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City of Prince George

Integrated Stormwater Management Plan

Technical Working Paper #1 – Technical Background

Prepared by:

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AECOM: 2015-04-13

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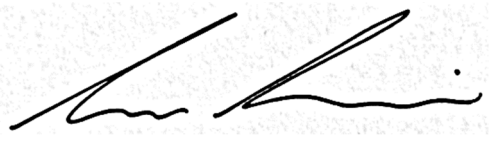

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Executive Summary

As part of the City's Integrated Stormwater Management Plan (ISMP), AECOM conducted a review of the City's Watershed Drainage Plans (WDP) and stormwater related GIS data. This Technical Working Paper (TWP) #1 summarises the results of this review; including.

- A review and summary of the City's six WDPs;
- A summary of the gaps with each of the WDPs with respect to geography, cost estimates, modeling, consideration of climate change, environmental assessments and geotechnical assessments;
- Recommendations for addressing gaps related to the WDPs;
- Identification of new stormwater related projects and completed projects since the WDPs were developed;
- A review of existing project prioritization frameworks;
- A proposed new project prioritization framework for the City of Prince George;
- A summary of the priorities of the action items from the WDPs (and other projects identified since the WDPs were developed) when the proposed new project prioritization is applied to them;
- A review of the City's GIS data related to stormwater; and
- A GIS gap reduction plan.

Recommendations resulting from this review are outlined below.

Future WDPs/WDP Updates

Some areas not currently included within a WDP are already developed or may be developed in the near future. Selecting areas for developing new WDPs, in order of priority, should be:

1. Areas with known issues (e.g. flooding, erosion, etc.);
2. Areas where new development is occurring or soon to occur (e.g. North Nechako); and
3. Areas of existing development.

Any future WDPs or updates of existing WDPs should include the items listed below.

1. Consideration of climate change. Use results from the IDF CC tool used for the West Fraser River & Parkridge Creek WDP until the City has developed a future looking IDF curve based on improved rainfall data and climate change considerations.
2. Cost estimates of proposed projects – using the City's new approach of providing high level cost estimates as a range.
3. Flow and water quality monitoring.
4. Use of a preferred modelling software package, as identified by the City
5. Development of a dual drainage model (1D) with 2D models developed, where needed, to assess problem areas where surface flooding issues have been identified.
6. Assess whether culverts are fish friendly and whether the watershed has intact riparian function.
7. Consider surficial geology, geomorphology, slopes, municipal and private well sites, contaminated sites and older industrial/commercial sites to identify areas where increased infiltration should not be done without site specific studies.
8. Action items should be prioritized using the newly proposed stormwater project prioritization framework.
9. Provide any updated catchments, asset inventory, elevations etc., to the City so they can update their GIS accordingly.
10. Model future conditions under full build-out, as defined by the OCP, as well as existing conditions.
11. Provide updates to the natural asset inventory that the City will soon be developing.

GIS

We recommend that the City update the following features in its GIS as staff availability allows:

- Correcting catchment boundaries, adding catchment areas and correcting typos (i.e. Beaverly);
- Adding creek names;
- Adding culverts, open channels/ditches, outfalls, natural ponds and asset attributes (e.g. elevations, material, condition etc.) that have been accurately identified through past WDPs, where the data has been readily provided to the City;
- Identifying and recording drainage systems associated with roadways that do not currently have a storm sewer or ditch associated with them in GIS;
- Adding stormwater asset condition and risk data into GIS when it becomes available;
- Adding all stormwater assets such as monitoring stations, dikes, grates/screens and subsurface infiltration facilities that are not currently in the City's GIS;
- Adding other asset attribute information that is currently missing such as storage basin size; and
- Adding natural assets such as riparian areas once the City has completed its natural asset inventory.

The ditch and screen/grate inventory could be completed as other O&M work is being conducted (e.g. collect screen/grate info during culvert inspections, collect ditch info during pavement condition assessments or street sweeping).

Recommended Projects

The Watershed Drainage Plans recommended a total of 261 action items. Since the WDPs were issued 6 action items have been completed and 4 new action items have been identified as new issues have arisen. A new project prioritization framework, that was developed for this ISMP, was applied to the action items in order to score them and sort them by high priority (maximum score of 9) to low priority (minimum score of 0). The following action items were given the highest priority score (i.e. scores of 7-9 out of a highest possible score of 9). The action items, which have a total estimated cost of $1.2M to $5M, are listed in order of priority

.

1. Replace the Domano culvert on Parkridge Creek with a structure that would be fish passable in response to DFO requirements.
2. Introduce better erosion and sediment control measures (e.g. new erosion and sediment control bylaw);
3. Update hazardous slope mapping.
4. Secure sustainable levels of stormwater funding (e.g. Drainage levy or stormwater utility with credit/rebate program). In order to successfully secure sustainable funding levels the public needs to be educated on the value of stormwater management.
5. Protect wetlands and important riparian areas that are not currently protected under municipal legislation (i.e. riparian areas of a stream that is not fish-bearing but drains to a fish-bearing stream or a wetland that is not directly connected to a fish-bearing stream).
6. Update Design Guidelines to consider climate change (e.g. increase the design storm and minimum pipe size/slope). This will be addressed further in TWP #2.
7. Replace/modify culverts in poor condition, under a significant road, whose modification/replacement would also provide fisheries benefits (e.g. Bittner Creek).
8. Protect important wildlife corridors and core habitat areas that are not addressed through existing riparian area protection.
9. Implement Best Management Practices/Low Impact Development (BMP/LID) standards for new development in catchments to fish-bearing streams and associated public education circulars. This concept will be discussed further in TWP's 2 and 3.
10. Expand floodplain development permit areas in certain areas along Parkridge Creek.
11. Update Prince George Bylaws (DCC, Development Procedures, and Tree Protection).

Through further discussions with City staff and the completion of this ISMP, additional action items may be identified and should be added to the overall Action Item List (see Appendix C). Similarly, the City may decide to eliminate action items proposed by completed WDPs. In this way, the compiled Action Item list can become a "living" document that is regularly updated as issues arise, projects are completed and priorities change.

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1. Introduction

As part of the City's Integrated Stormwater Management Plan (ISMP), AECOM conducted a review of the City's Watershed Drainage Plans (WDP) and stormwater related GIS data. This Technical Working Paper (TWP) #1 summarises the results of this review; including.

- Review watershed drainage plans for technical (capacity, environmental, geotechnical, hydrogeology, etc.) issues and to note any gaps;
- Apply climate projections for consideration, where needed;
- Develop a framework for prioritizing stormwater projects;
- Prioritize recommendations for addressing stormwater technical issues (with cost estimates, where possible);
- Develop a WDP gap reduction plan;
- Review existing GIS data; and
- Prepare GIS asset data inventory gap reduction plan.

2. Watershed Drainage Plan Review

2.1 Geography

The City has completed the following six watershed drainage plans (WDP):

- University Heights & Peden Hill;
- West Fraser River & Parkridge Creek;
- Gladstone, Varsity & Trent;
- Hudson's Bay Wetlands;
- McMillian Creek; and
- East Prince George.

The areas of the City not covered by any of the six watershed drainage plans are shown in green in the following figure. They are mostly areas along the Fraser and Nechako Rivers and along the northern, western, southern and northeastern edges of the City limits. In particular, the following catchments are not covered by a WDP: Wright Creek, Northwood, North Nechako, Otway, Rolling Mix, Foothills, Dornbierer, Nechako West, , Brodman Creek, South Fraser, Stirling, King, Lyon, Hammond, Cameron, Patricia, 17th Avenue, South Fort George and Queensway. Land uses that are within these areas include industrial (e.g. Canfor, railyards, Chemtrade, Pittman Asphalt, Rolling Mix Concrete etc.), commercial (downtown and other), agricultural, cleared but undeveloped areas (e.g. Domano Blvd), newly developing areas (e.g. Malaspina), forested areas, various residential areas (e.g. near downtown, North Nechako and rural), and Parks.

The areas that are hatched in the following figure are areas that are not included within a catchment in the City's GIS. These areas are mostly in East Prince George and along the south shore of the Nechako River (including the railyards). The catchments in East Prince George that are not within the City's GIS are Willow Creek South, Willow Creek North, Unnamed (Fraser River), Ellacott Creek and Haggith Creek (some of which is outside the City boundaries). The portions of these catchments that are within the City limits mostly contain industrial areas, forested areas, and the Prince George airport.

There are minor errors in the City's 'Stormwater Catchment Areas' GIS layer. These have been identified in the individual WDPs and through discussions with City staff. The following edits should be made to improve the accuracy of the City's GIS, to ensure that previous work is retained, and to aid in future asset management and infrastructure planning tasks. These edits would be easier if the City had the original data files from each of the WDPs.

- Update Peden Hill and neighbouring catchments as per the suggested catchment area in the WDP for University Heights/Peden Hill.
- Update the new and existing catchment areas (including the stream headwater areas that extend beyond the City's boundary) as delineated in the East Prince George WDP.
- Update the new and existing catchment boundaries included in the West Fraser River and Parkridge Creek WDP.
- Review the extents of the South Fraser catchment to potentially correct the catchment delineations of the neighbouring catchments north of Parkridge Creek.
- Review Appendix A of the MacMillan Creek WDP to update catchment boundaries.
- Consider updating other catchment areas beyond the City's boundary including Brodman Creek, Beaverly, Nechako West, Otway, North Nechako, Wright Creek, and Northwood.
- Update the spelling of Beaverly.

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5980000 5980000

Wright Creek

McMillan Creek

Northwood

North Nechako

Nechako River

Otway

Foothills

Rolling Mix

Dornbierer

Fraser River

Hudson Bay Slough

Bittner

Nechako West

Peden Hill

BCR

Hwy 97 South

Varsity

Haggith Creek

Gladstone

Boundary

Ellacott Creek

Parkridge Creek

Danson

South Fraser

Beaverly

Brodman Creek

5970000 5970000

1. Stirling
2. King
3. Lyon
4. Hammond
5. Cameron
6. Patricia
7. 17th Ave
8. Fort George Park
9. South Fort George
10. Queensway
11. Ferry Ave
12. Lansdowne
13. Hwy 16 West
14. Cowart
15. Trent
16. Delhi
17. Essex
18. Fairmont
19. Guelph
20. Imperial
21. Jean De Brebeuf
22. Malaspina
23. Latrobe
24. Willow Creek South
25. Continental Way
26. Willow Creek North
27. Great Street
28. Unnamed (Fraser River)
29. Guay
30. Pickering Outfalls
31. Hawk
32. Airport Hill
33. Hwy 16 East
34. Graves
35. Foreman

5960000 5960000

510000 520000

Basemapping from ESRI (World Topology), Gov't of BC GeoBC), AECOM 2014.

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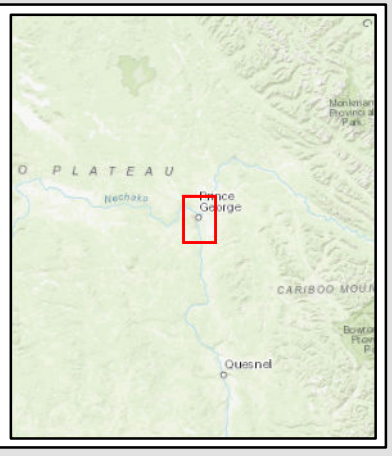
Legend

Watershed Drainage Plan Catchment Areas

- No Watershed Drainage Plan
- East Prince George
- Gladstone, Varsity, & Trent
- Hudson Bay Slough
- McMillan Creek
- Parkridge Creek & West Fraser
- University Hill / Peden Hill
- Catchment not in City GIS
- Prince George Boundary
- Provincial Highways

Overview Map



CITY OF PRINCE GEORGE

City of Prince George Integrated Stormwater Management Plan
Location: Prince George, BC

Watershed Drainage Plans Catchment Areas

10 December 2020

AECOM

Figure 1

File Location: C:\Workspace\60628231 - Pringe George ISMP\434 GIS\FIG1-2020-12-10-Catchment Map-60628231.mxd Date Revised: December 10, 2020 Reviewed By: Paper Size: 11"x17" Scale is referenced to the specified paper size.

2.2 Existing Watershed Drainage Plans Summary

A general summary of the six WDPs is provided in the following table in order of completion (from the earliest to most recently completed). Additional descriptions of the six WDPs are provided in the sub-sections that follow.

The estimated costs of WDP recommendations in the following table have been extracted directly from the reports and have not been increased to account for inflation or climate change. This will be addressed in **Section 2.7**. **Section 2.7** also provides details about what else is missing from the WDP cost estimates. Therefore, the cost estimates provided in the following table should be considered as low (i.e. underestimates the actual cost of achieving all the action items outlined in each respective WDP).

Table 1 WDP Summary

WDP	Year	Significant Considerations	Recommendations	Original Cost Estimates
Gladstone, Varsity & Trent	2002	• Negative impacts from previous/ existing development, including sediment, fecal coliform, urban debris and encroachments into riparian setbacks • Upgrades needed to meet City's Design Criteria • Fish habitat downstream of study area	• Storm sewer upgrades to convey the 5-year future development flow; • Detention ponds/constructed wetlands to limit post-development flows for the 2 and 5-year return periods to pre-development (Gladstone/Trent) or limit the 5-year post-development peak flow to less than 50% of the 2-year (Varsity). Ponds will also limit the 100-year post-development flow to pre-development levels. • Creek erosion protection • Maintain stream setbacks	$8.8 M
Hudson's Bay Slough	2007	• Natural watercourses • Escarpment	• Upgrade capacity of select storm sewers, culverts, channels and Queensway flood box capacity • Lower upper slough pool • Implement source controls and detention storage for future development on Cranbrook Hill • Require source controls on properties that are likely to produce sediment or hydrocarbons • Enhance the upper wetland (for improved water quality treatment, aesthetics, maintenance and recreation) and lower wetland (for improved fisheries habitat). • Assess the sediment accumulations in the downtown drainage system. • Implement a sediment management program and by-law. • Prioritize the drainage system for CCTV.	$17.5 M plus cost to remove sediment from downtown storm sewers (costs TBD)
East Prince George	2013	• Fish bearing streams • Culverts in poor condition • Watercourses susceptible to erosion • Ravine stability concerns	• Water quality monitoring for BCR/Danson sites • Protect existing riparian buffers along the Fraser River • Wetland compensation program/protocol. • Beaver management plan • Culvert assessment (fish passage and hydraulics) • Improve sediment control along Foreman Road • Monitor the terrain instability associated with the main drainage course within the Airport Hill catchment. • Improve erosion and sediment control at key watercourse crossings. • Monitor slope instabilities of the main drainage course within the BCR catchment. • Replace / modify key Haggith Creek culverts *(Willowcale culvert subsequently replaced and bridge installed).* • Enforce 30 m top of bank riparian setbacks from all future developments. • Use vegetated open channel bioswales in lieu of piped systems.	No cost estimates provided

WDP	Year	Significant Considerations	Recommendations	Original Cost Estimates
			• Require stormwater best management practices (BMP) on future developments and training of City inspection staff. • Encourage the Prince George Airport Authority to apply the recommended stormwater best management practices. • Develop a flow monitoring program. • Monitor and complete remediation, as necessary, of the five identified erosion sites • Create a Stormwater Best Management Practices Circular. • Create a Stormwater Management Rebate Program linked to DCCs. • Create a drainage utility fee based on effective impervious area. • Modify applicable City of Prince George bylaws.	
University Heights & Peden Hill	2016	• Fish-bearing streams downstream of study area • Erosion of the escarpment watercourses • 14 pipes in the minor system and 4 pipes in the major system do not have sufficient capacity under existing conditions	• Use diversion piping to convey excess run-off from existing development down the escarpment to prevent erosion of the escarpment watercourses. • Volume reduction and source controls in new development where soils permit and slope stability is not a concern. • Use detention and diversion piping to convey excess run-off from new development where soils or stability concerns do not permit stormwater infiltration. • Treat and monitor stormwater entering Lansdowne Creek. • Improve the City's Erosion and Sediment Control regulations. • Retain riparian areas.	$4.5 M
McMillan Creek	2017 started 2011	• condition of infrastructure • fish passage • water quality • wildlife values • future expansion • maintenance • erosion and stability issues	• Replacement of critical crossings (Aberdeen crossing completed using an open bottom structure - $1M). • Culvert maintenance program • Public education on the importance of this watershed • Continued replacement of infrastructure • Incorporation of BMP for capture, infiltration and retention • Update of the City Design Guidelines • Securing long term funding for infrastructure • Limitation of development in sensitive riparian areas • Best management practices for construction and maintenance activities.	$10.2M
West Fraser River & Parkridge Creek	2020	• Capacity constraints	• Capacity upgrades • Establishing a minimum building elevation within the Parkridge Creek floodplain • Strengthening bylaws and design criteria to establish BMP for new development • Treatment at outfalls • Protect wetland habitat • Water quality monitoring • Erosion protection at outfalls to the Fraser River	$14M

2.2.1 Gladstone, Varsity and Trent WDP

The Gladstone, Varsity and Trent WDP was completed in 2002 by Associated Engineering. The Gladstone, Varsity, and Trent catchments are located in the southwestern section of the City of Prince George. Significant development has occurred in these watersheds and consists primarily of residential development with pockets of institutional and commercial development. If the impacts of continued urban development on storm water runoff are not addressed, the peak runoff rates will increase as a result of diminished naturally occurring flood storage and ground infiltration areas.

To provide a level of service consistent with the City's Design Criteria, a combination of detention ponds and sewer/culvert upgrades are recommended for the three watersheds. The recommended storm sewer upgrades provide sufficient capacity to convey the 5-year future development flow. In Gladstone and Trent, the proposed detention ponds are designed to limit post-development flows for the 2 and 5-year return periods to pre-development levels. In Varsity, the proposed ponds are designed to limit the 5-year post-development peak flow to less than 50% of the 2-year post-development peak. As well, the reported storage volume of each pond limits the 100-year post-development flow to pre-development levels.

Recommended upgrades to the Gladstone drainage network include creek erosion protection, 10 wet pond/constructed wetlands, and 16 storm sewer upgrades. The new ponds/wetlands are mostly proposed in undeveloped areas except for one constructed wetland within a grassed site between St. Mark's Crescent and Domano Blvd. A figure showing the proposed ponds and upgrades is provided in **Appendix E.** The total capital cost for all recommended upgrades is estimated at $4,190,000 in 2002 dollars. Urban development in the lower portion of this catchment eliminated the former watercourses. The undeveloped upper areas contain open channels with limited aquatic values. However, retaining the riparian corridors through these areas provides opportunities for trail networks and environmental protection. Maintaining stream setbacks can limit sediment and other pollutants from entering the stream.

Recommended upgrades to the existing Trent drainage network include three wet ponds/constructed wetlands and 16 storm sewer upgrades. The estimated cost of the three ponds, which are proposed in currently undeveloped areas, is $725,200 and the total cost of the storm sewer upgrades is $427,600 including engineering and contingency. The total estimated capital cost is $1,152,800 in 2002 dollars. No environmental recommendations are provided for the Trent watershed as no streams or suitable fish habitats were identified.

Recommended upgrades to the existing Varsity drainage network include 2 new wet ponds/constructed wetlands in undeveloped areas, 14 storm sewer upgrades, 2 culvert upgrades, and creek improvements. The total estimated capital cost for all the recommended upgrades is $3,350,200 in 2002 dollars. Impacts of existing urban development in the Varsity catchment include increased fine sediment input, reduced water quality including fecal coliform levels in Varsity Creek, encroachments on riparian setbacks, and increased urban debris in and around streams. Stream setbacks (leave strips) should be provided downstream of Domano Boulevard. As well, setbacks are recommended for future development areas in the upper watershed. Although no fish are expected in this area, flow from these upper areas drain directly into fish bearing waters. The lower portions of Varsity Creek should be considered for community-based clean-up and restoration efforts.

2.2.2 Hudson's Bay Slough WDP

The Hudson's Bay Slough WDP, now named the Hudson's Bay Wetlands, was completed in 2007 by Associated Engineering. The Hudson Bay Wetlands is located in the center of Prince George. The upland areas of Cranbrook Hill include protected wilderness areas, Shane Lake, the University of Northern B.C., and numerous natural watercourses. The central escarpment is mostly undeveloped and is bisected by University Way. The lower gradient area, east of the escarpment, is largely developed and includes residential, commercial, institutional, and

recreational areas. The Hudson's Bay Slough WDP combined parks and trail development with storm water management needs.

Most development within the current urban area is expected to be redevelopment and densification of existing areas. Changes in drainage characteristics caused by development can increase flooding concerns, channel erosion and sediment loads, and lead to degradation of water quality and aquatic habitat.

Issues and recommendations within the WDP are outlined below.

- Upgrading sections of the enclosed drainage system subject to surcharging as per the hydraulic model and re-routing certain sub-catchments.
- Preventing flooding in the low-lying areas by upgrading culverts, improving channels, lowering the upper slough pool, and increasing the Queensway flood box capacity.
- Implementing source controls and detention storage for future development on Cranbrook Hill.
- Require source controls on properties that are likely to produce large quantities of sediment or hydrocarbons (e.g. automobile service stations and maintenance shops, machinery storage areas, commercial parking lots etc.).
- Enhancing the upper wetland for more effective water quality treatment, to improve its aesthetics, address maintenance issues, and provide recreational opportunities.
- Enhancing the lower wetland to improve fish habitat.
- Maintaining the integrity of the flood protection provided by Queensway flood box.
- Assessing the sediment accumulations in the downtown area drainage system. Note that since this WDP was prepared the City has conducted sediment sampling in the Winnipeg St Stormwater System and is completing a Management & Treatment Plan for this system.
- Commencing a sediment management program, including the installation of sediment trapping manholes, catch basins, chambers, basins, and ponds, and the development of an erosion and sediment control by-law.

The WDP also discussed O&M activities for sediment removal and the prioritization of the drainage system for a condition survey. The total cost of the proposed initiatives was $17.5 million, in 2007 dollars, plus any cost to remove sediment from the downtown storm sewer system. These costs will be provided upon completion of the current Winnipeg St. Stormwater Management & Treatment Plan.

2.2.3 East Prince George WDP

The East Prince George WDP was completed as draft in 2013 by Associated Engineering. The East Prince George watershed is lightly developed (66% undeveloped – mostly forest) with the primary developed land uses being urban residential (18%) and industrial (9%) and includes the Prince George airport. Approximately half of the study area is located within the City of Prince George and the other half is part of the Regional District of Fraser – Fort George.

The majority of flow routes within the watershed are natural watercourses (including streams classified as fish-bearing), roadside ditches and associated culverts. 32 of the 303 culverts are in poor physical condition.

There are five watercourses within the watershed that are highly susceptible to erosion. Large portions of their upstream drainage areas are allotted for future development. Recommendations include a ravine stability assessment with monitoring and to prevent development from directing increased flows to these watercourses.

The WDP identified four locations in the watershed where inadequate hydraulic capacity may cause localized flooding. It was recommended that hydraulic investigations of each location be conducted to determine if culverts should be upgraded or upstream controls should be put in place. The four locations are:

- 2400 mm diameter CSP culvert within Haggith Creek at Willow Cale Road. Note that this culvert has subsequently been replaced;

- 600 mm diameter CSP culvert within the Airport Hill watercourse at Hwy 16,
- 1500 mm diameter CSP culvert within Bittner Creek at Graves Road, and
- System of several culverts that conveys flow within the lower Boundary catchment.

The WDP recommends suites of best management practices (BMP) for different land uses to be applied to future development in the watershed.

Specific recommendations listed in the WDP are outlined below.

- Implement a water quality monitoring program for streams entering the Fraser River from the BCR and Danson sites to identify possible contaminant loadings.
- Designate significant forested slopes and existing riparian buffers along the Fraser River as “protected greenway corridors” to allow for wildlife movement through East Prince George.
- Develop a wetland compensation program/protocol to maintain the quantity of existing wetland habitat during future land development.
- Develop and implement a beaver management plan that includes dam modification, debris management, population management, and dam removal, as required.
- Conduct a detailed Fish Passage assessment of culverts within the Bittner Creek watershed and replace or modify problem culverts in a prioritized manner.
- Improve runoff control along Foreman Road to minimize sediment introduction to the drainage courses. Since the completion of this WDP, new commercial development on Foreman Road has implemented on-site stormwater controls but there is concern that longer duration of peak flows may increase, not decrease downstream erosion.
- Monitor the terrain instability associated with the main drainage course within the Airport Hill catchment.
- Improve erosion and sediment control at the Guay catchment watercourse crossing of the power line ROW access road and the steep access road near Continental Way at the main BCR drainage course. City staff have noted that this crossing is problematic with flows sometimes over-topping Continental Way during the spring melt.
- Monitor the slope instabilities of the main drainage course within the BCR catchment.
- Replace / modify culverts at the Willow Cale Road and CN Rail crossings with Haggith Creek. The culvert at the Willow Cale Rd crossing was replaced along with a bridge subsequent to the development of this WDP.
- Enforce 30 m top of bank riparian setbacks from all future developments.
- Use vegetated open channel bioswales in lieu of piped systems for surface water conveyance.
- Enforce the application of the recommended stormwater best management practices on future industrial, commercial and urban developments (based on infiltration testing results). City staff noted that infiltration does not work in the uplands but there may be potential (to be confirmed) for BCR and Danson.
- Encourage the Prince George Airport Authority to apply the recommended stormwater best management practices.
- Complete detailed hydraulic analyses of several culverts to determine if upgrades are required.
- Develop a flow monitoring program.
- Create a Stormwater Best Management Practices circular.
- Educate and train City of Prince George staff responsible for inspection of required on-site stormwater best management facilities.
- Create a Stormwater Management Rebate Program linked to DCCs.
- Create a drainage utility fee with the rate structure developed to reflect the effective impervious area of each property. It should be noted that the City attempted to implement a drainage utility in 2012 with little uptake from the community.
- Modify applicable City of Prince George bylaws.

The East Prince George WDP is currently being updated to include the Boundary Road project and Industrial development that has occurred since the report was first developed.

2.2.4 University Heights and Peden Hill WDP

The University Heights and Peden Hill WDP was conducted in 2016 and finalized in 2020 by KWL. The 747 ha University Heights/Peden Hill (UH/PH) watershed is located in the south-central portion of the City of Prince George. The western half of the watershed is a largely undeveloped forested upland area. East of the uplands is a steep escarpment that separates the uplands from the largely developed lowlands that extend to the Fraser River. The watershed drains into Lansdowne Creek that flows just south and adjacent to the WWTP and directly into the Fraser River. Approximately 45% of the catchment is zoned forest or greenbelt, 27% is institutional, 14% is single-family residential and the remaining land is comprised of multifamily, commercial, industrial, utilities, and road dedication. Future development activities include redevelopment in the lowlands and new development in the uplands resulting in an increase from 23% to 48% total impervious area once built-out to the OCP.

All the watercourses in the catchment area are non-fish bearing and do not contain overwintering habitat or suitable spawning habitat. The Cranbrook Hill escarpment is acknowledged as a barrier to upstream fish passage. As well, the storm sewer outfall on Lansdowne Creek is an impassable barrier to upstream fish passage. Lansdowne Creek is the receiving water for the watershed and is known to support fish, therefore maintaining water quality is critical. The catchment area provides a variety of habitat types and seral stages for wildlife indigenous to the area.

124 pipes were assessed, and it was found up to 14 pipes in the minor system and 4 pipes in the major system do not have sufficient capacity under existing conditions. Build-out conditions were also assessed but no considerations were made for climate change.

The one detention pond located in the study area (Maurice Drive Pond) was found to have sufficient capacity using the City's criteria under current land use conditions. However, under future land use conditions, additional ponds or an expansion of this pond would be required to meet the criteria. City staff have noted that a large amount of sediment has already accumulated in this pond that requires removal, but the pond design does not accommodate easy maintenance access nor does it provide an area to decant sediment prior to removal by truck.

In order to mitigate the impacts of development it was recommended to:

- Use diversion piping to convey excess run-off from existing development down the escarpment to prevent erosion of the escarpment watercourses;
- Volume reduction and source controls in new development where soils permit and slope stability is not a concern;
- Use detention and diversion piping to convey excess run-off from new development where soils or stability concerns do not permit stormwater infiltration;
- Monitor and treat stormwater through wet detention ponds/constructed wetlands, on-site source controls and OGS prior to entering Lansdowne Creek;
- Improve the City's Erosion and Sediment Control regulations; and
- Retain riparian areas.

Recommended measures were estimated to cost a total of $4.5 million in 2016 dollars.

2.2.5 McMillan Creek WDP

The McMillan Creek WDP was started in 2011 and revised in 2017 by DWB Consulting. McMillan Creek watershed is primarily undeveloped with rural residential, commercial, and light industrial activity. The watershed system includes both traditional stormwater systems and natural drainage with many crossing structures. There is future development proposed in the watershed in both developed and undeveloped portions of the watershed.

Major concerns include the condition of infrastructure, fish passage through the system, water quality, wildlife values, future expansion, maintenance, erosion and stability issues. Proposed improvements include:

- Replacement of critical crossings;
- Execution of a culvert maintenance program;
- Public education for the understanding of the importance of this watershed;
- Continued replacement of infrastructure;
- Incorporation of alternative stormwater management strategies including capture, infiltration and other natural retention methodologies;
- An update of the City Design Guidelines to account for increased runoff and minimum pipe sizes for both storm sewers and drainage culverts;
- Securing of long-term funding for infrastructure;
- Limitation of development in sensitive riparian areas;
- Limitation of sedimentation and contamination, protection of areas for parks and concise best management practices for construction and maintenance activities.

In addition to the items recommended above, the City is conducting water quality monitoring of McMillan Creek.

Maintenance costs were estimated at $630,000 including the Hofferkamp chamber upgrades and required crossing replacements were estimated at $9.6 million in 2017 dollars.

2.2.6 West Fraser River & Parkridge Creek WDP

The West Fraser River & Parkridge Creek WDP was completed in 2020 by Associated Engineering. The West Fraser River drainage area itself is not a single watershed but consists of 12 subcatchments that drain independently to the Fraser River. The West Fraser River subcatchments are highly developed with predominantly single-family residential land use and are drained primarily by underground storm infrastructure leading to outfalls into the Fraser River. Some of the northern subcatchments (Cowart, Hwy 16 W., Lansdowne, and Ferry Avenue) have some overland drainage features (i.e. ditch/culverts).

The Parkridge Creek watershed encompasses the area from the main stem outlet to the Fraser River to the creek's headwaters. The Parkridge Creek watershed is primarily rural, with limited single family and commercial developments and meanders across the BC Hydro power line between Hwy 16W and the Fraser River at two locations. Except for a small developed area downstream of Parkridge Pond that has a local piped storm system, most of the area is drained by a ditch and culvert network discharging to various tributaries of Parkridge Creek.

The study's drainage areas were modelled to assess the performance of the existing drainage system as well as future development conditions with considerations of the impacts of climate change on increased rainfall within the area. The study recommendations addressed the following issues:

- Capacity constraints and recommended upgrades to reduce the risk of flooding;
- Establishing a minimum building elevation within the Parkridge Creek floodplain;
- Limiting land clearing unless proper stormwater controls are implemented;. City staff noted that this could be achieved with a new erosion and sediment control bylaw.
- Strengthening bylaws and design criteria to establish BMP (best management practices) for new development; and
- Additional environmental considerations such as treatment at outfalls (consisting of OGS or settling tanks), protecting wetland habitat, water quality monitoring, and erosion protection measures at outfalls to the Fraser River.

2.3 Modelling Assessments

The following table outlines the software packages used to model the minor system and the major system for each of the WDP. The minor system is typically designed to convey the flow from frequent storms (i.e. less than 5-year storm) and generally consists of storm sewers, catch basins, gutters and ditches. The major system is typically designed to manage the flow from larger storms (i.e. 5-100 year storm) and generally consists of streets, channels, ponds, natural watercourses, and ravines.

The table also notes the extent to which the major system was modeled for each of the WDP.

Table 2 WDP Modeling Software

WDP	Minor System Modeling Software	Major System Modeling Software
Gladstone, Varsity & Trent	Hydra 6.1	No major system modeling done except for pond volume sized for 100-year storm. Overland flow path capacity was not analysed.
Hudson's Bay Slough	Visual Hydro	Visual Hydro (lowland areas)
East Prince George	PCSWMM	PC SWMM
University Heights & Peden Hill	XPSWMM	XP SWMM – overland flow paths on private property, storm sewers on private property and culverts in open channels. Did not assess road surfaces or creek open channels.
McMillan Creek	EPA SWMM	EPA SWMM - Main stem crossings and detention ponds only
West Fraser River & Parkridge Creek	PCSWMM	Mike 21 (2D model)

As can be seen in the previous table, the City's previous WDPs have been developed using six different modeling software packages. The City may want to consider selecting one or two preferred modeling software packages for any future WDPs. This would allow the City to:

- Ensure that consultants use modeling software that can produce accurate results for the conditions within the City of Prince George;
- Consolidate models between watersheds particularly where there is overflow from one watershed to another;
- More easily develop in-house modeling capabilities for conducting simple updates (e.g. pipe rebuilt), for conducting "what-if" scenarios (e.g. proposed new development, or proposed system upgrade), and for reviewing consultants' work; and
- More easily work with a single consulting firm for model updates.

Most of the City's WDPs (four out of six) were produced using a SWMM based model. SWMM based hydrology models work particularly well in urban areas. SWMM based hydrology models can also be applied to rural areas but this must be done carefully as SWMM models are often badly misapplied when used for rural areas. A modeling software such as Visual Otthymo works well in rural areas.

In selecting a preferred software package(s) the City should consider the:

- Price to purchase the software and on-going licensing costs;
- Ability to have licenses for more than one user;
- Usability, particularly for staff that do not model regularly;
- Ability to model urban and rural areas;
- Compatibility with the City's GIS, risk models and other planning tools; and
- Whether the consultant community has the knowledge/software to support future modeling projects cost-effectively.

2.4 Environmental Assessments

Each of the WDP included an environmental assessment. We reviewed each of the WDP to determine if they included the following:

1. Inventory and condition of watercourses, wetlands, sloughs and lakes etc.; noting any issues such as erosion, stream channel stability and substrate condition.
2. Noted which waterbodies within the study area are fish-bearing and/or drain to a fish-bearing waterbody.
3. Identified the presence of fish barriers and whether culverts are fish friendly.
4. Identified areas of fish habitat including any critical habitats (i.e. spawning) and whether there were signs of negative impacts.
5. Assessed water quality and noted any water quality issues.
6. Noted any water quantity issues.
7. Determined whether there was intact riparian function (i.e. natural vegetation, sufficient width and connected corridors).

The table below summarizes whether each of the WDP addressed the six issues identified above and whether there were any notable gaps. Note that a checkmark under column 2 “Fish bearing analysis” does not mean that the watershed is fish bearing but that the WDP determined whether any waterbodies within the study area are fish-bearing or not. Likewise, a checkmark under column 4 “Fish habitat analysis” does not mean that there is fish habitat within the study area but that the WDP determined whether there is fish habitat or not. A black checkmark indicates that the issue was fully addressed, a grey checkmark indicates that the issue was partially addressed, and an X indicates that the issue was not addressed at all.

Table 3 Issues Reviewed as Part of Each WDP Environmental Assessment

WDP	1. Inventory & condition of waterbodies	2. Fish-bearing analysis	3. Fish barriers & fish friendly culverts	4. Fish habitat analysis	5. Water Quality	6. Water Quantity	7. Riparian Function	Gap Summary
Gladstone, Varsity & Trent	✓	✓	✓	✓	✓	✓	✓	No comments on whether culverts are fish friendly.
Hudson's Bay Slough	✓	✓	✓	✓	✓	✓	X	Field information is old (2003). EDI recommended spring sampling to determine fish species present and additional assessments prior to completing any works, with particular consideration of the lower slough. No comments on whether culverts are fish friendly. Water quality investigations were preliminary in nature. They recommend further water quality investigations prior to implementation of proposed measures. No mention of riparian corridors.
East Prince George	✓	✓	✓	✓	✓	✓	✓	No comments on whether culverts are fish friendly. No mention of flow monitoring or model calibration. Mentions possible water quality issues but no water quality sampling completed or historic data available.
University Heights & Peden Hill	✓	✓	✓	✓	✓	✓	✓	No comments on whether culverts are fish friendly. The condition of the greenbelt and riparian area/wildlife corridors is not known; therefore, can't determine intact riparian function. Mentions water quality concerns but no water quality sampling completed or historic data available. No flow monitoring conducted or model calibration.
McMillan Creek	✓	✓	✓	✓	✓	✓	✓	No mention of flow monitoring or model calibration.
West Fraser River & Parkridge Creek	✓	✓	✓	✓	✓	✓	✓	Insufficient information on riparian vegetation, width sufficiency and connectivity. No flow monitoring of minor drainage system or Parkridge Creek.

Table Legend

- ✓ Issue was fully addressed
- ✓ Issue was partially addressed
- X Issue was not addressed

In general, the environmental assessments were comprehensive and addressed most of the issues relevant to a watershed drainage plan. The most common gap noted is that the four oldest WDP did not comment on whether the culverts within the study area are fish friendly. Also four of the WDPs did not indicate any flow monitoring. Flow monitoring can help assess current flow conditions within critical fish-bearing streams and can improve the reliability of future hydrologic and hydraulic models through model calibration. The third most common gap is that three of the WDP did not sufficiently determine intact riparian function and two of the WDPs were completed with no water quality data (either historic or acquired during the WDP).

2.5 Geotechnical Assessments

A summary of the geotechnical and hydrogeological issues reviewed in each of the WDP and any noted gaps are provided below.

Geological/ Geotechnical information
Most of the WDP relied on Surficial Geology Mapping (Armstrong JE and Leaming SF, 1969, GSC Map 3-1969). This is likely the best source of geological information and represents the upper 2m of unconsolidated material. The East Prince George WDP relied on BC Soil mapping for geological information which represents shallower soils and is more intended for agricultural purposes but will still provide some useful information.

The West Fraser & Parkridge Creek WDP used a geotechnical hazard assessment map which considers surficial geology, geomorphology and slope analysis. This is a good approach and should be extended across the entire City to highlight areas where increased infiltration should not be done without site specific studies to determine if there would be a negative geotechnical result such as slope instability or excessive seepage onto nearby properties (especially downslope).

Water Supply
Prince George relies on groundwater for its water supply. Over 80 per cent of the city's water wells tap into aquifers that are refilled by the Nechako River. These aquifers provide nearly 18 billion litres of water each year through six municipal wells. Raw water is chlorinated according to Northern Health Authority guidelines. Three of the municipal wells are along the south side of the Nechako River, two of the wells are along the west shore of the Fraser River and one of the wells is along the east side of the Fraser River. The later 3 wells are standby. Only one of the WDP considered the presence of these wells and recommended not infiltrating stormwater near the municipal wells.

The provincial government’s aquifer and well mapping site indicates many aquifers and wells within City limits. The presence and need to protect these wells were not mentioned or assessed in any of the WDP.

Contaminant Sources
Infiltration is not recommended in areas of soil contamination such as landfills, contaminated sites or older industrial/ commercial areas. This issue is recognized in some of the WDP but none of them provided maps or detailed information. The BSC contaminated site registry is searchable and can provide maps and other information on contaminated sites. This should be considered before spending effort on increased infiltration by preparing mapping with both zoning and contaminated site registry information.

If the City conducted more water quality monitoring as part of future/updated WDPs or as part of an on-going water quality monitoring it would help identify and confirm contaminant sources.

Gap Summary
Based on the gaps identified above we would recommend that the City develop the following:

1. City wide geohazard map based on slopes, soil types, drainage channels and riparian setbacks;
2. Aquifer map with municipal wells, municipal well capture zones and residential wells;
3. City wide map showing contaminated sites and older industrial areas; and
4. Ensure that future WDP and WDP updates consider surficial geology, geomorphology, slopes, municipal and private well sites, contaminated sites and older industrial/commercial sites to identify areas where increased infiltration should not be done without site specific studies.

2.6 Climate Projections

The City has completed the following studies recently in the areas of climate change adaptation and stormwater:

- Adapting to Climate Change in Prince George: An overview of adaptation priorities (2009)
- Implementing Climate Change Adaptation in Prince George, BC Volume 4: Flooding (2012)
- Climate Change Impacts on Rainfall and Freeze-Thaw Events in Prince George (2014)
- Climate Change Adaptation Strategies for the Community of Prince George (2020)

These reports have made the following observations with respect to stormwater related climate change for the City of Prince George:

- More precipitation will likely fall as rain rather than snow
- More frequent incidences of extreme rainfall events and “localized?” flooding.
- Incidences of flooding could result from a variety of causes: riverine flooding from freshets or ice jams; and drainage system flooding from storm sewers surcharging or overland flow.
- Increased slope instability including riverbank erosion and loss of riparian habitat.
- Based on the limited available rainfall data (mostly Prince George Airport) the existing IDF curve seems sufficient for statistically representing historical rainfall events, but the City has not yet reviewed the IDF curves in consideration of future climate change.
- The number of freeze-thaw cycles has not recently increased, but City staff report that the apparent severity or impact of the freeze-thaw cycles seems to have increased.
- Rising annual temperatures leading to increased invasive species. This may be an issue for detention ponds, ditches, watercourses, riparian setbacks, wetlands and other forms of green infrastructure.
- Warmer winters and changes in freeze-thaw cycles could result in an increase in required road salting (and associated water quality impacts).

The extent to which each of the WDP have considered climate change are presented in the following table.

Table 4 WDP Considerations of Climate Change

WDP	Year	Considered Climate Change?
Gladstone, Varsity & Trent	2002	No.
Hudson’s Bay Slough	2007	No.
East Prince George	2013	No but an update to the East PG WDP is underway.
University Heights & Peden Hill	2016	No. The consultant concluded that the summer events are the governing storms and they did not think that there will be an increase in summer storms.
McMillan Creek	2017	Modelled the 1 in 10-year storm rather than the 1 in 5-year storm to account for climate change. This represents a 20% increase in the 1-hour storm and a 13% increase in the 24-hour storm.
West Fraser River & Parkridge Creek	2020	Used IDF-CC tool for climate projections. 2100 increase in precipitation of 35% (RCP 8.5 emissions scenario)

It is recommended that once the City has developed a future looking IDF curve based on improved rainfall data that considers climate change, that the hydraulic/hydrologic models created to support each WDP be updated with the new IDF curves and that the recommendations from each WDP be updated accordingly.

In the meantime, if the City is completing any of the projects identified in one of the WDP that did not consider climate change, then it should as a minimum, consider the impacts of increased rainfall by 35% (as per the IDF CC tool used for the West Fraser River & Parkridge Creek WDP). It should be noted that increasing a pipe by one size represents a 34% increase in capacity, on average (when considering pipes from 375 mm to 1200 mm in diameter). Increasing the diameter of a storm sewer replacement project by one size will typically increase the cost of a project

by a marginal amount (e.g. 15%). Note that the percentage increase for each jump in pipe size is not equal and should be assessed for each project. Likewise, the impact and associated cost of considering climate change for non-pipe projects (e.g. detention pond, erosion stabilization etc.), would need to be reviewed separately for each recommended project.

2.7 Cost Estimates

The estimated costs of WDP recommendations that were provided in Table 1 in **Section 2.2** were extracted directly from the reports. The costs provided in each of the WDP typically only included capital costs that would be incurred by the City. Developer costs or "internal" City costs for policy changes etc. were not typically provided. Operations and maintenance costs are provided in few WDPs and were estimated as a percentage of capital cost (i.e. 1-4%).

The West Fraser River & Parkridge Creek WDP provided most of their cost estimates in the form of ranges (i.e. $10k, $10-$100k, $100k-$1M). Averages within the range provided were used to develop the total in **Table 1**.

In addition to internal costs, the WDPs omitted specific information as follows:

- McMillan Creek – Did not provide cost estimates for some of the recommended projects (i.e. proposed wetland, establishing parks & trails, culvert condition assessment, general mainstem crossing improvements, providing incentives to landowners to replace creek crossings that are fish barriers, develop and use BMP). They also did not detail what types of incentives could be offered to landowners to replace creek crossings that are fish barriers.

- University Heights/Peden Hill – Did not provide cost estimates for some of the recommended projects (i.e. cleaning out accumulated sediment from storm inlets, capping trails, establishing greenbelt areas/wildlife corridors, diverting runoff from watercourses, oil-grit separators, snow-dumps, upgrading culverts at the end of their service lives, water quality monitoring).

- Hudson Bay Slough – Did not provide a cost estimate for conducting a field investigation and assessment of sediment accumulations in the downtown area. This work is currently being done.

- Gladstone, Varsity and Trent – Did not provide cost estimates for some of the recommended projects (i.e. public trails and stream corridor management).

As previously noted, the costs provided in the summary table in **Section 2.2** were not increased to consider inflation or climate change. We have therefore provided a high-level estimate of the relevant cost increases for each of the WDP to consider inflation and climate change.

Construction Cost Inflation

Five of the six WDP were completed between 2002 and 2017 and therefore the cost estimates of the recommended projects need to be updated. In order to bring the costs to 2020 values, we would need to consider inflation.

The B.C. Construction Industry inflation rates are provided in the following table. These inflation rates are general to B.C. and not specific to Prince George. However, the City of Prince George has found that they have been experiencing an average annual inflation rate of approximately 5% recently, which is similar to the BC Construction Inflation Rates. Therefore, we will be using the BC Construction Inflation Rates to bring the historic cost estimates to 2020 levels.

Table 5 BC Construction Inflation Rates

Year	Inflation Rate
2002	6%
2003	8%
2004	9%
2005	10%
2006	10%
2007	6%
2008	5%
2009	3%
2010	3%
2011	2%
2012	2%
2013	2%
2014	2%
2015	3%
2016	3%
2017	4%
2018	6%
2019	6%
2020	4%

In **Section 2.6**, we estimated that modifying pipe related projects to consider climate change could result in a project cost increase of 15%. Note that this a very high-level estimate and the actual increase for any given project would need to be assessed individually.

Most of the estimates provided in the WDPs were very high level and should be presented as a range to better reflect their level of accuracy. The high-level cost estimates provided in the WDPs should be presented as a range from -50% to +100%.

The original cost estimates in the WDPs were:

- increased by 15% to account for climate change if climate change had not already been considered in the WDP;
- increased to 2020 levels based on the construction cost inflation rates previously presented; and
- adjusted and presented as a range from -50% to +100% to consider the level of accuracy of the cost estimating within the WDPs.

The cost estimate adjustments and revised cost estimates are provided in the following table.

Table 6 Adjusting WDP Cost Estimates for Climate Change and Inflation

WDP	Year	Considered Climate Change	Original Cost of Recommendations & Inflation Increase	Cost of Recommendations when considering climate change, inflation and range of accuracy
Gladstone, Varsity & Trent	2002	No. Increase cost estimate by 15%.	$8.8M Increase cost estimate by 84% for inflation.	$9M - $35M
Hudson's Bay Slough	2007	No. Increase cost estimate by 15%.	$17.5M plus cost to remove sediment from downtown sewers - costs TBD. Increase cost estimate by 41% for inflation.	$14M-$55M plus cost to remove sediment from downtown sewers

WDP	Year	Considered Climate Change	Original Cost of Recommendations & Inflation Increase	Cost of Recommendations when considering climate change, inflation and range of accuracy
East Prince George	2013	No. increase cost estimate by 15%.	No cost estimates provided	No cost estimates provided
University Heights & Peden Hill	2016	No. Increase cost estimate by 15%.	$4.5M Increase cost estimate by 16% for inflation	$3M - $12M
McMillan Creek	2017 started 2011	Somewhat. No increase for climate change required.	$10.2M Increase cost estimate by 12% for inflation.	$6M-$23M
West Fraser River & Parkridge Creek	2020	Yes. No increase for climate change required.	$14M	$7M-$28M
Total				**$38M-$152M** plus East PG projects and cost to remove sediment from downtown sewers

2.8 Gap Analysis

The following table outlines the main gaps identified as part of the WDP review and priorities for addressing these gaps. Ideally the City would address all the gaps identified in the following table to get a better view of the City's stormwater system. In light of limited funds and staff time, many of the recommended activities to address the gaps can be deferred until particular trigger events occur (i.e. proposed development, implementation of WDP recommendations, new or revised WDP).

Table 7 WDP Gap Summary and Priorities for Reducing Gaps

Gap	Description	Priority for Addressing
Geographic Area	Parts of the City are not addressed by a WDP	Some areas not currently included within a WDP are already developed or may be developed in the near future. Priorities for developing new WDPs should be: 1. Areas with known issues (flooding, contamination etc.). 2. Areas where new development is occurring or soon to occur i.e. North Nechako 3. Areas of existing development.
Climate Change	4 out of the 6 WDP did not consider climate change	Need to address climate change whenever a new WDP is being completed, an existing WDP plan is being updated and/or any recommended projects from an existing WDP are being considered/implemented.
Prioritization	The six WDP did not use a consistent methodology for prioritizing projects.	New and updated WDPs should use the same prioritization framework for recommended projects (see **Section 3**).
Modeling Software	Different software packages were used for different WDP, making updates, reviews and consolidation more challenging.	The City should select preferred stormwater modeling software package(s) before completing any new WDPs or WDP updates. Having all of the City's watersheds modelled in the same or similar software will make it easier for the City to complete updates or assessments in house. It will also allow the City to consolidate the models between two areas that were assessed under different WDPs but may be hydraulically connected, even if the connection is only due to "overflows/spilling" during design storms. This will result in easier and more accurate modeling of these "spillover" events.
Major System Modeling	McMillian Creek, University Heights and Peden Hill WDP only completed selective modeling of the major system.	New or updated WDP should develop a dual drainage model (1D) with the use of 2D modeling, where needed to assess problem areas where surface flooding issues have been identified.

Gap	Description	Priority for Addressing
Flow/quality Monitoring	Some of the WDPs were developed with no data from water quality or flow monitoring.	In the absence of an on-going flow monitoring/water quality sampling program (ideal scenario), the City should conduct water quality sampling and flow monitoring in conjunction with each WDP in order to: identify, confirm and improve understanding of watershed issues; and to improve the reliability of hydrologic and hydraulic models through model calibration.
GIS	Not all the catchment areas and stormwater assets are accurately depicted in GIS	The City could update their GIS catchment areas and stormwater assets with those identified in each of the WDP as workloads allow. See **Section 5**.
Future Conditions	Hudson Bay Slough WDP only modelled existing conditions and not future conditions under future development.	The City should model future conditions before any future development occurs in the watershed.
Cost Estimates	The East PG WDP did not provide cost estimates for any of the recommendations and other WDPs did not provide cost estimates for some of the recommendations.	The City will need to develop cost estimates when evaluating or considering recommended projects that have not had a cost estimate provided.
Environmental Assessments	Some of the WDP did not assess whether culverts are fish friendly and whether the watershed has intact riparian function.	New and updated WDPs should address whether culverts are fish friendly and whether the watershed has intact riparian function. Any drainage projects or development plans should consider, where relevant, fish friendly culverts and preserving riparian function.
Geotechnical Assessments	Not all the WDP considered well sites, contaminated sites, and historical land use.	New and updated WDPs should consider surficial geology, geomorphology, slopes, municipal and private well sites, contaminated sites and older industrial/commercial sites to identify areas where increased infiltration should not be done without site specific studies.
Natural Assets	The WDPs mentioned the presence and importance of natural assets without developing a natural asset inventory.	The City will be developing a natural asset inventory that future WDPs should update, as necessary.

3. Additional Drainage Planning

In addition to and subsequent to the development of the Watershed Drainage Plans (WDPs), the City has:

- Completed some of the action items proposed in the WDPs;
- Reassessed and revised some of the action items proposed in the WDPs;
- Collected new information about its system and drainage related issues; and
- Identified new priorities not identified in the WDPs.

These changes and additional information are outlined below.

The Hudson's Bay Slough WDP recommended assessing the sediment in the downtown drainage system. Since this WDP was prepared the City has conducted sediment sampling in the Winnipeg St Stormwater System and is completing a Management & Treatment Plan for this system. The City is working to address downstream contamination in the Hudson's Bay wetland.

The University Heights and Peden Hill WDP recommended introducing volume control measures for stormwater run-off. One proposed project to help achieve this would be the installation of a diversion pipe through the Pine Valley Golf Course to an infiltration gallery. This project has been added to the list of action items.

Maurice Drive Pond, within the University Heights and Peden Hill Watershed, already has accumulated a large amount of sediment. It will not be easy to clean-out as the pond design does not accommodate easy maintenance access nor does it provide a drying area to decant sediment prior to removal by truck. The pond should be retrofitted to establish good maintenance vehicle access, to improve grouting, and sediment should be removed. The City would first need to complete a study to prepare a design and confirm the amount of sediment to be removed. This project has been added to the list of action items.

In the spring of 2020, the Parkridge Creek culvert at Domano Boulevard failed and was repaired. While the City has implemented a temporary fix, there is a need for a more permanent solution which provides fish passage. The proposed permanent solution is an open bottom structure at an estimated cost of $1 million. The City will likely get warnings about the need for fish passage from DFO in the spring of 2021. This project was already proposed by the WDP and has given the highest priority due to the fact that it is likely to become a regulatory requirement.

Groundwater seepage has been found to be problematic in some areas, particularly for homes built at the bottom of slopes (e.g. Brock Drive, Selkirk Crescent, sidewalk lifting on the west side of Domano Boulevard just before College Heights etc.). This needs to be considered when implementing proposals for stormwater infiltration.

There are issues in the Varsity watershed due to erosion caused by upstream development. In particular, there is erosion downstream of Simon Fraser as a result of more continuous flows from the Domano/Westgate Storm Pond. This erosion will need to be addressed and changes to the Domano/Westgate Storm Pond should be investigated. This project has been added to the list of action items.

In 2018 a large storm sewer pipe (2400 mm CSP) along Winnipeg Street (near the intersection of 20th Avenue) collapsed, causing a sinkhole. A large section of pipe was replaced at a cost of $1.7 million.

Other projects identified in the Watershed Drainage Plans that have been completed since the WDPs were issued are outlined below.

- Parkridge Creek and West Fraser WDP: Culvert upgraded at Highway 16 during the Highway's project to expand to 4 lanes.

- McMillan Creek WDP: Replaced a crossing structure with a clear span bridge on Aberdeen Road.
- McMillan Creek WDP: Replaced a crossing structure with a clear span bridge on Goose Country Road.
- University Heights/Peden Hill: Diverted flow from culvert C11 south along the east side of Tyner Boulevard by blocking culvert C12.
- East Prince George WDP: Airport Hill drainage project completed (terrain instability associated with the drainage course).
- East Prince George WDP: Replaced Willow Cale Road culvert on Haggith Creek with a bridge and culvert.

The City will be developing a natural asset inventory in 2021, with the assistance of grant funding.

4. Prioritization Framework

Due to limited available funding and the need to demonstrate prudent risk-based fiscal management, the City must prioritize the completion of identified projects. The City, and its consultants, have used different methods for prioritizing projects for different initiatives. The City would like to develop a standard framework that can be used for comparing and prioritizing all projects.

This section describes existing prioritization frameworks used within the City, standard frameworks developed by industry organizations and proposes a new consolidated framework that can be used by the City to compare projects from different initiatives.

4.1 Existing Frameworks

The City of Prince George is investigating and/or implementing 3 types of prioritization frameworks:

1. A network level risk framework: they are currently being used within Powerplan (formerly called RIVA) for the water and sanitary systems and have been used for their Water and Sanitary Master Plans. As part of the ISMP, a network level risk assessment will be done for the City's storm sewer system.
2. A project prioritization framework: this is what AECOM will be developing for prioritizing action items from the six WDP's. The City had previously developed a draft framework that was not implemented. See Appendix A).
3. An option selection framework for selecting between various options for a given project. This is commonly based on a cost-benefit analysis type of framework. This type of prioritization is out of scope for this assignment.

A detailed summary of the existing prioritization frameworks used within the City and standard frameworks developed by industry organizations is provided in Appendix A. A brief summary of each of the frameworks is provided in the following table.

Table 8 Existing Framework Summary

	Framework	Summary	Pros	Cons	Recommendations
1	West Fraser River & Parkridge Creek WDP	• Cost • Risk/criticality • Land requirements • Life cycle cost analysis • Environmental Impact • Feasibility • Functionality • Acceptability to Environmental Agencies • Acceptability to the Public • Acceptability to the City • Environmental Mitigation/Compensation Works	Based on OCP goals: - Protect life and property from stormwater related flooding - Provide appropriate drainage service to the community - Preserve and improve environmental quality - Protect watercourses from erosion and sedimentation - Reduce inconvenience from surface ponding and flooding - Promote orderly, cost effective, and sustainable development - Minimize the overall cost of the stormwater system to the City (liability, capital, environmental and operational) - Promote public access for recreational and environmental education or pursuits	No point system Could streamline goals (current overlap)	Use some of the factors as input into a prioritization framework, then reintegrate projects into a new prioritization framework
2	University Heights/Peden Hill WDP	Addressed flooding, erosion and water quality issues in short (existing issues); medium (future issues) and long (policy issues) term.	Addressed economic and environmental issues	Not a risk-based approach	Need to integrate projects into a new prioritization framework
3	East PG WDP	The proposed action items were given a score of one (low) to ten (high) for each of the following three considerations: • the relative costs versus benefits (cost-benefit ratio score); • difficulty to implement, and; • their probable effectiveness within the East Prince George watershed.	Scoring system	Not clear how points were awarded. Would require quantification of environmental benefits, social benefits, difficulty to implement and probable effectiveness.	Good general approach but would need more information/direction to apply to other studies. May also want to think about how to best capture social and environmental benefits.
4	McMillan Creek WDP	Projects broken into Major/secondary concerns based on risk. Projects then based on location (main stem, tributary, closed piped network) and broken into short, medium, long term.	Risk based	Not sure if location (main stem, tributary or closed pipe network) consistently correlates with risk levels. Need more info on what constitutes high vs low risk.	
5	Hudson's Bay Slough WDP	Projects were prioritized based on perceived need.	Good approach for dealing with a specific topic (stormwater) in a specific area.	No formal prioritization framework.	Would be difficult to apply to a consolidation of multiple studies.

6	Gladstone, Trent & Varsity WDP	Prioritization based on timing (existing vs future needs)	Addressed the timing of development.	Doesn't address the issue of too many existing projects	The issue of timing with development should be applied to an overall prioritization framework
7	CPG Enterprise Risk Management	Priorities based on financial, operational, staff/public, reputational and strategic consequences.	Risk based approach.	Doesn't address environment, benefits, or regulatory requirements. Hasn't received senior management approval. Redundancy between categories.	Base framework could be used with modifications to content.
9	Water Master Plan	Risk based approach that considers condition and capacity.	Risk based approach. Aligned with Powerplan, GIS, sanitary mains, drainage mains.	Specific to water mains.	See #12 below.
11	Sewer Master Plan	Risk based approach that considers condition and capacity.	Risk based approach. Aligned with Powerplan, GIS, water mains, drainage mains.	Specific to sanitary mains.	See #12 below
12	Powerplan (RIVA) – Drainage	Risk based approach that considers condition and insufficient capacity (i.e. that causes flooding).	Risk based approach. Aligned with Powerplan, GIS, water mains, sanitary mains.	Does not consider environmental impacts from quantity or quality. Does not consider benefits (i.e. amenities).	Could be used as a sub-prioritization framework for renewal of drainage mains only within a greater prioritization framework
13	CPG Project Level Risk Analysis	Risk based approach that considers H&S, reputation, legal, relationships, services/systems, environment, cultural heritage.	Risk based approach that encompasses more considerations than ERM framework.	Does not consider costs or benefits (i.e. looks at negative not positive).	Base framework could be used with modifications to content.
14	EMBC (Emergency Management BC)	Risk based approach based on consequences of failure.	Risk based approach which is similar to CPG's ERM (Enterprise Risk Management).	Does not consider environmental impact. Does not consider cost or benefit of solutions.	Base framework could be used with modifications to content.
15	NAMS (National Asset Management System)	Risk based approach for identifying asset priorities	Risk based approach that CPG has used on previous AM projects	Does not consider cost or benefit of solutions. Mixed opinions in industry about the NAMS risk framework	
16	Eagle Creek ISMP (City of Burnaby)	Cost benefit point-based approach that considers economic, environmental and social consequences.	Simple but comprehensive scoring system Based on drainage project considerations.	Doesn't consider likelihood. Not aligned with other CPG systems.	Content could be used to modify other risk-based approaches.

4.2 Proposed Framework

Through discussions with City Staff and a review of existing documents we have developed a generic project prioritization framework for the City of Prince George as shown in **Appendix B**. This prioritization framework could be applied to any asset type.

The following table (Table 9) takes the intentions of the generic prioritization framework but adds stormwater related details so that it can be used to prioritize stormwater related projects. This stormwater specific table will be used to prioritize the action items from the six watershed drainage plans.

It is recommended that the City complete an additional check for each of the prioritized projects to see if it meets the City's strategic objectives and if is it already identified as an action item within one of the City's existing action plans.

Table 9 Stormwater Project Prioritization Framework for the City of Prince George

	High Score=3	Medium Score=2	Low Score=1	None Score=0
Social	• Prevents known/existing flooding risk that impacts > 25 developed properties and/or 500 people/users (traffic turnover rate) • Prevents closure of critical road. (i.e. due to flooding or pipe collapse). Critical road can include an arterial, road without an easy detour or impacts access to critical facilities such as hospital. Projects include monitoring of asset condition or replacement of assets in poor condition. • Provides a park/trail of regional significance • Protects > 5 developed properties from erosion • Will result in the equitable distribution of costs and services across the City and across generations	• Prevents theoretical flooding risk (modeled) based on existing development and design standards • Prevents closure of non-critical road and > 5 users/traffic turnover rate (i.e. due to flooding or pipe collapse). Projects include monitoring of pipe condition or replacement of assets in poor condition. • Provides local amenity – small park, beautification (i.e. rain gardens, trees etc.) • Protects 5 or fewer developed properties from erosion.	• Prevents theoretical flooding risk (modeled) based on future development • Not completing the project may result in nuisance flooding • Prevents closure of non-critical roads with minimal user impact (< 5 users/traffic turnover rate) • Replacement of asset in fair condition • Leads to a more informed and educated public • Improves aesthetics (i.e. debris pick-up)	• No social benefit from completing the project and no negative social impact from not completing the project.
Economic	• Net cost is positive or <$10,000 to the City • Replacement of an asset in poor condition • Unrecoverable cost to the community is <$10,000	• Net capital cost is between $10,000 and $250,000 and/or net annual cost is < $25,000 • Unrecoverable cost to the community is between $10,000 and $250,000	• Net capital cost is between $250k and $1 M and/or annual cost is between $25k and $100k • Unrecoverable cost to the community is between $250,000 and $1,000,000	• Cost is >$1M and/or annual cost is >$100k • Unrecoverable cost to the community is > $1,000,000
Environmental	• Preserves, creates or provides access to high level habitat (wetlands, spawning grounds, fish-bearing channels, wildlife corridors) • Protects valuable natural asset and provides ecosystem services (e.g. drinking water aquifer, wetland known to moderate flow/heat, capture contaminants, etc.) • Reduces City's environmental liabilities • Is broad reaching and has multiple environmental benefits (e.g. climate adaptation, fisheries, air quality, water quality/quantity, etc.)	• Preserves moderate level habitat (riparian areas, non-fish bearing channels, large forested areas) • Removes sediment or contaminants? from the system in fish bearing watersheds (or prevents sediment from entering the watershed) • Install water quality treatment in fish bearing watersheds • Controls flows in fish-bearing watersheds • Replace culvert in poor condition in fish bearing stream (avoids collapse and negatively impacting stream)	• Removes sediment from the system in non-fish bearing watersheds • Install water quality treatment in non-fish bearing watersheds • Controls flows in non-fish-bearing watersheds • Replaces culvert in poor condition in non-fish bearing stream or culvert in fair condition in fish-bearing stream • Remove debris • Public education promoting environmental stewardship	• No environmental benefit from completing the project and no negative environmental impact from not completing the project.

Notes
- *Maximum score is 9. Scores can range from 0-9.*
- *Mandated projects (i.e. through municipal, provincial or federal legislative requirements, orders, warnings, and agreements such as development or partnership agreements) have an automatic score of 9.* This includes projects that are mandated through environmental legislation, including locally protected areas (Riparian Protection – DP areas).*
- *Unrecoverable costs to the community include costs that will not be reimbursed through insurance nor can be passed on to the consumer without significant impacts (i.e. significant loss of sales).*
- *Note that planned service disruptions (e.g. due to maintenance/construction) typically result in less significant impacts because alternatives can be put in place. Whereas unplanned service disruptions due to emergencies (e.g. pipe collapse, extreme weather event) typically result in greater service impacts.*
- *Many of the proposed projects will result in some costs to the City but some of the projects will also result in some savings (i.e. deferred maintenance). Therefore, Net costs = total costs – total savings*

4.3 Prioritized Projects - WDP

We compiled a list of action items from the six WDPs. There was a total of 261 action items. Note that some of the action items are duplicates as multiple WDPs might have made the same recommendation such as “Develop an Erosion and Sediment Control Bylaw”. The prioritization framework was applied to each of the action items resulting in a prioritization score. The highest score possible (meaning a high priority project) is nine (9) and the lowest score possible (meaning a very low priority project) is zero (0). The percentage of action items that were assigned a prioritization score from 0 to 9 are shown in the following figure.

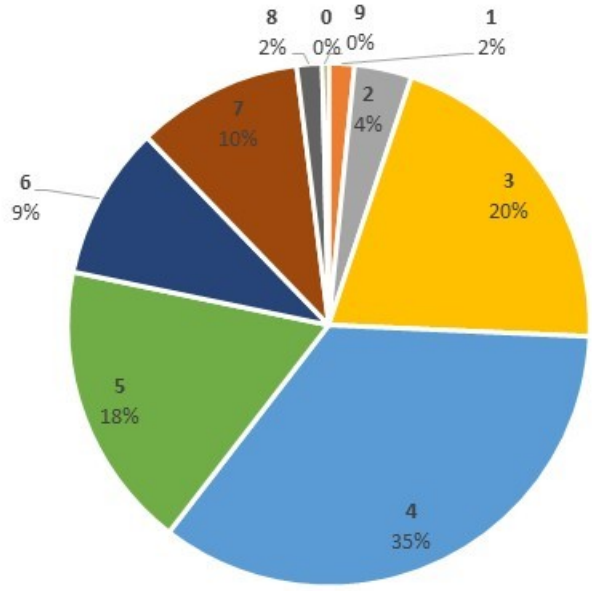


Figure 2 Percentage of Action Items with a Prioritization Score from 0 (low) to 9 (high)

No proposed WDP projects received a score of zero. This is not surprising as an action item with no economic, social or environmental benefit is unlikely to be recommended within a WDP. The majority of the projects (74%) have a score of 3-5, meaning that they have a moderate priority. The highest priority projects have a score of 6-8 (20%). Because of the way the prioritization framework was set-up, these projects are typically ones that provide economic, environmental and social benefits and/or avoid significant negative economic, environmental and social impacts. In other words, these are synergistic projects that provide multiple benefits and/or reduce multiple risks.

The number of actions items and estimated cost of completing the action items in each of the score categories are presented in the following table. The cost estimates have been updated to consider inflation since the respective WDP was produced and increased by 15% if the WDP didn’t consider climate change. The cost estimates do not include costs for action items proposed by the East Prince George as no cost estimates were developed as part of that WDP. Note that some of the action items are similar in scope (e.g. implementation of BMP/LID standards for new development or better protection of riparian areas was recommended by several WDPs). The action items that are duplicated tend to be policy related and will therefore not have a significant impact on the cost estimates (e.g. have a cost estimate of approximately $10,000).

The cost estimates are presented in a range (lower to upper) to reflect that they there are high level cost estimates produced for general planning purposes.

Table 10 Summary of Action Item Cost Estimates by Prioritization Score

Score	# of Action Items	Lower range (-50%) Cost Estimate	Upper range (+100%) Cost Estimate
9	1	$ 500,000	$ 2,000,000
8	4	$ 15,000	$ 60,000
7	26	$ 730,000	$ 2,920,000
6	24	$ 2,093,000	$ 8,371,000
5	45	$ 4,135,000	$ 16,542,000
4	88	$ 9,006,000	$ 36,024,000
3	52	$ 7,549,000	$ 30,196,000
2	9	$ 6,096,000	$ 24,384,000
1	4	$ 1,100,000	$ 4,400,000
0	0	$ -	$ -
Total	253	$ 31,224,000	$124,896,000

A summary of the projects with the highest priority score are provided below.

Only one project received a score of nine, the Domano culvert on Parkridge Creek, as the City has been informed by DFO that the culvert needs to be fish passable during all seasons. In other words, it was given a score of nine due to regulatory requirements. No projects score a nine by receiving the highest score in all three categories (economic, social and environmental).

There are four action items with a score of eight (8) with an estimate cost to complete of $15,000 to $60,000 (mostly internal staff work). Three of these action items are related to introducing better erosion and sediment control measures (e.g. new erosion and sediment control bylaw); and one of the action items is to update hazardous slope mapping.

There were 26 projects with a score of seven (7) at an estimated cost to the City of $730,000-$2,920,000. Projects with a score of seven fell under the categories listed below.

- Secure sustainable levels of stormwater funding (e.g. Stormwater utility with credit/rebate program). In order to successfully secure sustainable funding it will be important to educate the public on the value of stormwater management.
- Protect wetlands and important riparian areas that are not currently protected under municipal legislation (i.e. riparian areas of a stream that is not fish-bearing but drains to a fish-bearing stream or a wetland that is not directly connected to a fish-bearing stream).
- Protect important wildlife corridors and core habitat areas that are not addressed through existing riparian area protection.
- Expand floodplain development permit areas in certain areas along Parkridge Creek.
- Update Design Guidelines to consider climate change (e.g. increase the design storm and minimum pipe size/slope). This will be addressed further in TWP #2.
- Update Prince George Bylaws (DCC, Development Procedures, and Tree Protection).
- Implement Best Management Practices/Low Impact Development (BMP/LID) standards for new development in catchments to fish-bearing streams and associated public education circulars. This concept will be discussed further in TWP's 2 and 3.
- Replace/modify culverts in poor condition, under a significant road, whose modification/replacement would also provide fisheries benefits (e.g. Bittner Creek).

There are 24 projects with a score of six (6) at an estimated cost to the City of $2M - $8.2M. The projects fell under the categories listed below.

- Culvert upgrades/replacements where the existing culvert is in poor condition and under a critical road or a road with moderate use and an upgrade would provide fisheries' benefits (e.g. McMillan Dr, Parkridge Creek/West Fraser).
- Assess culverts for condition and ability to allow fish passage, where relevant
- Stormwater system maintenance including culvert maintenance
- Update GIS
- Monitor beaver activity
- Cap trails near escarpment watercourses with less erodible material
- Investigate capacity of Hudson Bay Slough storm sewer
- Include water quality treatment features in detention ponds where possible for new developments
- Require developments through bylaws and the Design Guidelines to install BMP/LID to control flow and quality in catchments to non-fish bearing streams. Feasibility should be confirmed through infiltration testing.
- BMP/LID integrated into existing/upgraded roadways that control flow and quality in catchments to fish-bearing streams
- Address Foreman road drainage channel issues as a result of commercial development at the corner of Foreman Rd and Hwy 16E
- Hudson's Bay Wetlands - enhance wetland along with providing improved educational and recreational opportunities
- Improve fish habitat in the Lower Hudson Bay Wetland along with providing improved educational and recreational opportunities
- Protect undevelopable land

There are 45 projects with a score of five (5) at an estimated cost to the City of $4.1M - $16.5M. The projects with a priority score of five fall under the categories listed below.

- Culvert upgrades that provide multiple benefits (i.e. fisheries, prevent flooding, prevent road closure/sinkhole) but where the benefits/risk are not as great as those projects that have a score of 6 (ex. Victoria/Pine/Oak St)
- Establishing flood construction levels for Parkridge Creek upstream of Highway 16
- Improved sediment management (e.g. cleaning sediment from the system, construction of sediment ponds & forebays, sediment capture from snow storage)
- Improving outfalls (e.g. treatment at Hwy 16 and Latrobe, cleaning Cowart Road, cleaning Heyer Road)
- Public engagement
- Enforcement of existing/proposed regulations included staff training and increased inspections
- Oil & Grit Separator (OGS) requirements for certain industrial properties and large parking lots
- Remedial creek work
- Use of native species (e.g. planting of roadside ditches)
- Protecting creeks from vehicles (e.g. preventing recreational vehicle crossing at Park Drive and adjusting future road alignments away from riparian areas)
- Culvert upgrades to be completed by other organizations (e.g. BC Hydro, CN Rail)
- Storm sewer and zoning bylaw upgrades
- BMP/LID integrated into existing/upgraded roadways that control flow and quality in catchments to non-fish-bearing streams
- Design manual updates
- Protecting areas from aggregate extraction
- Controlling flows (e.g. subcatchment diversions in Hudson Bay watershed, new detention ponds in already developed areas in fish-bearing watersheds, addressing Domano/Westgate pond)

Note that this is a high-level project prioritization framework. Each project should be reviewed for compliance with City strategies and undergo a more detailed cost-benefit review. This is especially important for projects where no cost was given in the WDP.

All the Action Items, with their prioritization score, are listed **in Appendix C**. Through further discussions with City staff and the completion of this ISMP, additional action items may be identified and should be added to the overall Action Item List. Similarly, the City may decide to eliminate action items proposed by completed WDPs. In this way, the compiled Action Item list can become a “living” document that is regularly updated as issues arise, projects are completed and priorities change.

5. GIS

5.1 Existing GIS

The City's GIS data is publicly accessible through the City's Open Data Portal. The City of Prince George's stormwater data is well structured and is modeled as a geometric network in GIS allowing the City to track flow paths and direction.

All the key stormwater asset attributes are set up in the City's GIS, but much of the attribute data is missing. This can be common with municipalities because they tend to set up their data based on an ESRI model and keep most of the default attribute settings, but don't have the data or resources to gather the data to fill the attributes. For instance, there is very little condition data or risk scores. It is likely that the City does not have condition data or risk scores on the majority of its stormwater assets rather than it being a GIS issue. However, once this data is obtained, it will be important to add it to the GIS database. Data resulting from the Network Level Risk Assessment task for the next Technical Working Paper (TWP #2: Engineering Issues) should be uploaded into the City's GIS database.

The City's GIS does not include green infrastructure (e.g. rain gardens) or stormwater assets related to LID (e.g. permeable pavement). It is assumed that the City does not currently have any of these types of assets. The City's GIS does denote streams, marshes and swamps, but not their riparian areas. Creeks are not named in the City's GIS. The City's pending new natural asset inventory initiative should help address any of these gaps. It is important that once the City's natural asset inventory is completed, the City's GIS should be updated accordingly.

As the six WDPs were completed, the respective consultants found that some important data was missing and used LIDAR, aerial imagery and field investigations to obtain the data necessary to complete the WDP. The following WDPs reported that the listed assets weren't accurately or comprehensively included in the City's GIS:

- Hudson Bay Slough - culverts and open channels
- Gladstone, Varsity and Trent - creeks & culverts
- McMillan - culverts, outfalls & natural ponds
- East Prince George WDP - culvert locations/ material/ size/ condition, watercourse, roadside ditches dimensions
- West Fraser River & Parkridge Creek WDP - none of the culverts in GIS had invert elevations, and 85% of the storm pipes in the study area were missing invert elevations.

The consultant for the University Heights Peden Hill WDP completed the culvert inventory (table provided in Appendix B).

24% of Prince George's roads within GIS (224 km of 945 km) don't have a storm sewer or ditch associated with them, which suggests that the City's ditch inventory is not complete. We determined that only 8% of the gravity mains in the City had invert elevations.

The areas that are hatched in Figure 1 are areas that are not included within a catchment in the City's GIS. These areas are mostly in East Prince George and along the south shore of the Nechako River (including the railyards). The catchments in East Prince George that are not within the City's GIS are Willow Creek South, Willow Creek North, Unnamed (Fraser River), Ellicott Creek and Haggith Creek (some of which is outside the City boundaries).

The following table indicates which key attributes for specific stormwater assets are within the City's GIS. A black check indicates that the data is complete (i.e. >75%) or nearly complete. A grey checkmark indicates that some of the data is there (i.e. 25-75%). An x indicates that very little data is within the City's GIS (i.e. < 25%).

Table 11 GIS Info Summary

Asset Type	City Quantity *	Known Inventory Gaps	Install Date	Size	Elevation	Condition	Material	Sub-assets	Owner
Catch basins	5755	✓	✓	✓	X 256/5846 have values	X	X 4/5846 have values	X 5/5846 show grates	✓
Catchment areas	53	✓ missing 5	n/a	✓	n/a	n/a	n/a	n/a	n/a
Discharge points	348	✓	✓	X 68/371 have values	X 105/371 have values	X	X 16/371 have values	X Wall/ apron	✓
Fitting	284	✓	✓	✓	✓	X	✓	n/a	✓
Gravity mains	383 km	✓	✓ WDP reported some culverts missing	✓	……..X	X	✓	n/a	✓
Inlet	213	✓	✓	✓	✓	X	✓	✓ Wall/ apron but no grates or screens	✓
Lift station	8	✓	✓	X	✓	X	…….X	X	✓
Storm structure (lift facilities)	7	✓	✓	…….X	✓	X	…….X	X	X
Manhole	4072	✓	✓	✓	X 451/4072 have values	X	…….X	X	✓
Pressurized main	150 m	✓	✓	✓	X	X	✓	X	✓
Storage basin	25	✓	✓	X < 6% show capacity	✓	X	X	X	✓
Lateral line	227 km, 21,227	✓	✓	✓	✓	X	✓	X	✓
Open channel	690 km	✓ ✓24% of roadways show no sewer or ditch	X	X	X	X	…….X	X	✓
Hydrography line/ poly	1982 km, 28 km^2	✓	n/a	X	X	X	……X	✓ 25% indicate fish presence or not	X
Flow monitoring station	1	X	X	……X	X	X	……..X	X	X
Subsurface infiltration facilities	73	X	X	…….X	X	X	……..X	X	X
Dike	3.6 km	X	X	…….X	X	X	……..X	X	X

* The quantity is taken from GIS where the asset type is in GIS, otherwise it was taken from the NWWBI data.

✓ *Indicates that the data is complete or nearly complete (i.e. >90%) in GIS*
✓ *Indicates that a significant portion (i.e. >25%) of the data is in GIS*
X *Indicates that very little (i.e. < 25%) of the data is in GIS*

5.2 GIS Gap Reduction Plan

As previously mentioned, many of the asset attributes do not have data. However, some attributes are more critical than others. For instance, knowing the installation date is generally more useful than knowing the manufacturer. The following table below outlines the more critical GIS gaps.

Table 12 Key Stormwater Related GIS Gaps

Asset Type	Attribute	Gap
Various	Elevation	Only 8% of storm mains, 4% of catch basins, 0.12% of open channels and 28% of discharge points have elevations.
Various	Condition	There is a lack of stormwater asset condition data in the City's GIS. This is likely due to the City having limited information about the condition of its stormwater assets. The City must first conduct the condition assessments and then enter the data into GIS.
Various	Inventory	The following asset types are missing from the City's GIS: some of the catchment areas (see Figure 1), dikes, monitoring stations, subsurface infiltration facilities, and some of the ditch network.
Various	Risk scores	The City has yet to conduct a risk assessment of its storm system. Once this has been done, the results should be linked to the City's GIS.
Various	Size/capacity	City's GIS doesn't include the size/capacity for its lift stations, storage basins, and open channels
Creeks	Names	Creek names should be added to GIS to facilitate system analysis and understanding.
Water bodies (Hydrography line)	Sub-assets	Only 25% of the waterbodies indicate whether there are fish present or not.
Inlets/ Discharge Points	Sub-assets	The presence of grates or screens could not be found in the City's GIS, which is important for maintenance planning.

Based on the GIS gaps identified in the previous section, we recommend that the City address the most significant gaps by completing the following actions.

- Incorporate missing data that was obtained during the preparation of each of the WDP (i.e. inventories, elevations, presence of fish etc.)
- Complete condition assessments of its stormwater assets and record the results within GIS
- Complete a risk assessment of its stormwater system and record the results within GIS
- Complete the ditch and screen/grate inventory as other O&M work is being conducted (i.e. collect screen/grate info during culvert inspections, collect ditch info during pavement condition assessments or street sweeping)

6. Conclusions & Recommendations

6.1 Conclusions

In conclusion, this Technical Working Paper #1 provided the following items:

1. A review and summary of the City's six WDPs (see **Section 2**);
2. A summary of the gaps with each of the WDPs with respect to geography, cost estimates, modeling, consideration of climate change, environmental assessments and geotechnical assessments (see **Section 2.8**);
3. Recommendations for addressing gaps related to the WDPs (see **Section 2.8** and **6.2**);
4. Identification of new stormwater related projects and completed projects since the WDPs were developed (see **Section 3**);
5. A review of existing project prioritization frameworks (see **Section 4.1**);
6. A proposed new project prioritization framework for the City of Prince George (see **Section 4.2**);
7. A summary of the priorities of the action items from the WDPs (and other projects identified since the WDPs were developed) when the proposed new project prioritization is applied to them (see **Section 4.3**);
8. A review of the City's GIS data related to stormwater (see **Section 5.1**); and
9. A GIS gap reduction plan (see **Section 5.2** and **Section 6.2**).

6.2 Recommendations

Future WDPs/WDP Updates

Some areas not currently included within a WDP are already developed or may be developed in the near future. Selecting areas for developing new WDPs, in order of priority, should be:

1. Areas with known issues (e.g. flooding, erosion, etc.);
2. Areas where new development is occurring or soon to occur (e.g. North Nechako); and
3. Areas of existing development.

Any future WDPs or updates of existing WDPs should include the items listed below.

1. Consideration of climate change. Use results from the IDF CC tool used for the West Fraser River & Parkridge Creek WDP until the City has developed a future looking IDF curve based on improved rainfall data and climate change considerations.
2. Cost estimates of proposed projects – using the City's new approach of lower to upper range for high level estimates.
3. Flow and water quality monitoring.
4. Use of a preferred modelling software package, as identified by the City
5. Develop a dual drainage model (1D) with the use of 2D modeling, where needed, to assess problem areas where surface flooding issues have been identified.
6. Assess whether culverts are fish friendly and whether the watershed has intact riparian function.
7. Consider surficial geology, geomorphology, slopes, municipal and private well sites, contaminated sites and older industrial/commercial sites to identify areas where increased infiltration should not be done without site specific studies.
8. Action items should be prioritized using the newly proposed stormwater project prioritization framework.
9. Provide any updated catchments, asset inventory, elevations etc. to the City so that they can update their GIS accordingly.
10. Model Future conditions under full build-out as well as existing conditions.
11. Provide updates to the natural asset inventory that the City will soon be developing.

GIS

We recommend that the City update the following features in its GIS as staff availability allows:

1. Correcting catchment boundaries, adding catchment areas and correcting typos (i.e. Beaverly);
2. Adding creek names;
3. Adding culverts, open channels/ditches, outfalls, natural ponds and asset attributes (e.g. elevations, material, condition etc.) identified through past WDPs, where the data had been readily provided to the City;
4. Identifying and recording drainage systems associated with roadways that do not currently have a storm sewer or ditch associated with them in GIS;
5. Adding asset condition and risk data into GIS when it becomes available;
6. Adding all stormwater assets such as monitoring stations, dikes, grates/screens and subsurface infiltration facilities that are not currently in the City's GIS;
7. Adding other asset attribute information that is currently missing such as storage basin size; and
8. Adding natural assets such as riparian areas once the City has completed its natural asset inventory.

The ditch and screen/grate inventory could be completed as other O&M work is being conducted (e.g. collect screen/grate info during culvert inspections, collect ditch info during pavement condition assessments or street sweeping).

Recommended Projects

By applying the newly developed stormwater prioritization framework to identified actions items we recommend that the City prioritize completing the following projects listed below at an estimated cost of $1.2M to $5M.

1. Replace the Domano culvert on Parkridge Creek with a structure that would be fish passable in response to DFO requirements.
2. Introduce better erosion and sediment control measures (e.g. new erosion and sediment control bylaw);
3. Update hazardous slope mapping.
4. Protect wetlands and important riparian areas that are not currently protected under municipal legislation (i.e. riparian areas of a stream that is not fish-bearing but drains to a fish-bearing stream or a wetland that is not directly connected to a fish-bearing stream).
5. Update Design Guidelines to consider climate change (e.g. increase the design storm and minimum pipe size/slope). This will be addressed further in TWP #2.
6. Secure sustainable levels of stormwater funding (e.g. Stormwater utility with credit/rebate program).
7. Replace/modify culverts in poor condition, under a significant road, whose modification/replacement would also provide fisheries benefits (e.g. Bittner Creek).
8. Protect important wildlife corridors and core habitat areas that are not addressed through existing riparian area protection.
9. Implement Best Management Practices/Low Impact Development (BMP/LID) standards for new development in catchments to fish-bearing streams and associated public education circulars. This concept will be discussed further in TWP's 2 and 3.
10. Expand floodplain development permit areas in certain areas along Parkridge Creek.
11. Update Prince George Bylaws (DCC, Development Procedures, and Tree Protection).

If the City is completing any of the projects identified in one of the WDPs that did not consider climate change, then it should, as a minimum, consider the impacts of increased rainfall by 35% (as per the IDF CC tool used for the West Fraser River & Parkridge Creek WDP).

City staff should identify if there are any desired action items, such as condition assessment of the storm sewer system, that are currently not captured by the compiled action list.

AECOM Imagine it. Delivered.

Appendix A

Existing Prioritization Frameworks

AECOM Imagine it. Delivered.

City of Prince George

Prioritization Framework Review

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Date: September, 2020

Project #: 60628231

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1. Prioritization from PG WDP's

1.1 Parkridge Creek & West Fraser

The goals of this WDP were based on the City's stormwater management policy and OCP and are listed below.

- Protect life and property from stormwater related flooding
- Provide appropriate drainage service to the community
- Preserve and improve environmental quality
- Protect watercourses from erosion and sedimentation
- Reduce inconvenience from surface ponding and flooding
- Promote orderly, cost effective, and sustainable development
- Minimize the overall cost of the stormwater system to the City (liability, capital, environmental and operational)
- Promote public access for recreational and environmental education or pursuits
- Develop a watershed drainage plan process to define and access drainage servicing schemes for different catchment areas of the City.

Each of the recommended projects were evaluated using the criteria listed below.

- Cost
- Risk/criticality
- Land requirements
- Life cycle cost analysis
- Environmental Impact
- Feasibility
- Functionality
- Acceptability to Environmental Agencies
- Acceptability to the Public
- Acceptability to the City
- Environmental Mitigation/Compensation Works

This WDP didn't have a formal prioritization framework but some proposed projects were noted as high priorities based on the attributes of a given project (i.e. treatment for outfall into fish-bearing waters). Presumably the high priority projects were ones that best met the goals of the WDP and scored well based on the evaluation criteria, as previously listed.

1.2 University Heights/Peden Hill

The objectives of the University Heights/Peden Hill WDP are to:

- Identify areas currently or potentially susceptible to flooding and erosion;
- Analyse the performance of the existing infrastructure drainage system;
- Identify water quantity and quality constraints; and
- Recommend optimal short term, medium term and long term plans.

The WDP noted that the key issues in the watershed are:

- Adequacy of the drainage conveyance systems;
- Erosion, sedimentation and slope failures;
- Mitigating the impacts of future development;
- Protection of environmental values; and
- Operations works, monitoring, and maintenance.

Recommendations from this WDP were categorized as short, medium and long term based on the following criteria:

- Short term: stormwater system improvements to address existing deficiencies;
- Medium term: stormwater servicing strategy to accommodate proposed new development; and
- Long term: long term strategies for rainfall management policy, monitoring, asset management and operational management to meet the need for growth.

1.3 East Prince George

The East Prince George WDP was developed with the following objectives in mind:

- Consider the City's long-range growth needs;
- Facilitate sustainable growth of development;
- Enhance and protect natural areas; and
- Address current drainage problems and inadequacies.

The proposed action items were given a score of one (low) to ten (high) for each of the following three considerations:

- the relative costs versus benefits (cost-benefit ratio score);
- difficulty to implement, and;
- their probable effectiveness within the East Prince George watershed.

The maximum possible score is thirty. Proposed actions items were then categorized as high, medium and low priority based on the following scores:

- High > 24
- 20 $\leq$ Medium <24
- Low < 20

1.4 McMillan Creek

The McMillan Creek WDP broke down problem areas into two main categories:

- Areas of major concern; and
- Areas of secondary concern.

Areas of major concerns were identified as problem areas where extensive flooding or failing crossing structures may pose serious threats to public safety and/or downstream infrastructure, including risks to riparian habitat. These areas of concern have been recognised as critical and were recommended for immediate attention and upgrading. They were further prioritised based on the location within the watershed:

- McMillan Creek mainstem crossings both private and City owned;
- Tributary crossings; and
- All other storm infrastructure including storm sewer and drainage culverts (Mainstem, tributary or stormwater drainage system).

Secondary concerns pose a lower risk than areas of major concern. These drainage structures are in lower risk areas or where capacities constraints are less of a concern. As with areas of major concern these problem areas have been separated by the location within the watershed, such as McMillan Creek, tributaries or storm drainage infrastructure.

Proposed projects were then categorized based on short (1-5 year), medium (5-10 year) and long term (+10 year). Short term improvements include those classified to have the greatest benefit on the health of the watershed and limit the risk to public safety. The major concerns are those found to be associated with the highest level of risk regarding public safety and deterioration of the watershed. Replacement or remediation of all of the structures

outlined under major concerns is costly and may not be achievable within one or even two years. Therefore, a plan was developed that will allow for the replacement or repair of the various structures as budget permits.

Medium term planning strategies were developed to provide recommendations for stormwater management in new developments that include passive systems to provide remedial treatment and limit peak flows. Furthermore, medium term planning concepts ensure that short-term improvements have been successfully implemented and that improvements have been monitored for ease of future applications.

The long term projects involve the implementation of new long term stormwater management strategies to address new development and rehabilitation of existing deficiencies.

1.5 Hudson's Bay Slough

Recommended projects were listed in order of priority. No formal prioritization framework was provided, only that project priority was based on the most pressing issues identified. The WDP reports that the most pressing issue was frequent flooding of the downtown bowl area.

Projects were divided into horizons of 5, 10 and 20 years based on the following:

- 5-year projects involve relieving the capacity constraints of the lowland drainage channel of the Hudson's Bay Slough and sediment interception facilities at the base of Cranbrook Hill and within the closed drainage system;
- 10-year projects involve enclosed system capacity upgrades and dredging of the lower slough pool; and
- 20-year projects involve environmental enhancements and integration with the trail network and lesser enclosed system upgrades.

1.6 Gladstone, Trent & Varsity

Implementation of the recommended improvements of the three watersheds involved prioritizing each upgrade according to present need and projected future development patterns. Proposed projects were categorized based on short (1-5 year), medium (5-10 year) and long term (+10 year).

Existing sewers which are undersized for the existing development condition and existing creek erosion areas were identified as high priority for the short-range. Following this immediate need, the remaining upgrades were prioritized according to the expected development patterns within the three watersheds.

2. City of Prince George Risk Frameworks

2.1 Enterprise Risk Management

The table below is the Impact Table of CPG's Enterprise Risk Management Tool Kit that was developed for the Canada Winter Games in 2015. This was developed knowing the City did not already have an existing ERM Framework in place and therefore had to fast track its development and implementation in a fashion that would work both for the City and the Host Society. Every effort was taken to keep it as simple as possible in order to maximize its efficacy. The formalized foundational process involving the City's Senior Management level to develop its own risk appetite was deliberately bypassed due to time constraints.

		Risk Category				
		Financial	**Operational**	**Staff & Public**	**Reputational**	**Strategic**
1	**Insignificant**	The NET financial impact to the City is likely to be below <$500,000	Minimal impact on the City's operational objectives in the lead up to and during the Canada Winter Games. ➢ No noticeable change in service from the public perspective	Minimal impact on the staff and public. For example: ➢ Single or multiple persons unable to perform work for one day ➢ Single or multiple Canada Winter Games participants unable to perform their roles for a period of one day	Minimal negative impact on the City's reputation. ➢ No unusually negative coverage of the City as a host of the CWG	Minimal impact on the City's strategic objectives and ability to achieve them.
2	**Minor**	The NET financial impact to the City is likely to be between $500,000 - $2,000,000	Minor impact on the City's operational objectives in the lead up to and during the Canada Winter Games: ➢ Intermittent loss of services to the public of less than 3 hours ➢ Intermittent interruption of IT systems/e-mail less than once per month	Minor impact on the staff and public. For example: ➢ Single or multiple persons unable to perform work for a period of one week ➢ Single or multiple Canada Winter Games participants unable to perform their roles for a period of more than one day	Minor impact on the City's reputation. For example: ➢ Local news coverage of a negative nature for less than two days ➢ Independent report published which is somewhat negative ➢ A few Isolated reports critical of the city as host of the CWG (short lived)	Minor impact on the City's strategic objectives and ability to achieve them. For example: ➢ City policy decision has some negative impact on sustainability
3	**Moderate**	The NET Financial impact to the City is likely to be between $2,000,000 - $5,000,000	Moderate impact on the City's operational objectives in the lead up to and during the Canada Winter Games; for example: ➢ Routine loss of services to the public of between 3 hours and week ➢ Routine interruption of IT systems/e-mail each week ➢ A noticeable change in normal service as a result of hosting the CWG	Moderate impact on the staff and public. For example: ➢ One person with serious long-term injury/illness connected with City endeavours or Canada Winter Games participants ➢ Low morale amongst staff from a single department	Moderate impact on the City's reputation. For example: ➢ Significant negative local media attention about the City's conduct of the Canada Winter Games ➢ Some negative national attention in the media about the City's conduct of the Canada Winter Games	Moderate impact on the City's strategic objectives and ability to achieve them. For example: ➢ City policy decision has moderate negative impact on a large segment of the population ➢ The decision has serious effects on sustainability for the City.
4	**Major**	The NET financial impact to the City is likely to be between $5,000,000 - $10,000,000	Major impact on the City's operational objectives in the lead up to and during the Canada Winter Games; for example: ➢ Loss of basic services to the public for a period longer than a week ➢ Any event that could affect the quality of the water supply ➢ A very noticeable change in normal service as a result of hosting the CWB	Major impact on the staff and public. For example: ➢ Multiple persons with serious long-term injury/illness connected with City endeavours or Canada Winter Games participants ➢ Low morale amongst most City staff	Major impact on the City's reputation. For example: ➢ Public safety issue receives significant press coverage and public attention ➢ Extensive negative local story with significant negative national exposure about the City's conduct of the Canada Winter Games ➢ Organizational effectiveness called into question ➢ The 2015 CWG will not be the next "best games ever".	Major impact on the City's strategic objectives and ability to achieve them. For example: ➢ City policy decision has major impact on public services or safety ➢ City policy decision has significant negative sustainability implications

Risk Category					
	Financial	Operational	Staff & Public	Reputational	Strategic
5 Catastrophic	The NET financial impact to the City is likely to be greater than $10,000,000	Catastrophic impact on the City's operational objectives in the lead up to and during the Canada Winter Games. For example: ➢ Complete operational failure of a critical system for a sustained amount of time ➢ Total inability to provide basic civic services for an extended period of time ➢ Substantial loss of staff resources and civic infrastructure	Catastrophic impact on the staff and public. For example: ➢ Deaths (single or multiple) of anyone connected with City endeavours or Canada Winter Games participants	Catastrophic impact on the City's reputation. For example: ➢ Poor public safety response results in significant loss of life and property ➢ Major litigation against City immanent ➢ Significant negative national media coverage about the City's conduct of the Canada Winter Games ➢ The 2015 CWG are considered unsuccessful	Catastrophic impact on the City's strategic objectives and ability to achieve them. For example: ➢ City policy decision has catastrophic impact on public safety, services and emergency response ➢ Extent of incident has significant effect on policy decision in the foreseeable future ➢ Sustainability of the City is critically compromised

RISK PRIORITY MATRIX (Heat Map)

		Impact				
		1 Negligible	2 Minor	3 Moderate	4 Major	5 Catastrophic
Likelihood	5 Almost Certain					
	4 Likely					
	3 Possible					
	2 Unlikely					
	1 Improbable - Rare					
	Emerging					

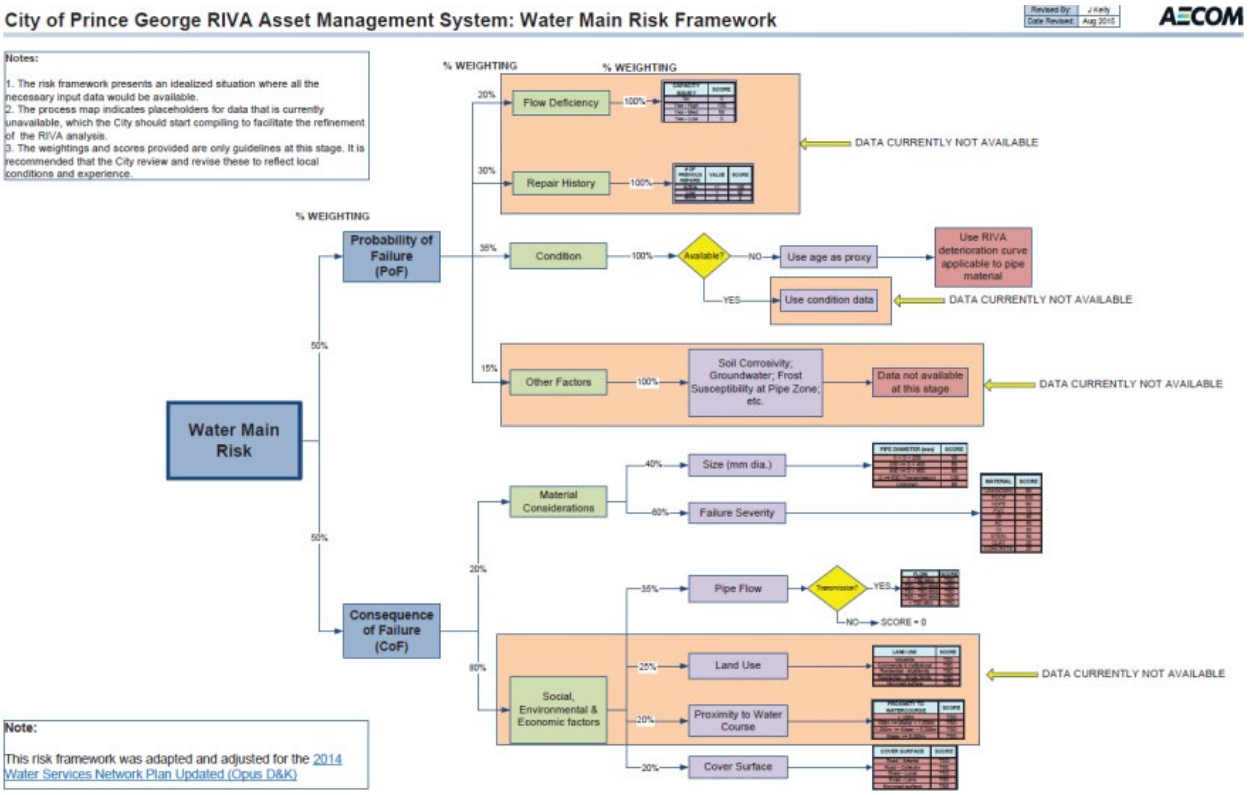
RISK MANAGEMENT PRIORITIES

Probability and impact assessments will enable us to develop priority ratings for each risk. Risks will be assessed and prioritized into the following four risk categories:

	Very High	• Management of this risk is critical to the success of the City in meeting its goals and avoiding negative outcomes. • Improving the risk mitigation is required • Requires detailed research, planning and decision making at senior levels of management, may require attention from the Senior Management Team • ERM Steering Committee must be kept informed
	High	• Management of this risk is very important but not critical to the success of the City in meeting its goals and avoiding negative outcomes. • Improving the risk mitigation (if possible) is recommended • Senior management attention and action needed.
	Moderate	• Management of this risk is important to the success of the City in meeting its goals and avoiding negative outcomes. • Improving the risk mitigation is not required at this stage • Management control and responsibility must be specified.
	Minor	• Management of this risk is not material to the success of the City in meeting its goals and avoiding negative outcomes. • Improving the risk mitigation is not required • Can be managed by routine controls and procedures.
	Emerging	• Continue to monitor this risk • ERM Steering Committee to be kept informed of any significant change.

2.2 RIVA – Water Main Risk Framework

In 2009 the City implemented RIVA – Real-time Infrastructure Valuation Analysis, long-term capital planning tool for our linear infrastructure. During that process Water, Sewer, Storm and Pedestrian Risk Frameworks were developed. This is the Water Main Risk Framework. The weightings and scores provided by AECOM were only guidelines at that point.



2.3 Water Service Network Plan 2014

CPG's Water Master Plan was updated in 2014, which included a review of the RIVA Water Main Risk Framework and subsequent analysis. CPG's GIS provided some of the criteria and the analysis resulted in a list of capital projects. CPG is working towards including the risk scores as attributes to our water assets within our GIS.

The risk score is based on the following attributes:

- Pipe Diameter/Type
- Pipe Age
- Pipe Material
- Transmission Mains
- Land Use Classification
- Cover Surface
- Pressure Classification
- Riparian Protection Area Classification

Table 3-1 Parameters for Scenario Development

Parameters for Scenario Development			
Land Use	Diameter/Type	Cover Surface	Riparian Protection Area
Single Family	<250 mm	Local Roads & Lanes	Within
Multi-Family	≥250 mm	Major/Minor Collectors	Outside
Light Commercial	Transmission Main	Highway/Arterial	-
Highway Commercial	-	-	-
Industrial & Non-Essential Institutional	-	-	-
Community Facilities	-	-	-

Table 3-2 Probability of Failure Ranking

	Rank				
	1-2	3-4	5-6	7-8	9-10
Age	<10 years	-	10-50 years	-	50-70 years
Material	HDPE, Polyethylene, Ductile Iron and Steel	-	PVC and Copper	Asbestos Cement	Cast Iron
Static Pressure	-	-	<40 psi 40-60 psi 60-80 psi	80-100 psi	>100 psi

Tables 4-2 and 4-1 show the Land Use and Road Class rankings that were used in the Water Master Plan.

Table 4-1 Land Use Ranking

Land Use	Rank
Unassigned	0
Single Family	1
Multi-Family	2
Light Commercial	3
Highway Commercial	4
Industrial & Institutional	5
Community Facilities	6

Table 4-2 Road Use Classification

Road class	Road type
0	Hwy Connector
1	N/A
2	Highways
3	Arterial
4	Major Connector
5	Minor Connector
6	Local
7	Lanes
8	Unassigned
9	Highway Ramps

Tables 3-3 and 3-4 show the heat map and actions required depending on the level of risk. The High and very high ranked capital projects are either in the works or are in our Capital Expenditure Plan for the next 5 years.

Table 3-3 Risk Matrix

Risk Matrix					
Probability	Consequences				
	Insignificant	Minor	Moderate	Major	Catastrophic
Rare	L	L	M	M	H
Unlikely	L	L	M	M	H
Possible	L	M	H	H	H
Likely	M	M	H	H	VH
Almost Certain	M	H	H	VH	VH

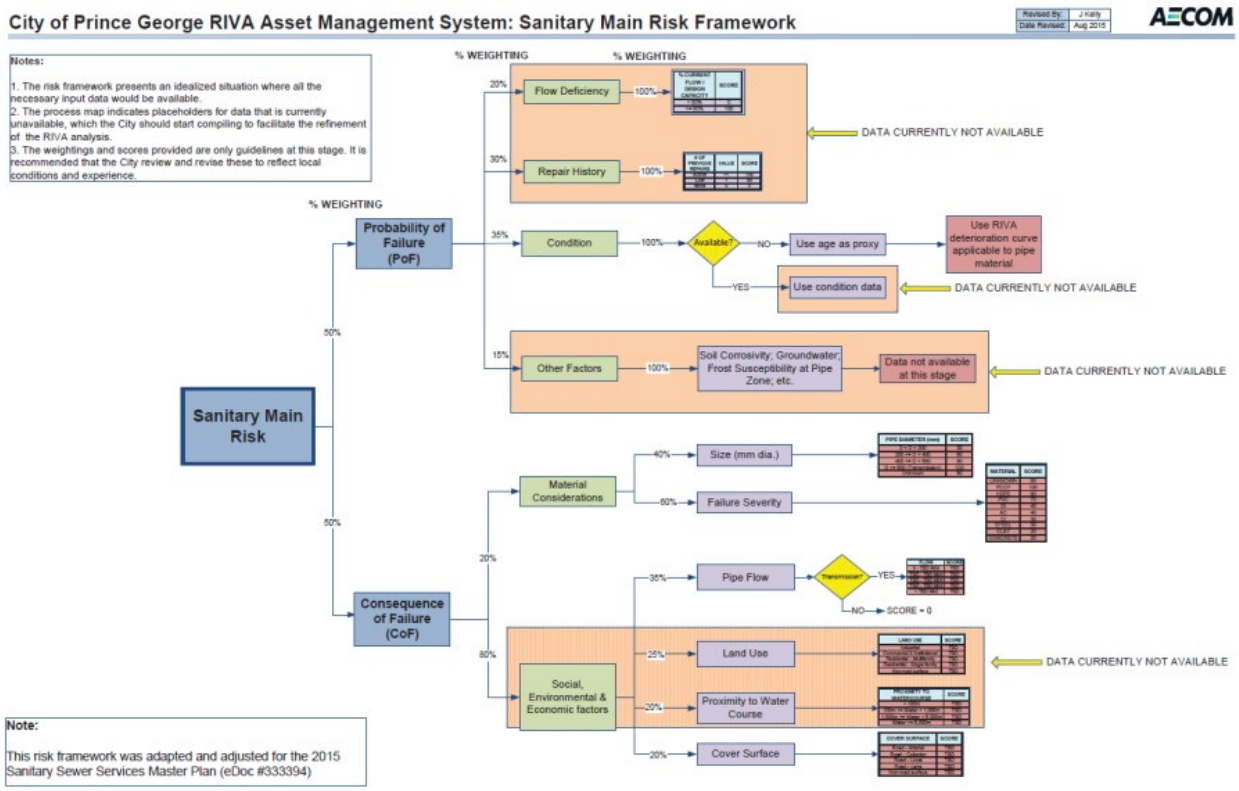
For each risk level, an 'Action Required' was identified. The appropriate response for each risk level was crafted in collaboration with expert asset management staff in BC and New Zealand, and follows Table 3-4 below.

Table 3-4 Risk Rating & Action Priority

Level of Risk	Rank	Action required timing
Very High Risk	9-10	Immediate corrective action (i.e. action is required now)
High Risk	7-8	Prioritized action required (i.e. make safe and program in current/next program)
Medium Risk	5-6	Planned action required (i.e. make safe and include in forward programs)
Low Risk	1-4	Manage by routine procedures

2.4 RIVA - Sanitary

This is the Sanitary Main Risk Framework that came from CPG's RIVA implementation.



2.5 Sewer Master Plan

The RIVA framework was used in the Sewer Master Plan project to assess the risk associated with each recommended project of which you can see an example in Table ES-2. CPG will be working towards adding the risk scores as attributes to their Sewer network within their GIS.

Table 5.5 - Risk Score Summary

Criteria		Score	Description
Probability of Failure	Capacity	25*	Modelled Flow / Existing Capacity
	Known Service Issues	12.5	Service issue identified during workshop
	Pipe Age	12.5	Refer to ***Table 5.6***
Consequence of Failure	Pipe Size & Material	10	Refer to ***Table 5.7*** and ***Table 5.8***
	Restricts Development	10	OCP PWWF > Existing PWWF = score of 5 OCP PWWF > Existing PWWF and Existing PWWF > (Design capacity – 5 L/s) = score of 10
	Impacts ICI	10	ICI parcels impacted
	Environmental Impact	20	Asset failure harms environmentally sensitive area or watercourse
Total Risk Score		100*	

* Score may be greater than listed value if modelled flow exceeds 100% of the existing capacity

Table 5.6 - Risk Score from Age

Asset Age	Score %
Unknown	60
100<=A	100
90<=A<100	95
80<=A<90	85
70<=A<80	75
60<=A<70	65
50<=A<60	60
40<=A<50	35
30<=A<40	25
20<=A<30	15
10<=A<20	5
0<A<10	1

Table 5.7 - Risk Score from Pipe Size

Diameter (mm)	Score %
Unknown	80
0<D<300	25
300<=D<500	80
500<=D	100

Table 5.8 - Risk Score from Material

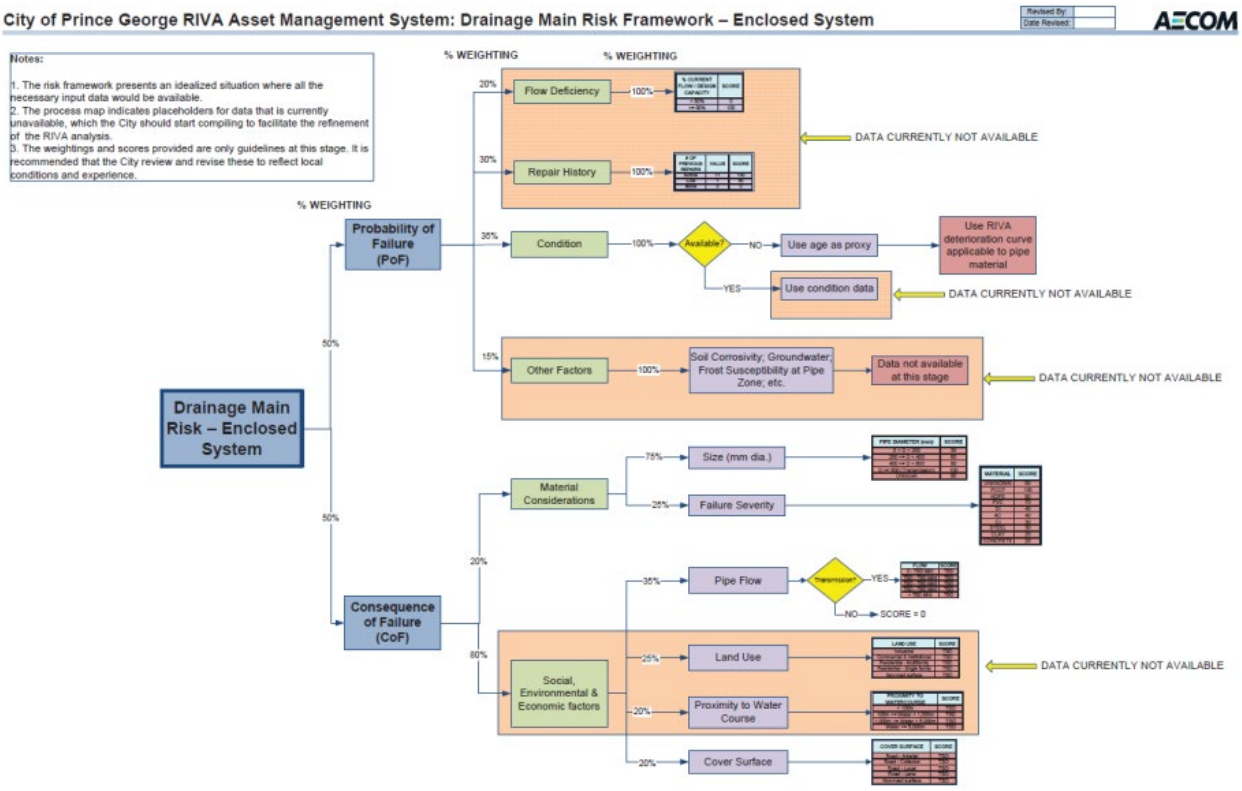
Material	Score %
Unknown	80
PCCP	100
HDPE	80
PVC	70
DI	40
AC	40
CI	30
Steel	30
Clay	20
Concrete	20

Table E5-2 - Short Term Upgrades

Project ID	Project Description	Probability of Failure			Consequence of Failure					Risk Score	Length	Model ID	Existing Dia. (mm)	Proposed Diameter (mm)	Capital Cost
		Capacity Deficiency	Asset Age	Known Service Issue	Failure Severity (Size & Material)	Restricts Development	ICI Impact	Environmental Impact	> 5000 PE Impact						
E-1	Replace PW115 with 125 L/s firm capacity pump station, expandable to 375 L/s firm capacity	✓✓		✓	✓	✓✓		✓		141	-	PW115	-	-	$ 2,000,000
E-2	Decomission existing pump station PW125, construct new 2297 m, 300 mm dia. gravity sewer from PW125 to Southridge Dr.	✓✓			✓	✓✓	✓	✓		124	2,297	CDT-119	-	300	$ 2,596,061

2.6 RIVA - Drainage

A Drainage Risk Framework was also developed during the RIVA implementation. CPG has not done any work on this since the implementation but are working towards condition assessments on their storm network which will help answer a part of the risk framework.



2.7 Project Level

PG has a large focus right now on project level risk analysis where a project is investigated, and several options are recommended. They are holding Risk workshops with all levels of their organization to brainstorm the risks of each option and determine which option would result in a lower residual risk.

CONSEQUENCE ANALYSIS

Consequence	Insignificant	Minor	Moderate	Major	Catastrophe
General Description	No injuries, low financial loss	Minor injuries, not requiring medical treatment. Minor financial loss	First Aid treatment required, on-site release immediately contained; medium financial loss.	Medical treatment required, on-site release contained with outside assistance; high financial loss.	Extensive injuries; off-site release with detrimental effects; major financial loss.
Health and Safety	No Injuries	Minor first aid treatment required only	Reversible injury requiring hospitalization	Moderate, reversible injury or impairment (<30%) to several people	Single fatality or significant irreversible injury to > 10 people
Community / Government / Reputation / Media	Minor Complaint	Public concern restricted to local complaints	Minor, adverse local public or media attention and complaints	Serious public or media outcry with national coverage	International media condemnation
Legal	Legal Action Unlikely	Low-level legal matter	Minor legal issues, non-compliances and breaches of regulation.	Serious breach of regulation with investigation or report to authourity with prosecution and / or moderate fine possible.	Very significant fines and prosecutions. Multiple litigation actions.
Relationships	Damage Easily Rectified by City Staff	Concerted effort required by City Staff to rectify damage	Serious issues; requires Senior Management involvement	Very critical issues which regire Mayor and Council and CAO intervention	Irreparable damage requiring Provincial or Federal involvement intervention
Services/Systems	Failure of a service with a known workaround	Minor failure of a service on a local basis	Moderate failure of a service on a community basis.	Serious failure of a key service on a regional basis.	Serious and extended failure of a key service on a regional basis.
Environmental Effects	No lasting effects. Low-level impacts on biological or physical environment. Limited damage to minimal area of low significance.	Minor effects on biological or physical environment. Minor short-medium term damage to small area of limited significance.	Moderate effects on biological or physical enviornment but not affecting ecosystem. Moderate short-medium term widespread impacts (e.g. Oil spill causing impacts on shoreline)	Serious environmental effects with some impairment of ecosystem function (e.g. displacement of a species). Relatively widespread medium-long term impacts.	Significant environmental impacts with complete impairment of ecosystem function. Long-term widespread impacts on significant environment (e.g. unique habitat, national park)
Cultural Heritage	Low-level cultural impacts. Low-level repairable damage to commonplace Structures	Minor medium-term cultural impacts on local population. Minor damage to structures / items of some significance. Minor infringement or cultural heritage. Mostly repairable.	On-going cultural issues. Permanent damage to structure / items of cultural significance or significant infringement of cultural heritage / sacred locations.	On-going serious cultural issues. Significant damage to structures / items of cultural significance or significant infringement or destruction of cultural heritage / secred locations.	Significant widespread cultural impacts Irreparable damage to highly valued structures / items / locations of cultural significance. Highly infringement of cultural heritage.

PROBABILITY ANALYSIS

Likelihood	Likelihood Description
Probable	Happens repeatedly during the project life
Likely	Could easily happen and has occurred on a previous project more than once
Possible	Could happen and has occurred in other situations / other projects
Unlikely	Hasn't happened yet but it is possible that it could
Rare	Hasn't happened and can't imagine it actually ever happening.

RISK ANALYSIS MATRIX

Consequence / Likelihood	Insignificant	Minor	Moderate	Major	Catastrophic
Probable	H	H	E	E	E
Likely	M	H	H	E	E
Possible	L	M	H	E	E
Unlikely	L	L	M	H	E
Rare	L	L	M	H	H

RISK STATUS KEY

L - LOW
M - MEDIUM
H - HIGH
E - EXTREME

The table below shows an example of one option of the Foothills Watermain Twinning project that OPUS recommended and the resulting residual risk.

East Side Risk Issues - Concerns resulting from:

Item	Description	Concerns	Mitigation	Construction Probability after mitigation	O&M Probability after mitigation	Consequence	Risk Impact
1	Gas Main Interference and Issues	Crossings (3) Incorrect field locator	Diligence on Crossings Extra care on locates - vactor Fortis standing by on crossings	1	1	4	Moderate 1
2	Hydro Conflict and Issues	Light poles @ 650 & Highl'd Dr No conflicts foreseen	Locate / be diligent in light pole areas	1	1	1	Low 0
3	Conflict with Storm	Dictates watermain alignment Separation regulation forces watermain into road	No defined mitigation measures	1	2	2	Low 0
4	Traffic	Conflict during construction Possible conflict during ops	Arrange for lane closures Traffic control Detour signs and notifications	2	3	5	Extreme 4
5	Watermain Failure	Corrosion Joint separation Freezes	Poly wrap DI pipe TR Flex pipe Insulate. Increase depth, away from Rd.	1	3	5	Extreme 4
6	Loss of Road Structure	Watermain joint failure Improper or weak Re & Re Bedding carries groundwater Poor or misdirected drainage Alignment too close to edge	TR Flex pipe Good construction inspection and testing Trench bulkheads Drainage control by design	1	1	1	Low 0
7	Trench Issues	Trench stability Trench slopes impinge on road Spoil pile	Subcut Trench cage Shoring	2	4	4	High 3
						Total	4.3

2.8 CPG Draft Project Prioritization Framework

City staff began developing a project prioritization framework for the City of Prince George. It was never finalized and implemented. Points and weighting were given in the following areas:

- Mandate;
- Population-user impact;
- Project readiness;
- Risk to City service delivery;
- Growth & renewal;
- Change in demand; and
- Strategic alignment.

3. EMBC Consequence of Loss Rating Table

Emergency Management of BC's Critical Infrastructure Identification & Rating Workbook "All Hazards Approach" for the Flood Protection Program, dated July 4, 2008, includes the following table. The table shows consequence of loss which is one aspect of risk management (i.e. risk = consequence x probability).

APPENDIX E: CI CONSEQUENCE OF LOSS RATING TABLE

JELC Critical Infrastructure - Consequence of Loss Criteria – Lower Mainland Region of British Columbia

General Rating Instructions:

- For each asset, choose the appropriate Consequence of Loss rating (0.1 to 15) for each impact below using the descriptions in the rows. The total will be the asset rating.
- Consider all hazards; evaluate maximum credible damage to asset (definition overleaf) from any hazard. E.g. Terrorism may result in highest impact for Public confidence.

Impact Factor	Severe	Very High	High	Medium	Low	Very Low
Score	15	5	3	1	0.5	0.1
Population Impact • Estimate number of possible fatalities, serious injuries or people evacuated due to loss of asset being ranked. • Do not include people inconvenienced. • Consider maximum credible damage only.	Greater than 10,000 people	Between 1,000 and 10,000 people	Between 100 and 1000 people	Between 50 and 100 people	Between 4 and 50 people	Less than 4 people
Recovery Cost Impact • Estimate cost to restore the asset to a functional state. • Consider alternate solutions if less costly.	Direct damage and restoration > $1 billion	Direct damage and restoration $100 million to $1 billion	Direct damage and restoration $10 to $100 million	Direct damage and restoration $5 to $10 million	Direct damage and restoration $1 to $ $5 million	Direct damage and restoration under $1 million
Own Sector Impact • Estimate effect of loss of the asset on the sector in which asset resides (e.g. Transportation). • Consider redundancies, alternate suppliers if available.	Sector may shut down nationally or debilitating impact internationally	Debilitating impact on sector nationally	Debilitating impact on sector provincially or regionally	Debilitating impact on sector municipally **Or** Significant impact on sector provincially or regionally	Significant impact on sector municipally	Moderate impact on sector municipally
Other Sectors Impact • Estimate effect of loss of the asset on the other sectors (not the one in which asset resides). • Consider redundancies, alternate suppliers if available.	Debilitating impact on other sectors nationally	Debilitating impact on other sectors provincially or regionally	Debilitating impact on other sectors municipally **Or** Significant impact on other sectors provincially or regionally	Significant impact on other sectors municipally	Moderate impact on other sectors municipally	Minor impact on important missions of other sectors (municipally)
Recovery Time Impact • Estimate the time to restore the asset to a functional state. • Consider alternate solutions if time can be reduced (consistent with Recovery Cost Impact above).	Very long recovery time (longer than one year)	Long recovery time (months to 1 year)	Significant recovery time (weeks to 1 month)	Brief recovery time (days to 1 week)	Very Brief recovery time (hours to 1 day)	Minimal recovery time (minutes)
Public Confidence Impact • Estimate the effect of the loss of the asset on public confidence in the ability of the relevant government to preserve public health and safety, economic security, or to assure the provision of essential services.	High National risk & ability to control in doubt	Perceived high National risk & low ability to control risk **Or** High Provincial or Regional risk & ability to control in doubt	Perceived high Provincial or Regional risk & low ability to control risk **Or** High Municipal risk & ability to control in doubt	Perceived high Municipal risk & low ability to control risk	Perceived moderate Municipal risk & moderate ability to control risk	Perceived low Municipal risk & high ability to control risk

4. NAMS Risk Management Template

Several City staff attended the NAMS (National Asset Management Strategy) workshop supported by Asset Management BC that was developed by the Institute of Public Works and Engineering Australasia. This is a program that provides templates and analytics to create Asset Management Plans and includes an Infrastructure Risk Management Plan. CPG is just starting down the road of implementing NAMS as a standard for the City's AMP's and are working inter-departmentally to further explore the Risk Management Plan template and how it would fit within the organization.

5. Prioritization Frameworks – Other ISMP

5.1 Eagle Creek ISMP (City of Burnaby)

The projects were prioritised (high, medium, low) using the scoring system laid out in **Table 1** below.

Table 1 Scoring System based on Anticipated Social, Economic and Environmental

	High score=3	Medium score=2	Low score=1
Social	- Not completing the project will result in significant risks to public health and safety or property damage - Provides a "destination" amenity to residents from across the City	- Not completing the project may result in a risk to public health and safety or property damage - Provides an amenity to local residents	- Unlikely risk - No significant amenity
Economic	- Not completing this project will result in a significant cost to the City of Burnaby - No construction or operating cost to complete this project - Would result in overall cost savings	- Not completing the project may result in future costs to the City - <$100,000 capital cost and <$1,000 per year operating cost	- no available funding source - >$100,000 capital cost and/or >$1,000 per year operating cost
Environmental	- Would provide significant new spawning, overwintering and rearing habitat for anadromous fish -Would provide significant new spawning habitat for resident fish	- Would significantly benefit downstream habitat for anadromous fish (i.e. control flows and water quality) - Would provide significant new rearing habitat for resident fish	- Possible secondary environmental benefits (i.e prevention of incidents through greater public education) - No gain in habitat

Each project was given a score of 1-3 based on anticipated social, economic and environmental benefits. The scores in each of these areas were added up to a maximum score of nine (9). Each project was then given an overall ranking based on its total score; as outlined below.

- High – total score of 8 to 9;
- Medium – total score of 5 to 7;
- Low – total score of 3 to 4

6. Summary – Existing Frameworks

The City of Prince George is investigating and/or implementing 3 types of prioritization frameworks:

1. A network level risk framework: they are currently being used within RIVA for the water and sanitary systems and have been used for their Water and Sanitary Master Plans (see descriptions in previous sections). As part of the ISMP, a network level risk assessment will be done for the City's storm sewer system.
2. A project prioritization framework: this is what AECOM will be developing for prioritizing action items from the six WDP's. The City has developed a draft framework (was never implemented and is presented in the previous sections.
3. An option selection framework for selecting between various options for a given project. This is commonly based on a cost-benefit analysis type of framework.

The table below provides a summary and evaluation of the various prioritization frameworks described in the previous sections.

	Framework	Summary	Pros	Cons	Recommendations
1	Parkridge Creek & West Fraser WDP	• Cost • Risk/criticality • Land requirements • Life cycle cost analysis • Environmental Impact • Feasibility • Functionality • Acceptability to Environmental Agencies • Acceptability to the Public • Acceptability to the City • Environmental Mitigation/Compensation Works	Based on OCP goals: - Protect life and property from stormwater related flooding - Provide appropriate drainage service to the community - Preserve and improve environmental quality - Protect watercourses from erosion and sedimentation - Reduce inconvenience from surface ponding and flooding - Promote orderly, cost effective, and sustainable development - Minimize the overall cost of the stormwater system to the City (liability, capital, environmental and operational) - Promote public access for recreational and environmental education or pursuits	No point system Could streamline goals (current overlap)	Use some of the factors as input into a prioritization framework, then reintegrate projects into a new prioritization framework
2	University Heights/Peden Hill WDP	Addressed flooding, erosion and water quality issues in short (existing issues); medium (future issues) and long (policy issues) term.	Addressed economic and environmental issues	Not a risk based approach	Need to integrate projects into a new prioritization framework
3	East PG WDP	The proposed action items were given a score of one (low) to ten (high) for each of the following three considerations: • the relative costs versus benefits (cost-benefit ratio score); • difficulty to implement, and; • their probable effectiveness within the East Prince George watershed.	Scoring system	Not clear how points were awarded. Would require quantification of environmental benefits, social benefits, difficulty to implement and probable effectiveness.	Good general approach but would need more information/direction to apply to other studies. May also want to think about how to best capture social and environmental benefits.
4	McMillan Creek WDP	Projects broken into Major/secondary concerns based on risk. Projects then based on location (main stem, tributary, closed piped network) and broken into short, medium, long term.	Risk based	Not sure if location (main stem, tributary or closed pipe network) consistently correlates with risk levels. Need more info on what constitutes high vs low risk.	
5	Hudson's Bay Slough WDP	Projects were prioritized based on perceived need.	Good approach for dealing with a specific topic (stormwater) in a specific area.	No formal prioritization framework.	Would be difficult to apply to a consolidation of multiple studies.
6	Gladstone, Trent & Varsity WDP	Prioritization based on timing (existing vs future needs)	Addressed the timing of development.	Doesn't address the issue of too many existing projects	The issue of timing with development should be applied to an overall prioritization framework
7	CPG Enterprise Risk Mgmt	Priorities based on financial, operational, staff/public, reputational and strategic consequences.	Risk based approach.	Doesn't address environment, benefits, or regulatory requirements. Hasn't received senior management approval. Redundancy between categories.	Base framework could be used with modifications to content.
9	Water Master Plan	Risk based approach that considers condition and capacity.	Risk based approach. Aligned with RIVA, GIS, sanitary mains, drainage mains.	Specific to water mains.	See #12 below.
11	Sewer Master Plan	Risk based approach that considers condition and capacity.	Risk based approach. Aligned with RIVA, GIS, water mains, drainage mains.	Specific to sanitary mains.	See #12 below

12	RIVA – Drainage	Risk based approach that considers condition and insufficient capacity (i.e. that causes flooding).	Risk based approach. Aligned with RIVA, GIS, water mains, sanitary mains.	Does not consider environmental impacts from quantity or quality. Does not consider benefits (ie amenities).	Could be used as a sub-prioritization framework for renewal of drainage mains only within a greater prioritization framework
13	CPG Project Level Risk Analysis	Risk based approach that considers H&S, reputation, legal, relationships, services/systems, environment, cultural heritage.	Risk based approach that encompasses more considerations than ERM framework.	Does not consider costs or benefits (ie looks at negative not positive).	Base framework could be used with modifications to content.
14	EMBC	Risk based approach based on consequences of failure.	Risk based approach which is similar to CPG's ERM.	Does not consider environmental impact. Does not consider cost or benefit of solutions.	Base framework could be used with modifications to content.
15	NAMS	Risk based approach for identifying asset priorities	Risk based approach that CPG has used on previous AM projects	Does not consider cost or benefit of solutions. Mixed opinions in industry about the NAMS risk framework	
16	Eagle Creek ISMP	Cost benefit point-based approach that considers economic, environmental and social consequences.	Simple but comprehensive scoring system Based on drainage project considerations.	Doesn't consider likelihood Not aligned with other CPG systems	Content could be used to modify other risk based approaches

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Appendix B

Proposed Generic Prioritization Framework for the City of Prince George

Table B1 Generic Project Prioritization Framework for the City of Prince George

	High Score=3	Medium Score=2	Low Score=1	None Score=0
Social	• Not completing the project will result in significant impacts to public health and safety, property and/or highly valued cultural assets • Provides a "destination" amenity to residents from across the City (recreational, educational or cultural) • Not completing the project will impact other infrastructure and result in significant service disruptions *(*e.g. significantly impacts critical infrastructure/services, >25 developed properties and/or > 500 traffic turnover rate*)* • Will result in the equitable distribution of costs and services across the City and across generations	• Not completing the project will result in moderate impacts to public health and safety, property and/or highly valued cultural assets • Provides an amenity to local residents (recreational, educational or cultural) • Not completing the project will impact other infrastructure and result in moderate service disruptions *(*e.g. impacts non-critical infrastructure/services >500 traffic turnover rate and/or impacts critical services < 500 traffic turnover rate, • Not completing the project will result in a significant loss of public confidence, typically due to intense negative media exposure.	• Not completing the project may result in minor service disruptions (i.e. minor impact to < 500 traffic turnover rate or significant impact to < 5 traffic turnover rate) • Minor recreational, educational or cultural benefits • Not completing the project may result in minor negative recreational, educational or cultural impacts • Not completing the project will result in a small loss of public confidence (e.g. localized, < 50 people).	• No risk to health, safety, property or other services • No amenity • No cultural impact • No service disruptions • No loss in public confidence (may include single letter to local press with no adverse media article)
Economic	• Not completing the project will result in a significant unrecoverable cost to the community (>$1M) • City's net life cycle cost to complete the project is ≤ $10,000. Consider costs and savings resulting from the project, including the costs that would have resulted from not completing the project) • Large borrowing debt decision required through Council and Alternate Approval Process or Referendum • Completing the project will result in significant economic benefits to the community (i.e. development, tourism etc.)	• Not completing the project will result in a moderate unrecoverable cost to the community ($250k - $1M) • City's net life cycle cost to complete the project is between $10k to $250k capital cost and <$25,000 per year operating cost • Completing the project will result in moderate economic benefits to the community (i.e. development, tourism etc.)	• Not completing the project may result in minor unrecoverable cost to the community (<$250k) • Net cost to the City is between $250k and $1M capital cost and/or between $100k and $25k per year operating cost • Possible minor economic benefits to the community	• Not completing the project will not likely result in costs to the community • Net cost to the City >$1M capital cost and/or >$100k operating cost • No economic benefits to the community
Environmental*	• Not completing the project will result in a significant negative environmental impact • Completing the project will result in a significant positive environmental impact, improved ecosystem services or protect natural assets? • Should also include meeting environmental regulations	• Not completing the project will result in a moderate negative environmental impact • Completing the project will result in a moderate positive environmental impact	• Not completing the project will result in a minor negative environmental impact • Completing the project will result in a minor positive environmental impact	• No environmental impact (positive from doing the project or negative from not doing the project)

Notes

Maximum score is 9. Scores can range from 0-9.

Mandated projects (i.e. through municipal, provincial or federal legislative requirements, orders, warnings, and agreements such as development or partnership agreements) have an automatic score of 9.* This includes projects that are mandated through environmental legislation, including locally protected areas (Riparian Protection – DP areas).

Unrecoverable costs to the community include costs that will not be reimbursed through insurance nor can be passed on to the consumer without significant impacts (i.e. significant loss of sales).

Note that planned service disruptions (e.g. due to maintenance/construction) typically result in less significant impacts because alternatives can be put in place. Whereas unplanned service disruptions due to emergencies (e.g. pipe collapse, extreme weather event) typically result in greater service impacts.

Many of the proposed projects will result in some costs to the City but some of the projects will also result in some savings (i.e. deferred maintenance). Therefore, Net costs = total costs – total savings

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Appendix C

Watershed Drainage Plans – Action Items Prioritization & Scoring

See Edoc #564822 for Prioritized Action Items

Some important notes regarding the Action Items and their Scoring:

1. Because some of the WDPs did not provide cost estimates, AECOM had to develop a very high level approximation of the cost of some of the action items (i.e. <$10k, $10k-$250k, $250k-$100M, >$1M) in order correctly score the action item. The actual cost estimate for these action items is still unknown and therefore not included.
2. Sometimes the "same action item" in different WDP's or within the same WDP will have a different score depending on whether it has an impact on a fish-bearing stream or not or a significant roadway or not.
3. The impact of a road closure due to an asset failure was estimated based on the location of the road, seeing how many properties it served etc. Traffic counts were not readily available.
4. Assigning the correct score for some of the action items was clear, but for some it was more ambiguous. In other words, the total score for an action item could be ±1. Some of these more "controversial" action item scorings can be discussed further with City staff. Comments on action items that warrant further discussion are highlighted in the action item spreadsheet.

ID	Action Item / Recommendation	Watershed Drainage Plan	Year	Economic score	Social Score	Env't Score	Score Total	WDP Prioritization	Original Capital Costs	City Cost increased for Inflation and CC	O&M Costs	Environmental benefits/ detriment	Social benefits (including protection of property)	Bylaw / Guidelines	Overlap with other Actions	Asset ID or Model ID	Discharge Point	Completed?
F100-1	Upgrade three pipe segments (258 m)	Parkridge Creek & West Fraser	2020	1	1	0	2	Deficient under future climate change	$405,000	$405,000		Potentially aggravate existing erosion processes in downstream watercourses	Mitigate future flooding issues upstream			63, 69, 67	Ferry Ave	
F100-2	Upgrade one pipe segment (8 m)	Parkridge Creek & West Fraser	2020	2	1	0	3	Deficient under future climate change	$18,000	$18,000		Potentially aggravate existing erosion processes in downstream watercourses	Mitigate future flooding issues upstream			4761	Wiens Road	
F100-3	Upgrade eleven pipe segments (502 m)	Parkridge Creek & West Fraser	2020	1	2	0	3	Deficient under existing and future climate change	$847,000	$847,000		Potentially aggravate existing erosion processes in downstream watercourses	Mitigate future flooding issues upstream			1255, 1267, 1266, 1256, 1257, 1261, 1258, 1262, 1260, 1264, 1265	Cowart cross-culvert to a pipe down to the river backwater channel	
F100-4	Upgrade five pipe segments (341 m)	Parkridge Creek & West Fraser	2020	1	1	0	2	Deficient under future climate change	$517,000	$517,000		Potentially aggravate existing erosion processes in downstream watercourses	Mitigate future flooding issues upstream			3080, 3083, 3078, 3081, 3082	Drains to wetlands on lower bench that parallels the future Malaspina Extension	
WF-1- This series relates to West Fraser catchmen	Treatment at outfalls. This series relates to West Fraser Subcatchments	Parkridge Creek & West Fraser	2020	2	0	3	5	Prioritize Hwy 16 and Latrobe (fish bearing)	$10,000-$100,000	$55,000		Positive: Remove contaminants before runoff is discharged from the storm system for all subcatchments					Drains to cowart Rd outfall and Parkridge creek south of Latrobe Pl. also collects Loedel Cres	
WF-2	Protect / Preserve wetland habitat in Malaspina Watershed	Parkridge Creek & W	2020	3	2	2	7		N/A	10000		Positive: Wetland areas should be preserved, or compensation provided for lost natural wetlands due to development of future roadways along the lower Fraser River bench.	Preserved wetlands can be kept for educational/recreational purposes as well.				Drains to Fraser River Benchland s outfall recently up graded	
WF-3	Water Quality monitoring at Latrobe Outfall	Parkridge Creek & W	2020	2	0	2	4	Pre-treatment should be prioritized at this outfall.	$10,000-$100,000	$55,000		Positive: Identify specific contaminant concerns with poor water quality from this outfall during rain on snow events.					Drains directly to Parkridge Cr.	
WF-4	Erosion protection measures at outfalls	Parkridge Creek & West Fraser	2020	2	0	2	4	Outfalls requiring erosion protection include Imperial, Guelph, Latrobe, Fairmont, Essex, Delhi, Cowart, Ferry Avenue	$100,000-$1,000,000	$550,000		Positive					Most drain to Wetlands on Fraser River Benchlands other than Ferry Ave. that drains directly into the Fraser River.	
WF-5	Clean Cowart Road outfall culvert inlet	Parkridge Creek & W	2020	3	0	2	5		<$10,000	$5,000		Neutral	Prevent washing of ditch material into the culvert.				Fraser River backwater Channel	
	Culvert Upgrade - Leslie Road (AEID: C-310)	Parkridge Creek & West Fraser	2020	1	1	1	3	Fair condition, upgrade not recommended	$100,000-$1,000,000	$550,000		May have negative effects downstream as the resulting higher flows increases the erosion potential.	May exacerbate downstream flooding risks.			Not in City Database		
	Culvert Upgrade - Collena Street (AEID: C-312)	Parkridge Creek & W	2020	1	1	1	3	Fair condition, upgrade not recommended	$100,000-$1,000,000	$550,000		May have negative effects downstream as the resulting higher flows increases the erosion potential.	May exacerbate downstream flooding risks.			Not in City Database		
	Culvert Upgrade - Hilltop Road (AEID: C-254)	Parkridge Creek & W	2020	1	1	1	3	Fair condition, upgrade not recommended	$100,000-$1,000,000	$550,000		May have negative effects downstream as the resulting higher flows increases the erosion potential.	May exacerbate downstream flooding risks.			Not in City Database		
	Culvert Upgrade - Hilltop Road (AEID: C-255)	Parkridge Creek & W	2020	1	1	1	3	Fair condition, upgrade not recommended	$100,000-$1,000,000	$550,000		May have negative effects downstream as the resulting higher flows increases the erosion potential.	May exacerbate downstream flooding risks.			Not in City Database		
	Culvert Upgrade - Hilltop Road (AEID: C-257)	Parkridge Creek & W	2020	1	0	0	1	Good condition, upgrade not recommended	$100,000-$1,000,000	$550,000		May have negative effects downstream as the resulting higher flows increases the erosion potential.	May exacerbate downstream flooding risks.			Not in City Database		
	Culvert Upgrade - Hilltop Road (AEID: C-503)	Parkridge Creek & W	2020	1	1	1	3	Fair condition, upgrade not recommended	$100,000-$1,000,000	$550,000		May have negative effects downstream as the resulting higher flows increases the erosion potential.	May exacerbate downstream flooding risks.			Not in City Database		
	Culvert Upgrade - Lattman Road (AEID: C-260)	Parkridge Creek & W	2020	1	2	2	5	Poor condition	$100,000-$1,000,000	$550,000		May have negative effects downstream as the resulting higher flows increases the erosion potential.	May exacerbate downstream flooding risks.			3982		
	Culvert Upgrade - Bunce Road (AEID: C-117)	Parkridge Creek & West Fraser	2020	1	1	1	3	Fair condition, upgrade not recommended	$100,000-$1,000,000	$550,000		May have negative effects downstream as the resulting higher flows increases the erosion potential.	May exacerbate downstream flooding risks.			3969		
	~~Culvert Upgrade - Highway 16 (AEID: C-217)~~	~~Parkridge Creek & West Fraser~~	~~2020~~	~~1~~	~~3~~	~~2~~		~~Poor condition~~	~~$100,000-$1,000,000~~			~~May have negative effects downstream as the resulting higher flows increases the erosion potential.~~	~~May exacerbate downstream flooding risks.~~			~~Not in City Database~~		Complete
	Culvert Upgrade - Kimball Road (AEID: C-249)	Parkridge Creek & West Fraser	2020	1	1	1	3	Fair condition, upgrade not recommended	$100,000-$1,000,000	$550,000		May have negative effects downstream as the resulting higher flows increases the erosion potential.	May exacerbate downstream flooding risks.			Not in City Database		
	Culvert Upgrade - Bilnor Road (AEID: C-243)	Parkridge Creek & West Fraser	2020	1	1	1	3	Fair condition, upgrade not recommended	$100,000-$1,000,000	$550,000		May have negative effects downstream as the resulting higher flows increases the erosion potential.	May exacerbate downstream flooding risks.			Not in City Database		
	Culvert Upgrade - Reynolds Road (AEID: C-504)	Parkridge Creek & West Fraser	2020	1	0	0	1	Upgrade not recommended	$100,000-$1,000,000	$550,000		May have negative effects downstream as the resulting higher flows increases the erosion potential.	May exacerbate downstream flooding risks.			15801		
	Culvert Upgrade - Reynolds Road (AEID: C-225)	Parkridge Creek & West Fraser	2020	1	1	0	2	Fair condition, upgrade not recommended	$100,000-$1,000,000	$550,000		May have negative effects downstream as the resulting higher flows increases the erosion potential.	May exacerbate downstream flooding risks.			Not in City Database		

	Culvert Upgrade - Reynolds Road (AEID: C-227)	Parkridge Creek & West Fraser	2020	1	0	0	1	Good condition, upgrade not recommended	$100,000-$1,000,000	$550,000		May have negative effects downstream as the resulting higher flows increases the erosion potential.	May exacerbate downstream flooding risks.			Not in City Database		
	Culvert Upgrade - Haldi Lake Road (AEID: C-139)	Parkridge Creek & West Fraser	2020	1	0	0	1	Good condition, upgrade not recommended	$100,000-$1,000,000	$550,000		May have negative effects downstream as the resulting higher flows increases the erosion potential.	May exacerbate downstream flooding risks.			3972		
	Culvert Upgrade - Purdue Road (AEID: C-221)	Parkridge Creek & West Fraser	2020	1	1	1	3	Fair condition, upgrade not recommended	$100,000-$1,000,000	$550,000		May have negative effects downstream as the resulting higher flows increases the erosion potential.	May exacerbate downstream flooding risks.			Not in City Database		
	Culvert Upgrade - Buckingham Road (AEID: C-232)	Parkridge Creek & West Fraser	2020	1	2	1	4	Poor condition	$100,000-$1,000,000	$550,000		May have negative effects downstream as the resulting higher flows increases the erosion potential.	May exacerbate downstream flooding risks.			3990		
	Establishing a Flood Construction Level (FCL) (Parkridge Creek-Upstream of Highway 16)	Parkridge Creek & West Fraser	2020	2	3	0	5		Internal Costs to City, increased development costs	$5,000			Reduces building damage potential over time.					
Parkridge Creek watershed PK-1	Plant roadside ditches with native species	Parkridge Creek & West Fraser	2020	3	0	2	5		<$10,000	$5,000		Positive						
PK-2	Implement roadside BMPs on future boundary road extension	Parkridge Creek & West Fraser	2020	2	2	2	6		$10,000-$100,000 individually, cost goes down per unit if part of a larger program	$55,000	$500	Positive			X			
PK-3	Monitor beaver activity at Highway 16 culverts	Parkridge Creek & West Fraser	2020	3	2	1	6		<$10,000	$5,000		N/A						
PK-4	Floodplain development permits in flooded area upstream of Highway 16	Parkridge Creek & West Fraser	2020	3	3	1	7		Internal Costs to City, could charge an application fee.	$5,000		N/A		X				
PK-5	Maintain cleaning of utility corridor along Parkridge Creek, initiated in 2018	Parkridge Creek & West Fraser	2020	1	1	2	4		$100,000-$1,000,000			Positive						
PK-6	Upgrade culvert at Domano Boulevard to remove barrier to fish passage	Parkridge Creek & West Fraser	2020	1	2	3	9	Fair condition, Bridge recommended	>$1,000,000	$1,000,000		Positive, particularly if bridge is installed			X			
PK-7	Develop future residential areas in Parkridge Creek with stringent stormwater management considerations	Parkridge Creek & West Fraser	2020	2	1	2	5		Internal Costs to City/Developers	$5,000		Positive		X	X			
PK-8	Treat runoff from snow storage facilities	Parkridge Creek & West Fraser	2020	1	0	2	3		$100,000-$1,000,000	$55,000		Positive			X			
PK-9	Prevent recreational vehicle crossing at Park Drive	Parkridge Creek & West Fraser	2020	3	0	2	5		Internal Costs to City	$10,000		Positive						
PK-10	Clean debris at Heyer Road Outfall	Parkridge Creek & West Fraser	2020	3	1	1	5			$10,000		Positive						
PK-11	Adjust future road alignments along Parkridge Creek to avoid riparian impacts.	Parkridge Creek & West Fraser	2020	3	0	2	5		Internal Costs to City	$10,000		Positive						
PK-12	Beaver protection	Parkridge Creek & West Fraser	2020	2	2	0	4		$10,000-$100,000	$55,000		Negative						
PK-13	Snow Removal in Vanway Neighbourhood	Parkridge Creek & West Fraser	2020	2	2	0	4		$10,000-$100,000	$55,000		N/A						
PK-14	Culvert upgrades for fish passage	Parkridge Creek & West Fraser	2020	1	1	3	5					Positive			X			
West Frase	Strengthen wording in Subdivision and Development Servicing Bylaw around stormwater management	Parkridge Creek & West Fraser	2020	3	0	2	5		Internal Costs to City	$10,000		Positive		X	X			
G-2	Implement a Sediment and Erosion Control Bylaw	Parkridge Creek & West Fraser	2020	3	3	2	8		Internal Costs to City	$10,000		Positive		X	X			
G-3	Update Design Criteria Manual to include Climate Change Considerations	Parkridge Creek & West Fraser	2020	3	2	2	7		Internal Costs to City	$50,000		Positive		X	X			
G-4	Update Storm Sewer System Bylaw	Parkridge Creek & West Fraser	2020	3	0	2	5		Internal Costs to City	$10,000		Positive		X	X			
G-5	Update Zoning Bylaw	Parkridge Creek & West Fraser	2020	3	0	2	5		Internal Costs to City	$10,000		Positive		X				
G-6	Culvert Inspections/Replacement	Parkridge Creek & West Fraser	2020	2	2	2	6		$10,000-$100,000	$55,000		Positive			X			
G-7	Public Engagement	Parkridge Creek & West Fraser	2020	3	1	1	5		Internal Costs to City	$10,000		Positive						
G-8	Implement residential on-site stormwater management techniques and include requirements in appropriate bylaws	Parkridge Creek & West Fraser	2020	2	1	2	5		Internal Costs to City, Costs to Residents	$25,000		Positive			X			
G-9	Stormwater BMPs for commercial and multifamily lots	Parkridge Creek & West Fraser	2020	2	0	2	4		Internal Costs to City, Costs to Developers	$25,000		Positive			X			
G-10	Stormwater BMPs for roadways	Parkridge Creek & West Fraser	2020	2	1	2	5		Costs to City, Depends on Scope			Positive			X			
G-11	Update GIS Database for Stormwater	Parkridge Creek & West Fraser	2020	2	3	1	6		Internal Costs to City	$125,000		N/A						
G-12	Update Hazardous Slope mapping	Parkridge Creek & West Fraser	2020	3	3	2	8		Internal Costs to City	$10,000		N/A						

G-13	Regular stormwater system maintenance	Parkridge Creek & West Fraser	2020	2	2	2	6		$10,000-$100,000	$55,000		Positive			X			
G-14	Conserve natural vegetation, limit tree removal	Parkridge Creek & West Fraser	2020	3	1	3	7		$10,000-$100,000	$55,000		Positive			X			
G-15	Improve inspection related to stormwater management	Parkridge Creek & West Fraser	2020	2	1	2	5		$10,000-$100,000	$55,000		Positive			X			
G-16	Update IDF Curves	Parkridge Creek & West Fraser	2020	3	2	2	7		Internal Costs to City, may require outside consultant, $10,000-	$55,000		Positive			X			
G-17	Recommend open ditches over paved swales	Parkridge Creek & West Fraser	2020	3	1	2	6		$10,000-$100,000	$55,000		Positive						
G-18	Protect wetlands	Parkridge Creek & West Fraser	2020	2	2	3	7		$10,000-$100,000	$55,000		Positive			X			
G-19	Update Design Standards Manual	Parkridge Creek & West Fraser	2020	2	1	2	5		$10,000-$100,000	$55,000		Positive			X			
	Replace crossing structure with clear span bridge - Hofferkamp Road	McMillan Creek	2017	0	2	3	5	Short Term (1-5 years), Replacement Priority 1	$1,180,000	$1,321,600						159	Nechako River at Cameron Street Bridge	
	~~Replace crossing structure with clear span bridge - Aberdeen Road~~	~~McMillan Creek~~	~~2017~~	~~0~~	~~2~~	~~3~~		~~Short Term (1-5 years), Replacement Priority 2~~	~~$1,448,000~~							~~157~~		Complete
	Replace crossing structure with clear span bridge - McMillan Drive	McMillan Creek	2017	1	2	3	6	Short Term (1-5 years), Replacement Priority 3	$563,000	$630,560						138		
	Replace crossing structure with clear span bridge - Northwood Road	McMillan Creek	2017	0	1	3	4	Short Term (1-5 years), Replacement Priority 4	$1,233,000	$1,380,960						160		
	2-year culvert maintenance program	McMillan Creek	2017	1	2	2	5	Short Term (1-5 years)	$254,800	$285,376					X			
	5-year culvert maintenance program	McMillan Creek	2017	2	2	2	6	Short Term (1-5 years)	$126,000	$141,120					X			
	Onsite storage of snow	McMillan Creek	2017	1	1	2	4	Short Term (1-5 years)				Positive			X			
	Conduct culvert condition assessments in other PG watersheds and implement a similar program.	McMillan Creek	2017	2	2	2	6	Short Term (1-5 years)							X			
	Further public education through the establishment of parks and trails that inform on watershed health.	McMillan Creek	2017	1	3	1	5	Short Term (1-5 years)										
	Follow BMPs for improvements to existing practices and for the construction of new systems.	McMillan Creek	2017	3	1	2	6	Short Term (1-5 years)							X			
	Replace crossing structure with clear span bridge - Private Drive	McMillan Creek	2017	1	1	2	4	Medium Term (5-10 years)	$376,000	$421,120						176		
	Replace crossing structure with clear span bridge - Highway 97 Crossing	McMillan Creek	2017	0	3	1	4	Medium Term (5-10 years)	$1,340,000							188		
	Replace crossing structure with clear span bridge - Iona Road	McMillan Creek	2017	1	1	0	2	Medium Term (5-10 years)	$676,000	$757,120						173		
	Replace crossing structure with clear span bridge - OSL Road Crossing	McMillan Creek	2017	1	2	1	4	Medium Term (5-10 years)	$676,000	$757,120						153		
	Replace crossing structure with clear span bridge - OSL Road Crossing	McMillan Creek	2017	1	2	1	4	Medium Term (5-10 years)	$676,000	$757,120						154		
	~~Replace crossing structure with clear span bridge - Goose Country Road~~	~~McMillan Creek~~	~~2017~~	~~1~~	~~2~~	~~3~~		~~Medium Term (5-10 years)~~	~~$676,000~~							~~156~~		Complete, waiting for
	Replace crossing structure with clear span bridge - Private Drive	McMillan Creek	2017	1	1	1	3	Medium Term (5-10 years)	$376,000	$421,120						179		
	Replace crossing structure with clear span bridge - Private Drive	McMillan Creek	2017	1	1	2	4	Medium Term (5-10 years)	$376,000	$421,120						180		
	Incorporate alternative stormwater management strategies [LIDs] in to new developments.	McMillan Creek	2017	3	1	2	6	Medium Term (5-10 years)							X			
	Construct a wetland at the outlet of the proposed Nordic Drive storm trunk.	McMillan Creek	2017	1	2	2	5	Medium Term (5-10 years)										Outlet structure
	Consider environmental constraints such as sensitive riparian features for proposed developments.	McMillan Creek	2017	3	2	2	7	Medium Term (5-10 years)		$10,000					X			
	Update City Design Guidelines to account for 1 in 10 year storm events, minimum pipe sizes, and gradients for both storm sewers and culverts.	McMillan Creek	2017	3	2	2	7	Medium Term (5-10 years)		$10,000				X	X			
	Preserve watershed health through mainstem crossing improvements and integrated stormwater management strategies.	McMillan Creek	2017	0	0	3	3	Long Term (10+ years)										
	Secure consistent funding through the integration of a stormwater utility program.	McMillan Creek	2017	2	3	2	7	Long Term (10+ years)		$200,000				X	X			

	Enforce existing policies and bylaws on new developments and existing landowners regarding sedimentation and stormwater management. Implement new regulation regarding onsite snow storage and sediment capture, including the maintenance of new and existing systems.	McMillan Creek	2017	2	1	2	5	Long Term (10+ years)		$10,000	$50,000			X	X			
	Limit future land use [of] rural development near sensitive riparian areas. Discourage any further crossings over the mainstem of McMillan Creek and provide incentive to existing landowners to replace crossings that have been found to be barriers.	McMillan Creek	2017	2	0	2	4	Long Term (10+ years)						X	X			
	Prohibited areas for aggregate extraction should be extended to include undeveloped areas of the watershed.	McMillan Creek	2017	3	0	2	5	Long Term (10+ years)		$5,000				X				
	Careful consideration should be given to development in wetlands and sensitive riparian ecosystems	McMillan Creek	2017	3	2	2	7	Long Term (10+ years)		$10,000				X	X			
	Monitor areas in close proximity to major tributaries for sedimentation and contamination such as Meadow Park.	McMillan Creek	2017	2	0	2	4	Long Term (10+ years)		$0	$10,000							
	Protect undevelopable land through the establishment of parks and protected zones to reduce the possibility of any future development in these areas.	McMillan Creek	2017	1	3	2	6	Long Term (10+ years)		$1,000,000				X				
	Continue to use and develop BMPs that can be used for the construction and maintenance of new and existing systems.	McMillan Creek	2017	2	2	2	6	Long Term (10+ years)							X			
S1	Minor system pipe upgrade	University Heights/P	2016	2	2	0	4	Short Term	$26,000	$34,060						ST_1221		
S1	Minor system pipe upgrade	University Heights/P	2016	2	2	0	4	Short Term	$26,000	$34,060						ST_1222		
S1	Minor system pipe upgrade	University Heights/P	2016	2	2	0	4	Short Term	$22,000	$28,820						ST_1223		
S1	Minor system pipe upgrade	University Heights/P	2016	2	2	0	4	Short Term	$14,000	$18,340						ST_1224		
S1	Minor system pipe upgrade	University Heights/P	2016	2	2	0	4	Short Term	$13,000	$17,030						ST_1225		
S1	Minor system pipe upgrade	University Heights/P	2016	2	2	0	4	Short Term	$49,000	$64,190						ST_1226		
S1	Major system pipe upgrade	University Heights/P	2016	2	2	0	4	Short Term	$130,000	$170,300						ST_2354		
S1	Major system pipe upgrade	University Heights/P	2016	0	2	0	2	Short Term	$998,000	$1,307,380						ST_2422		
S1	Major system pipe upgrade	University Heights/P	2016	1	2	0	3	Short Term	$666,000	$872,460						ST_2580		
S1	Major system pipe upgrade	University Heights/P	2016	2	2	0	4	Short Term	$102,000	$133,620						ST_3157		
S1	Major system culvert upgrade	University Heights/P	2016	2	2	0	4	Short Term	$198,000	$259,380						C11		
S2	Cleanout accumulated sediment from storm sewer inlets at escarpment base.	University Heights/P	2016	2	1	2	5	Short Term	N/A	$25,000								
S2	Cap trails near escarpment watercourses with less erodible material.	University Heights/P	2016	2	2	2	6	Short Term	N/A	$70,000								
S2	Enforce current ESC regulations for ongoing development.	University Heights/P	2016	2	1	2	5	Short Term	N/A		$ 25,000.00				X			
S3	Investigate capacity of Hudson Bay Slough storm sewer	University Heights/Peden Hill	2016	2	2	2	6	Short Term	$100,000	$131,000								
M1	Minor system pipe upgrade	University Heights/P	2016	2	1	0	3	Medium Term	$35,000	$45,850						ST_641		
M1	Minor system pipe upgrade	University Heights/P	2016	2	1	0	3	Medium Term	$143,000	$187,330						ST_1046		
M1	Minor system pipe upgrade	University Heights/P	2016	2	1	0	3	Medium Term	$98,000	$128,380						ST_1047		
M1	Minor system pipe upgrade	University Heights/P	2016	2	1	0	3	Medium Term	$104,000	$136,240						ST_1050		
M1	Minor system pipe upgrade	University Heights/P	2016	2	1	0	3	Medium Term	$118,000	$154,580						ST_1051		
M1	Minor system pipe upgrade	University Heights/P	2016	2	1	0	3	Medium Term	$31,000	$40,610						ST_2365		
M1	Minor system pipe upgrade	University Heights/P	2016	2	1	0	3	Medium Term	$38,000	$49,780						ST_2377		
M1	Minor system pipe upgrade	University Heights/P	2016	2	1	0	3	Medium Term	$39,000	$51,090						ST_2383		
M1	Major system pipe upgrade	University Heights/P	2016	2	1	0	3	Medium Term	$22,000	$28,820						ST_3166		
M1	Major system culvert upgrade	University Heights/P	2016	1	1	0	2	Medium Term	$337,000	$441,470						C7		
M1	Major system culvert upgrade	University Heights/P	2016	2	1	0	3	Medium Term	$189,000	$247,590						C9		
M2	Establish greenbelt areas to provide several large core habitat areas for wildlife. Enlarge greenbelt area around Watercourse J to encompass all the tributaries	University Heights/Peden Hill	2016	3	2	2	7	Medium Term	N/A					X	X			
M2	Establish designated wildlife corridors for connectivity between large core habitat areas concentrating on Watercourses B and C. Enlarge riparian/wildlife corridor through Watercourse B2 to create continuous connection between Watercourses B and C	University Heights/Peden Hill	2016	3	2	2	7	Medium Term	N/A					X	X			
M3	~~Divert runoff from watercourses~~	~~University Heights/P~~	~~2016~~	~~1~~	~~0~~	~~2~~		~~Medium Term~~	~~N/A~~									Complete
M3	Where possible, use existing storm sewers (need to confirm existing downstream capacities)	University Heights/P	2016	2	0	2	4	Medium Term	N/A									

M4	Construct detention facilities in all new development to detain post-development flows to pre-development rates. Developers and consultants should consult with the City for the current criteria.	University Heights/P	2016	3	2	1	6	Medium Term	N/A						X			
M5	Include water quality treatment features in detention ponds where possible for new developments.	University Heights/P	2016	3	1	2	6	Medium Term	N/A						X			
M5	Construct oil/grit separators as spill control devices for gas stations, high risk spill industry, large parking lots.	University Heights/P	2016	2	1	2	5	Medium Term	N/A									
M5	Provide ESC measures during construction.	University Heights/P	2016	2	1	2	5	Medium Term	N/A									
M6	City to adjust current development design standards and typical road cross sections to accommodate snow storage within the arterial road ROW.	University Heights/Peden Hill	2016	2	1	0	3	Medium Term	N/A						X			
M6	Provide micro snow-dumps in local parks.	University Heights/Peden Hill	2016	2	1	0	3	Medium Term	N/A						X			
L1	Upgrade 20 lowest priority undersized conduits only when they have reached the end of their service life (see Table 6-7).	University Heights/Peden Hill	2016	3	0	0	3	Long Term	Not Provided									
L2	Adopt the City's Design Guidelines (2001) as a Development Bylaw.	University Heights/Peden Hill	2016	3	0	0	3	Long Term	N/A					X				
L2	Enact Erosion & Sediment Control Bylaw.	University Heights/Peden Hill	2016	3	3	2	8	Long Term	N/A					X	X			
L3	Implement water quality monitoring at outfall to Lansdowne Creek to meet Aquatic Life standards of the Provincial Water Quality Guidelines.	University Heights/Peden Hill	2016	2	0	2	4	Long Term	N/A		$10,000							
L3	Implement flow monitoring program to establish baseline values.	University Heights/Peden Hill		2	0	1	3	Long Term	$50,000	$65,500	$20,000							
	Study/prelim design to assess the clean-out and retrofit of Maurice Drive Pond	Post UHPH watershed		2	1	2	5			$100,000								
	Installation of a diversion pipe through the Pine Valley Golf Course to an infiltration gallery	Post UHPH watershed		2	1	1	4			$100,000								
-	Protect Greenway Corridors	East Prince George	2013	3	2	2	7	High Priority						X	X			
~~E4.1~~	~~Monitor terrain instability in drainage course (Airport Hill)~~	~~East Prince George~~	~~2013~~	~~2~~	~~0~~	~~1~~		~~High Priority~~										Complete
E8.1	Monitor slope instabilities of main drainage course (BCR)	East Prince George	2013	2	0	2	4	High Priority										
-	Wetland compensation program	East Prince George	2013	2	2	3	7	High Priority						X	X			
E15.1	Replace/modify ~~Willow Cale Road &~~ CN Rail culverts (Haggith)	East Prince George	2013	1	1	3	5	Moderate Priority										Willowcale Rd Crossing
-	Beaver management plan	East Prince George	2013	2	2	0	4	Moderate Priority							X			
E1.2	Replace/modify problem culverts (Bittner)	East Prince George	2013	2	2	3	7	Moderate Priority		$1,000,000								
E6.1	Improve erosion & sediment control at power line R.O.W. crossing (Guay)	East Prince George	2013	2	0	2	4	Moderate Priority										
E8.2	Improve erosion & sediment control along access road near Continential Way (BCR)	East Prince George	2013	2	0	2	4	Moderate Priority										
E1.1	Fish passage culvert inspection (Bittner)	East Prince George	2013	2	0	3	5	Moderate Priority										
E3.1	Improve runoff control along Foreman Road (Graves)	East Prince George	2013	2	0	1	3	Low Priority										
-	Water quality monitoring program	East Prince George	2013	2	0	2	4	Low Priority										
.1	Establish 30m riparian setbacks	East Prince George	2013	3	2	2	7	High Priority						X	X			
.3	Require Industrial & Commercial BMPs	East Prince George	2013	2	2	2	6	High Priority						X	X			
.4	Require Urban BMPs	East Prince George	2013	3	1	1	5	High Priority						X	X			
.11	Educate and train City inspectors	East Prince George	2013	3	0	2	5	High Priority										
.14	Update City of Prince George bylaws (DCC, Development Procedures and Tree Protection)	East Prince George	2013	3	2	2	7	High Priority						X				
.2	Bioswales in Lieu of Piped Conveyance	East Prince George	2013	3	2	2	7	Moderate Priority							X			
.7	~~Upgrade Willow Cale / Haggith Culvert~~	East Prince George	2013	2	0	3	5	Moderate Priority										Complete

.9	Monitor and remediate erosion sites	East Prince George	2013	2	0	2	4	Moderate Priority										
.10	Create a Stormwater Best Management Practices Circular	East Prince George	2013	3	2	2	7	Moderate Priority										
.12	Stormwater Management Rebate Program	East Prince George	2013	2	3	2	7	Moderate Priority										
.13	Create a drainage utility fee	East Prince George	2013	2	3	2	7	Moderate Priority						X	X			
.5	Encourage Airport BMPs	East Prince George	2013	2	0	2	4	Low Priority										
.8	Flow monitoring program	East Prince George	2013	2	0	2	4	Low Priority										
.6	Infiltration testing	East Prince George	2013	2	2	2	6	Low Priority										
	Assess Foreman road drainage channel issues as a result of commercial development at the corner of Foreman Rd and Hwy 16E.	Post EPG WDP		2	2	2	6			$100,000								
	~~Field investigation/assessment of sediment accumulations in downtown area.~~	Hudson Bay Slough	2007	2	3	2	7					Positive						
	Commence a sediment management program.	Hudson Bay Slough	2007	1	2	2	5					Positive						
P03-1	Winnipeg Street Pipe Upgrade	Hudson Bay Slough	2007	1	3	0	4		$360,000	$561,600	$3,600					Not provided		
P03-2	~~Patricia Boulevard Interconnection Pipe~~	~~Hudson Bay Slough~~	~~2007~~	~~2~~	~~3~~	~~0~~			~~$22,000~~		~~$220~~					~~Not provided~~		Complete
P03-3	Subcatchment diversion	Hudson Bay Slough	2007	0	3	0	3		$774,000	$1,207,440	$7,740					Not provided		
P03-4	Subcatchment diversion	Hudson Bay Slough	2007	2	3	0	5		$150,000	$234,000	$1,500					Not provided		
P03-5	Subcatchment diversion	Hudson Bay Slough	2007	2	3	0	5		$100,000	$156,000	$1,000					Not provided		
P04-1	Highway 16 Culvert Twinning	Hudson Bay Slough	2007	1	3	0	4		$310,000	$483,600	$3,100					Not provided		
P04-2	Utility Crossing Upgrade	Hudson Bay Slough	2007	1	3	0	4		$340,000	$530,400	$3,400					Not provided		
P04-3	Upland St. Crossing Upgrade	Hudson Bay Slough	2007	1	3	0	4		$340,000	$530,400	$3,400					Not provided		
P04-4	Victoria St. Crossing Upgrade	Hudson Bay Slough	2007	2	3	0	5		$340,000	$530,400	$3,400					Not provided		
P04-5	Pine St. Crossing Upgrade	Hudson Bay Slough	2007	2	3	0	5		$340,000	$530,400	$3,400					Not provided		
P04-6	Oak St. Crossing Upgrade	Hudson Bay Slough	2007	2	3	0	5		$340,000	$530,400	$3,400					Not provided		
P04-7	Dredge/Widen Lowland Channels	Hudson Bay Slough	2007	2	3	0	5		$120,000	$187,200	$1,200					Not provided		
P04-8	Queensway Floodbox Capacity Increase	Hudson Bay Slough	2007	1	3	0	4		$450,000	$702,000	$4,500					Not provided		
P06	Lower Main Slough Pool	Hudson Bay Slough	2007	0	2	0	2		$3,000,000	$4,680,000	$30,000					Not provided		
P01	Jarvis Street Pipe Upgrade	Hudson Bay Slough	2007	0	2	0	2		$1,480,000	$2,308,800	$14,800					Not provided		
P02A	Ospika Boulevard Pipe Upgrade with Shane Creek Detention Pond	Hudson Bay Slough	2007	1	2	1	4		$673,000	$1,049,880	$6,800					Not provided		
P07	Redwood Street Pipe Upgrade	Hudson Bay Slough	2007	1	2	0	3		$198,000	$308,880	$2,000					Not provided		
P08	Redwood Street Pipe Upgrade	Hudson Bay Slough	2007	2	2	0	4		$36,000	$56,160	$400					Not provided		
P09	Johnson Street Pipe Upgrade	Hudson Bay Slough	2007	1	2	0	3		$390,000	$608,400	$3,900					Not provided		
P10	Irwin Street Pipe Upgrades	Hudson Bay Slough	2007	1	2	0	3		$672,000	$1,048,320	$6,800					Not provided		
	Future development on Cranbrook Hill should limited flows to pre-development levels.	Hudson Bay Slough	2007	3	2	1	6							X				
	Improve stormwater quality from properties that are likely to produce large quantities of sediment or hydrocarbons.	Hudson Bay Slough	2007	2	0	2	4							X				
SP08	Sediment pond in Carrie Jane Gray Park - Winnipeg St. Branch	Hudson Bay Slough	2007	1	2	2	5		$212,000	$330,720	$8,500							
SP09	Sediment pond in Carrie Jane Gray Park - Massey St. Branch	Hudson Bay Slough	2007	1	2	2	5		$212,000	$330,720	$8,500							
E01	Hudson's Bay Slough Sediment Forebay	Hudson Bay Slough	2007	0	3	2	5		$750,000	$1,170,000	$30,000	Positive						
E02	Hudson's Bay Slough Enhanced Wetland	Hudson Bay Slough	2007	0	3	3	6		$758,000	$1,182,480	$30,400	Positive						

E03	Improve fisheries habitat in lower slough.	Hudson Bay Slough	2007	1	3	2	6		$372,000	$580,320	$14,900	Positive							
	Implement infiltration LIDs	Hudson Bay Slough	2007	3	2	2	7							X	X				
	Use simpler infiltration approaches of SFD properties where appropriate.	Hudson Bay Slough	2007	3	1	2	6							X	X				
	Micellaneous deficiencies (numerous)	Hudson Bay Slough	2007	0	2	0	2		$1,225,000	$1,225,000	$49,000								
7.3.1	Sediment Control Bylaw for Construction Sites	Hudson Bay Slough	2007	3	3	2	8			10000				X	X				
7.3.2	Bylaws regulating discharge from private property (primary concern is quality, peak flows could also be included)	Hudson Bay Slough	2007	3	1	2	6							X	X				
7.3.3	Development standards that support stormwater infiltration (LIDs)	Hudson Bay Slough	2007	3	2	2	7							X	X				
GS-1	Four locations for remedial creek work.	Gladstone, Trent, & Varsity	2002	2	1	1	4	Short Term (5 year plan), existing creek concerns	$7,000	$13,930									
VS-1	Eight locations for remedial creek work.	Gladstone, Trent, & Varsity	2002	2	1	2	5	Short Term (5 year plan), existing creek concerns	$42,000	$83,580									
TS-1	Storm sewer upgrades on Caledonia Crescent.	Gladstone, Trent, & Varsity	2002	2	2	0	4	Short Term (5 year plan), undersized for 2-year RP, existing condition	$24,000	$47,760							HF62B-HF63D		
TS-1	Storm sewer upgrades on Caledonia Crescent.	Gladstone, Trent, & Varsity	2002	2	2	0	4	Short Term (5 year plan), undersized for 2-year RP, existing condition	$21,000	$41,790							HF62A-HF62B		
TS-2	Storm sewer upgrades on the 7100-block of St. Lawrence Avenue.	Gladstone, Trent, & Varsity	2002	2	2	0	4	Short Term (5 year plan), undersized for 2-year RP, existing condition	$31,000	$61,690							HE52A-HE64A		
TS-2	Storm sewer upgrades on the 7100-block of St. Lawrence Avenue.	Gladstone, Trent, & Varsity	2002	2	2	0	4	Short Term (5 year plan), undersized for 2-year RP, existing condition	$28,000	$55,720							HE53B2-HE52A		
TS-3	Storm sewer upgrades on Rideau Drive.	Gladstone, Trent, & Varsity	2002	2	2	0	4	Short Term (5 year plan), undersized for 2-year RP, existing condition	$35,000	$69,650							HF64C-HF64D		
TS-3	Storm sewer upgrades on Brock Drive.	Gladstone, Trent, & Varsity	2002	2	2	0	4	Short Term (5 year plan), undersized for 2-year RP, existing condition	$27,000	$53,730							HF64B-HF64C		
TS-3	Storm sewer upgrades on Rideau Drive.	Gladstone, Trent, & Varsity	2002	2	2	0	4	Short Term (5 year plan), undersized for 2-year RP, existing condition	$31,000	$61,690							HF64D-HF64A2		
VS-2	Storm sewer upgrades near the outfall at York Drive / Varsity Avenue	Gladstone, Trent, & Varsity	2002	2	2	0	4	Short Term (5 year plan), undersized for 2-year RP, existing condition	$11,000	$21,890							HF65B_V7		
VS-2	Storm sewer upgrades near the outfall at York Drive / Varsity Avenue	Gladstone, Trent, & Varsity	2002	2	2	0	4	Short Term (5 year plan), undersized for 2-year RP, existing condition	$15,000	$29,850							HF65A_HF65B		
VS-3	Storm sewer upgrade on the outfall at Laval Place	Gladstone, Trent, & Varsity	2002	2	2	0	4	Short Term (5 year plan), undersized for 2-year RP, existing condition	$82,000	$163,180							HG31A_V13		
GS-2	Storm sewer and culvert upgrades on St. Patrick Avenue at Glen Lyon Way.	Gladstone, Trent, & Varsity	2002	2	2	0	4	Short Term (5 year plan), undersized for 2-year RP, existing condition	$23,000	$45,770							GC22_GC21		
GS-2	Storm sewer and culvert upgrades on St. Patrick Avenue at Glen Lyon Way.	Gladstone, Trent, & Varsity	2002	2	2	0	4	Short Term (5 year plan), undersized for 2-year RP, future condition	$13,000	$25,870							HD24A_HD24B		
VS-4	Storm sewer upgrade for proposed Westgate Development	Gladstone, Trent, & Varsity	2002	2	2	0	4	Short Term (5 year plan), Westgate Development	$138,000	$274,620							A-B		
VS-4	Storm sewer upgrade for proposed Westgate Development	Gladstone, Trent, & Varsity	2002	1	2	0	3	Short Term (5 year plan), Westgate Development	$273,000	$543,270							B-C		
VS-4	Storm sewer upgrade for proposed Westgate Development	Gladstone, Trent, & Varsity	2002	2	2	0	4	Short Term (5 year plan), Westgate Development	$95,000	$189,050							D-C		
VS-4	Storm sewer upgrade for proposed Westgate Development	Gladstone, Trent, & Varsity	2002	1	2	0	3	Short Term (5 year plan), Westgate Development	$256,000	$509,440							C-E		
VS-4	Storm sewer upgrade for proposed Westgate Development	Gladstone, Trent, & Varsity	2002	1	2	0	3	Short Term (5 year plan), Westgate Development	$380,000	$756,200							E-F		
VS-4	Storm sewer upgrade for proposed Westgate Development	Gladstone, Trent, & Varsity	2002	2	2	0	4	Short Term (5 year plan), undersized for 2-year RP, existing condition	$35,000	$69,650							VC18_VC17		
VS-4	Storm sewer upgrade for proposed Westgate Development	Gladstone, Trent, & Varsity	2002	2	2	0	4	Short Term (5 year plan), Westgate Development	$90,000	$179,100							VC21_VC20(F-G)		
VS-5	Storm sewer upgrades near Westgate Avenue for future conditions	Gladstone, Trent, & Varsity	2002	2	1	0	3	Short Term (5 year plan), undersized for 5-year RP, future condition	$44,000	$87,560							GE25A_GE25B		
VS-5	Storm sewer upgrades near Westgate Avenue for future conditions	Gladstone, Trent, & Varsity	2002	2	1	0	3	Short Term (5 year plan), undersized for 5-year RP, future condition	$49,000	$97,510							GE24A_GE25A		
VS-5	Storm sewer upgrades near Westgate Avenue for future conditions	Gladstone, Trent, & Varsity	2002	2	1	0	3	Short Term (5 year plan), undersized for 5-year RP, future condition	$48,000	$95,520							GE24B_GE24A		

VS-5	Storm sewer upgrades near Westgate Avenue for future conditions	Gladstone, Trent, & Varsity	2002	2	1	0	3	Short Term (5 year plan), undersized for 5-year RP, future condition	$24,000	$47,760						DETENTION POND_GE24B		
VS-5	Storm sewer upgrades near Westgate Avenue for future conditions	Gladstone, Trent, & Varsity	2002	2	1	0	3	Short Term (5 year plan), undersized for 5-year RP, future condition	$15,000	$29,850						GE24D_DETENTION POND		
VS-6	Storm sewer upgrades on Chartwell Crescent	Gladstone, Trent, & Varsity	2002	2	1	0	3	Short Term (5 year plan), undersized for 5-year RP, future condition	$40,000	$79,600						GE23B_GE23C		
TM-1	Storm sewer upgrades at 6000 Simon Fraser Avenue.	Gladstone, Trent, & Varsity	2002	2	1	0	3	Medium Term (10 year plan), undersized for 5-year RP, existing condition	$19,000	$37,810						HF63C-HF63D		
TM-1	Storm sewer upgrades at 5900 Simon Fraser Avenue.	Gladstone, Trent, & Varsity	2002	2	1	0	3	Medium Term (10 year plan), undersized for 5-year RP, existing condition	$22,000	$43,780						HF63B-HF63C		
TM-2	Storm sewer upgrades on Selkirk Crescent.	Gladstone, Trent, & Varsity	2002	2	1	0	3	Medium Term (10 year plan), undersized for 5-year RP, existing condition	$31,000	$61,690						HF63G-HF63B, HF63F-HF63G, HF63E1-HF63F, HF63A-HF63E1		
TM-3	Storm sewer upgrades on the 6500-block of Domano Boulevard.	Gladstone, Trent, & Varsity	2002	2	1	0	3	Medium Term (10 year plan), undersized for 5-year RP, future condition	$63,000	$125,370						HF61D-HF61C, HF61C-HF61B, HE65F-HF61D		
TM-4	Proposed storm water detention pond in the vicinity of O'Grady Road and Marleau Road.	Gladstone, Trent, & Varsity	2002	2	1	1	4	Medium Term (10 year plan), stormwater detention	$139,000	$276,610						Pond P1		
VM-1	Storm sewer upgrade on Tyner Boulevard	Gladstone, Trent, & Varsity	2002	2	1	0	3	Medium Term (10 year plan), undersized for 2-year RP, future condition	$116,000	$230,840						HF15C_V19		
VM-2	Storm sewer upgrade on O'Grady Road near Domano Boulevard.	Gladstone, Trent, & Varsity	2002	2	2	0	4	Medium Term (10 year plan), undersized for 5-year RP, existing condition	$30,000	$59,700						HF24F_HF24A		
VM-3	Storm sewer upgrade on Moriarty Place	Gladstone, Trent, & Varsity	2002	2	2	0	4	Medium Term (10 year plan), undersized for 5-year RP, existing condition	$17,000	$33,830						HF45B_HF45A		
VM-4	Storm sewer upgrade on the 5500-block of Trent Drive.	Gladstone, Trent, & Varsity	2002	2	2	0	4	Medium Term (10 year plan), undersized for 5-year RP, existing condition	$23,000	$45,770						A5_V1		
GM-1	Detention pond west of Southridge Avenue near O'Grady Road and St. Anne Crescent.	Gladstone, Trent, & Varsity	2002	1	2	1	4	Medium Term (10 year plan), stormwater detention	$273,000	$543,270						Pond P4-1		
GM-1	Detention pond west of Southridge Avenue near O'Grady Road and St. Anne Crescent.	Gladstone, Trent, & Varsity	2002	1	2	1	4	Medium Term (10 year plan), stormwater detention	$385,000	$766,150						Pond P4-2		
GM-1	Storm sewer upgrade west of Southridge Avenue near O'Grady Road and St. Anne Crescent.	Gladstone, Trent, & Varsity	2002	2	1	0	3	Medium Term (10 year plan), undersized for 2-year RP, future condition	$18,000	$35,820						G7_HE13D		
GM-2	Storm sewer upgrades along Domano Boulevard	Gladstone, Trent, & Varsity	2002	2	2	0	4	Medium Term (10 year plan), undersized for 5-year RP, existing condition	$74,000	$147,260						HE42D_HE42E, HE41A_HE42D		
GM-3	Storm sewer upgrade on Domano Boulevard south of Glen Lyon Way	Gladstone, Trent, & Varsity	2002	2	2	0	4	Medium Term (10 year plan), undersized for 5-year RP, existing condition	$48,000	$95,520						HD44C_HD44B		
GM-4	Storm sewer upgrades on O'Grady Road just before Southridge Avenue.	Gladstone, Trent, & Varsity	2002	2	2	0	4	Medium Term (10 year plan), undersized for 5-year RP, existing condition	$74,000	$147,260						HE14B_HE14A, HE24A2_HE14B		
GM-5	Storm sewer upgrade on 7800-block of Queens Crescent.	Gladstone, Trent, & Varsity	2002	2	2	0	4	Medium Term (10 year plan), undersized for 5-year RP, existing condition	$8,000	$15,920						HE52F_HE52B		
GM-6	Storm sewer upgrade on 7700-block of Queens Crescent.	Gladstone, Trent, & Varsity	2002	2	2	0	4	Medium Term (10 year plan), undersized for 5-year RP, existing condition	$22,000	$43,780						HE62B_HE62A		
GM-7	Storm sewer upgrade on 7700-block of Osgoode Drive.	Gladstone, Trent, & Varsity	2002	2	2	0	4	Medium Term (10 year plan), undersized for 5-year RP, existing condition	$22,000	$43,780						HE61C_HE61B		
GM-8	Storm sewer upgrade on 7600-block of Kingsley Crescent.	Gladstone, Trent, & Varsity	2002	2	2	0	4	Medium Term (10 year plan), undersized for 5-year RP, existing condition	$21,000	$41,790						HE81C_HE81B		
GM-9	Storm sewer upgrade on Hartford Crescent.	Gladstone, Trent, & Varsity	2002	2	2	0	4	Medium Term (10 year plan), undersized for 5-year RP, existing condition	$20,000	$39,800						JE13E_JE13A		

GM-10	Storm sewer upgrades on 7600-block of St. Patrick Avenue.	Gladstone, Trent, & Varsity	2002	2	2	0	4	Medium Term (10 year plan), undersized for 5-year RP, existing condition	$94,000	$187,060						HD45E1_HE31B, HD35B_HD45E1		
GM-11	Storm sewer upgrade on Vista View Road	Gladstone, Trent, & Varsity	2002	2	2	0	4	Medium Term (10 year plan), undersized for 5-year RP, existing condition	$42,000	$83,580						GE82A_GE82B		
GM-12	Proposed storm water detention pond at Domano Blvd. / Glen Lyon Way	Gladstone, Trent, & Varsity	2002	1	2	1	4	Medium Term (10 year plan), stormwater detention	$156,000	$310,440						Pond P1A		
GM-13	Proposed storm water detention pond at Glen Lyon Way / St. Patrick Ave.	Gladstone, Trent, & Varsity	2002	1	2	1	4	Medium Term (10 year plan), stormwater detention	$356,000	$708,440						Pond P1-1		
GM-14	Proposed storm water detention pond at Glen Lyon Way / St. Patrick Ave.	Gladstone, Trent, & Varsity	2002	1	2	1	4	Medium Term (10 year plan), stormwater detention	$231,000	$459,690						Pond P1-2		
GL-1	Storm water detention pond (undevloped area - St. Lawrence Ave.)	Gladstone, Trent, & Varsity	2002	1	2	1	4	Long Term (10+ years), stormwater detention	$274,000	$545,260	$14,000					GLADP3		
GL-2	Storm water detention pond (undevloped area - St. Mary Cres.)	Gladstone, Trent, & Varsity	2002	1	2	1	4	Long Term (10+ years), stormwater detention	$207,000	$411,930	$10,500					GLADP6		
GL-3	Storm water detention pond (undevloped area)	Gladstone, Trent, & Varsity	2002	1	2	1	4	Long Term (10+ years), stormwater detention	$367,000	$730,330	$18,500					GLADP2		
GL-4	Storm water detention pond (undevloped area)	Gladstone, Trent, & Varsity	2002	1	2	1	4	Long Term (10+ years), stormwater detention	$262,000	$521,380	$13,500					GLADP5-1		
GL-5	Storm water detention pond (undevloped area)	Gladstone, Trent, & Varsity	2002	1	2	1	4	Long Term (10+ years), stormwater detention	$256,000	$509,440	$13,000					GLADP5-2		
TL-1	Proposed storm water detention pond in the near Albert Pl. (south).	Gladstone, Trent, & Varsity	2002	1	2	0	3	Long Term (10+ years), stormwater detention	$209,000	$415,910						Pond P2-1		
TL-2	Proposed storm water detention pond in the near Domano Blvd. (west).	Gladstone, Trent, & Varsity	2002	1	2	0	3	Long Term (10+ years), stormwater detention	$215,000	$427,850						Pond P2-2		
VL-1	Proposed storm water detention pond north of Hwy. 16 / Marleau Rd.	Gladstone, Trent, & Varsity	2002	1	2	2	5	Long Term (10+ years), stormwater detention	$405,000	$805,950						Pond 3-1		
VL-2	Proposed storm water detention pond north of Hwy. 16 / Westgate Ave.	Gladstone, Trent, & Varsity	2002	1	2	2	5	Long Term (10+ years), stormwater detention	$354,000	$704,460						Pond 3-2		
VL-3	Culvert upgrade underneath the road parallel to Hwy. 16 (Marleau Rd.).	Gladstone, Trent, & Varsity	2002	2	2	0	4	Long Term (10+ years), undersized for 5-year RP, existing condition	$19,000	$37,810						VC35_VC34		
9.1	Storm Water Control Strategies (Ponds and Policies)	Gladstone, Trent, & Varsity	2002	3	2	2	7		Not Provided					X	X			
9.2	Stream Corridor Management	Gladstone, Trent, & Varsity	2002	3	2	2	7		Not Provided					X	X			
9.2.1	Public Access Trails	Gladstone, Trent, & Varsity	2002	2	2	0	4		Not Provided									
	Address erosion downstream of Simon Fraser resulting from the Domano/Westgate Storm Pond and changes to the pond.	Post GTV WDP		2	1	2	5			$200,000								

Appendix D

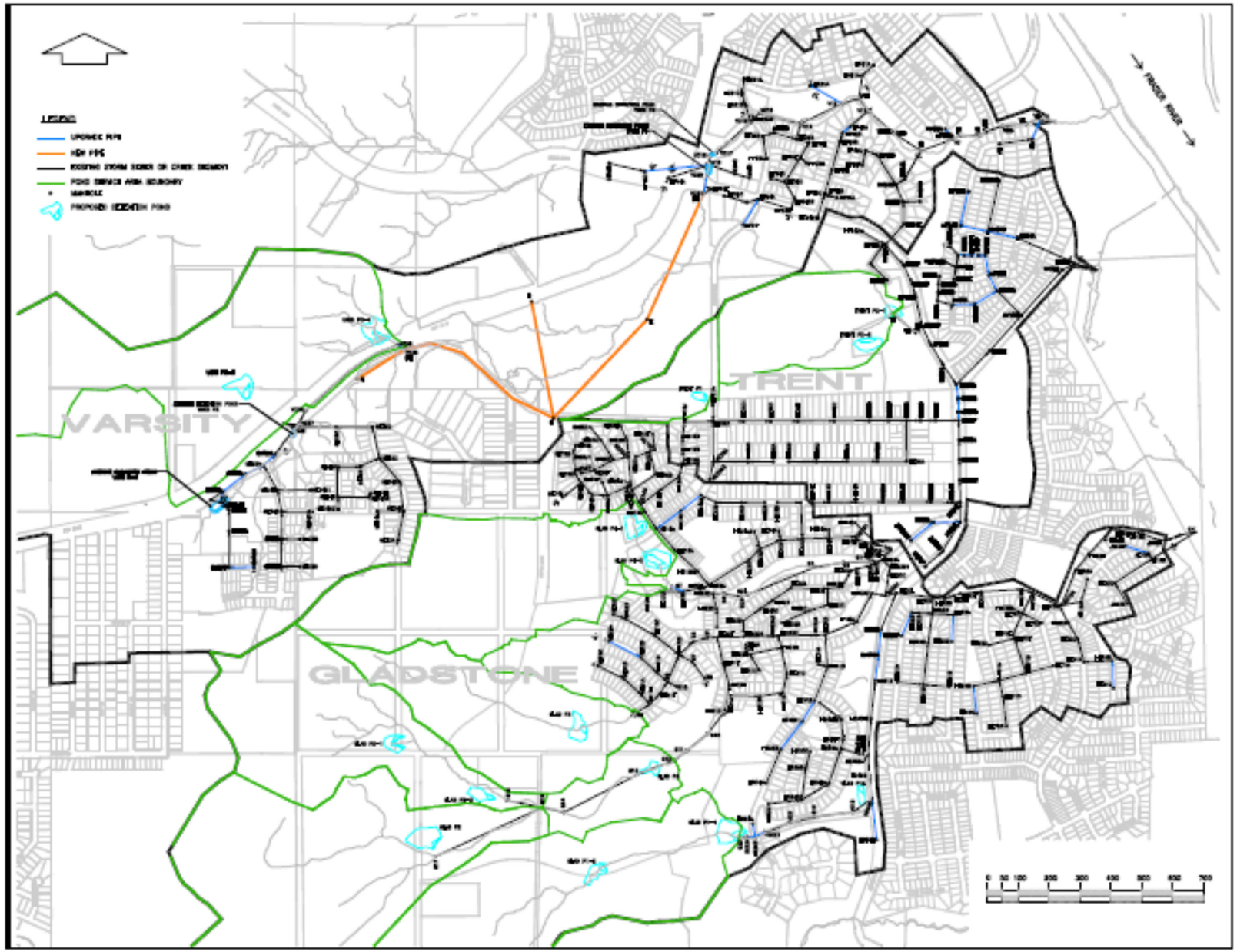
Existing Watershed Drainage Plans

- Gladstone Varsity & Trent – eDoc #19521
- Hudson Bay Wetland – eDoc #461586
- East PG – eDoc #316371
- University Heights – eDoc #556253
- McMillan Creek – eDoc #446995 and Appendices eDoc #446999
- West Fraser River & Parkridge Creek – eDoc #524269

AECOM Imagine it. Delivered.

Appendix E

Proposed Upgrades for the Gladstone, Varsity and Trent WDP



NO.	DATE	REVISIONS	BY	SUBJECT

PROJECT NO.	51216
SCALE	NOT TO SCALE
DRAWN	S.C.
DESIGNED	J.L.
CHECKED	
APPROVED	
APPROVED	
DATE	NOV. 2002

ASSOCIATED ENGINEERING

CITY OF PRINCE GEORGE
WATERSHED DRAINAGE PLANS

RECOMMENDED
UPGRADES PLAN

FUTURE DEVELOPMENT
CONDITION

DRAWING NUMBER	REV. NO.	SHEET
2142-0-023		23 / 27

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