000	3,262,500	7,837,500	3,750,000	4,612,500	9,900,000	40,110	33,302,610	10 m strips of ground densification on each side of the dike to 12.5 m depth.
SEISMIC CONSTRUCTION CONTINGENCY 50%				1,950,000	1,631,250	3,918,750	1,875,000	2,306,250	4,950,000	20,055	16,651,305	
TOTAL SEISMIC CONSTRUCTION				**5,850,000**	**4,893,750**	**11,756,250**	**5,625,000**	**6,918,750**	**14,850,000**	**60,165**	**49,953,915**	
PROFESSIONAL SERVICES ALLOWANCE												
10% of Construction Cost				585,000	489,375	1,175,625	562,500	691,875	1,485,000	6,017	4,995,392	
TOTAL SEISMIC AMOUNT (excl. GST)				**6,435,000**	**5,383,125**	**12,931,875**	**6,187,500**	**7,610,625**	**16,335,000**	**66,182**	**54,949,307**	
Grand Total with Seismic Performance Improvement												
TOTAL AMOUNT WITH SEISMIC (excl. GST) ROUNDED				**17,281,077**	**13,510,372**	**38,462,103**	**12,938,339**	**15,074,974**	**27,682,984**	**31,545,574**	**156,495,000**	

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Table F2: Vedder Dike Long-Term Upgrading Class D Cost Estimate

Item	Description	Unit	Unit Rate ($)	Reach 1 Cost ($)	Reach 2 Cost ($)	Reach 3 Cost ($)	Total Cost ($)	KWL Assumptions
Vedder Dike								
General Dike Upgrade								
1.1	Dike Fill	lin.m	1,500	3,930,000	2,610,000	561,000	7,101,000	Unit rate is for 1 m dike raise based on previous dike upgrade projects along the Lower Fraser. The cost includes dike fill, crest surfacing, topsoil, and seeding.
1.2	Utilities	each	1	0	0	0	-	
1.3	Seepage Mitigation - Toe Berm	cu.m	70	1,834,000	1,218,000	154,000	3,206,000	Gravel toe berm where dike height >4m.
1.4	Seepage Mitigation - Fill	cu.m	40	0	0	0	-	No noted seepage locations.
1.5	Access & Roads	sq.m	100	210,000	90,000	30,000	330,000	Includes 5% grade tie-ins to existing roads and assumes all roads paved.
1.6	Turnouts	cu.m	60	150,522	67,878	0	218,400	Turnout ramps (6m wide for 20 m with 15 m tapers on either side)
1.7	Rail Crossings	each	200,000	0	0	0	-	
1.8	Drainage	lin.m	NA	0	0	0	-	Drainage includes ditch relocation if required and small floodboxes.
2.1	Bank Protection	lin.m	420	1,100,400	730,800	0	1,831,200	Assuming 100% of Vedder dike canal/river slope will have riprap bank protection 0.5 m thick at 2H:1V slope.
2.2	Habitat Mitigation and Compensation	L.S.	5% of above items	361,246	235,834	37,250	634,330	Estimated as 5% of total cost of items 1.1 to 1.8 and item 2.
3	Land Acquisition	sq.m	2	0	0	0	-	
4	Pump Stations	L.S.	NA	0	0	27,352,000	27,352,000	Pump station costs from Earthtec-AECOM 2008 *Drainage Pump Station PSAB 3150 Study* with 20% allowance for additional unaccounted items (decomissioning, fish-friendly pump station, water control).
SUBTOTAL CONSTRUCTION (ROUNDED)				7,586,168	4,952,512	28,134,250	40,673,000	
CONSTRUCTION CONTINGENCY (50%)				3,793,084	2,476,256	14,067,125	20,336,500	
TOTAL CONSTRUCTION - EXCLUDING SEISMIC				**11,379,251**	**7,428,768**	**42,201,375**	**61,009,500**	
PROFESSIONAL SERVICES ALLOWANCE								
10% of Construction Cost				1,137,925	742,877	4,220,138	6,100,950	
TOTAL AMOUNT - EXCLUDING SEISMIC (excl. GST)				**12,517,177**	**8,171,645**	**46,421,513**	**67,110,450**	

Item	Description	Unit	Unit Rate ($)	Reach 1 Cost ($)	Reach 2 Cost ($)	Reach 3 Cost ($)	Total Cost ($)	KWL Assumptions
Seismic Performance Improvement								
Seismic Performance Improvement		cu.m	15	9,825,000	6,525,000	825,000	17,175,000	10 m strips of ground densification on each side of the dike to 12.5 m depth.
SEISMIC CONSTRUCTION CONTINGENCY 50%				4,912,500	3,262,500	412,500	8,587,500	
TOTAL SEISMIC CONSTRUCTION				**14,737,500**	**9,787,500**	**1,237,500**	**25,762,500**	
PROFESSIONAL SERVICES ALLOWANCE								
10% of Construction Cost				1,473,750	978,750	123,750	2,576,250	
TOTAL SEISMIC AMOUNT (excl. GST)				**16,211,250**	**10,766,250**	**1,361,250**	**28,338,750**	
Grand Total with Seismic Performance Improvement								
TOTAL AMOUNT WITH SEISMIC (excl. GST) ROUNDED				**28,728,427**	**18,937,895**	**47,782,763**	**95,449,000**	

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Table F3: Sumas Dike Long-Term Upgrading Class D Cost Estimate

Item	Description	Unit	Unit Rate ($)	Reach 1 Cost ($)	Reach 2 Cost ($)	Reach 3 Cost ($)	Reach 4 Cost ($)	Reach 5 Cost ($)	Reach 6 Cost ($)	Reach 7 Cost ($)	Total Cost ($)	KWL Assumptions
Sumas Dike												
General Dike Upgrade												
1.1	Dike Fill	lin.m	1,500	5,820,000	3,180,000	2,040,000	3,840,000	4,320,000	6,055,500	411,000	25,666,500	Unit rate is for 1 m dike raise based on previous dike upgrade projects along the Lower Fraser. The cost includes dike fill, crest surfacing, topsoil, and seeding. Minor cost increase in Reach 6 to account for space limitations.
1.2	Utilities	L.S.	1	65,000	0	250,000	75,000	0	0	0	390,000	
1.3	Seepage Mitigation - Toe Berm	cu.m	70	0	0	0	0	0	0	0	-	Gravel toe berm where dike height >4m.
1.4	Seepage Mitigation - Fill	cu.m	40	0	0	0	0	0	0	0	-	No noted seepage locations.
1.5	Access & Roads	sq.m	100	112,000	0	70,000	42,000	14,000	42,000	14,000	294,000	Includes 5% grade tie-ins to existing roads and assumes all roads paved.
1.6	Turnouts	cu.m	60	83,340	39,753	0	41,307	98,809	97,499	0	360,708	Turnout ramps (6m wide for 20 m with 15 m tapers on either side)
1.7	Rail Crossings	each	200,000	0	0	0	0	0	0	0	-	
1.8	Drainage	L.S.	1	204,000	96,000	157,000	124,000	0	124,000	0	705,000	Drainage includes replacement of several small floodboxes.
2.1	Bank Protection	lin.m	735	0	1,385,067	199,920	1,724,800	1,693,440	1,798,300	0	6,801,527	Assuming bank protection not required for Arnold Slough Reach 1.
2.2	Habitat Mitigation and Compensation	L.S.	5% of above items	314,217	235,041	135,846	292,355	306,312	405,865	21,250	1,710,887	Estimated as 5% of total cost of items 1.1 to 1.8 and item 2.
3	Land Acquisition	sq.m	2	85,698	50,010	17,112	36,034	41,683	68,097	0	298,633	
4	Pump Stations	L.S.	NA	0	0	0	0	0	0		-	Pump station costs from Earthtec-AECOM 2008 *Drainage Pump Station PSAB 3150 Study* with 20% allowance for additional unaccounted items (decomissioning, fish-friendly pump station, water control).
SUBTOTAL CONSTRUCTION (ROUNDED)				6,684,255	4,985,871	2,869,878	6,175,496	6,474,244	8,591,261	446,250	36,227,000	
CONSTRUCTION CONTINGENCY (50%)				3,342,127	2,492,935	1,434,939	3,087,748	3,237,122	4,295,630	223,125	18,113,500	
TOTAL CONSTRUCTION - EXCLUDING SEISMIC				**10,026,382**	**7,478,806**	**4,304,817**	**9,263,244**	**9,711,367**	**12,886,891**	**669,375**	**54,340,500**	
PROFESSIONAL SERVICES ALLOWANCE												
10% of Construction Cost				**1,002,638**	**747,881**	**430,482**	**926,324**	**971,137**	**1,288,689**	**66,938**	**5,434,050**	
TOTAL AMOUNT - EXCLUDING SEISMIC (excl. GST)				**11,029,020**	**8,226,686**	**4,735,298**	**10,189,569**	**10,682,503**	**14,175,580**	**736,313**	**59,774,550**	

Item	Description	Unit	Unit Rate ($)	Reach 1 Cost ($)	Reach 2 Cost ($)	Reach 3 Cost ($)	Reach 4 Cost ($)	Reach 5 Cost ($)	Reach 6 Cost ($)	Reach 7 Cost ($)	Total Cost ($)	KWL Assumptions
Seismic Performance Improvement												
Seismic Performance Improvement		cu.m	15	14,550,000	7,950,000	5,100,000	9,600,000	10,800,000	13,762,500	450,000	62,212,500	10 m strips of ground densification on each side of the dike to 12.5 m depth.
SEISMIC CONSTRUCTION CONTINGENCY 50%				7,275,000	3,975,000	2,550,000	4,800,000	5,400,000	6,881,250	225,000	31,106,250	
TOTAL SEISMIC CONSTRUCTION				**21,825,000**	**11,925,000**	**7,650,000**	**14,400,000**	**16,200,000**	**20,643,750**	**675,000**	**93,318,750**	
PROFESSIONAL SERVICES ALLOWANCE												
10% of Construction Cost				2,182,500	1,192,500	765,000	1,440,000	1,620,000	2,064,375	67,500	9,331,875	
TOTAL SEISMIC AMOUNT (excl. GST)				**24,007,500**	**13,117,500**	**8,415,000**	**15,840,000**	**17,820,000**	**22,708,125**	**742,500**	**102,650,625**	
Grand Total with Seismic Performance Improvement												
TOTAL AMOUNT WITH SEISMIC (excl. GST) ROUNDED				**35,036,520**	**21,344,186**	**13,150,298**	**26,029,569**	**28,502,503**	**36,883,705**	**1,478,813**	**162,425,000**	

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Appendix G

Stormwater Criteria

Table G1: Comparison of Adjacent Jurisdiction Stormwater Management Criteria

Category	City of Maple Ridge	Township & City of Langley	City of Surrey	City of Burnaby	Corp of Delta
Flood and Erosion Protection					
Minor Drainage System	1:10-year event[1]	1 in 5-year storm[1] 1 in 10-year storm [4]	• 1:5-year event[1]	• 1:10-year event.[1]	1:10-year event typically.[1] 1:5-year for low density residential areas; 1:25-year for high value comm / ind dev.[1]
Major Drainage System	1:100-year event[1]	1 in 100-year storm[1,4]	• 1:100-year event[1]	• 1:100-year event.[1]	1:100-year event for floodway routing.[1] 1:25-year for dyked or reclaimed land.[1]
Lowland		ARDSA[5]	ARDSA[2]		ARDSA[2]
Environmental Protection					
Volume Reduction	< 50% Mean Annual Rainfall (MAR)[1] 25 mm in 24 hours infiltration facilities	25 mm in 24 hours infiltration facilities[1]			
Rate Control - Control post-development flows to pre-development levels	Control runoff from larger events – From 50% of MAR to MAR[1] Minor storm released at the 1:2-year pre-development rate. [1] Major system release at the 1:10-year pre-development rate for upland areas.[1]	1 in 2-year, 1 in 5-year, 1 in 100-year events.[1] 1:1:2-year & 1:10-year for upland areas.[1] Limit post-development 1:2-year design storm to 50% of the 1:2-year natural peak flow.	The more stringent of:[1] • 1:5-year post-development flow to 50% of the 1:2-year post development rate; or • 1:5-year post-development flow to 5-year pre-development flow rate	• 5-year storms.[1]	• On fish bearing stream, up to & including 10-year storm.[1]
Water Quality Treatment	TSS level must not be > 25 mg/L during dry weather & < 75 mg/L during wet season; turbidity levels must not be > 20 NTU, and the pH of water discharged should fall between 6.0 and 9.0.			• comply with City, federal, provincial and regional statutes and guidelines.[2,3]	
Erosion & Sediment Control	ESC Plan (Schedule C[2])	Lesser of turbidity of 25 NTU except within 24 hours of a significant rainfall event (meets or exceeds intensity of 25 mm in 24-hour period) at which time the turbidity can be up to 100 NTU [2]	Follow Erosion control BMPs (Appendix B[3])		
Riparian Setbacks		Class A watercourse, excluding Class A roadside watercourses, a min width of 30 m.[3] Class B natural watercourses, excluding Class B constructed & roadside watercourses, a min width of 15 m.[3] Agricultural Land Reserve lands are excluded from riparian setback.[3]	Land Development Guidelines for the Protection of Aquatic Habitat[4]	Protection of riparian areas in setbacks of 5 to 30 metres on either side of streams, subject to limitations.[4]	Delta Streamside Protection and Enhancement Areas Bylaw[3] and Riparian Areas Regulation.
Bylaws	1. City of Maple Ridge Design Criteria Manual, 2015 2. Maple Ridge Watercourse Protection Bylaw No. 6410 – 2006 3. Maple Ridge Official Community Plan Bylaw No. 7060-2014	1. Township of Langley Subdivision and Development Servicing Bylaw No. 4861, 2011 2. Township of Langley Erosion & Sediment Control Bylaw No. 4381, 2006 3. Township of Langley OCP Bylaw No. 1842, 1979 & Amendment (Streamside Protection) Bylaw No. 4485, 2006 4. City of Langley Subdivision and Development Servicing Bylaw, 2008, No. 2744. 5. ARDSA = Agriculture and Rural Development Subsidiary Agreement.	1. City of Surrey, Engineering Department, Design Criteria Manual, 2016. 2. ARDSA = Agriculture and Rural Development Subsidiary Agreement. 3. Erosion Control Bylaw, No 16138 4. DFO, Land Development Guidelines for the Protection of Aquatic Habitat, 1992	1. City of Burnaby Engineering Department Design Criteria Manual, 2014 2. Burnaby Rainwater Management Design Guidelines 3. Burnaby Watercourse Bylaw 1988 (Bylaw No. 9044) 4. Burnaby Zoning Bylaw 1965, Section 6 – Supplementary Regulations.	1. Corporation of Delta Stormwater Management Design Manual, February 1989, Revised January 1994. 2. ARDSA Agricultural Drainage Criteria, 2002 3. Corporation of Delta Development Permit Area to Establish Streamside Protection and Enhancement Areas Bylaw No. 6349, 2005.

Appendix H

Detention Facility Management

Table H1: Detention Pond Database

City ID	Project ID	Facility Type	Sub Type	Owner	Capitalization Date	House #	Street Name	GIS Volume (m^3)	GIS Volume Assumed	Infiltration System	Control Structure	Type of Control	Right of Way Plan #	As-Built	GIS Area (m^2)	As-Built or Report Facility Area (m^2)	Contributing Catchment Area (ha)	As-Built or Report Volume (m^3)	RIM Elev. (m)	Storage Invert (m)	Orifice Size (mm)	Orifice Invert (m)	Overflow Type	Overflow Width (m)	Max Water Level (m)	10yr Max Outflow (m^3/s)	100yr Max Outflow (m^3/s)	Unit Flow (m^3s)
Pond with Completed Detailed Studies																												
117454	A	Pond	Dry Pond	Municipal	6/30/1983	3700	QUALICUM ST	1061.0	No	No	No		66856	Yes	566.0	680.0	10.90									0.623	0.72	57.16
117439	B	Pond	Wet Pond	Private	6/30/1996	32250	DOWNES RD	1222.0	Yes	No	No		28081	Yes	1917.6	500.0	2.30									0.061	0.251	26.52
117453	C	Pond	Dry Pond	Municipal	6/30/1996	3680	CLEARBROOK RD	6680.0	No	No	No		N/A	Yes	6800.4	7300.0	31.25									0.823	0.885	26.34
117456	D	Pond	Dry Pond	Municipal	6/30/1992	3717	CLEARBROOK RD	770.0	Yes	Yes	No		N/A	Yes	1872.6	2300.0	1.00									2.403	2.611	2403.00
117429	E	Pond	Dry Pond	Private	6/30/2005	31655	DOWNES RD	7.0	No	No	No		NO	Yes	144.4													
117430	E	Pond	Dry Pond	Private	6/30/1997	31655	DOWNES RD	322.0	No	No	No		LMP36273	Yes	797.2													
117452	G	Pond	Dry Pond	Municipal	6/30/1997	31638	DOWNES RD	3802.0	No	No	No		NO	Yes	15506.9	3168.0	13.90									0.067	0.109	4.82
117463	H	Pond	Wet Pond	Private	6/30/1992	31445	RIDGEVIEW DR	3747.9	Yes	No	No		5455	Yes	2295.7	2600.0	6.70									0.008	0.009	1.19
117459	I	Pond	Playing Field or Rain Garden	Private	6/30/1992	31321	BLUERIDGE DR	1671.4	Yes	No	No		NO	No	1266.4	13200.0	3.00									0.017	0.03	5.67
117129	J	Tank	Chamber	Municipal	6/30/1999	31253	WAGNER DR	2517.0	No	No	Yes		40419	Yes	1433.1	1085.0	12.10									0.395	0.903	32.64
117457	K	Pond	Dry Pond	Municipal	6/30/1999	3600	TOWNLINE RD	3800.0	No	No	No		40341	Yes	1711.9	3800.0	4.30									0.019	0.098	4.42
117464	M	Pond	Playing Field or Rain Garden	Municipal	6/30/1985	3540	SPARWOOD ST	4260.0	Yes	No	No		N/A	No	8728.0	2000.0	13.80									0.984	1.163	71.30
117425	P1	Pond	Wet Pond	Municipal	6/30/2006	4401	BLAUSON BLVD	4650.0	No	No	No	Flow Control Manhole	NO	Yes	2899.9	2899.9	9.94	9995.2	151.7		115	148.0	Pipe	0.375	151.7		0.079	7.95
117443	P10-1	Pond	Playing Field	Private	6/30/1989	3836	OLD CLAYBURN RD	4160.0	Yes	No	No	Flow Control Manhole	NO	No	4129.6	4129.6	4.31	1298.2	66.4		115	61.9	None			0.283		65.72
117444	P10-2	Pond	Playing Field	Private	6/30/1989	3836	OLD CLAYBURN RD	5184.0	Yes	No	No	Flow Control Manhole	NO	No	5169.6	5169.6	4.31	187.6	66.4		115	61.9	None			0.283		65.66
117115	P11	Tank	Chamber	Municipal	6/30/2004	35314	MCKINLEY DR	790.0	No	No	No	Flow Control Manhole	NO	Yes	268.5	268.5	4.05	792.1			375	79.5	Pipe	0.375	82.9	0.302		74.49
117121	P12	Tank	Chamber	Municipal	6/30/2003	35458	NAKISKA CT	442.0	No	No	No	Flow Control Manhole	P02999	Yes	351.4	351.4	1.60	429.1			60	104.8	None			0.016		9.98
117451	P13	Pond	Wet Pond	Municipal	6/30/1989	3700	MCKINLEY DR	900.0	Yes	No	No	Flow Control Manhole	87340	No	147.4	147.4	9.53	964.7			444	103.0	Weir	1.05	104.0	0.425		44.58
117455	P14	Pond	Dry Pond	Municipal	6/30/1989	35300	SANDY HILL RD	2100.0	Yes	No	No	Flow Control Manhole	N/A	No	168.4	168.4	6.09	116.4			197/343	79.9	Pipe	0.375	81.9	0.284		46.62
117126	P15	Tank	Chamber	Municipal	6/30/1989	35410	SANDY HILL RD	2550.0	Yes	No	Yes	Office Plate and Flap Gate	N/A	No	144.2	144.2	35.22	5.8			526	90.1	None			0.618		17.55
117128	P16	Tank	Chamber	Municipal	6/30/1991	3583	MCKINLEY DR	651.0	Yes	No	Yes	Office Plate and Flap Gate	574	Yes	185.9	185.9	4.55	521.0			75	90.4	Weir	5	93.5	0.122		26.86
117120	P17	Tank	Chamber	Municipal	6/30/1998	35702	MCKEE RD	1584.0	Yes	No	Yes	Flow Control Manhole	39543	Yes	689.5	689.5	20.22	1589.3			77	145.0	Weir	2.25	148.6		0.322	15.93
117134	P18	Tank	Chamber	Municipal	6/30/2004	3532	MCKINLEY DR	710.0	No	No	No	Flow Control Manhole	P07664	Yes	305.6	305.6	1.89	730.0	114.9					3.95	114.9	0.156		82.67
117130	P19-1	Tank	Chamber	Municipal	6/30/1998	3514	BASSANO TERRACE	649.0	No	No	Yes	Flow Control Manhole in tank	37059	Yes	212.4	212.4	9.42	745.5	151.8		102	148.0	Pipe	0.45	151.7	0.605		64.22
117131	P19-2	Tank	Chamber	Municipal	6/30/1998	3500	BASSANO TERRACE	649.0	No	No	Yes	Flow Control Manhole in tank	37059	Yes	212.4	212.4	9.42	745.5	154.9		102	151.1	Pipe	0.45	154.8	0.863		91.64
117132	P19-3	Tank	Chamber	Municipal	6/30/1998	3500	BASSANO TERRACE	649.0	No	No	Yes	Flow Control Manhole in tank	37059	Yes	212.4	212.4	9.42	745.5	158.0		102	154.2	Pipe	0.45	157.9	0.728		77.22
117105	P2	Tank	Chamber	Municipal	6/30/1997	4300	SHEARWATER DR	965.0	No	No	Yes	Flow Control Manhole	33808	Yes	534.5	534.5	4.93	969.1			83	47.6	Weir	1.05	50.3	0.404		81.98
117135	P20-1	Tank	Chamber	Municipal	6/30/1998	35490	MCKEE RD	728.0	No	No	Yes	Flow Control Manhole in tank	39397	Yes	132.7	132.7	5.88	405.2			58	134.1	Pipe	0.45	137.2	0.064		10.88
117136	P20-2	Tank	Chamber	Municipal	6/30/1998	3471	WHATCOM RD	728.0	No	Yes	Yes	Flow Control Manhole in tank	39397	Yes	133.5	133.5	3.83	1273.8			58	136.0	Pipe	0.45	138.9	0.048		12.54
117137	P20-3	Tank	Chamber	Municipal	3/3/2008	3471	WHATCOM RD	1483.0	No	No	No	Flow Control Manhole	B34916	Yes	353.7	353.7	4.20	401.8			42	133.4	Pipe	0.45	136.3	0.144		34.29
117142	P21	Tank	Chamber	Municipal	6/30/1999	3391	MCKINLEY DR	858.0	No	No	No	Flow Control Manhole	40302	Yes	322.4	322.4	1.57	552.4			50	112.1	None, waterproof flap gate			0.064		40.92
117473	P22	Pond	Settling Pond	Private	6/30/2005	35782	WESTVIEW BLVD	1278.0	No	No	No	Flow Control Manhole	NO	Yes	728.7	728.7	4.75	3490.5	242.0		84	237.9	Pipe	0.525	241.7	0.013		2.73
117483	P23	Pond	Settling Pond	Private	6/30/2006	3343	BOXWOOD CT	590.0	No	No	No	Flow Control Manhole	NO	Yes	630.8	630.8	27.89	819.2	228.0		74	226.2	Pipe	0.9	227.6	0.730		26.17
117151	P24-1	Tank	Chamber	Municipal	6/30/2000	35479	TWEEDSMUIR DR	702.0	No	No	Yes	Flow Control Manhole in tank	34222	Yes	238.3	238.3	5.85	721.1			84	110.4	Pipe	0.3	113.3	0.223		38.11
117150	P24-2	Tank	Chamber	Municipal	6/30/2000	35479	TWEEDSMUIR DR	98.0	No	No	Yes	Flow Control Manhole in tank	45264	Yes	41.9	41.9	5.70	119.0	135.5	119.4	86	113.8	Pipe	0.3	117.0	0.060		10.53
117149	P24-3	Tank	Chamber	Municipal	6/30/2000	35479	TWEEDSMUIR DR	314.0	No	No	Yes	Flow Control Manhole in tank	45264	Yes	110.0	110.0	5.80	345.8			84	116.7	Pipe	0.3	120.3	0.084		14.50
117148	P24-4	Tank	Chamber	Municipal	6/30/2000	35479	TWEEDSMUIR DR	403.0	No	No	Yes	Flow Control Manhole in tank	45264	Yes	139.3	139.3	5.74	415.1			84	119.9	Pipe	0.3	123.5	0.110		19.17
117162	P25	Tank	Chamber	Municipal	6/30/2001	35404	WELLS GRAY AVE	1110.0	No	No	No	Flow Control Manhole	NO	Yes	521.2	521.2	12.73	1140.8			80	94.0	None			0.192		15.08
117155	P26-1	Tank	Chamber	Municipal	6/30/1998	3225	WHATCOM RD	1335.0	No	No	Yes	Flow Control Manhole in tank	N/A	Yes	413.3	413.3	11.59	1678.2			105	138.0	2 Pipes	0.525	140.4	0.612		52.81
117156	P26-2	Tank	Chamber	Municipal	6/30/1998	3225	WHATCOM RD	1335.0	No	Yes	Yes	Flow Control Manhole in tank	N/A	Yes	421.7	421.7	11.59	1613.6			105	136.0	2 Pipes	0.525	137.2	0.546		47.12
116679	P27-1	Infiltration	Trench	Municipal	6/30/1993	34638	BATEMAN RD	5.8	Yes	Yes	No	Flow Control Manhole	N/A	Yes	173.0	173.0	15.36	2914.7	7.1		132	3.7	Pipe	0.6	7.0	0.075		4.88
241896	P27-2	Pond	Dry Pond	Municipal	6/30/1993	34638	BATEMAN RD	3560.0	Yes	Yes	No	0	N/A	Yes	5752.2	5752.2	4.69	0.0								0.020		4.27
116681	P27-3	Infiltration	Trench	Municipal	6/30/1993	34700	HEARTHSTONE CT	5.2	Yes	Yes	No	Flow Control Manhole	N/A	Yes	146.0	146.0	4.60	2425.4	9.3		84	5.4	Pipe	0.45	9.0			
117437	P27-4	Pond	Dry Pond	Municipal	6/30/1993	34700	HEARTHSTONE CT	2805.0	Yes	Yes	No	0	N/A	Yes	2806.9	2806.9	4.60	0.0										
117433	P28	Pond	Dry Pond	Municipal	6/30/1993	34800	HARTNELL PL	3641.0	No	Yes	No	Flow Control Manhole	N/A	No	6157.4	6157.4	14.10	6040.6			172	4.2	Pipe	0.2	6.6	0.076		5.39
116683	P29-1	Infiltration	Trench	Private	6/30/1993	3939	OLD CLAYBURN RD	76.8	Yes	Yes	No	Flow Control Manhole	NO	Yes	60.0	60.0	0.32	0.0			55	44.5	Weir	1.8	47.7	0.002		6.17
117441	P29-2	Pond	Playing Field	Private	6/30/1993	3939	OLD CLAYBURN RD	71.5	Yes	No	No	None-further down below 29-1	NO	Yes	5860.2	5860.2	0.32	4170.4		Goes into P 29-1						0.002		6.17
117106	P3	Tank	Chamber	Municipal	6/30/1992	35298	BELANGER DR	1150.0	No	No	No	Flow Control Manhole	2484	Yes	468.7	468.7	5.95	1156.8									0.103	17.30
117116	P31	Tank	Chamber	Municipal	6/30/1995	35020	KOOTENAY DR	1133.9	No	No	Yes	Flow Control Manhole	21933	Yes	526.9	526.9	3.91	1138.6			88	39.8	Weir	2.5	42.5	0.052		13.29
117119	P32	Tank	Chamber	Municipal	6/30/2001	3841	TESLIN DR	2345.0	Yes	No	No	Flow Control Manhole	48670	Yes	975.2	975.2	8.47	2347.9								0.372		43.94
117450	P33	Pond	Playing Field	Municipal	6/30/1993	35045	EXBURY AVE	1200.0	No	No	No	Flow Control Manhole	NO	No	2020.8	2020.8	6.49	1213.0	47.6		120	46.0	None			0.046		7.08
117122	P35	Tank	Chamber	Municipal	6/30/1997	3700	OLD CLAYBURN RD	267.0	No	No	No	Flow Control Manhole	32322	Yes	203.1	203.1	1.48	261.5			42	71.7	None			0.011		7.43
116688	P36	Infiltration	Trench	Municipal	6/30/1987	34900	EXBURY AVE	98.7	No	Yes	No	Flow Control Manhole	N/A	No	146.6	146.6	2.17	0.0			171	50.5	Pipe	0.375	52.8	0.210		96.69
116698	P39-1	Infiltration	Trench	Private	6/30/1987	3292	VERNON TERRACE	200.0	Yes	Yes	No	Flow Control Manhole	NO	No	369.0	369.0	8.54	0.0			93/220	66.6	Pipe	1.219	69.1	0.302		35.36
116699	P39-2	Infiltration	Trench	Municipal	6/30/1987	3292	3292 VERNON TERRACE	165.0	Yes	Yes	No	Flow Control Manhole	NO	No	281.7	281.7	8.54	0.0			93/220	66.6	Pipe	1.219	69.1	0.302		35.35
117108	P4	Tank	Chamber	Municipal	6/30/2001	35235	FIRDALE AVE	3130.0	No	Yes	No	Flow Control Manhole	50962	Yes	727.2	727.2	3.52	3137.1			91	52.6	Pipe	0.45	56.3	0.027		7.76
117478	P40	Pond	Playing Field	Private	6/30/1995	35011	OLD CLAYBURN RD	2030.0	No	Yes	No	Flow Control Manhole	NO	Yes	6029.3	6464.3	3.52	2536.1			72	68.6	None			0.156		44.19
117424	P43-1	Pond	Settling Pond	Private	6/30/2012	35131	STRAITON RD	1028.0	Yes	No	No	Flow Control Manhole	B21592	Yes	1595.6	1688.0	5.57	1810.1			42	12.8	Pipe	0.25	15.1		0.013	2.34
116675	P43-2	Infiltration	Trench	Private	6/30/2012	35131	STRAITON RD	232.0	No	Yes	No	Flow Control Manhole	EPP22714	Yes	237.5	237.5	2.12	0.0	15.0		200	13.9	Pipe	0.2	15.0	0.257		121.23
117112	P45	Tank	Chamber	Private	6/30/2005	36260	@36260 MCKEE RD	516.0	No	No	No	Flow Control Manhole	BCP22983	Yes	258.9	255.9	4.76	0.0			75	186.3	None				0.092	19.33
117114	P46	Tank	Chamber	Municipal	6/30/2003	36217	BUCKINGHAM DR	2142.0	No	No	No	Flow Control Manhole	BCP10384	No	726.2	726.2	14.65	2141.4									0.315	21.50
117426	P47	Pond	Wet Pond	Municipal	6/30/2005	35550	STRAITON RD	930.0	No	No	No	Flow Control Manhole	NO	Yes	259.8	259.8	18.36	329.5	81.7		115	77.0	Pipe	0.6	81.6		0.299	16.29
117125	P48-1	Tank	Chamber	Private	6/1/2012	35676	MCKEE RD	145.7	No	No	Yes	Flow Control Manhole	B35809	Yes	88.2	80.8	1.70	137.4			42	145.5	Pipe	0.3	148.1	0.016		9.41
117124	P48-2	Tank	Chamber	Private	6/1/2012	35626	MCKEE RD	145.7	No	No	Yes	Flow Control Manhole	B38509	Yes	86.5	80.9	1.70	137.4			42	146.7	Pipe	0.3	149.4	0.018		10.59
117123	P48-3	Tank	Chamber	Private	6/1/2012	35676	MCKEE RD	145.7	No	No	Yes	Flow Control Manhole	B38509	Yes	86.5	80.9	1.37	137.4			42	147.9	Pipe	0.3	150.5	0.029		21.18
117127	P49	Tank	Chamber	Private	6/1/2012	35626	MCKEE RD	97.0	No	No	Yes	Flow Control Manhole	B38509	Yes	100.9	80.7	0.16	113.9			23	142.4	Pipe	0.3	144.2	0.001		7.36

City ID	Project ID	Facility Type	Sub Type	Owner	Capitalization Date	House #	Street Name	GIS Volume (m^3)	GIS Volume Assumed	Infiltration System	Control Structure	Type of Control	Right of Way Plan #	As-Built	GIS Area (m^2)	As-Built or Report Facility Area (m^2)	Contributing Catchment Area (ha)	As-Built or Report Volume (m^3)	RIM Elev. (m)	Storage Invert (m)	Orifice Size (mm)	Orifice Invert (m)	Overflow Type	Overflow Width (m)	Max Water Level (m)	10yr Max Outflow (m^3/s)	100yr Max Outflow (m^3/s)	Unit Flow (m^3s)
Pond with Completed Detailed Studies																												
117104	P5	Tank	Chamber	Municipal	6/30/2003	4326	PIONEER CT	333.0	No	No	No	Flow Control Manhole	53504	No	303.0	303.0	0.89	336.3			38	6.1	None				0.013	14.27
117133	P50	Tank	Chamber	Municipal	10/26/2007	35586	MCKEE RD	178.0	No	No	Yes	Flow Control Manhole	B14569	Yes	80.2	80.2	0.47	0.0			29	142.8	Weir	3	145.4	0.004		8.58
117495	P51	Pond	Dry Pond	Municipal	6/30/1990	35000	MORGAN WAY	1350.0	Yes	No	No	Flow Control Manhole	N/A	No	899.7	899.7	2.55	622.8			50	99.8	Pipe	0.45	102.9	0.084		32.89
116693	P52	Infiltration	Trench	Private	6/30/1994	34800	WRIGHT ST	36.0	Yes	Yes	No	Flow Control Manhole	33884	Yes	20.0	20.0	0.17	0.0			200	54.4	Pipe	0.2	55.6			
117138	P53	Tank	Chamber	Private	6/30/1994	34800	WRIGHT ST	15.1	Yes	Yes	No	Flow Control Manhole	33884	Yes	14.0	14.0	0.17	18.6			70	54.0	Pipe	0.15	55.9	0.012		71.43
117427	P6	Pond	Wet Pond	Municipal	6/30/1997	4001	OLD CLAYBURN RD	2720.0	Yes	No	No	Flow Control Manhole	NO	Yes	1560.1	1560.1	47.56	2809.8	13.6		305	10.9	Orifice	300	13.4	0.751		15.79
117428	P7	Pond	Wet Pond	Municipal	6/30/2005	3800	GOLF COURSE DR	1200.0	No	No	Yes	Flow Control Manhole	NO	Yes	1253.4	1253.4	4.17	1640.3	155.6		68	155.3	Weir	0.98	156.6		0.088	21.09
117431	P8	Pond	Playing Field	Municipal	6/30/1989	3900	OLD CLAYBURN RD	560.0	No	No	No	Flow Control Manhole	N/A	Yes	718.1	718.1	27.25	761.8			165	51.3	None			0.216		7.93
117113	Q	Tank	Chamber	Municipal	6/30/2004	3990	BRIGHTON PL	708.0	No	No	No		P11238	Yes	290.5	Not Reported	0.90			0						0.053	0.146	58.89
117139	T	Tank	Chamber	Municipal	6/30/1993	31846	LINK CT	6.2	Yes	No	No				5.0	600.0	2.20			0						0.062	0.092	28.18
117447	W	Pond	Dry Pond	Private	6/30/1995	32040	DOWNES RD	1693.0	No	No	No		39957	Yes	3353.3	2900.0	5.00			0						0.308	0.457	61.60
117496	X	Pond	Playing Field/ Rain Garden	Private	6/30/2001	3174	CLEARBROOK RD	1700.0	No	Yes	No		49677	Yes	4744.8	5700.0	4.20			0						0.336	0.497	80.00
117446	SU01	Pond	Wet Pond	Municipal	6/30/1981	3700	ROBSON DR	6390.0	YES	NO	NO		83180	YES	6155.3		21.7	3580.0	9.0	8.5	N/A	N/A			8.7	0.168	0.306	7.75
117458	SU02	Pond	Wet Pond	Municipal	6/30/1994	3600	PICTON ST	1808.0	NO	NO	NO			NO	4866.1		17	3943.0	9.4	7.88	117	6.6	Orifice	0.375	8.7	0.034	0.040	2.00
117364	SU03	Tank	Parking Lot	Municipal	6/30/2005	33353	MARSHALL RD	439.2	NO	NO	NO		B11506	YES	179.8		1.662	439.0	49.8	47.39	50	46.7			48.6	0.005	0.006	3.24
117484	SU04	Pond	Dry Pond	Municipal	6/30/1986	3300	HORN ST	1098.0	NO	NO	NO		72986	YES	548.8		1.3897	1047.0	10.0	8.399	250	39.6	Orifice	0.45	8.7	0.030	0.049	21.26
236995	SU05	Pond	Wet Pond	Municipal	12/5/2011	34038	WALNUT AVE	4311.0	NO	NO	YES			NO	4805.8		40.2	3389.0	41.8	40.815	220	39.7	Orifice	0.45	42.0	0.112	0.147	2.79
117530	SU06	Pond	Dry Pond	Municipal	6/30/1990	2800	TRETHEWEY ST	828.0	NO	NO	NO		80862	YES	1218.4		1.38	670.0	57.6	56.04	204	54.7	Orifice	0.375	56.4	0.068	0.082	49.06
117520	SU07	Pond	Dry Pond	Municipal	6/30/1980	2962	NELSON PL	74.0	NO	NO	NO		63698	YES	838.4		4.0925	757.0	43.0	42	250	39.6	Orifice	0.45	42.1	0.087	0.135	21.32
117489	SU08	Pond	Wet Pond	Municipal	6/1/2008	33391	MACLURE RD	2139.0	YES	NO	NO		B16472	YES	1838.2		2.8741	2808.0	7.3	4.75	77	4.6	Orifice	0.375	5.9	0.004	0.007	1.35
117117	SU09 ? (unlabelled)	Tank	Chamber	Municipal	6/30/1994	32777	CHILCOTIN DR	288.0	YES	NO	NO		23715	YES	120.0		1.1071	212.0	48.7	46.11	42	45.6	Orifice	0.45	46.9	0.003	0.003	2.62
117317	SU10	Tank	Chamber	Municipal	6/30/2007	2357	BEDFORD PL	132.0	NO	NO	NO		B27095	YES	57.5		0.4076	132.0	82.7	80.56	26	79.7	Orifice	0.25	81.7	0.001	0.002	3.14
117508	SU11	Pond	Dry Pond	Municipal	6/30/1986	3054	TRAFALGAR ST	72.0	NO	NO	NO		68783	YES	1454.6		8.3297	1511.0	28.9	26.55	260	26.9			28.2	0.126	0.170	15.11
117513	SU12	Pond	Dry Pond	Municipal	6/30/1985	3000	BABICH ST	2340.0	YES	NO	NO			NO	538.0		6.4707	219.0	27.6	26	248	23.4	Orifice	0.45	26.0	0.135	0.207	20.79
117183	SU13	Tank	Chamber	Municipal	12/2/2011	3091	LUKIV TERRACE	270.0	NO	NO	NO		B49052	YES	95.1		1.6827	270.0	45.5	42	46	42.5	Orifice	0.375	45.0	0.007	0.083	4.37
117153	SU14	Tank	Chamber	Municipal	6/30/2000	3281	SADDLE ST	636.0	NO	NO	YES		46751	YES	281.8		0.8027	637.0	61.2	57.17	53	57.2	Orifice	0.3	58.1	0.003	0.003	3.41
247414	SU15	Pond	Wet Pond	Municipal	6/30/2005	33825	VALLEY RD	3550.0	NO	NO	NO			YES	4301.0		1658	139238.0	4.0	2								0.00
117438	SU16	Pond	Wet Pond	Municipal	6/30/2000	3950	ABB MISSION HWY	22000.0	NO	NO	YES			NO	15061.8			78220.0	4.0	2								
117448	SU17	Pond	Wet Pond	Municipal	6/30/2000	3950	ABB MISSION HWY	90000.0	NO	NO	YES			NO	89468.7			300153.0	4.0	2								
242138	SU18	Pond	Wet Pond	Municipal	12/5/2012	3950	ABB MISSION HWY	7889.0	NO	NO	NO			YES	22557.4			38171.0	4.0	2								
	SU19 - Mill Lake	Pond	Wet Pond	Municipal													196.9964	293279.0	53.0	51.65					51.9	1.053	1.188	5.35
117445	SU20	Pond	Dry Pond	Municipal	6/30/1980	32981	ASPEN AVE	7200.0	YES	YES	NO			NO	6223.5													
Pond Without Detailed Studies Completed																												
117185		Tank	Chamber	Municipal	6/30/2004	27823	FRASER HWY	4869.0	No	No	Yes	Flow Control Wall	NO	Yes	2281.5	2000.0	32.10	9911.00	105.50	101.77	157.00	101.77	Weir	5.50	104.92	0.061		1.89
117187		Tank	Chamber	Municipal	6/30/2000	27823	FRASER HWY	5042.0	No	No	Yes	Flow Control Wall	NO	Yes	2218.9	2000.0	32.10	9911.00	105.50	101.77	157.00	101.77	Weir	5.50	104.92	0.061		1.89
117173		Tank	Chamber	Municipal	6/30/2004	3172	STATION RD	1213.0	No	Yes	Yes	Flow Control Wall	NO	Yes	749.6	780.0	4.59	1213.00	102.48	99.97	77	99.95	Weir	1.9	101.02	0.020		4.36
117393		Tank	Chamber	Municipal	6/30/2004	34238	AMBLEWOOD PL	1226.7	No	No	Yes	Flow Control Wall	NO	Yes	563.8	565.0	4.06	1206.00	33.6	31.15	79	30.55	Overflow Pipe	0.2	33.6	0.020		5.00
117218		Tank	Chamber	Municipal	6/30/2003	34504	STONELEIGH AVE	1158.0	No	No	Yes	Flow Control Manhole	53638	Yes	391.7	390.0	2.33	1170.00	60.3	57.3	56	57.15	Overflow Pipe	0.3	60.2	0.012		4.99
117502		Pond	Wet Pond	Municipal	6/30/1991	30872	SANDPIPER DR	1189.0	No	No	Yes	Flow Control Wall	N/A	Yes	610.2	6500.0	17.30	1185.00	71.84	69.00	300.00	69.08	None		71.64	0.033		1.91
117479		Pond	Wet Pond	Municipal	6/30/1991	10	N OF AUTOMALL DR	8320.0	No	No	Yes	Control Structure	88433	Yes	4925.8		83.50	8320.00	92	80.50						0.890		10.66
117542		Pond	Wet Pond	Municipal	6/30/2005	36282	LOWER SUMAS MTN RD	2889.6	No	No	Yes	Flow Control Manhole	B11922	No	538.0		9.63	2890.00	50.5	48	120	46.319	Overflow Pipe	0.375	48.9	0.046		4.78
117591	2 Ponds	Pond	Wet Pond	Municipal	6/30/2001	1812	VEDDER WAY	1598.0	No	No	Yes	Control Pipes	B00611	Yes	747.5	2200.0	8.54	4497.00	11.7	9.25	179	9.25	Weir	300	11.5	0.075	0.08	8.78
253547		Tank	Chamber	Municipal	1/20/2016		AUGUSTON PKWY E	1075.0	No	No	Yes	Flow Control Manhole		Yes	641.9	715.0	2.16	1076.00	185.1	182.92	65	182.92	Overflow Pipe	0.45	185	0.011		5.00
117599		Pond	Wet Pond	Municipal	6/30/2004	1425	SUMAS WAY	2695.0	No	No	Yes	Flow Control Weir	51267	Yes	1429.5	4300.0	2.91	2695.00	6.50	5.85	99.00	6.00	Weir	5.00	6.50	0.015		5.14

Note

1. Detention Criteria: Development Bylaw (2070-2011), Appendix F, Section No. 5-2 Storage Facility Requirements, State:

(b): The allowable release rate is 5 litres per second per hectare (L/s/ha) of the net developed area or as otherwise directed by the Engineer.

2. Unit Flow Column is Cordinated as follows:

GREEN	*Meets the 5 L/s/ha release rate*
YELLOW	*Exceeeds the 5 L/s/ha release rate but minor modifications would bring the facility to 5 l/s/ha*
RED	*Major modifications required to bring release rate to 5 L/s/ha*