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Bridgeview – North Slope

Integrated Stormwater Management Plan

March 2015

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March 3, 2015

Jeannie Lee
Project Engineer
Drainage & Environment – Engineering Section
City of Surrey
13450 104th Ave
Surrey, BC V3T 1V8

Dear Jeannie:

Project No: 60270841

Regarding: Bridgeview – North Slope Integrated Stormwater Management Plan (Final Issue)

We are pleased to present to you our final issue of the Bridgeview – North Slope Integrated Stormwater Management Plan (ISMP).

Please do not hesitate to contact me if you have any further questions or comments regarding the report, and thank you for the opportunity to work with you on this project.

Sincerely,
AECOM Canada Ltd.

James Brotherson
Project Manager
+1 604 444 6495
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Version Log

Version No.	By	Date	Description
1	MP	Feb 21, 2013	Stage 2 Draft Report Submission
2	MP	Oct 30, 2013	Final Draft Report
3	JB	Aug 15, 2014	Version 2 Draft Report
4	JB	Mar 5, 2015	Final Report

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Executive Summary

Background and Context

An Integrated Stormwater Management Plan (ISMP) is an over-arching, long-term strategy that focuses on the protection and enhancement of watershed health. ISMPs combine concepts of urban planning, stormwater management and environmental management to facilitate sustainable development within a watershed.

The City of Surrey ("the City") retained AECOM to develop the Bridgeview-North Slope ISMP ("the ISMP") in line with the requirements of the Metro Vancouver LWRMP and the Environmental Management Act. The ISMP relates to the Bridgeview and North Slope areas in the north-west sector of the City.

Stage 1: What Do We have?

General

- The population of the study area is likely to increase, with a significant increase forecast for the City Centre portion of the study area.
- There are several contentious major projects proposed within the study area, however they are all in the planning stages with the final direction generally uncertain. It is important that the ISMP is re-examined once there is more certainty about the projects, as they may significantly affect the ISMP outcomes, particularly the proposed extension of the Fraser River Dykes.

Legislative Context

- The study area falls within the jurisdiction of four levels of government: Federal, Provincial (BC), Regional (Metro Vancouver) and Municipal (City of Surrey), and all four levels of government enforce legislative requirements relevant to the ISMP.
- There is a significant amount of legislation from all four levels of government relating to the ISMP. The most significant regulatory items are the BC Environmental Management Act, and the Metro Vancouver Integrated Liquid Waste and Resource Management Plan, which are the drivers for developing the ISMP.
- It will be important to monitor changes in legislation relating to environmental management, water and flood management to ensure that the ISMP remains compliant.

Land Use Planning

- The study area is effectively fully built out with a combination of industrial, commercial and urban residential land uses
- Land use planning for the Bridgeview-North Slope study area is guided by strategic plans, policies and objectives which have been developed at the regional and municipal government levels
- The City Centre is undergoing significant growth and renewal, guided by a detailed City Centre Plan that includes best management practices for stormwater and specifies no net flow increases, both of which will assist in improving outcomes for the ISMP
- There are few parks and very limited open space
- Opportunities for improvements to stormwater management will be triggered by applications for redevelopment or subdivision
- The Metro Vancouver Regional Growth Strategy specifies that existing industrial land is to be retained, limiting opportunities for re-zoning properties in the industrial fringe along the Fraser River to lower-impact land uses

Hydrology

- The study area is made up of six major catchments, all of which drain south to north into the Fraser River

- The Fraser River and its tidal cycles, freshets and flood tendency has a significant influence on the hydrology of the study area
- Climate change related sea level rise may have a significant impact on the study area, particularly in the lowlands adjacent to the Fraser River. It is likely to increase the frequency and severity of flooding in vulnerable areas, and it will be important to monitor these issues and update the ISMP accordingly.

Existing Drainage System

- The study area generally drains south to north through a network of roadside ditches, sewers and creeks before discharging to the Fraser River in several locations
- The three western catchments are dyke protected, and discharge through either flood boxes or the Royal City PS, dependant on the Fraser River water level
- The three eastern catchments discharge naturally to the Fraser River via several creeks
- The drainage system predominately comprises of traditional pipe and channel, and there are few existing examples of modern low impact urban design and best management stormwater management practices
- City staff and residents have reported that there are several issues with the drainage system, including flooding, poor water quality, ditch infilling, encroachment on streams and connected roof leaders
- The City Centre is to be developed in line with a land use plan that incorporates BMPs, and there is an opportunity to apply some of these BMPs across other areas in the study area

Hydrogeology and Soils

- There are limited opportunities to increase infiltration within the lowland areas due to the shallow water table and potential for upward hydraulic gradients at the toe of the slopes
- Increased infiltration near the top of steep slopes can lead to a rise in the water table and decreased slope stability. Measures to increase infiltration should be limited to areas away from steep slopes
- The presence of peat in the study area may result in settlement issues and provide very little structural strength if not compacted effectively
- The BC Contaminated Site Registry shows several contamination sites located within the study area, predominately in the industrial areas. There is also considerable potential for additional unknown sites within the study area. It is recommended that if the City elects to thoroughly assess this item then a comprehensive study beyond the ISMP should be completed.

Hydraulic Modelling and Assessment

- Hydraulic analysis of the existing stormwater system in the study area was a significant component of the ISMP
- A detailed hydraulic model of the study area was established in PCSWWM using GIS data and previous models provided by the City. Inputs included Fraser River water level, tide cycles, rainfall, base flow assumptions and a variety of hydrologic parameters.
- The hydraulic model was used to assess the ability of the system to convey numerous design storms, the capacity of the Royal City pump station and the storage capacity available in the existing ditch network
- The model was also used to assess and recommended resolutions to issues such as localised flooding in the Bridgeview area, roadside ditches, flood construction levels and the proposed dyke extension

Stage 2: What Do We Want?

Stakeholder Engagement

- Once the opportunities and challenges of the study area were identified, the next step in the ISMP process was to define a future vision and set goals for the ISMP to achieve this vision

- Vision and goals for the study area were identified through community engagement and workshops with internal stakeholders
- Several common themes were identified through both processes including improving drainage, preserving the scarce environmental value, improving water quality and aesthetic appeal of ditches, and promoting community awareness in the Bridgeview area
- The preference of the City staff and the community was found to generally differ on the issue of roadside ditches

Vision and Goals

- A vision and list of goals for the ISMP were compiled based on the findings of the community engagement and internal workshops
- The vision statement for the ISMP was established as:

  "Create a healthy, clean and safe community environment by managing stormwater quality and quantity, protecting watercourses and natural resources that will improve liveability and appeal"

Stage 3: How do we put this into action?

- Once the goals and expectations of the ISMP were established, the next step in the ISMP process was develop an implementation plan with the focus on delivering those goals. The implementation plan comprises of two main components: action plans and capital works.
- Eight (8) action plans were formulated to address the following:
  - Manage Local Flooding
  - Increase Fraser River Flood Protection
  - Protect & Enhance Water Quality
  - Protect, Preserve and Enhance Stream Health and Fisheries Habitat
  - Protect Escarpment Integrity
  - Protect and Preserve Green Space and Wildlife Habitat
  - Clean Up Garbage and Unsightly Properties
  - Establish Long-Term Cohesive Planning
- Capital works projects were identified to improve stormwater capacity and resolve flooding issues. A summary of the capital works projects is shown in Table E1 below
- Hydraulic analysis and field inspection of the roadside ditches found that the ditches are likely providing important storage capacity and flow velocity reduction, and should not be removed
- A strategy for the implementation of Best Management Practices (BMPs) was outlined

Table E1 Proposed Capital Works

Project	No. Projects	Total Length (m)	Investment ($CA 2012)
Pipe Upgrades			
Short Term (1- 3yrs)	18	1,409	$2,520,583
Medium Term (4 -6yrs)	5	381	$508,022
Long Term (7 - 10yrs)	3	46	$141,417
Sub-Total	**26**	**1,836**	**$3,170,022**
Pump Stations			
Upgrade Royal City PS	1	-	$1,500,000
New Bolivar PS	1	-	$5,000,000
Sub-Total	**2**		**$6,500,000**
TOTAL	**28**	**-**	**$9,670,022**
Avg. Yearly Investment	**-**	**-**	***$967,002***

Stage 4: How Do We Stay On Target?

- The ISMP contains long-term goals and objectives that have a planning horizon of up to 30 years. Predicting changes in factors such as the economy, technology, policy, land-use and public opinion over the long term horizon is challenging.
- In order to ensure that the ISMP remains on the track of the long-term, the following recommendations were made:
  - Assign a City team member the role of ISMP Coordinator. The coordinator will be responsible for implementing the recommendations of the ISMP and ensuring the plan is updated to remain relevant
  - Undertake consistent flow monitoring and water quality sampling in various locations through the study area to verify that implemented works are effective, and monitor for changes that may require update to the ISMP
  - Continue to monitor erosion and slope stability through the study area
  - Continue to engage the community and stakeholders to ensure that the objectives in the plan reflect their expectations
  - Continue to review and adapt the ISMP on a regular basis, and when there are significant changes that necessitate a change

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1 Introduction

1.1 Overview

Figure 1.1 Location of Bridgeview-North Slope ISMP Study Area

The Environmental Management Act is the primary regulatory instrument of environmental protection in British Columbia. The Act allows municipalities to develop community specific solutions to manage the environmental risks of liquid waste streams such as sanitary sewage and stormwater runoff.

Metro Vancouver has delegated the responsibility of managing environmental risks of stormwater runoff to its member municipalities. Metro Vancouver's Integrated Liquid Waste and Resource Management Plan (ILWRM) requires member municipalities to manage these risks through the development and implementation of Integrated Stormwater Management Plans for the watersheds within their jurisdiction.

An **Integrated Stormwater Management Plan (ISMP)** is an over-arching, long-term strategy that focuses on the protection and enhancement of watershed health. ISMPs combine concepts of urban planning, stormwater management and environmental management to facilitate sustainable development within a watershed.

The City of Surrey ("the City") retained AECOM to develop the Bridgeview-North Slope ISMP ("the ISMP") in line with the requirements of the Metro Vancouver LWRMP and the Environmental Management Act. The ISMP relates to the Bridgeview and North Slope areas in the north-west sector of the City.

1.2 Goals and Objectives

The primary, over-arching goals of the Bridgeview-North Slope ISMP are as follows:

- Facilitate the creation of a healthy, clean and safe community environment by managing stormwater quality and quantity, protecting watercourses and natural resources that will improve liveability and appeal
- Provide a roadmap for long-range management of creeks, conveyance and community

In addition to the aforementioned goals, the City specified several specific objectives for the ISMP project which are summarised as follows:

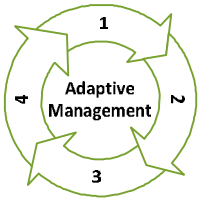
- Support the future conditions of the Bridgeview – North Slope area (which is essentially built-out)
- Account for projected climate change and sea level rise as it pertains to the Fraser River and boundary conditions for the study area
- Identify which existing ditches within the Bridgeview community must be retained to provide adequate storage capacity and stormwater conveyance
- Identify storm pipes that require upsizing in order to provide the area with an acceptable level of service
- Recommend improvements to the Royal City Pump Station and pump design requirements for the future Bolivar Pump Station
- Improve water quality in open channels that are near or adjacent to industrial land uses and that have been exposed to pollution or dumping
- Recommend setbacks and/or protection of existing watercourses that are deemed fish sensitive as well as ecological areas that support wildlife
- Include a BMP implementation strategy along with associated operation and maintenance work required
- Optimize improvements so as to reduce construction costs and disturbance

1.3 Approach

Development of the ISMP occurred in four stages, as outlined in Table 1.1, and was based on the approach outlined in *Chapter 9: Developing and Implementing an ISMP* in *Stormwater Planning: A Guidebook for British Columbia*.

Table 1.1 Overview of ISMP Development Process

Stage	Question Answered	Description of tasks	Relevant ISMP Sections
1	What do we have?	Review background information and summarize existing conditions	Study Area Regulatory Context Land Use Hydrology Stormwater System Hydrogeology and Soils Environment Hydraulic Modelling and Assessment
2	What do we want?	Establish the vision for future development	Vision and Goals
3	How do we put this into action?	Development of an implementation plan, funding and enforcement strategies	Implementation Plan
4	How do we stay on target?	Development of a monitoring and assessment program	Monitoring and Adaptive Management Plan



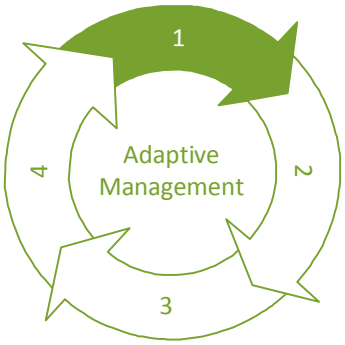
The ISMP contains long-term goals and objectives that have a planning horizon of up to 30 years. Predicting changes in factors such as the economy, technology, policy, land-use and public opinion over the long term horizon is challenging.

Subsequently, an **Adaptive Management** approach is proposed, in which the ISMP is periodically updated to ensure that it remains relevant and applicable. The adaptive process is cyclical - the last stage in the cycle focuses on monitoring, and will generate new information that should be reviewed in the first stage of the next cycle.

Stage 1

What Do We Have?

A review of background information and summary of existing conditions



2 Study Area

2.1 Overview

The Bridgeview – Northslope ISMP study area is 750ha in area and is located within in the north-west corner of the municipality of the City of Surrey. The majority of the study area is within the Whalley and City Centre communities, with a small area in the north-west intersecting the Guildford community.

The study area is fully within the catchment of the lower Fraser River and divided by Bolivar Creek, which runs from south to north. Figure 2.1 below and the map ***Overview of Study Area*** both provide an overview of the ISMP study area.

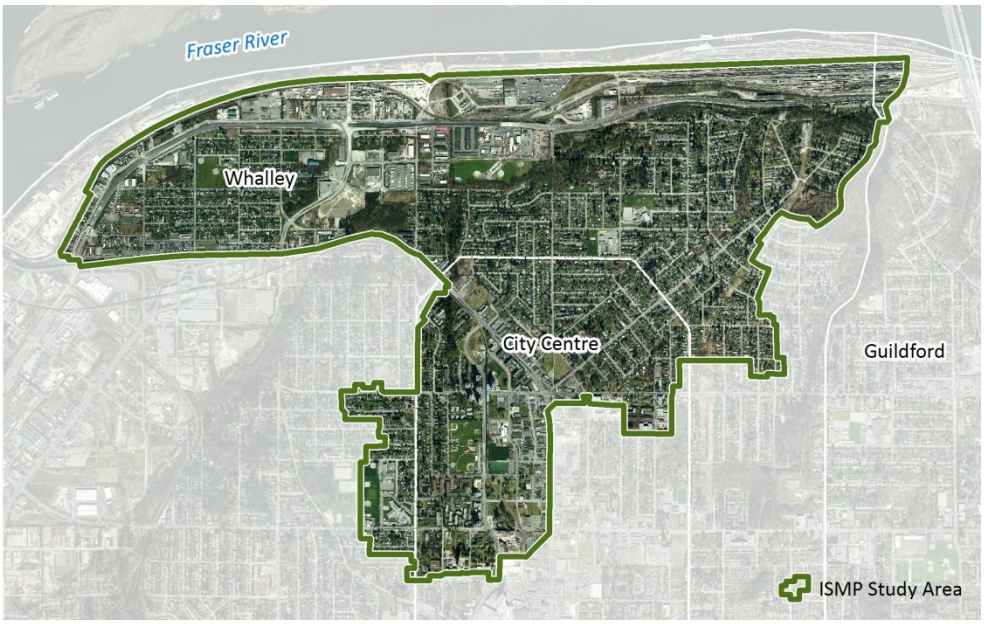


Figure 2.1 Overview of Study Area

2.2 Population

The population of the City of Surrey in 2014 is estimated at 509,610, and is forecast to increase by 59% to 812,000 by 2046, at a rate of 1.9% per annum. A significant proportion of this population growth will be within the ISMP study area, notably the City Centre community which is forecast to increase by 153% to 85,290 (~4.8% pa). Population projections for the study area are summarised in Figure 2.2.

If left unmitigated, the population growth in the City may impact the environment and hydrology of the ISMP study area due to increases in impervious area and pollutant loads, and further reduction in green space and vegetation cover. Mitigating the impacts of this significant population increase and subsequent land development will be an important component of the ISMP.

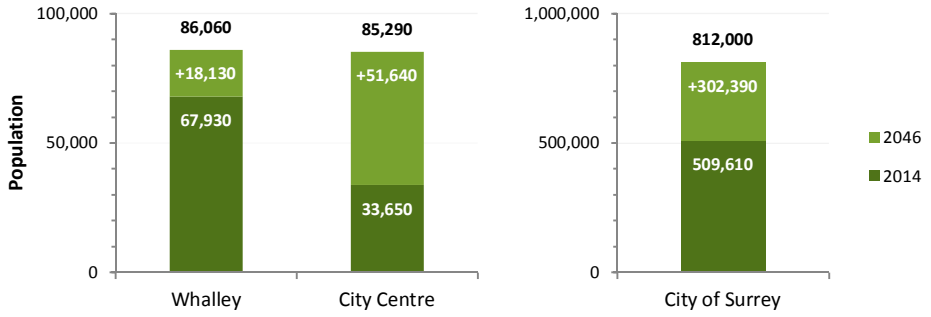


Figure 2.2 2014-2046 Population projections for Whalley, the City Centre and the entire City of Surrey

2.3 Topography

The study area is divided into six main catchments, all of which drain into the Fraser River. The area generally slopes from south to north towards the Fraser River.

The northern half of the study area is within the Fraser River low lands, which is typically below 4m elevation and extremely flat. The lowest point in the study area, at an elevation of 2m, is within these lowlands. The south-east half of the study area is undulating, with the highest point in the study area located at the southern boundary of the Bedford catchment, at an elevation of 111m.

The topography of the study area is shown in **Map 1 Topography**.

2.4 Climate

The study area is located within the Lower Mainland ecoregion that surrounds Metro Vancouver. The region is bounded by the Coast and Cascade Mountains to the north and east, and the Pacific Ocean to the west. The climate of the study area is typical of the inter-coastal Pacific-Northwest, with wet winters with heavy rainfall often lasting into the spring, and mild summers. Surrey has the lowest annual rainfall in the Lower Mainland, and rarely experiences significant winter snowfalls.

The Kwantlen Park rain gauge, located at 104 Avenue east of Old Yale Road, is the closest rainfall gauge to the study area. Rainfall recorded at this gauge between 1960 and 2007 is summarised in Figure 2.3 below. The rainfall data shows that the average annual precipitation in the ISMP study area is 1562mm, with the highest average rainfalls typically in November and the lowest in July. The daily mean temperature varies between 18°C in August and 3°C in January.

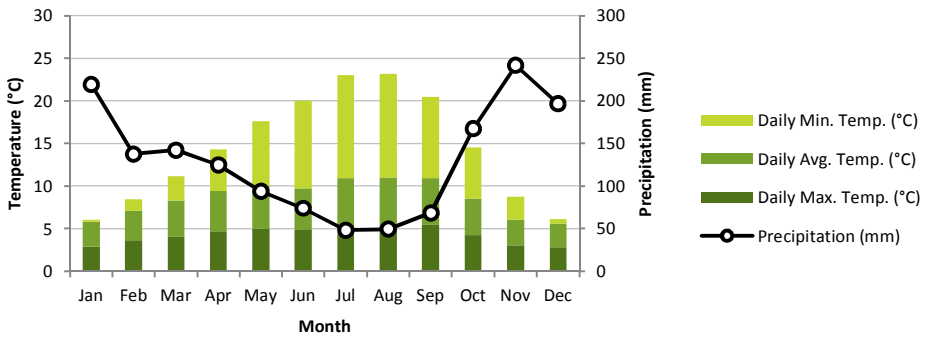


Figure 2.3 Climate of the Study Area

2.5 Historical Development

The study area has been subject to a significant level of development within the past twenty years, which is likely to have resulted in a considerable increase in impervious surface area. An analysis of composite aerial images from 1998 and 2013 highlighted areas where development occurred during this period. The areas where significant development occurred include:

- A large industrial development on both sides of Bridgeview Drive, north of King George Boulevard
- South Fraser Perimeter Road, intersecting the northern section of the study area
- Railway laydown areas north of Bolivar Park

The results of this aerial imagery analysis are shown on **Map 2** .

2.6 Existing and Proposed Infrastructure

The ISMP study area contains several significant existing infrastructure elements, and is within the proposed footprint of several large future projects. The most noticeable existing infrastructure items within the study area are the recently completed South Fraser Perimeter Road (SFPR), and the network of railway yards and railways to the north of the SFPR.

There are also several significant projects proposed within the Bridgeview-North Slope region that may impact the outcomes of the ISMP. The nature and potential impact of these projects are summarised in Table 2.1. Locations of existing and proposed infrastructure described above are shown on **Map 3 Proposed Projects**.

Table 2.1 Proposed projects in ISMP region

Project	Current Project Direction	Potential Impact on ISMP Study Area
Extension of Fraser River Dykes	- Part of upgrades identified in 2007 review of flood protection measures - Extend existing dyke system east from 132 Street to 140 Street - Objective is to improve flood resilience in the area - City in discussion with BC government at time of report	- Significant modification to the hydrology of the ISMP study area, particular in lowlands - Assessing the impacts of the potential extension was not included the scope of this ISMP
New Pattullo Bridge	- Construction of new 6-lane bridge directly upstream (east) of existing Pattullo Bridge	- Bridge is unlikely to intersect ISMP study area, however it may result in indirect impacts such as increased traffic or modification to feeder road alignments
Kinder Morgan Trans Mountain Pipeline Expansion	- Expansion of existing pipeline, and installation of additional 36in steel oil pipeline - Kinder Morgan have proposed an alternative alignment that will bypass the ISMP study area (not shown)	- Existing corridor may intersect several open channels and several ditches may need to be enclosed - Significant community interest in ensuring that existing environmental values are protected from impacts by the pipeline expansion - Part of this ISMP will be to examine the potential impacts this pipeline may have to the hydraulic conveyance and impacts on watercourse corridors - Revised alignment may bypass ISMP study area completely
Metro Vancouver's North Surrey Interceptor (NSI) Twinning	- Duplicate existing sanitary 1200mm trunk sewer line	- Existing NSI intersects several open channels and several ditches may need to be filled to facilitate the duplication - Sewer alignment crosses several identified red-coded creeks which are environmentally sensitive and will require DFO review and approval

2.7 Summary

The key points relating to population, climate, topography and infrastructure issues relevant to the ISMP are as follows:

- The population of the study area is likely to increase, with a significant increase forecast for the City Centre portion of the study area.
- There are several contentious major projects proposed within the study area, however they are all in the planning stages with the final direction generally uncertain. It is important that the ISMP is re-examined once there is more certainty about the projects, as they may significantly affect the ISMP outcomes, particularly the proposed extension of the Fraser River Dykes.

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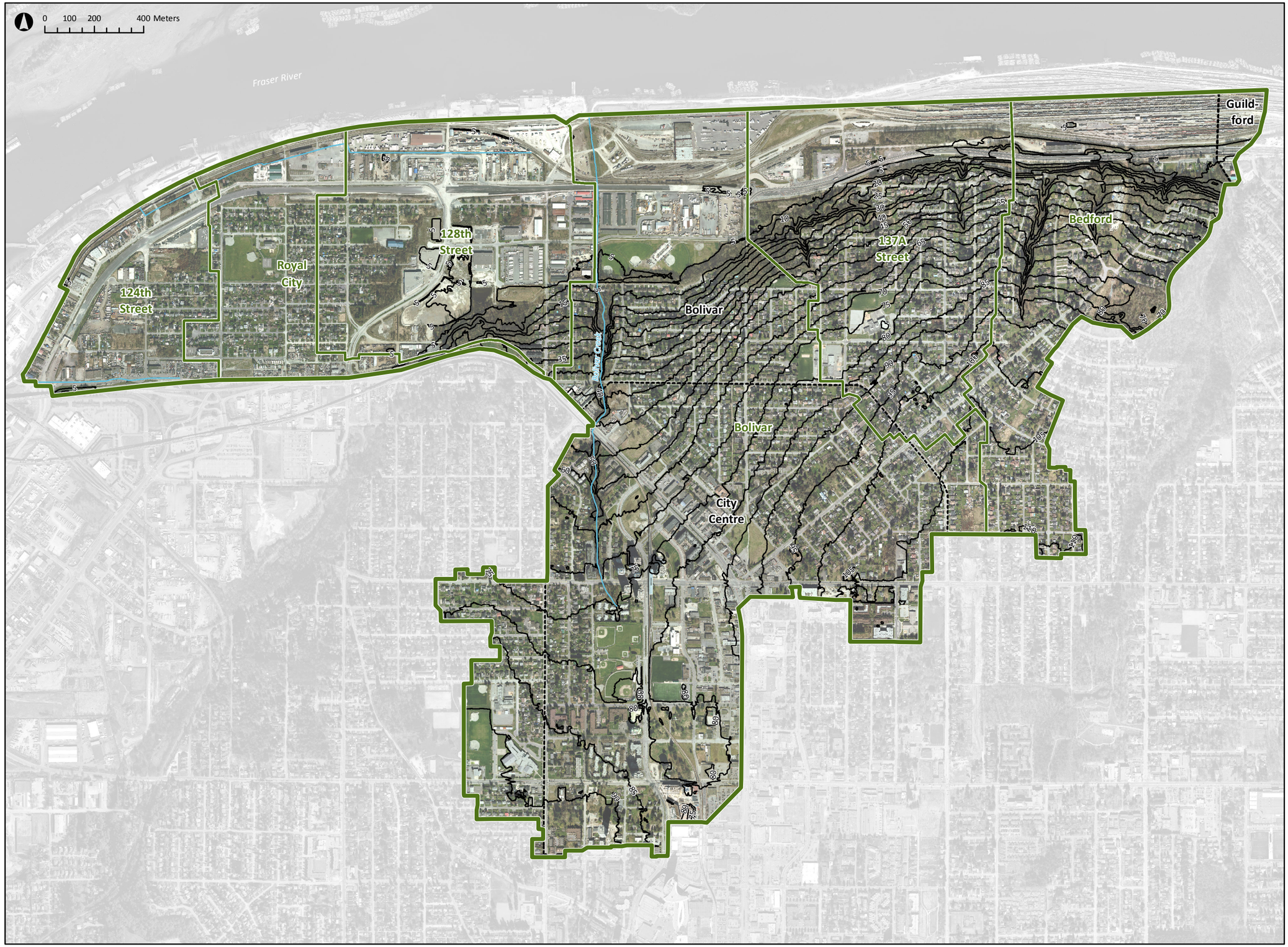
Project
Bridgeview - North Slope ISMP

Map 1
Topography

Legend

- ISMP Study Area
- Catchment Boundary
- Community Boundary
- Stream / Channel
- 5m Contour



Project
Bridgeview - North Slope ISMP

Map 2
Historical Development

Legend

- ISMP Study Area
- Catchment Boundary
- Areas of Vegetation Loss
- Stream / Channel

0 100 200 400 Meters

Fraser River

124th Street

Royal City

128th Street

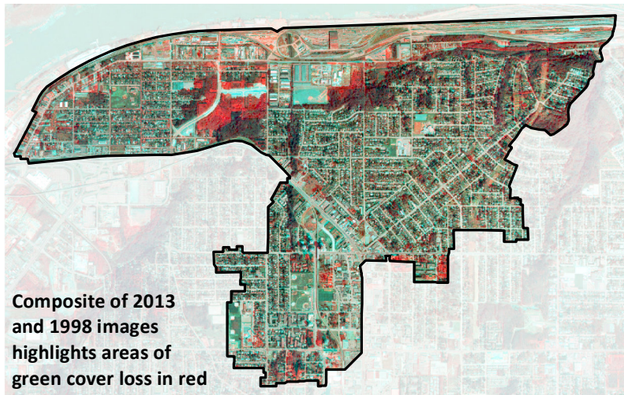
Bolivar Creek

Bolivar

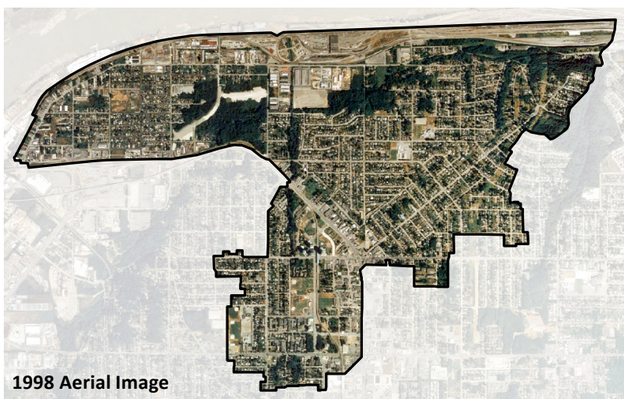
137A Street

Bedford

Development Since 1998



Composite of 2013 and 1998 images highlights areas of green cover loss in red



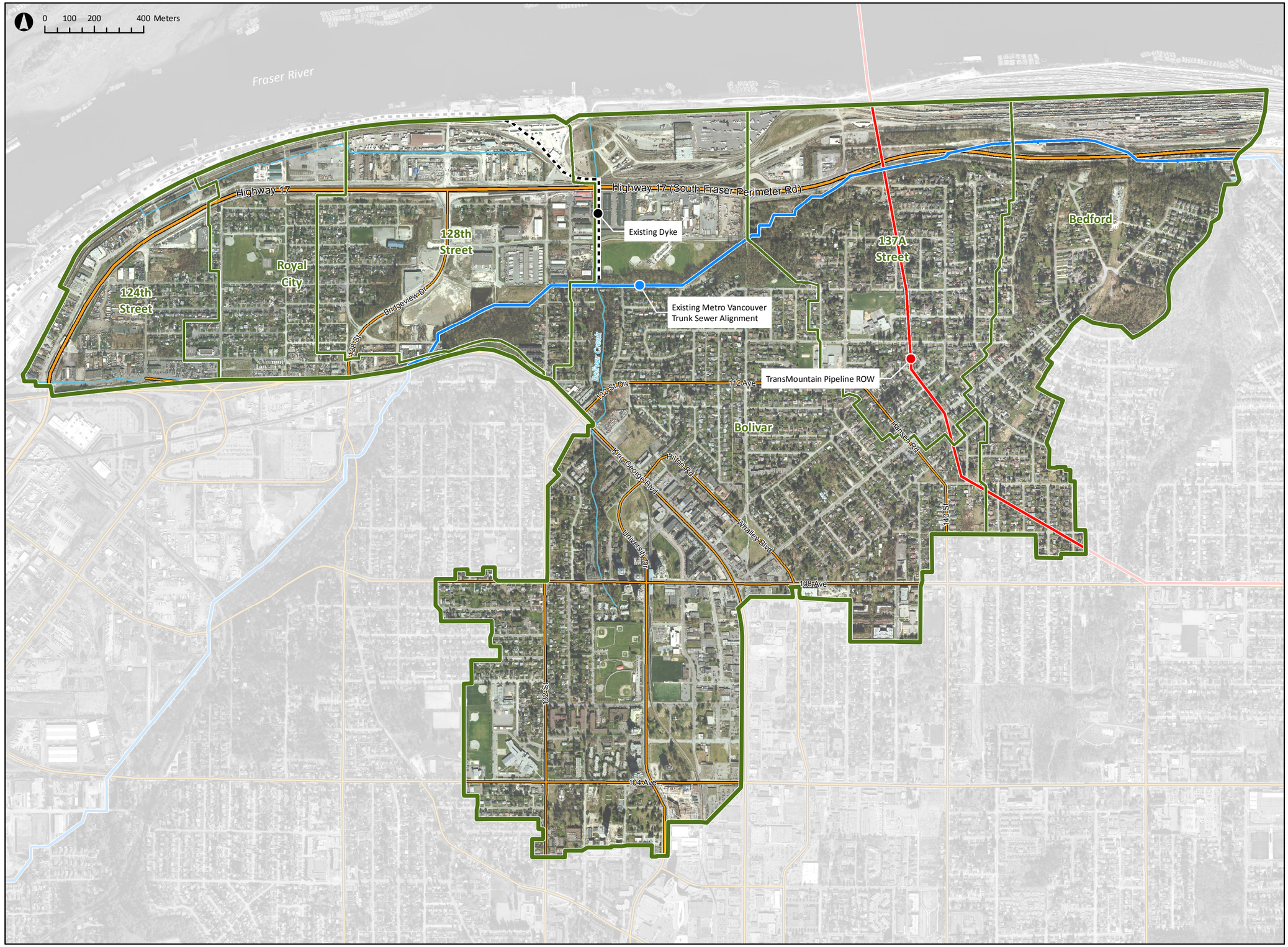
1998 Aerial Image

Project
Bridgeview - North Slope ISMP

Map 3
Existing and Proposed Infrastructure

Legend

- ISMP Study Area
- Catchment Boundary
- Dyke
- Metro Vancouver Sanitary ROW
- TransMountain Pipeline ROW
- Highway
- Arterial Road
- Stream / Channel



3 Regulatory Context

3.1 Overview

The study area falls within the jurisdiction of four levels of government, from federal down to municipal, and all four levels enforce legislation with which the ISMP will need to comply. The regulatory requirements of the ISMP include a variety of planning, engineering and environmental components, which is reflective of the multi-disciplinary nature of integrated stormwater management planning.

This section summarises the regulatory drivers, legal requirements, and other planning, engineering or environmental guidelines relevant to the ISMP.

3.2 Regulatory Drivers

The City was required to develop and implement this ISMP under Metro Vancouver's Integrated Liquid Waste and Resource Management Plan (MV ILWRM) as a member municipality of the Greater Vancouver Sewerage & Drainage District (GVS&DD).

Table 3.1 summarizes the context of the Bridgeview-North Slope ISMP in relation to Metro Vancouver's ILWRM and BC Environmental Management Act.

Table 3.1 Context of Bridgeview – North Slope ISMP

Government Body	Instrument	Key Points
BC Ministry of Environment	Environmental Management Act	- Protects human health and the quality of water, land and air in British Columbia - Allows municipalities to develop community-specific solutions for wastewater management under LWMPs - Authorizes and regulates LWMPs
Metro Vancouver	Metro Vancouver Integrated Liquid Waste and Resource Management Plan	- Identifies liquid waste management goals and actions for wastewater infrastructure operated by Metro Vancouver - Sets specific actions for GVS&DD members regarding their management of stormwater runoff - Prescribes that GVS&DD members submit an Integrated Stormwater Management Plan for drainage areas within their jurisdiction - Goal 3, Strategy 3.4.7: *"Municipalities will... Develop and implement integrated stormwater management plans at the watershed scale that integrate with land use to manage rainwater runoff"*
City of Surrey	Bridgeview – North Slope Integrated Stormwater Management Plan	- A comprehensive, ecosystem-based approach to long-term rainwater management in line with the requirements of the Metro Vancouver ILWRM - Provide direction for future development plans by balancing land use planning; stormwater engineering; flood and erosion protection; and environmental protection

3.3 Legislative Requirements

The Bridgeview – North Slope ISMP study area falls within the jurisdiction of four levels of government: Federal, Provincial (BC), Regional (Metro Vancouver) and Municipal (City of Surrey). All four levels of government enforce legislative requirements relevant to the ISMP, and the ISMP outcomes will need to comply with these requirements.

Table 3.2 summarizes the key purpose and requirements of legislation relevant to the ISMP.

Table 3.2 Legislative requirements of ISMP

Regulation / Policy	Key Points
Federal (Canada)	
Fisheries Act	- Protects riparian features and conditions that are crucial in maintaining long-term watercourse health
British Columbia (Provincial)	
Environmental Management Act 2004	- See Table 3.1
Fish Protection Act 1997	- Provides legislative authority for water managers to consider impacts on fish and fish habitat before approving new licenses, amendments to licenses or issuing approvals for work in or near streams - Focuses on four major objectives: ensuring sufficient water for fish; protecting and restoring fish habitat; improved riparian protection and enhancement; and stronger local government powers in environmental planning
- Riparian Areas Regulation 2004	- Protects riparian features and conditions that are crucial in maintaining long-term watercourse health - Requires local governments to protect riparian areas against developments that border along streams, lakes, and wetlands
- Sensitive Streams Designation and Licensing Regulation	- Protects water flows in streams significant to fisheries by designating them as "Sensitive Streams", which triggers a higher level of protection from development and other stressors
Water Act 1996 / Water Sustainability Act 2015	- Principal law for managing the diversion and use of provincial water resources - Specifies activities that may be conducted within a stream or a stream channel, as well as regulating dam safety and ground water protection - Water Act will be repealed upon introduction of the Water Sustainability Act in Spring 2015
Regional (Metro Vancouver)	
Regional Growth Strategy By-law	- "A Bylaw to adopt a Regional Growth Strategy for the Greater Vancouver Regional District (Metro Vancouver)" - Enforces the application of the MV Regional Growth Strategy by members
Sewer Use By-law 299	- "A bylaw respecting the direct or indirect discharge of waste into any sewers and drains connected to a Sewage Facility operated by the District" - Restricts the discharge of anything but stormwater, uncontaminated water or water from the provision of municipal services such as street flushing and fire extinguishing activities into stormwater sewers
Municipal (City of Surrey)	
Official Community Plan By-Law (12900)	- To guide land use and development over the next 5 to 20 years, focusing on orderly growth for complete sustainable communities with sensitivity to the environment, and includes both residential and business growth
Stormwater Drainage Regulation and Charges By-Law (16610)	- *"A By-law to regulate extensions, connections, and use of the stormwater drainage system, to impose connection charges to the stormwater drainage system, and to prohibit the fouling, obstructing, or impeding the flow of any stream, creek waterway, watercourse, ditch, or stormwater drainage system"* - Details the requirements for floodplain protection, on-site and stormwater management
Zoning By-Law (12000)	- *"A By-law to divide the City of Surrey into Zones and to make regulations in relation thereto, regulating the location, use and height of buildings, size of yards and other open spaces"* - This by-law is the regulatory instrument for implementing land use and community plans - Comply with specifications relating to imperviousness, property usage and density of development

Regulation / Policy	Key Points
Erosion and Sedimentation Control By-Law (16138)	- *"This By-law is to ensure that adequate protection of the City of Surrey drainage system is taken during any construction, by the implementation of erosion and sediment control measures"*
Tree Protection By-Law (16100)	- *"A Bylaw to regulate and prohibit the cutting, removal and damage of trees, the setting of fees and issuance of permits for the same and the requirement for replacement trees and of security for their provision and maintenance"*

Visit www.env.gov.bc.ca/wsd/water_rights/overview_legislation for more information on the water legislation framework in British Columbia

3.4 Related Policies, Strategies and Guidelines

The outcomes of the ISMP will also be influenced by non-legislative strategies, plans and engineering standards issued by the provincial, regional and municipal decision-making bodies. The non-legislative documents that are likely to influence the outcomes of the ISMP are summarized in Table 3.3.

Several land use plans also apply to the study area and the impact of these plans are discussed in section 4.3.

Table 3.3 Summary of relevant non-legislative documents

Policy / Plan	Key Points
British Columbia (Provincial)	
Stormwater Guidebook	- Provides a watercourse-level, site-specific approach to stormwater management in British Columbia
Regional (Metro Vancouver)	
Regional Growth Strategy (RGS)	- Establishes land use designations and policies to support growth and enhance economic prosperity whilst maintaining the environmental qualities that contribute to the livability and sustainability of the Vancouver region. - A core goal of the RGS is to protect the environment and respond to climate change impacts. This is supported by a number of strategies which include protecting conservation and recreation lands (Strategy 3.1) and protecting and enhancing natural features and their connectivity (Strategy 3.2). To support these objectives, municipalities are requested to consider integrated stormwater management when developing municipal plans
Integrated Liquid Waste and Resource Management Plan	- See Table 3.1
Municipal (City of Surrey)	
Regional Context Statement	- Explains relationship between Official Community Plan (Surrey) and Regional Strategic Plan (Metro Vancouver)
Natural Drainage Policy	- Supports keeping natural waterways open as part of the City's drainage conveyance system. Implemented in 1979, the policy was one of the earliest commitments made by the City to preserve the natural environment
Design Criteria Manual	- Specifies minimum standards for engineering design and project execution - Relates to roadways, stormwater, water, sanitary and utilities

Policy / Plan	Key Points
Sustainability Charter	- Defines sustainability in the City as: *"Meeting the needs of the present generation in terms of socio-cultural systems, the economy and the environment while promoting a high quality of life but without compromising the ability of future generations to meet their own needs"* - Identifies three Pillars of Sustainability (Socio-cultural, Economic, and Environmental), three time frames for implementing sustainable actions and processes, and three spheres of influence to achieve sustainable objectives (corporate operations, municipal jurisdiction, and external organisations) - The ISMP process touches on all three pillars, but is focused more on planning in the medium-term (3 to 10 year period) to long-term (10 years or more) - The scope of the ISMP includes significant opportunity to support the goals of the Sustainability Charter

Plan for the Social Well-Being of Surrey Residents (Social Plan)	- Outlines 65 actions to address 30 priority social issue elements within the Surrey community, with particular focus on 5 issues that the City has primary responsibility for
	- The "City Clean Up Programs and Civic Pride Initiatives" issue element include the following recommendations that are relevant to the ISMP:
	  - *"Study options and possible community partnerships for expanding and/or promoting programs such as City Clean-up Program"*
	  - *"Continue to include and enhance standards in by-laws and plans for street and median beautification"*

Fish Classification Map	- Designates streams in Surrey into Class A, AO, B or C watercourses in line with the requirements of the Federal Fisheries Act and the Provincial Water Act - Guides engineering and planning requirements regarding stream setbacks, culvert sizes, construction standards and vegetation
Ecosystem Management Study	- Describes in detail various wildlife and vegetation networks that are to be protected or enhanced - Divides the City's green infrastructure into a network consisting of hubs, sites, potential corridors, and the surrounding matrix of urban and agricultural lands - Provides City staff with the necessary information to establish tangible development boundaries in order to protect these environmental areas
Fraser River Freshet Preparedness Program	- Defines actions based on certain levels of flooding in the Fraser River - Divided into 4 phases to ensure that the potential Fraser River Flood Plain flooding is managed in an efficient manner by emergency response teams

Visit www.surrey.ca for more information on sustainability, engineering, social and environmental policies for the City of Surrey, including the recently released **Biodiversity Conservation Strategy (BCS)**. The strategy recognizes Surrey's biodiversity as a key foundation of a healthy, livable and sustainable City, and its goals are to preserve, protect, and enhance Surrey's biodiversity.

3.5 Summary

The key points relating to the regulatory context of the study area are summarised as follows:

- The study area falls within the jurisdiction of four levels of government: Federal, Provincial (BC), Regional (Metro Vancouver) and Municipal (City of Surrey), and all four levels of government enforce legislative requirements relevant to the ISMP
- There is a significant amount of legislation from all four levels of government relating to the ISMP. The most significant regulatory items are the BC Environmental Management Act, and the Metro Vancouver Integrated Liquid Waste and Resource Management Plan, which are the drivers for developing the ISMP
- It will be important to monitor changes in legislation relating to environmental management, water and flood management to ensure that the ISMP remains compliant

4 Land Use

4.1 Overview

Land use planning for the Bridgeview-North Slope study area is guided by strategic plans, policies and objectives which have been developed at the regional and municipal government levels. This section describes the existing land use, zoning classes, and plans that are in place for the study area and surrounding lands.

4.2 Existing Land Use

The study area is comprised of a mix of commercial, industrial, and urban residential land uses. The area is effectively built out, with few parks and open spaces. The distribution of the existing land use is characterised as follows:

- Urban residential occupies approximately half of the study area, with the largest area east of 132 Street, and smaller pockets to the west and south-west
- Commercial and city centre areas occupy approximately 12% of the study area, with the Surrey City Centre located in the southern half of the Bolivar catchment and other commercial areas located along the King George Highway
- Industrial lands occupy 12% of the study area, and are concentrated in a large strip along the Fraser River and smaller strip along 128th Street

The existing land use zoning of the study area is shown in **Map 4 Existing Land Use Zoning**.

4.3 Land-Use Planning

The ISMP study area falls within the planning jurisdiction of both Metro Vancouver and the City of Surrey. Metro Vancouver is responsible for land-use planning on a regional scale, with the City of Surrey responsible for municipal planning. The City is also obliged to align municipal plans and policies with regional planning goals.

4.3.1 Regional

Regional planning for the study area is guided by Metro Vancouver, which sets long-range goals and objectives for managing land use across the region. Member municipalities are required to produce Regional Context Statements to establish how their plans and policies align with regional goals. The regional planning documents that will impact the outcomes of the ISMP are listed in Table 4.1.

Table 4.1 Summary of Regional Planning Documents

Plan	Purpose and Description	Key Points for ISMP
Regional Growth Strategy 2040	- *"Looks out to 2040 and provides a framework on how to accommodate the over 1 million people and 600,000 new jobs that are expected to come to Metro Vancouver in the next 30 years"* - Identifies 5 goals for the region, and strategies to meet those goals - Specifies role of member municipalities in achieving roles	- Growth to be focused to Urban Centres (inc. Surrey City Centre) - Existing industrial and agricultural areas to be generally protected from land use change (e.g. industrial strip adjacent to Fraser River) - Existing conservation and recreation areas are to be generally maintained, and should be buffered from adjacent activities
Parks and Greenways Plan	- Identifies goals for the management and improvement of regional parks, and strategies to meet those goals	- There are no regional parks located within the ISMP study area

4.3.2 Municipal

The ISMP will need to align with the goals of the land use plans (LUPs) enacted by the City. The LUPs may also be used an instrument for implementing recommendations stemming from the ISMP. Table 4.2 summarises the

municipal-level land use plans that relate to the ISMP study area, and the likely impact of those plans on the ISMP.

Table 4.2 Summary of Municipal Planning Documents

Plan	Scope and Purpose	Key Points
Official Community Plan	- The Official Community Plan (OCP) is a statement of objectives and policies that guide City planning decisions - It is the principal land use document for the City of Surrey	- Residential infilling of undeveloped areas is expected to occur, however most of the area is essentially built-out
Surrey City Centre Plan	- Relates specifically to the Surrey City Centre - Maintains the City's goal of developing a regional downtown core as a hub for business and cultural activities for Surrey and the broader South Fraser region - Proposes a range of high-density commercial, office, institutional and residential land use that will support a diverse population	- There will be a general increase in density in the City Centre, which occupies approximately 230 hectares of the south portion of the study area
Surrey City Centre Plan: Part 7 Stormwater	- *Part 7 Stormwater Infrastructure* of the Surrey CC Plan specifically focusses on stormwater management, and is being developed by AECOM - Objective is *"to identify options for managing the stormwater, including best management practices… while supporting the Surrey City Centre vision of a sustainable, liveable and dynamic community".*	- An increase in density in the CC is unlikely to result in a significant increase in stormwater runoff as the area is already built out, however there may be an increase in pollutant load which will need to be mitigated - Specifies Best Management Practices (BMPs) for stormwater management, with a focus on infiltration, evapotranspiration (vegetation, green roofs etc) and detention (in order of priority) - Many of the recommendations made in Part 7 of the City Centre Plan will be relevant and applicable to the broader ISMP study area - Encourages zero net increase in flows from new developments
South Westminster Neighbourhood Concept Plan	- The over-arching goal of the plan is to improve the image of South Westminster from that of a salvage industrial area to an area with high quality development - Proposes an urban village realm along King George Boulevard and a Fraser River front realm, linked together with industrial and commercial core areas	- The South Westminster NCP borders the study area, but does intersect the study area at all - There is a proposed network of pedestrian and bicycle routes that will cross into the Bridgeview community, as well as three multi-use corridors - South Westminster shares similar challenges to that of the Bridgeview-North Slope area, particular the fringes bordering the Fraser River

4.4 Parks and Natural Areas

There are relatively few parks and natural areas within the study area, with only 3% of the study area classified as a natural area, and only 6% as park land. Table 4.3 below summarises the distribution of parks and natural areas in the study area.

The location of parks and natural areas within the study area are shown in **Map 5 Parks and Open Spaces**. The most significant parks are Bolivar Park, which features walking trails and baseball fields, and Victoria Park / Invergarry Park, which is mostly natural forest.

Table 4.3 Parks and Natural Areas

Catchment		Natural Areas		Parks	
Name	**Total Area (ha)**	**Area (ha)**	**Proportion of Catchment**	**Area (ha)**	**Proportion of Catchment**
124th Street	449,403	-	-	-	-
128th Street	978,432	-	-	740	0%
137A Street	1,122,296	19,500	2%	20,723	2%
Bedford	1,082,382	109,643	10%	100,919	9%
Bolivar	3,357,038	73,205	2%	274,227	8%
Royal City	487,992	-	-	36,454	7%
Study Area Total	**7,477,542**	**202,348**	**3%**	**433,063**	**6%**

Although there is limited green space in the study area, the City has identified several locations with environmental value. These environmental areas are described further in Section 7 Environment.

There may be opportunities to add value to these existing green spaces by viewing them as multi-functional areas. For example, water quality may be improved through the installation of bio-treatment wetlands and gardens in existing park lands.

4.5 Summary

The key points relating to land use in the study area are summarised as follow:

- The study area is effectively fully built out with a combination of industrial, commercial and urban residential land uses
- Land use planning for the Bridgeview-North Slope study area is guided by strategic plans, policies and objectives which have been developed at the regional and municipal government levels
- The City Centre is undergoing significant growth and renewal, guided by a detailed City Centre Plan that includes best management practices for stormwater and specifies no net flow increases, both of which will assist in improving outcomes for the ISMP
- There are few parks and very limited open space
- Opportunities for improvements to stormwater management will be triggered by applications for redevelopment or subdivision
- The Metro Vancouver Regional Growth Strategy specifies that existing industrial land is to be retained, limiting opportunities for re-zoning properties in the industrial fringe along the Fraser River to lower-impact land uses

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Project
Bridgeview - North Slope ISMP

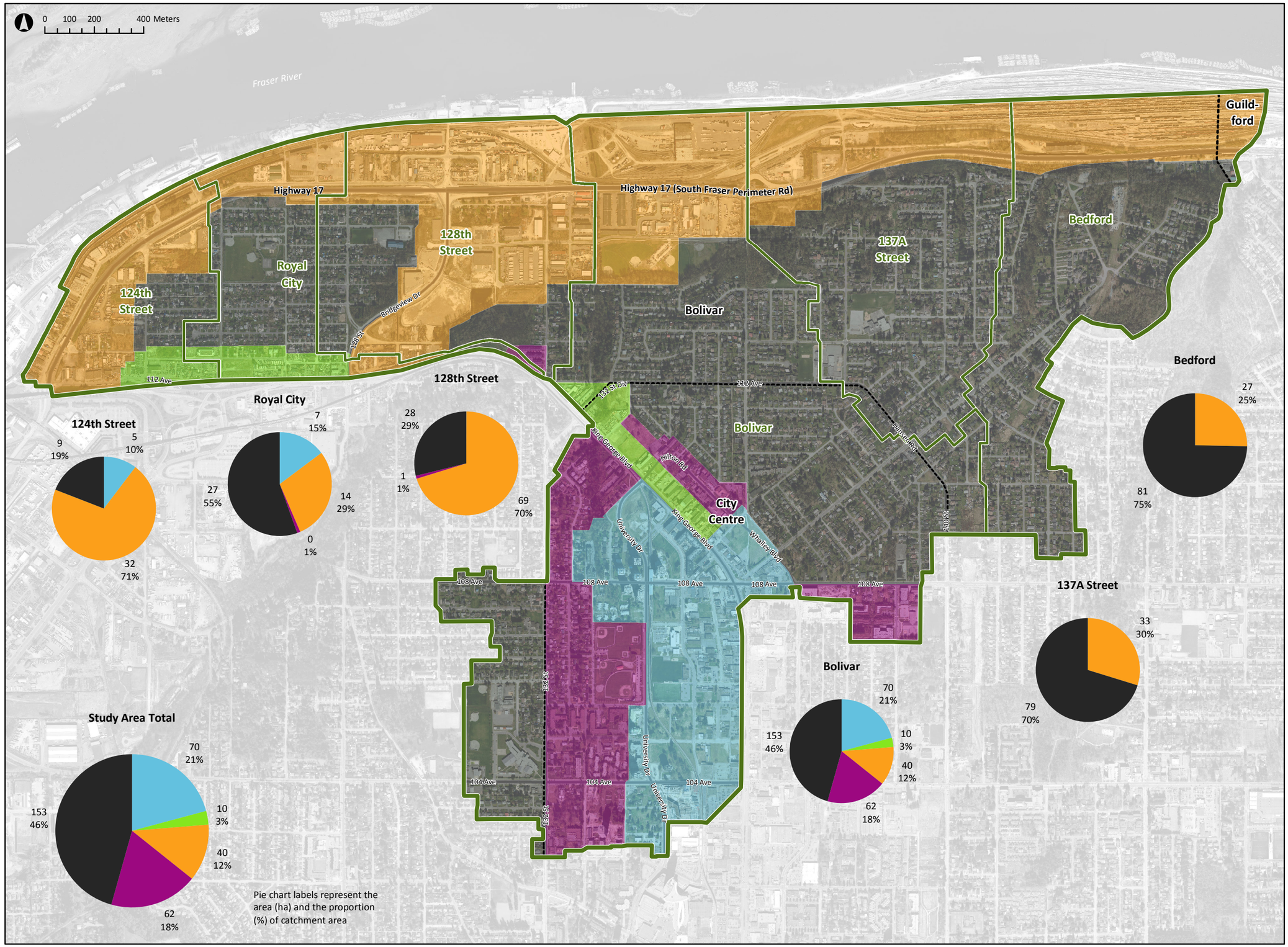
Map 4
Existing Land Use Zoning

Legend

- ISMP Study Area
- Catchment Boundary
- Community Boundary

Land Use

- City Centre
- Commercial
- Industrial
- Multiple Residential
- Urban
- Highway
- Arterial Road



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Map 5
Parks and Natural Areas

Legend

- ISMP Study Area
- Catchment Boundary
- Community Boundary
- Stream / Channel
- Highway
- Arterial Road
- Natural Areas
- Parks

5 Hydrology

5.1 Overview

Hydrology is the study of water on the Earth's surface, whether flowing above ground, frozen in ice or snow, or retained by soil.

Natural Resources Canada

This section describes the hydrological characteristics of the study area, including those within the study area such as catchments, creeks and impervious areas, and factors outside the study area, most notably the significant influence of the Fraser River and its associated tidal cycles, freshets and flood history.

Understanding the relationship between hydrologic aspects such as rainfall intensity and duration, tidal conditions, and freshet levels is an important component of integrated stormwater management planning.

5.2 Fraser River

The Fraser River is one of the most significant watercourses in British Columbia. It is the 10th longest river in Canada at a length of 1,735 km, beginning at Fraser Pass near Mount Robson and draining into the Strait of Georgia near the City of Vancouver. The Fraser River basin is 230,000km^2 in area, roughly a quarter of British Columbia. Approximately 99.8% of the basin is located upstream of the study area.

The City has 22 kilometres of frontage along the river. Approximately 5.5km of the study area boundary is exposed to the river, with 290 hectares of lowlands within the 200-year Fraser River flood level. Dykes protect 178ha of the lowlands from the Pattullo Bridge to 132 Street, while the remaining 112 hectares east of 132 Street are unprotected.

5.2.1 Flow Monitoring

The water level of the Fraser River is monitored by several organisations, including the City of Surrey, the BC Ministry of Environment and Environment Canada. The level is monitored at 70 locations along the main stretch of the river, and the data generated by this network of stations is used to provide flood warnings and calibrate the Fraser River flood model.

The closest river monitoring station is at the Port Mann Pump Station, in the north-east corner of the study area. The locations of several flow monitoring stations are shown in Figure 5.1. The City of Surrey also has two water level monitoring stations for the Fraser River at Manson Pump Station and at 192 Street.

Figure 5.1 Location of Fraser River Level Monitoring Stations

According to the Fraser River Hydraulic Model Report (NHC 2008), the highest recorded flow was in June of 1894, when the estimated peak flow was established at 18,900m^3/s at Mission (Fraser River Board, 1958), about 30km upstream of the study area, resulting in a river water level of 7.92m geodetic. This 1894 event has been adopted as the design condition that sets the 200-year flood plain level for Fraser River.

In 2007, another major flood event occurred in which a peak summer water level of 6.08 metres geodetic was observed at Mission. The difference between the 200-Year level adopted from the 1894 flood, and the 2007 level was 1.84 metres.

For the New Westminster gauge, the report identified a peak summer water level of 2.37 metres in 2007. When we compare this level with the river water level of 4.2 metres geodetic from Surrey's flood protection map we obtain a difference of 1.83 metres, which is exceptionally similar to the difference in river water levels between the 200 year flood and 2007 flood at Mission.

As a result, we can see that there is a correlation between river water levels from the Bridgeview Area to Mission. One might be able to use this information to extrapolate water levels in different years where there is missing data. For instance, if we knew that the Fraser River in Mission in a given year was 1 metre below the 200 year flood level then we would assume (in the absence of better information) that the river level at New Westminster during the same freshet was 1 metre below the 200 year flood level.

Table 5.1 Fraser River Water Levels Identified in the 2008 NHC Report

Gauge Location	200-Year River Level	Observed Peak Summer Water Level (2007)	Water Level Difference
Mission	7.92m	6.08m	1.84m
New Westminster (Bridgeview)	4.2m	2.37m	1.83m

5.2.2 Freshet

Freshets result from the thawing of alpine snow and ice that melt into the rivers, and typically occur during the spring. They can be exacerbated by heavy snowpack, abnormally warm weather in spring and heavy rainfall during freshet periods.

Figure 5.2 below highlights the impact of freshets on the Fraser River flow during the spring and summer months, with a difference of 3.41m between the March (0.93m) and June (4.34m) in monthly mean water levels at Mission, BC (1969-2013).

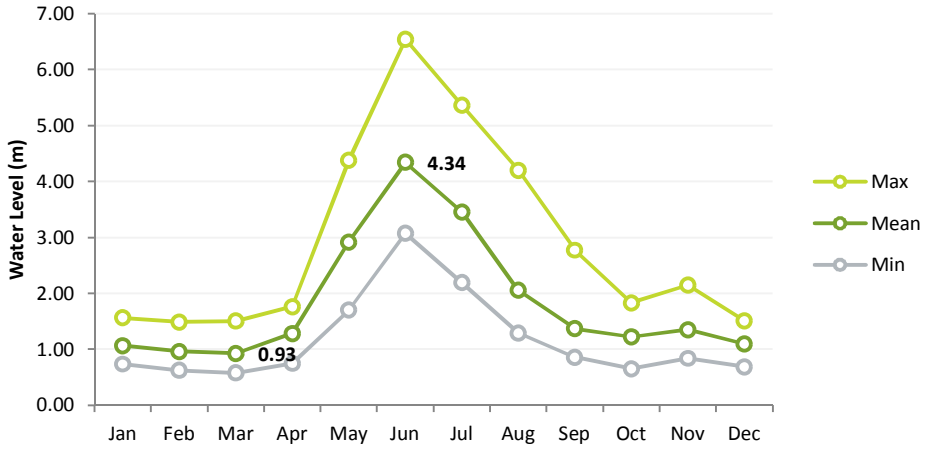


Figure 5.2 Fraser River Monthly Mean Water Level (Stn. 08MH024 Fraser River at Mission, 1969-2013)

5.2.3 Tidal Variations

The closest tide monitoring station is located at New Westminster, on the north-west bank of the Fraser River, and it is operated by Fisheries and Oceans Canada. The tide levels at New Westminster from 2004 to 2014 is shown in Figure 5.3. All levels are from chart datum. The trend lines show the general average across the entire tidal cycle is 1.93m, with an Mean High Water (MHW) level of 2.91m and Mean Low Water (MLW) level of 0.68m. The data also shows that the tide level appears to be generally lower in winter and higher in summer.

Figure 5.4 shows that the daily tidal range, the difference between the highest and lowest water levels of the daily cycle, is typically larger during the winter months.

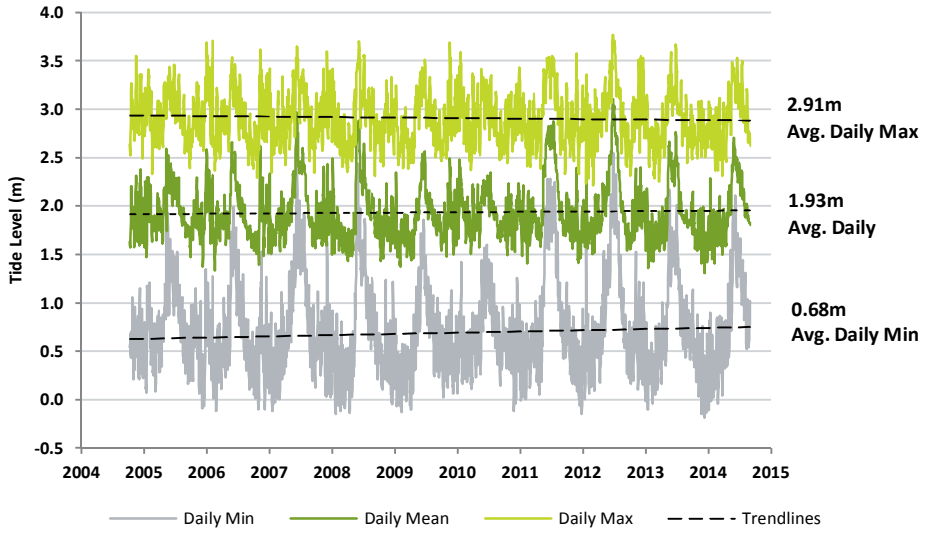


Figure 5.3 Tide Levels at New Westminster 2004 – 2014

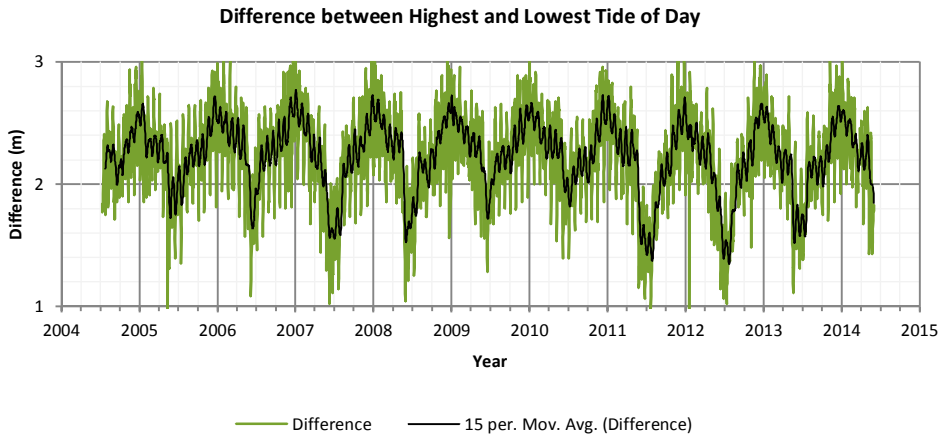


Figure 5.4 Difference between high and low tide levels at New Westminster, BC 2004 - 2014

5.2.4 Flood History and Flood Risk Factors

The Fraser River has experienced several major floods since flow monitoring commenced, the largest of which was in 1894, however the impacts were relatively minor due to the low level of development in the basin. The

1948 flood remains the most damaging event. Table 5.2 below summarises causes and impacts of recent significant flow events in the Fraser River.

Table 5.2 Fraser River Flood History

Year	Peak Level (m)	Cause and Impacts
1894	7.9m at Mission, BC	- The lower Fraser Valley was sparsely populated, and impacts were limited - Level adopted as the 200yr flood plain level
1948	7.6m at Mission	- Breached dyking systems - Evacuation of 16,000 people - Damage to or complete destruction of 2300 homes - 1500 residents left homeless - $150m (2007) flood recovery costs
1972	7.1m at Hope	- Caused by a frontal rainstorm - $10m (1972) damage, predominately in Surrey, Prince George and Kamloops
2007	6.1m at Mission 2.4m at New Westminster	- Caused by abnormally warm spring weather in the interior and a large snow pack volume (Fraser River Basin Snow Index 134% of normal) - Led to an enactment of emergency measures and review of existing flood protection systems along Fraser River on a municipal, provincial, and federal level
2012	6.7m at Mission 3.1m at New Westminster	- Forced several riverside communities and campgrounds to evacuate

According to the River Forecast Centre, part of B.C. Ministry of Forests, Lands and Natural Resource Operations, high flows in Fraser River are predominately caused by two scenarios:

- hot weather scenario that results in accelerated snowpack melt, where 5-6 days of temperatures above 25°C will result in high flows, and 8-9days will result in levels that approach the 1948 flood levels
- frontal rainstorm scenario, usually coinciding with the melt of heavy snowpack, where 30-50mm of rainfall in the upper catchment can result in high flows, and 70+mm will result in extremely high flows

Peak flow rates in upland creeks and longer duration rainfall events typically occur in the winter when river water levels are low. Smaller and shorter duration rainfall events typically occur in the summer when river water levels are high due to freshet and snowmelt conditions.

5.2.5 Flood Protection

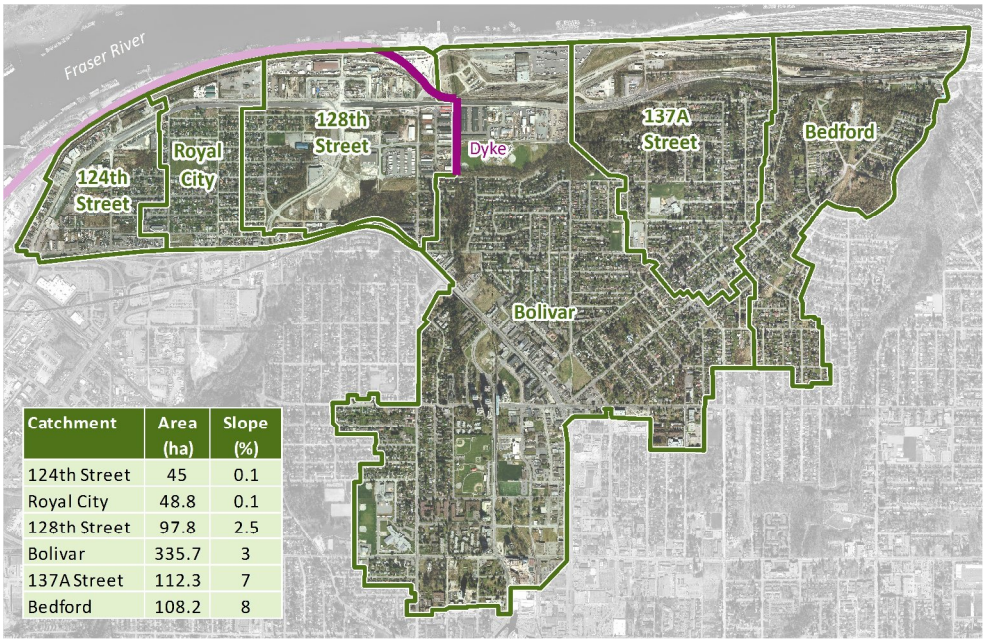
There is a system of dykes in the north-west of the study area that provides some level of flood protection to the low lands adjacent to the Fraser River. The City's *Fraser River Flood Protection Map* (http://www.surrey.ca/city-services/3655.aspx) indicates that the dyke system is as a level of 4.8m geodetic, which includes 0.6m of freeboard above the 200yr river level. The dyke system comprises of concrete flood walls and earth dykes, and is discussed in more detail in **6.2.5 Dyking System**.

For more information on Fraser River water levels and flow forecasting, visit the website of River Forecast Centre (http://bcrfc.env.gov.bc.ca), which is part of the BC Ministry of Forests, Lands and Natural Resource Operations

5.3 Catchments and Impervious Area

The Bridgeview-North Slope study area is made up of six major catchments, as shown in Figure 5.5 below, all of which drain south to north into the Fraser River. The largest catchment is Bolivar, with an area of 336ha, and the smallest is 124th St, which is only 45ha.

The average slope of each catchment was estimated based on contours. The 124th St, Royal City and 128th St catchments are relatively flat and almost wholly located within the Fraser River 200yr flood plan.



Catchment	Area (ha)	Slope (%)
124th Street	45	0.1
Royal City	48.8	0.1
128th Street	97.8	2.5
Bolivar	335.7	3
137A Street	112.3	7
Bedford	108.2	8

Figure 5.5 Catchments in study area

The City's Design Criteria Manual (May 2004) provides guidelines for percent imperviousness and runoff coefficients based on land use, which is summarized in Table 5.3.

Table 5.3 Standard Runoff Coefficients for City of Surrey

Land Use	% Impervious[1]	Runoff Coefficient[1]	Runoff Coefficient (100-Year Plans)[1]
Commercial	90	0.80	0.95
Industrial	90	0.80	0.95
Residential[2]	65	0.60	0.72
Parks and Green Space	20	0.25	0.30
Institutions and Schools	80	0.75	0.90

[1]Source: City of Surrey Design Criteria Manual Table 5.3(h) Runoff Coefficients, May 2004
[2]Based on Zoning Class RFs and RMs

A weighted percent imperviousness and runoff coefficient were calculated based on land use types in the City's Official Community Plan (OCP). These weighted values are shown in Table 5.4.

Table 5.4 Catchment Characteristics

Major Catchment	Area (ha)	% Impervious*	Runoff Coefficient*	Runoff Coefficient (100-Year Plans)*
124th Street	45	85	0.76	0.90
Royal City	48.8	75	0.68	0.81
128th Street	97.8	81	0.73	0.87
Bolivar	335.7	46	0.42	0.50
137A Street	112.3	72	0.66	0.78
Bedford	108.2	66	0.61	0.73

*Area Weighted

5.4 Climate Change and Sea Level Rise

The City recognizes that there is a need to understand how climate change and rising sea levels may impact stormwater management in the study area, particularly in regards to flood protection of the lowlands.

In 2008, the Government of BC released the report *Projected Sea Level Changes for British Columbia in the 21st Century*, which included projected relative sea level rise by 2100 for the Fraser River Delta. The report identifies the estimated relative sea level rise in the Fraser River Delta under three difference scenarios: Extreme Low, Mean, and Extreme High, which were estimated to be 0.35m, 0.50m and 1.2m respectively.

An frequency analysis was performed to identify locations within the study area that were likely to see an increased risk of tidal or riverine flooding as a result of this sea level rise.

Time series data of the Fraser River level at Manson Pump Station was obtained from the City. The time series data was for the period 2007 to 2012, and water levels were recorded in geodetic elevation. The estimated sea level rise for the three scenarios was added to the peak river level for each day. A frequency analysis was then performed to estimate the 95th percentile daily peak water level for each of the three sea level rise scenarios. The results of the frequency analysis are shown in Figure 5.6 below.

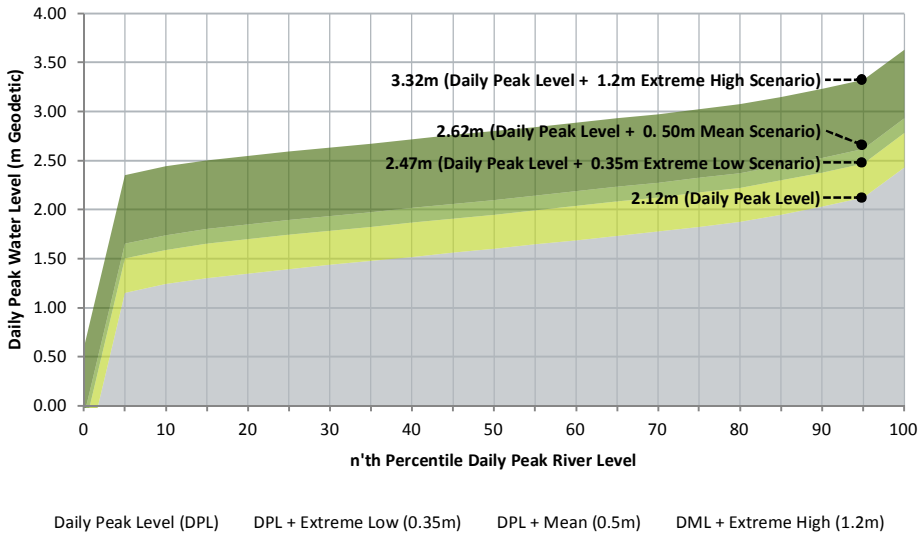


Figure 5.6 Frequency Analysis of Fraser River Levels with Sea Level Rise Scenarios

Contours provided by the City were used to develop an elevation model of the study area, and spatial analysis was used to calculate the total area of the study area where the elevation was below 95th percentile water level for each of the sea level rise scenarios. The results of the analysis are shown in Table 5.5 below.

Table 5.5 Estimated 2100 Sea Level Rise in Fraser River Delta

Forecast Limit[1]	Estimated Sea Level Rise (m)[1]	95%ile Daily Peak River Level (m)	Area below 95%ile Level (ha) *(Change)*	Proportion of study area below Forecast Level *(Change)*
No Change	-	2.12	94	12.5%
Extreme Low[1]	0.35	2.47	105 *(+11)*	14% *(+1.5%)*
Mean[1]	0.50	2.62	120 *(+26)*	16% *(+3.5%)*
Extreme High[1]	1.20	3.32	155 *(+61)*	20.7% *(+8.2%)*

[1]As per *Projected Sea Level Changes for British Columbia in the 21st Century, BC Government, 2008*
[2]Tide levels from New Westminster 2004-2014

The results show that under the mean sea level rise scenario, there will be an additional of 26ha (3.5%) of the study that has a ground elevation lower than the 95th percentile river level, on top of the existing 94ha that is below the 95th percentile river level without accounting for sea level rise.

The results of the spatial analysis are mapped in Figure 5.7. The analysis shows that the areas most likely to see an increase in the frequency of peak daily river levels above the ground elevation are east of the dyke, generally north of the South Fraser Perimeter Rd. These areas are predominately industrial, with a significant proportion being occupied by rail yards. It should be noted that the areas west of the dyke are protected by pumping systems.

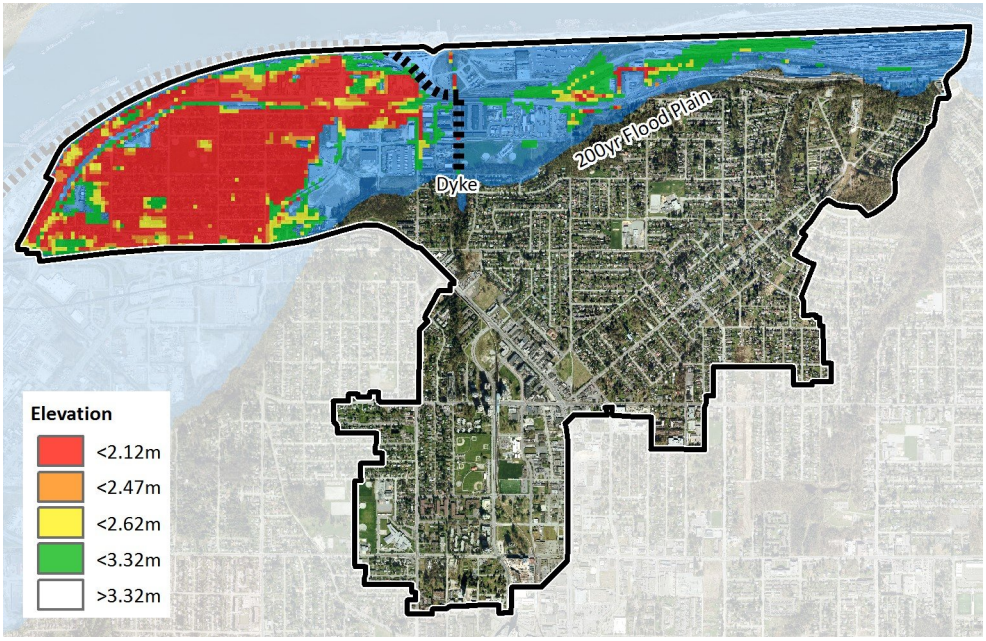


Figure 5.7 Spatial analysis of potential sea level rise impact

It is important that the sea level rise and other potential climate change impacts are monitored, and the ISMP is updated accordingly through the adaptive management process.

5.5 Summary

The key points relating to the hydrology of the study area are summarised as follows:

- The study area is made up of six major catchments, all of which drain south to north into the Fraser River
- The Fraser River and its tidal cycles, freshets and flood tendency has a significant influence on the hydrology of the study area
- Climate change related sea level rise may have a significant impact on the study area, particularly in the lowlands adjacent to the Fraser River. It is likely to increase the frequency and severity of flooding in vulnerable areas, and it will be important to monitor these issues and update the ISMP accordingly.

6 Stormwater System

6.1 Overview

The study area generally drains south to north through a network of roadside ditches, sewers and creeks before discharging to the Fraser River. A schematic of the catchments and discharge locations is shown in Figure 6.1. An overview of the stormwater system is shown in **Map 6 Stormwater System Overview**.

The three eastern catchments (Bolivar, 137A and Bedford) naturally drain into a series of creeks which lead into the Fraser River. The western catchments (124 St, Royal City and 128 St) contain a system of dykes, and discharge into the Fraser River through either the Royal City Pump Station (North of 116 Ave), or one of two flood boxes (124th St, 128th St), depending on the Fraser River water level.

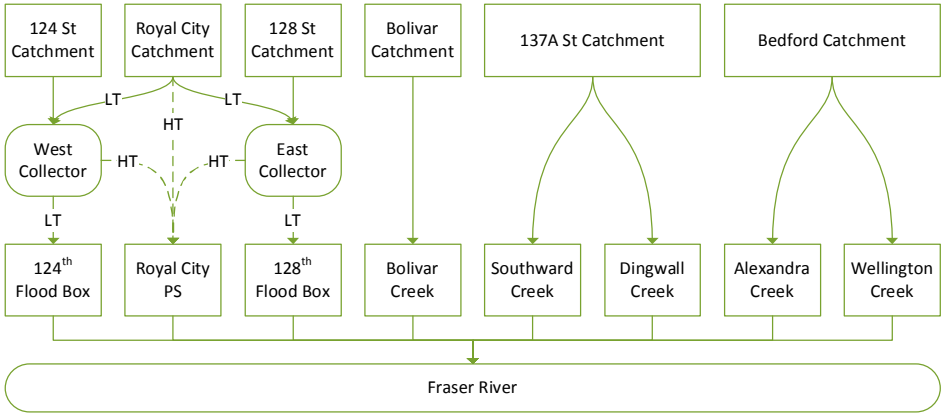
The flood boxes relieve local area drainage during the low tide. During high water conditions the flood boxes close, and stormwater is diverted to the Royal City Pump Station through two major collector canals. The west major collector canal starts at 114 Avenue and runs parallel along the south side of the CN railway ROW, and sits west of the Royal City pump station. This west collector canal services approximately half of the Bridgeview-North Slope study area. There is a second major collector canal to the east of the pump station between the CN railway right-of-way and 116 Ave.

Under high tide conditions, stormwater from the 124th St. flood box is diverted into the west collector that flows under 126A Street through two 1800mm diameter CMP culverts and into the pump station. Stormwater in the east collector backwaters the 128th St. floodbox channel and heads west along 116 Avenue then north along 126 A Street before reaching the pump station.

A significant proportion of the existing drainage system in the study area was constructed prior to acceptance of modern low impact urban design and stormwater best management practices. This is reflected in the composition of the drainage system, which is predominately traditional pipe and channel.

In general, the study area contains three major drainage systems which may be described as:

- The upland Bolivar Creek system services a portion of City Centre where urban development is expanding
- Alexandra Creek and the CN Railways along the Fraser River are the main drainage collectors for the study area east of 132 Street. This area is not dyked and there is erosion occurring down the north slope
- The low lying Bridgeview community consists mainly of an open-ditch system with two flood boxes and the Royal City Pump Station discharging stormwater to the Fraser River. This area is also protected by a dyking system that travels from the Fraser Port area at the Delta border to 132 Street



LL: Low Level (Fraser River level below flood box IL)
HL: High Level (Fraser River level above flood box IL)

Figure 6.1 Schematic of Bridgeview - North Slope Drainage System

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Map 6
Stormwater System Overview

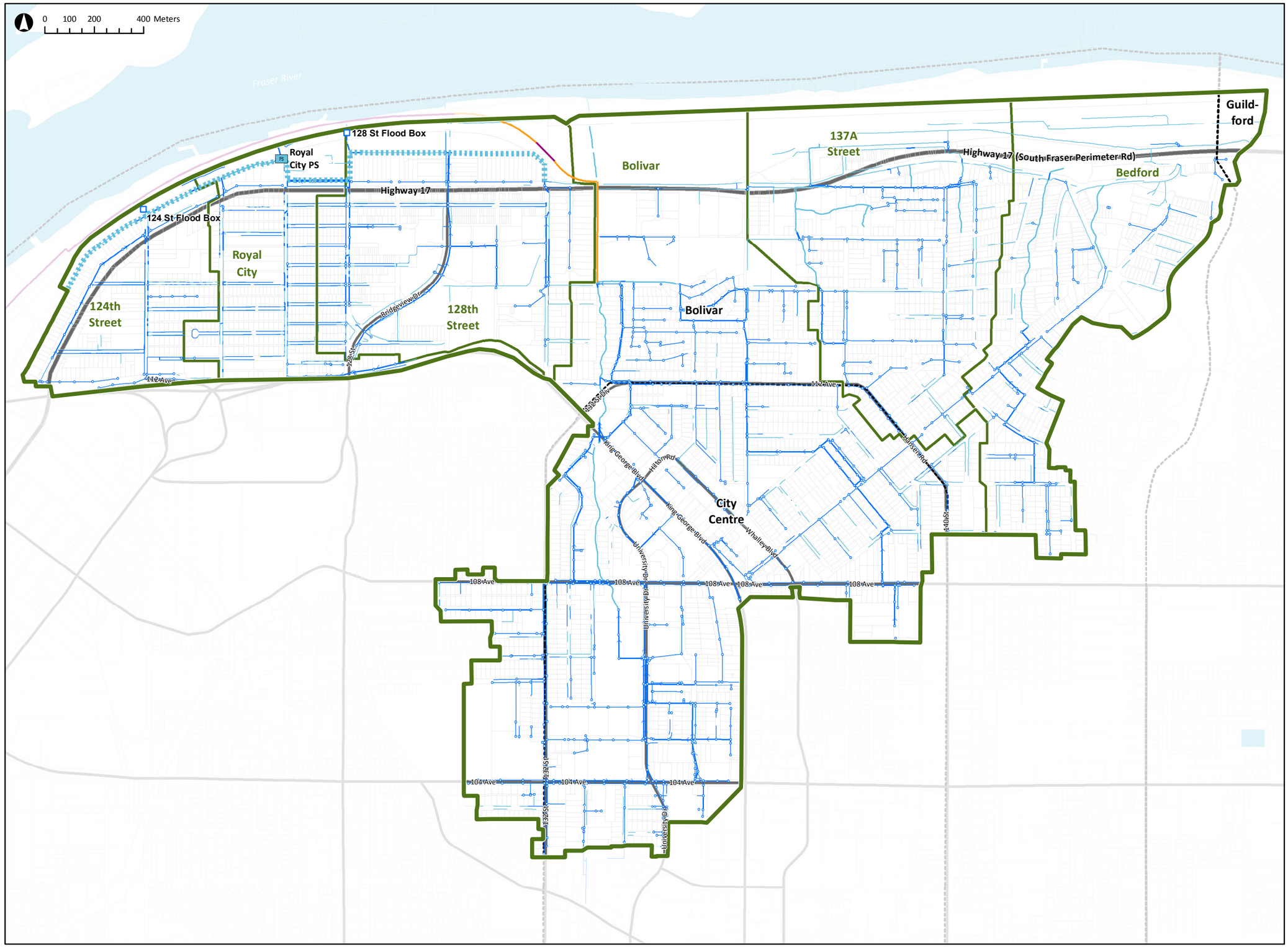
Legend

- Flood Box
- Pump Station
- ISMP Study Area
- Collector Canals
- Concrete Wall Dyke
- Earth Dyke
- Manholes
- Creeks

Stormwater Sewer

Sewer Size

- Minor (<525)
- Major (≥525)
- Ditches
- Community Boundary
- Lots
- Highway
- Arterial Road



6.2 Existing Drainage System

A review of the existing stormwater drainage system was performed to develop an understanding of the composition of the network, including the size, material, conduit type and age, and identify opportunities for improvements. The review was performed using GIS information obtained from the City. Table 6.1 summarizes composition of the drainage system as shown in the GIS data.

The data shows that the existing drainage system is a traditional network of ditches and sewers - gravity sewers and ditches make up over 85% of the network (by length).

Table 6.1 Summary of Existing Storm Pipes and Open Channels

Sub-System	Conduit Type	Length (m)	Proportion of Sub-Total	Proportion of System Total
Open Channel	Ditches	42,471	91%	35%
	Creeks	4,426	9%	4%
	Sub-Total (O/C)	**46,897**	**100%**	**39%**
Sewer	Culverts	782	1%	1%
	Gravity Pipes	62,240	84%	52%
	Perforated Pipes	10,753	15%	8%
	Sub-Total (Sewer)	**73,775**	**100%**	**61%**
Total		**120,672**		**100%**

6.2.1 Creeks and Ditches

There are a total of 5 major creeks within the study area: Alexandra, Bolivar, Dingwall, Southward and Wellington, however they collectively only account for 4% of the drainage system (by length). Ditches, including road side ditches and the collector channels along the Fraser River, account for a significant proportion of the drainage system (35%), and are a notable feature of the landscape within the lowland areas.

6.2.2 Sewers

Table 6.1 summarizes composition of the stormwater sewer system, and shows that there is a heavy reliance on gravity sewers. The 62km network of gravity sewers accounts for 52% of the drainage system total (by length).

The City's Design Criteria Manual (May 2004) defines trunk sewers as those that service areas in excess of 20 hectares in size, however it was assumed for the purpose of this study that all stormwater sewers ≥525mm in size were trunk sewers. Table 6.2 summarizes the existing pipes according to size.

Table 6.2 Summary of Pipe Sizes

Classification	Total Length (m)
Trunk (≥525mm)	17,456
Minor (<525mm)	56,319
Total	**73,775**

Figure 6.2 below summarises the construction material of the stormwater sewer network within the study area. The data shows that the vast majority of the system, over 97%, is constructed of concrete, PVC and corrugated metal pipe. The age of the pipes within the network is also presented in Map 7 Pipe Material.

Material	Length (m)
AC (Asbestos Concrete)	374
CMP (Corrugated Metal Pipe)	8,059
CP (Concrete Pipe or Rectangular)	45,320
CT (Clay Tile)	42
DIP (Ductile Iron Pipe)	48
PE (Polyethylene)	222
PVC (Poly Vinyl Chloride)	24,865
SP (Steel Pipe)	202
Wood (WD)	23
Unspecified Material	1,073
Grand Total	**80,229**

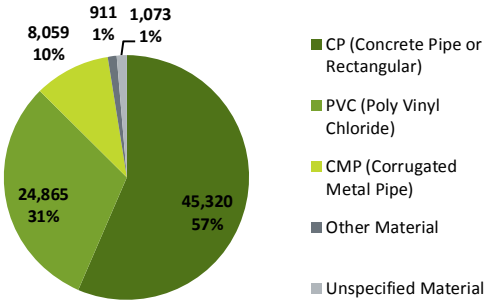


Figure 6.2 Summary of Stormwater Sewer Materials

Figure 6.3 below summarises the construction year of the stormwater sewer network. The data shows that almost 40% of the network was constructed in the 1970s, with 30km of main constructed over that period, however this includes 13km that is shown as being constructed in 1978 which may be erroneous. Following the 1970s, the average rate of replacement / construction has stabilised to around 1km per annum (10km per decade).

Decade	Length (m)	Proportion
Unknown	8,229	10%
1960	3,584	4%
1970	30,641	38%
1980	10,248	13%
1990	10,904	14%
2000	12,585	16%
2010	4,037	5%
Total	**80,229**	**100%**

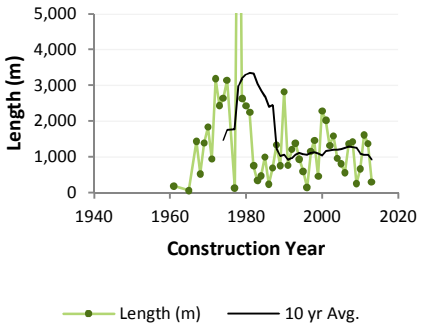


Figure 6.3 Stormwater network by decade of construction

The GIS data obtained from the City also shows that the drainage network also includes a large number of manholes and other devices. The quantity of manholes and other drainage features are summarised in Table 6.3.

Table 6.3 Other stormwater devices in network

Asset Type	Quantity
Manholes	1079
Devices (inc. Inlets, Grates, Property Connections)	3978
Detention Ponds	1
Driveway Culverts	629
Laterals (CB Lead)	3115

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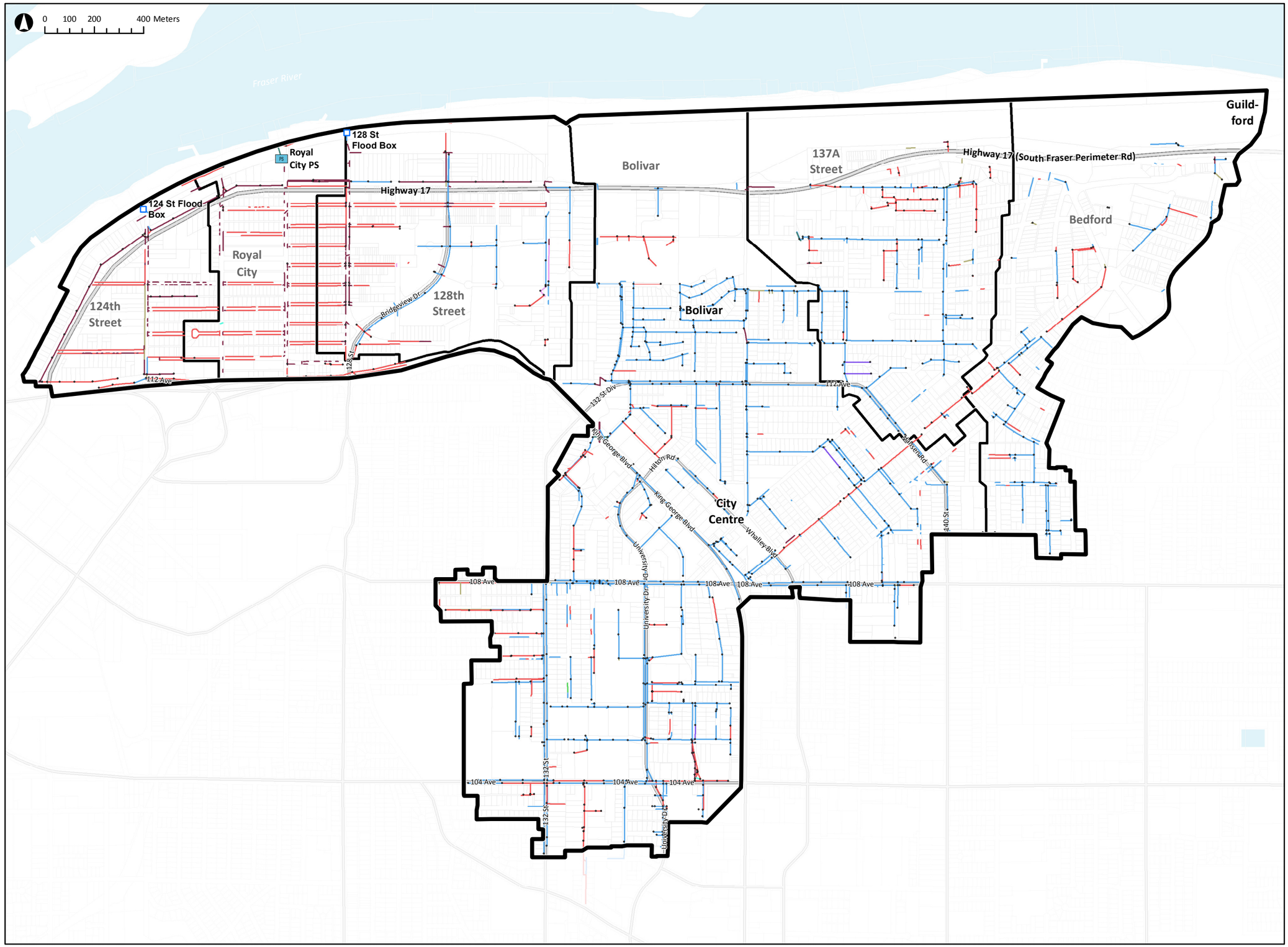
Map 7
Pipe Material

Legend

- Flood Box
- Pump Station
- ISMP Study Area
- Manholes

Stormwater Sewer
Material

- Unknown
- AC (Asbestos Concrete)
- CMP (Corrugated Metal Pipe)
- CP (Concrete Pipe or Rectangular)
- CT (Clay Tile)
- DIP (Ductile Iron Pipe)
- PE (Polyethylene)
- PVC (Poly Vinyl Chloride)
- SP (Steel Pipe)
- Wood (WD)
- Lots
- Highway
- Arterial Road



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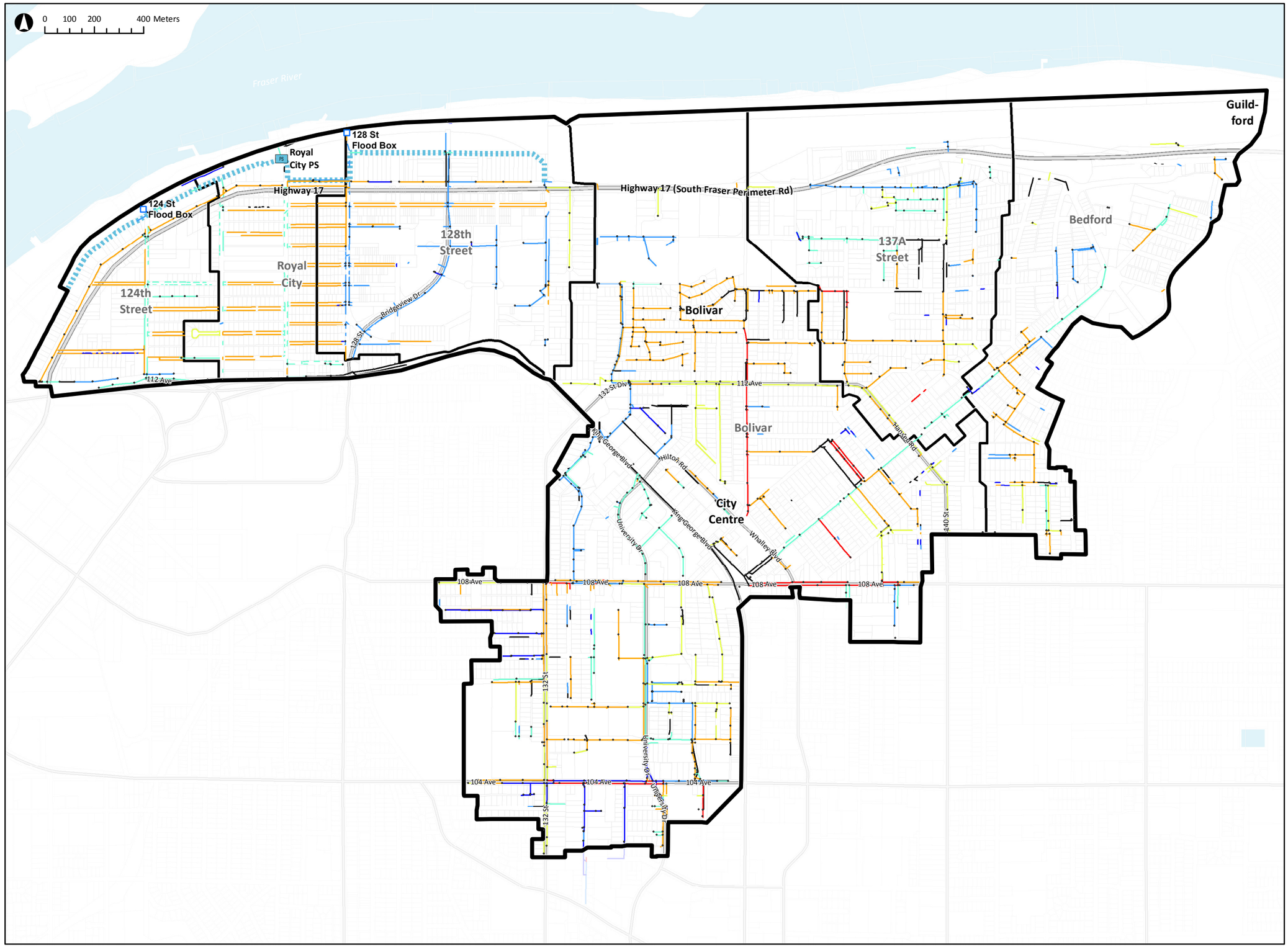
Map 8
Pipe Age

Legend

- Manholes
- Flood Box
- Pump Station
- ISMP Study Area

Stormwater Sewer
Decade of Construction

- 1960s
- 1970s
- 1980s
- 1990s
- 2000s
- 2010s
- Unknown Year
- Collector Canals
- Lots
- Highway
- Arterial Road



6.2.3 Flood Boxes

During low tides, the area drains via two flood boxes located at 124th and 128th Streets. Constructed in the 1970s, both flood boxes consist of 1800mm diameter reinforced concrete pipes that cross under the railway with cast-in-place inlet and outlet structures. Bar screens are present on both inlet and outlet sides and horizontally hinged cast iron gates are placed on the river side. From as-built information and the 1997 NECS report, the 124th Street flood box has an invert elevation of -0.75m geodetic and the 128th Street flood box invert elevation is at -1.0m geodetic. City Operations have stated that these flood boxes appear to be in good condition.

6.2.4 Royal City Pump Station

Built in 1977, the Royal City Pump Station is located north of 116 Avenue at 126 A Street housed in a wooden building founded on precast concrete slab supported on piles. Stormwater flows into the station from the south side through a trash rack. Timber skirting attached to the piles surrounds the remaining three sides to limit entry of water. Water discharged is discharge into the Fraser River from the pump station through 450mm and 600mm diameter forcemains with flap gates to prevent backwatering. The pump station receives power from a three phase service located on 126A Street.

From discussions with the City's Pump & Controls Manager, there are currently two pumps running at a 1,175 L/s capacity at 3.0m head and there have been no major operating issues.

6.2.5 Dyking System

The City of Surrey has a dyke system to protect low lying areas that are adjacent to rivers and foreshore areas. The dyke system comprises of 3.9km of concrete flood walls, 1.4km of earth dykes, 2.3km of raised ground and temporary earth dykes, and 16 crossing structures.

The study area includes 290 ha of lowlands within the 200-year Fraser River flood level, of which 178ha, from the Pattullo Bridge to 132 Street, are protected by the dyke system, while 112ha east of 132 Street is not protected. The 200yr Fraser River flood plain and the dyke system is shown in Figure 6.4.

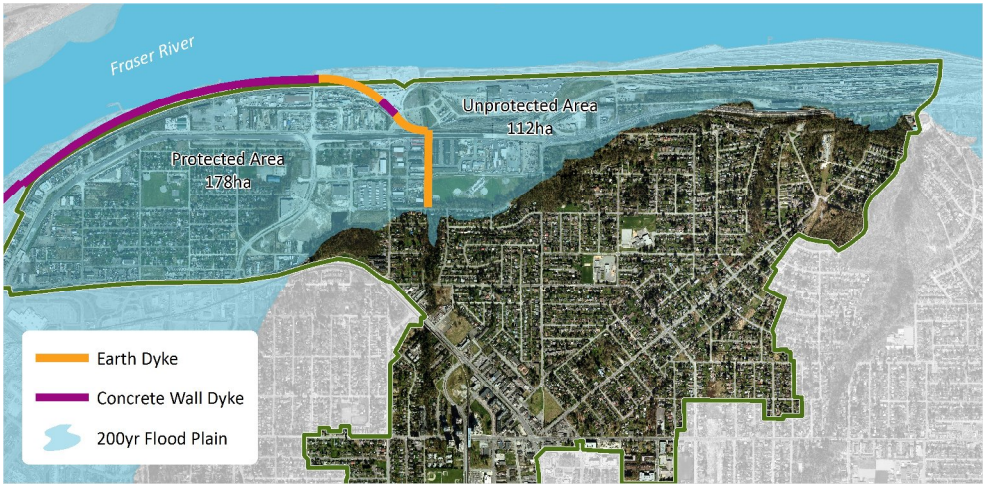


Figure 6.4 Flood areas and dyking system

The dyke system featured in this figure runs for 3,600m from Bolivar Creek at 132 Street to the Fraser Port Land at Elevator Road, and follows along the CN Rail embankment. This dyke protects the South Westminster/Bridgeview community including the Pattullo Bridge approach, the industrial lowlands, and the Fraser Port area to the Delta border.

Areas to the east of 132 Street currently do not have formal dyke protection. CN Rail owns most of this land fronting the Fraser River and would need to build their own dyke system to protect the railways.

The City is currently in discussions with the BC government regarding extensions to the existing dykes, and this project is outlined in Table 2.1 Proposed projects in ISMP region.

6.3 Field Inspection

A field review was completed on July 13, 2012 to review the west and east major collector ditches as well as the Royal City Pump Station and South Fraser Perimeter Road (SFPR) that was under construction at the time of the inspection.

Key observations from the site visit included:

- There was several ditches that contain unsightly stagnant water and debris
- The SFPR project has dramatically altered the existing flow pattern of the area north of 114 Avenue with several new culverts in place

Photos from the inspection are included in **Appendix E Site Inspection Findings**.

6.4 Existing Drainage Issues

City staff were engaged to develop an understanding of the existing drainage issues within the study area, and identify opportunities for resolving those issues through the ISMP. The issues can be broadly categorised as:

- flooding, including major flooding from the Fraser River and minor nuisance flooding
- poor water quality
- ditch infilling
- encroachment on streams and violation of setbacks
- roof leaders

6.4.1 Flooding

Approximately 300 hectares of the Bridgeview-North Slope area (750 hectares) is located within the 200-Year floodplain. Management of flood risk within this area is important due to the large number of residential homes and businesses. Flooding is an is important in this community due to the presence of residential homes and businesses.

Flooding can be defined in two ways:

- Nuisance flooding: water levels exceed lot levels (ground elevation) causing inconvenience or minor damage
- Major flooding: water level exceeds floor elevation causing major damage to property owners

City Engineering Operations and Maintenance staff stated that several locations within the study area experience frequent flooding. The worst areas are within 112A Avenue west of 124 Street where drainage ditches surcharge during almost every rain event and water levels reach up to residential front yards, however there has been no damage to buildings to date.

The City receives a significant amount of complaints from residents regarding inaccessibility and nuisance due to the floods. It was also observed that elevations of driveway culvert and drainage laterals are often too high, which causes runoff conveyance issues leading to pooling and flooding.

6.4.2 Water Quality

Poor water quality has been an ongoing issue within the study area. The presence of garbage, debris, significant sediment, and chemical contaminants in ditches and streams are problems that have a negative impact on downstream water quality, aesthetic appeal and community sentiment. The City frequently receives complaints about the buildup of algae and stagnant water in drainage ditches.

City operation and maintenance crews perform routine ditch maintenance, including general clean ups, ditch trimming, weeding, and plantings to mitigate this issue. The City also involves their Salmon Habitat Restoration Program (SHaRP), a student-based initiative that promotes watershed stewardship and habitat enhancement for fish species within the City, to participate in the maintenance and upkeep of ditches and creeks.

6.4.3 Ditch Infilling

There is a history of un-sanctioned ditch infilling in the study area, despite the City's enforcement of by-laws that regulate against it. It is important to protect drainage ditches against encroachment, as it reduces the stormwater conveyance and available storage capacity within the lowlands, increasing the frequency and impact of flooding. Aerial photos show that the east collector channel has also been infilled and culverted in several locations.

6.4.4 Stream Setback Encroachment

There are several properties within the study area that were constructed prior to present City regulations that specify properties must be setback from streams by 15-30m. This is usually resolved through application of conditions to development requests, however as the area is essentially built-out and there is little development activity within the problem areas, there is limited opportunity to rectify the issue at the present time.

The watercourses within the study area and their classification are shown in **Map 9 Watercourse Classification.**

6.4.5 Roof Leaders

The City has adopted a policy of disconnecting roof leaders on single family detached buildings in order to promote natural drainage. This is enforced for new connections through the Stormwater Drainage Regulations and Charges By-law.

There is no retrospective mandate for the disconnection of roof leaders on institutional, commercial or industrial (ICI) properties. Based on the average age of the properties within the study area, it is assumed that most ICI properties still have roof leaders connected to the drainage system. This concern is compounded by large proportion of industrial and commercial land use within the study area.

6.5 Best Management Practices

Best Management practices (BMPs), sometimes known as low impact development strategies, are tools that can be implemented to manage stormwater in order to protect natural resources such as watercourses and wetland areas. The objective of BMPs is to mimic the natural hydrologic regime within a development to provide a more sustainable way of managing stormwater. This objective is often accomplished through one or more of the following processes:

- Reducing imperviousness
- Conserving natural resources and ecosystems
- Maintaining natural drainage courses
- Reducing the use of and reliance on conventional pipe systems
- Minimizing clearing and grading of land for development (cluster housing)
- Maintaining pre-development time of concentration by strategically routing flows to maintain travel time
- Implementing effective public education programs to encourage property owners to use pollution prevention measures; and, maintain the on-lot hydrologically functional landscape management practices

BMPs can be utilized to aid in peak flow attenuation, volume reduction, and water quality protection. BMPs are not only beneficial for stormwater management and the environment, but they can also improve the aesthetic appeal of urban developments and contribute to a positive community sentiment.

As described earlier in Section 4 Land Use Planning, the study area overlaps the City Centre Plan which has a BMP strategy to encourage sustainability as the City Centre develops. The BMP strategy identifies the need to control stormwater runoff volume as well as peak flow rates in order to mitigate negative impacts to creeks.

The City Centre BMP strategy defines the following two goals for BMPs:

- Rainfall capture – Capture the low intensity, frequent rainfall events at the sources and return volumes to more natural hydrological pathways (i.e. volume reduction). This means that the small events would be infiltrated into the ground
- Rainfall control – Detain surface runoff from higher intensity, infrequent events (large storms) and release it under controlled conditions (i.e. rate control)

Although BMPs specified for the City Centre may not be suitable for application in the lowlands of the study area, the BMPs that are being implemented in the uplands are likely to indirectly affect the lowland drainage system downstream of the City Centre.

6.6 Summary

The key points relating to the stormwater system of the study area are summarised as follows:

- The study area generally drains south to north through a network of roadside ditches, sewers and creeks before discharging to the Fraser River in several locations
- The three western catchments are dyke protected, and discharge through either flood boxes or the Royal City PS, dependant on the Fraser River water level
- The three eastern catchments discharge naturally to the Fraser River via several creeks
- The drainage system predominately comprises of traditional pipe and channel, and there are few existing examples of modern low impact urban design and best management stormwater management practices
- City staff and residents have reported that there are several issues with the drainage system, including flooding, poor water quality, ditch infilling, encroachment on streams and connected roof leaders
- The City Centre is to be developed in line with a land use plan that incorporates BMPs, and there is an opportunity to apply some of these BMPs across other areas in the study area

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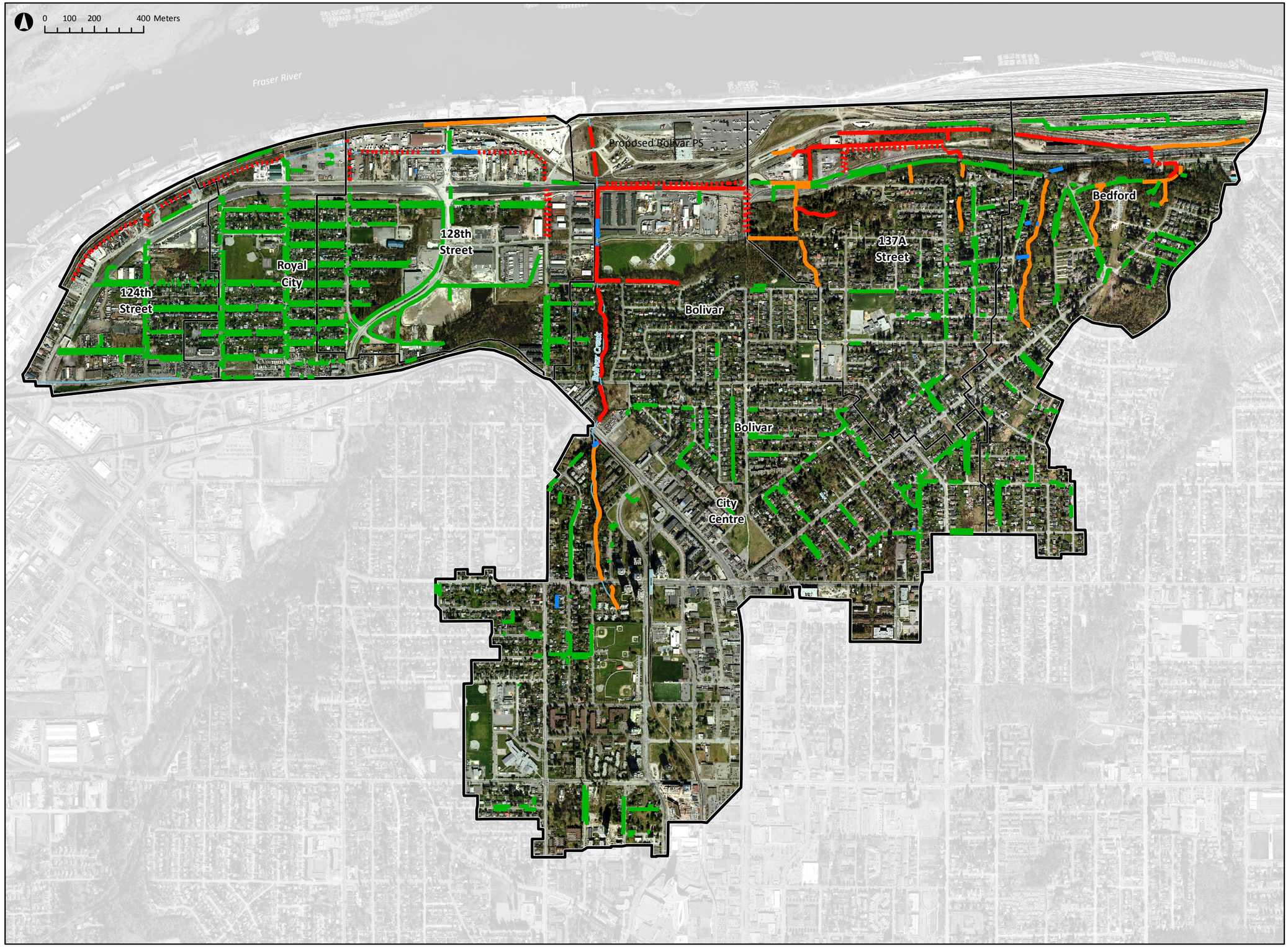
Map 9
Watercourse Classification

Legend

Watercourse Classification
- A
- AO
- B
- C
- UN
- ISMP Study Area
- Stream / Channel



7 Hydrogeology and Soils

7.1 Overview

This section summarizes the hydrogeological and geotechnical features of the Bridgeview-North Slope study area based on the review of previous reports, aerial photos, contour mapping, Ministry of Environment (MOE) water Atlas, and Surrey's ravine erosion reports.

7.2 Bedrock

Bedrock, which is blanketed by a very thick sequence of unconsolidated materials in this area, is situated more than 200m below the Fraser River level. Bedrock in the study area likely consists of Tertiary sedimentary rocks of middle Eocene and later aged sandstone Shale, conglomerate and minor tuff and coal. (Reference: The Geological Survey of Canada GSC Map 1151A Geology, Pitt Lake (Vancouver East Half) BC1965, JA Roddick and JE Armstrong).

7.3 Surficial Geology and Soils

Surficial soils are a key component of the hydrologic cycle. They form the interface between rainfall and infiltration/runoff. Soil is not a homogeneous material, it is composed of various mineral and organic components that may or may not be distributed and organized into vertical and horizontal patterns. The soil components and their distribution is a function of parent geological materials, topography, climate, biology, and geologic history. An understanding of the surficial soils is important to developing knowledge of the study area and its operation under a range of conditions. A review of the surficial soils was undertaken to establish an understanding of the potential engineering opportunities and constraints relating to drainage and possible infiltration as it relates to stormwater BMPs.

The surficial geology units in this area have been mapped by the Geological Survey of Canada (Reference: Surficial Geology GSC Map 1484A Surficial Geology, New Westminster, BC) and are shown in the map in Figure 6.1 along with the corresponding cross section showing the geological profile. The main surficial soil units that occur in the study area are described below.

7.3.1 Capilano Sediments (Ca)

The uplands area above elevation 50m is mapped as Capilano sediments. These are predominantly marine silts (Cd) which are less than 3m thick. In the western portion of the Bridgeview uplands, the Capilano sediments include some poorly sorted raised beach deposits of sand and gravel (Ca). These Capilano aged deposits were deposited after the last glaciation as a veneer over the dense Vashon Glacial Drift Till (Va) that comprises much of the Surrey upland area. This material includes very dense glacial till with occasional interbeds of sand gravel or silt.

The Vashon till is typically about 8m thick and outcrops along the steep slopes at between elevations 30 to 50 in the Bridgeview area. This dense till unit has a low permeability (typically 1E-08 to 1E-07 m/s) and infiltration through this unit will be very slow. It is considered to be an Aquitard and a confining layer. (Reference: Surficial Geology GSC Map 1484A Surficial Geology, New Westminster, BC).

7.3.2 Pre- Vashon Deposits

Below the Vashon glacial till lie the older, pre-Vashon Quadra Sand fluvial channel fill and flood plain deposits, which consist of cross bedded sands with minor gravel and silt lenses and interbeds. They occur from about elevation 30m to near sea level. The Quadra Sands are the same formation that is present in the cliffs at Point Grey/UBC and the cliffs in White Rock. This unit is dense due to glacial consolidation but these sands and silts are not as resistant to erosion as the overlying Vashon Till. The lower part of the Quadra formation is largely silt. Below the Quadra sands, and typically below the current level of the Fraser River, occur older Pre-Vashon till and organic deposits that extend under the Fraser River. These older deposits are blanketed by more recent Fraser River sand channel deposits and silt overbank deposits.

In the Bridgeview-North Slope areas near the Fraser there are organic bog, peat, and swamp deposits up to 14m thick. In these areas it is expected that a considerable amount of fill has been placed to allow for development. Areas of the Pre-Vashon deposits immediately to the east and west of the Bridgeview study area are mapped as recorded landslides (RS) on GSC Map 1484A.

7.3.3 Peat

Figure 7.1 Red peat in the study area

The Bridgeview-North Slope area contains a large layer of peat, a highly organic material that is usually found in marshy or damp regions. Peat consists of partially decayed vegetation matter that has accumulated in a water-saturated environment and can be used as fertilizer or fuel. Important physical properties of peat are its high water retention and hydraulic conductivity.

From AECOM's experience with the design and construction of the Bridgeview low pressure sewer system and West Cell Pump Station, a geotechnical investigation was completed for the area along 125A Street within 112 Avenue and 114 Avenue. In general, test holes showed that surface soils contained approximately 1m of sand and gravel over 2.5m of soft brown fibrous peat material. Below this peat layer exist roughly 8m of sand/silt.

The thick layer of reddish brown peat encountered in our sanitary sewer works in Bridgeview can be seen in Figure 7.1.

7.4 Aquifers and Wells

The BC Water Atlas allows users to prepare maps of aquifer productivity and registered water well locations, based on the MOE water well database. The database is voluntary and does not include all wells. Figure 7.2 shows aquifer productivity as textured areas and water wells as blue dots. The study area intersects two aquifer systems: the Quadra Sands Aquifer, and the Fraser River Sediment Aquifer. The location of these systems are shown in Figure 7.2 below.

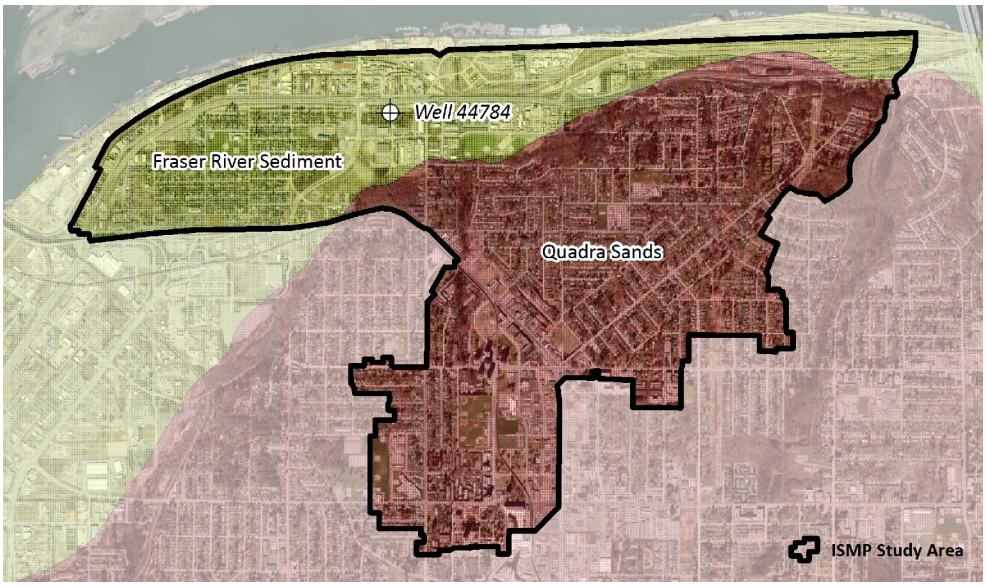


Figure 7.2 Aquifers Intersecting Study Area

The Quadra Sands Aquifer is classified as high productivity, low demand and low vulnerability to contamination. This unit has been mapped as an extensive aquifer (MOE Aquifer #49) in a number of areas in Metro Vancouver. The hydraulic conductivity (permeability) of this aquifer is expected to be between 1 E-05 and 5 E-05 m/s – more than two orders of magnitude higher than the Vashon till aquitard which occurs above it.

The Fraser River Sediment Aquifer, which is mapped as non-drinking water, sand and gravel aquifer of moderate productivity, low demand and moderate vulnerability to contamination. This aquifer is likely classed as non-drinking water because of the naturally occurring saline water quality. There is a wedge of saline water which reportedly extends below the Fraser River from the mouth to the Port Mann Bridge.

There is only one well record (Well Tag 44784) within the Bridgeview catchment area. This well was drilled in 1980 to a depth of 73m (240 feet). The reported yield is 10gpm from a 5' layer of sand and gravel from 235' to 240'. No water quality data is provided.

7.5 Groundwater Flow and Slope Stability

The regional groundwater flow direction is to the north and northwest toward the Fraser River, with localized components of flow towards the various small streams and large ditches that are present in the Bridgeview-North Slope area. The water table will likely vary about 1m seasonally with the highest levels occurring in the winter and the lowest elevations occurring during dry weather in the late summer.

Precipitation falling on the uplands area will generally encounter slow to moderate percolation rates through the Capilano silts and the deeper dense Vashon Till. There may be a perched water table in the till within 3m of the surface, particularly during the wet periods of the year. The Vashon till is under drained by the more permeable Quadra sands so there is a strong downward hydraulic gradient through the glacial till in the uplands area causing downward flow, albeit at a slow rate. The upper portion of the Quadra Sands is unsaturated near the steeper slopes. Springs or seepage zones may occur just above silt layers along the slopes. This seepage can cause soil piping and lead to increased erosion and potential slope instability. Increased infiltration near the top of steep slopes can lead to a rise in the water table and decreased slope stability. Therefore measures to increase infiltration should be restricted to areas that are not near steep slopes.

In the lowland area there is a shallow water table in the bog deposits and fill materials. The water table is likely within 1m of the ground surface during the wetter periods of the year. Percolation rates will be fairly rapid through these materials unless they have been compacted. However, the shallow water table and potential for upward hydraulic gradients at the toe of the slopes will restrict the potential for any substantial increases in infiltration in these areas.

The presence of the peat layer is a critical factor in infiltration. Essentially, peat material is very porous and is effective in retaining water. Although peat is helpful in providing some water quality filtration benefits, it possesses low vertical and lateral structural strength. As experienced with the SFPR, pre-load settlement was approximately 1m in depth. What is interesting to note about the properties of peat material is that once it is compacted it proves to be quite robust. However any potential for water retention or filtration is lost under this condition.

7.6 Contaminated Sites

The lower elevation portions of the Bridgeview area are primarily industrial and have been for many decades. There are a number of known contaminated sites in this area and there is considerable potential for more sites than those that are listed on the BC Contaminated Site Registry. From investigations into contaminated sites within the study area, it is recommended that if the City elects to thoroughly assess this item then a comprehensive study beyond the ISMP should be completed.

Development in the lower elevations near the river would have required the placement of large amounts of fill, particularly near the river. In the past there was less concern or understanding about the chemical quality of fill materials. Strict regulation of contaminated Sites in BC only was formalized in April 1997 when the Contaminated Sites Regulation came into effect. Any specific strategy to increase infiltration in the industrial portions of Bridgeview will require a search of the BC Site registry and other information to make sure that the infiltration strategy is not contributing to increase contaminant migration from a known contaminated site.

7.7 Geotechnical Requirements for New Dyke Seismic Design

The 2011 Seismic Design Guidelines for Dykes by Golder Associates for the Ministry of Forests, Lands, and Natural Resource Operations (MFLNRO) describes the required geotechnical investigations to ensure soil

conditions meet seismic standards. Historically, damages to river banks and shorelines have been mainly due to geotechnical failure such as slope instability, settlement, and lateral movement. As such, the provincial government has identified the need to complete soil tests to assess the vulnerability to liquefaction, shear strength, and movement.

Since the City is currently pursuing to extend the dyke system eastward, these provincial standards for seismic design also apply to soil conditions along the alignment of the new dyke. From preliminary review there are two options in managing this. First, any inadequate soils could be excavated and removed from site. This however will result in importing fill into the area which may prove to be quite costly for the City. In addition, there will be a need to maintain water levels from the Fraser River during the time of excavation.

The second option would be to provide pre-load to the area for compaction of the existing soils. This however may take a considerable length of time to accomplish and the City must be careful in monitoring what effects this will have on the drainage system and any upheaving of the surrounding ground and utility displacement. Therefore, careful analysis will be needed to ensure that geotechnical requirements for the new dyke are met while minimizing any impacts to surrounding infrastructure.

7.8 Summary

The key points relating to the hydrogeology and soil characteristics of the study area are summarised as follows:

- There are limited opportunities to increase infiltration within the lowland areas due to the shallow water table and potential for upward hydraulic gradients at the toe of the slopes
- Increased infiltration near the top of steep slopes can lead to a rise in the water table and decreased slope stability. Measures to increase infiltration should be limited to areas away from steep slopes
- The presence of peat in the study area may result in settlement issues and provide very little structural strength if not compacted effectively
- The BC Contaminated Site Registry shows several contamination sites located within the study area, predominately in the industrial areas. There is also considerable potential for additional unknown sites within the study area. It is recommended that if the City elects to thoroughly assess this item then a comprehensive study beyond the ISMP should be completed.
- The 2011 seismic design standards for dykes includes standards for geotechnical conditions. These standards should be considered during the design and development of the proposed dyke extension.

8 Environment

8.1 Overview

Phoenix Environmental Services Pty were engaged by AECOM to undertake an environmental assessment of the study area and submit a detailed Environmental Assessment report. The scope of the environmental assessment included:

- Confirmation of fisheries classification for key watercourses and assessment of current health conditions of selected watercourses, including associated terrestrial habitats such as ravines, riparian areas, and wetlands
- Identification of significant or sensitive terrestrial habitats including trees and forests, habitat hubs, wildlife corridors and habitat restoration opportunities
- Identification of key environmental risks and areas of concern, such as degraded watercourses or wildlife habitats, and water pollution sources

The detailed environmental assessment report is included in **Appendix A Environmental Assessment**. The executive summary of the environmental assessment is included below.

8.2 Summary

Scope and Objective

Phoenix Environmental Services Ltd. (Phoenix), in collaboration with Gebauer and Associates Ltd. and Sartori Environmental Services, conducted an environmental assessment for the Bridgeview-North Slope ISMP.

The Environmental Assessment report was completed in support of Stage 1 of the ISMP, and the objective was to provide an inventory and assessment of existing terrestrial (wildlife habitats and corridors) and aquatic habitats (watercourses, wetlands) within the Study Area using available information and limited 'ground-truthing' site reconnaissance. The scope of work by Phoenix included use of existing research and reports, as well as field verification where necessary.

Findings

The study area is characterized by predominantly urban and industrial land uses extending from commercial and high-density residential areas near the Surrey City Centre south of 108th Avenue to single family residential areas over most of the north-slope and mixed industrial, commercial and residential within the lowland floodplain areas near the Fraser River. The study area has been largely built-out with negligible undeveloped lands, such that remaining streams, forested and environmentally sensitive areas have become a scarcity and of significant retention value.

The environmental assessment found that the priority areas for protection include:

- Class A and Class B streams and their riparian areas
- groundwater springs and wetland areas within remaining forested areas near the base of the escarpment
- remaining forest stands along steep slopes and in the lower floodplain area

The watercourses within the ISMP study area can be separated roughly into three categories:

- ravine streams and tributaries
- constructed drainage watercourses (fish habitat)
- constructed drainage ditches (not fish habitat)

The City of Surrey's Fisheries Watercourse Classification system has been applied to assess and classify watercourses in the study area. Several changes are proposed to address unmapped watercourses, inaccurately mapped watercourses, and to address proposed re-classifications of watercourses. These are discussed in detail in section 2.3 of Appendix A Environmental Assessment.

A number of issues relating to watercourses in the ISMP study area have been identified, including:

- stream erosion
- fish migration barriers
- riparian habitat damage
- poor water quality

Previous sewer diversions have been installed to bypass high flows around the steep slopes and ravines on the North Slope area of the study area. Field observations and long term monitoring reports indicate that the high flow bypass diversions have resulted in relatively good stream stability. However, ravine stability assessments (2002 – 2009) indicate that numerous localized bank erosion problems persist within the North Slope ravine streams following the construction of the storm sewer diversions (ca. 2001).

Several barriers to upstream fish migration have existed for many years (e.g. CN Rail yard) such that all of the ravine streams are not fish accessible within the North Slope area; with the exception of Bolivar Creek, which is fish accessible to King George Boulevard. Depending on completion of the South Fraser Perimeter Road, there appear to be opportunities to restore fish access into some streams along the North Slope area (e.g. Southward Creek).

Riparian habitat damage from refuse disposal and long-term structures built at or very close to watercourse banks and ravine crests occurs extensively throughout the study area. Water quality issues are most prevalent in the lowland floodplain and industrialized areas of the ISMP study area. These issues are discussed in greater detail in section 2.4 of Appendix A Environmental Assessment.

The relatively few and fragmented forested areas remaining in the study area have not changed substantially over many years, given the long history and density of urban development in the study area. No sensitive plant or animal species were detected during the field program, although several sensitive species are likely, including Great Blue Heron, Trowbridge's Shrew, Pacific Water Shrew and Streambank Lupine.

Remaining forest patches need to be protected and wildlife movement corridors need to be maintained or established to improve the ecological integrity of the Study Area and to provide suitable living habitat for sensitive species including Trowbridge's Shrew, Pacific Water Shrew and Western Screech-Owl, among a number of other species. Provision of natural habitats that have protected corridors will result in increased biodiversity within the Study Area.

9 Hydraulic Modelling and Assessment

9.1 Overview

Hydraulic analysis of the existing stormwater system in the study area was a significant component of the ISMP. This section describes the scope, objectives, methodology and results of the hydraulic analysis. The hydraulic analysis was performed using a PCSWMM model, and was used to identify issues in the stormwater system such as surcharging or capacity constraints. Improvements to the stormwater system were recommended based on the issues identified.

Detailed outputs of the hydraulic modelling are included in Appendix E.

9.2 Model Development

9.2.1 Scope

From discussions with the City, it was agreed that for its intended purposes in the ISMP the model is to reflect the major drainage system and major flow routes across the study area. This includes modelling the Royal City Pump Station, the floodboxes at 124th and 128th Street, major collector ditches and canals, trunk sewers, diversions, and overland flow routes.

9.2.2 Previous Investigations

Previous studies such as the 1996 KWL Bridgeview Stormwater Management Study and the 1997 New East Consulting Ditch and Culvert Design Brief used XP-SWMM and MIDUSS software, respectively, to simulate the hydrological and hydraulic conditions in Bridgeview. However, these previous models did not include the areas east of 132 Street and the files were not available for our review and assessment at the time of this report (only the output files were included as an appendix to the reports).

9.2.3 Modelling System Selection

The revised drainage model for the Bridgeview-North Slope storm sewer system was completed in PCSWMM Professional 2011 software which allowed us to run continuous simulation as well as model synthetic design storm events, varying tidal conditions at outfalls, and input of pump station performance curves.

9.2.4 GIS Data Review

GIS data was obtained from the City and reviewed prior to building the model. This included reviewing:

- drainage pipes (conduits)
- drainage manholes (junctions)
- drainage catchments (sub-catchments)
- open channels (ditches and creeks)
- 1-metre contour elevations
- 200-year flood plain boundary
- City property lines

It was found that critical information such as pipe and manhole inverts, rim elevations, and major ditch and creek cross-section dimensions were missing for this area. In addition, non-circular conduits did not have cross-sectional dimensions in terms of shape and size. Correspondence with City GIS staff confirmed that this area possessed very little historical information. Invert information was obtained from COSMOS and manually applied to each corresponding conduit in GIS. Manhole rim elevations were derived from 1-metre contour elevations.

It was previously identified that the major drainage system would include all storm sewers 525mm dia. in size or larger. In some instances, storm sewers that were 375mm to 450mm in size were also included as they were

found to be major flow routes for some smaller sub-catchments. In total, 254 conduits were imported from GIS into the PCSWMM model representing the major drainage system. This includes major collector ditches, canals, and creeks for an approximate total length of 21 kilometres.

Model connectivity gaps were reviewed using connectivity tools available in PCSWMM to ensure all pipes are connected to manholes. Once the GIS data gaps were resolved, the drainage network attributes were imported into PCSWMM. Data imported into the model included pipe ID, diameter, length, material type, manhole ID, and "X-Y" coordinates. Figure 9.1 below shows a screen capture of the model layout in PCSWWM.

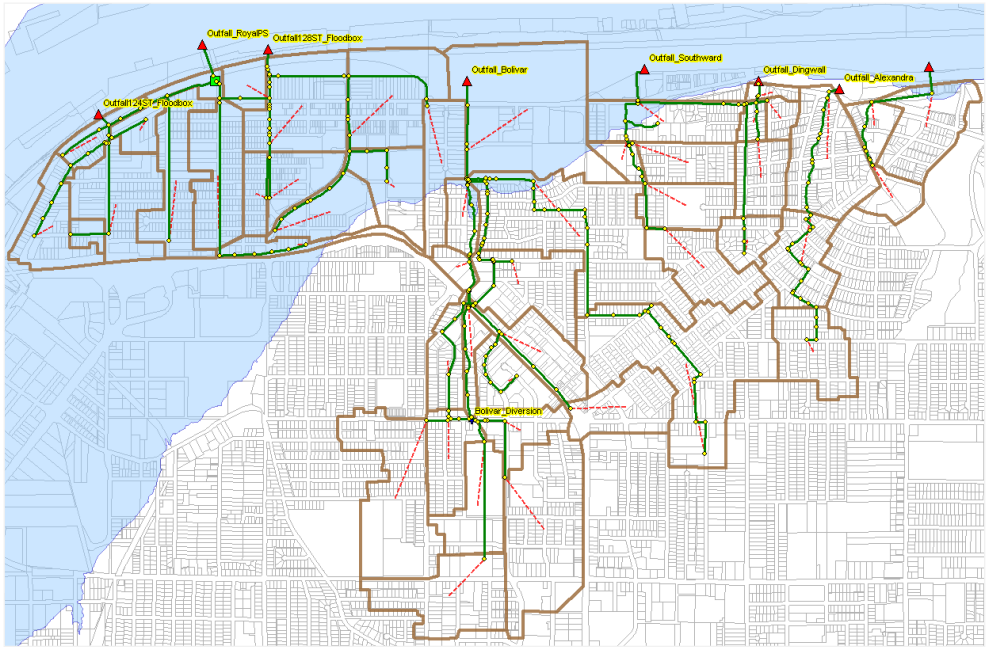


Figure 9.1 Screenshot of PCSWMM Model

9.2.5 Model Inputs

PCSWMM software utilizes both runoff and hydraulic modules. The runoff module generates hydrographs based on rainfall (or hyetographs), soil characteristics, catchment widths, depression storage, impervious area, and infiltration rates. The hydraulic module routes these hydrographs through the drainage system, on a real time basis, from the start to the end of the rainfall event. The drainage system is represented as links (pipes or other conduits) and nodes (manholes or other junctions). Therefore, the hydro-dynamic model provides simulated results that emulate the real flow pattern and parameters such as flow rates, velocities, water depths, and volumes.

The runoff module in PCSWMM requires input of various hydrologic parameters that define the catchment characteristics to be assigned to the nodes. These parameters include:

- catchment area, percent imperviousness, width, and overland slope
- initial abstractions (impervious and pervious areas)
- soil infiltrations (Horton's infiltration)
- rainfall hyetographs

Table 9.1 summarizes the hydrologic parameters that were used for the model and compares them to the previous parameters used in the 1996 KWL report and the 1997 New East Consulting Services report. The parameters from the 1997 report were generally taken forward into the update model, with some minor modifications based on knowledge of the area and the model behaviour.

Table 9.1 Hydrologic Parameter Comparison

Parameter	1996 KWL	1997 NECS	2013 AECOM
Horton's Max Infiltration Rate	0 mm/hr	3.5 mm/hr	3.5 mm/hr
Horton's Min Infiltration Rate	0 mm/hr	1.2 mm/hr	1.2 mm/hr
Horton's Decay	0.001 /sec	0.5 /hr	0.5 /hr
Depression Storage (Impervious)	0 mm	5.0 mm	2.5 mm
Depression Storage (Pervious)	0 mm	2.5 mm	2.5 mm
Imperv % w/ no depression storage	0	0.5	0
Impervious 'n'	0.04	0.015	0.015
Pervious 'n'	0.3	0.25	0.25

Catchment Areas and Impervious Area

The land use, imperviousness, slope and area of each catchment in the study varies, and each catchment was assigned hydrology parameters reflecting these characteristics. The land use by area and percent of total catchment area are shown in Tables 9.2 and 9.3 respectively.

Selection of land uses affects how we approach protection and mitigation measures for development. Choosing the appropriate mitigation technique can in many respects significantly reduce the effective impervious area (EIA) for a site from the equivalent total impervious area (TIA). For clarification:

- Total Impervious Area (TIA) – is the percentage of all the impervious surfaces divided by the total site area.
- Effective Impervious Area (EIA) – is the percentage of the impervious area that contributes to stormwater runoff from the site.

For example, a site that has impervious surface covering (such as a building/pavement) 80% of a site will have a TIA of 80%. If there are no mitigation measures implemented on this lot then the EIA will also be 80%. However, if there is mitigation implemented which controls stormwater runoff for a quarter of the impervious areas, then the EIA is now reduced to 60%. For model development purposes, we are using the impervious values as TIA=EIA. Table 9.4 summarized the range of catchment parameters used in the model.

Table 9.2 Catchment Area Land Use Composition

Catchment	Total Catchment Area (ha)	Land Use Area (ha)*					
		Commercial	Industrial	Residential Single Family	Residential Multi-Family	Parks, Open Space & Agricultural	Institutional
124th Street	45	4	32	9	-	-	-
Royal City	48.8	5.5	14.7	28	-	0.4	0.2
128th Street	97.8	0.3	65	29.5	0.3	2.5	0.2
Bolivar	335.7	90	33.3	172.9	27	6	6.5
137A Street	112.3	-	31	63	17	1.3	-
Bedford	108.2	-	19.6	35.6	39	14	-

*Based on City of Surrey OCP Zoning data. Values do not exclude roads, lanes or highways

Table 9.3 Land Use as a Percentage of Catchment Area

Catchment	Proportion of Total Catchment Area					
	Commercial	Industrial	Residential Single Family	Residential Multi-Family	Parks, Open Space & Agricultural	Institutional
124th Street	9%	71%	20%	-	-	-
Royal City	11%	30%	57%	-	1%	1%

Catchment	Proportion of Total Catchment Area					
128th Street	0.3%	65%	29.5%	0.3%	2.5%	0.2%
Bolivar	27%	10%	51%	8%	2%	2%
137A Street	-	28%	56%	15%	1%	-
Bedford	-	18%	33%	36%	13%	-

Table 9.4 Catchment Slopes and Impervious Values

Catchment	% Impervious	Slope (%)
124th Street	50 - 80	0.05
Royal City	50 - 75	0.05 – 1
128th Street	50 - 80	0.05 – 2.5
Bolivar	40 - 50	1 – 3
137A Street	60 - 72	3 – 7
Bedford	55 - 66	3 – 8

The six major drainage catchments were further refined into smaller sub-catchments to better reflect where the major flows were being routed in the study area. Delineation was based on 1-metre contour elevations as well as existing drainage system flow directions found in COSMOS.

A total of 49 sub-catchments were created in the model with areas ranging from 2 to 24 hectares. Each sub-catchment was then assigned the hydrologic parameters of the respective major catchment, with the exception of some catchments exhibiting different slopes and impervious values. Sub-catchments were then linked to the appropriate junction in the model.

Royal City Pump Station

One of the objectives in developing the model is to determine if upgrades are required for the Royal City Pump Station (RCPS). The RCPS currently services over 200 hectares of the western Bridgeview portion of the study area. As-built drawings along with a pump performance curve and SCADA information for pump cycle start and shutoff times from 2001 to 2012 were obtained from the City.

The RCPS currently has two pumps installed inside a concrete sump; both pumps are type Flygt 7081 submersible propeller pumps with 14-inch dia. impellers. Each pump has a capacity of 1.0 m3/s at a total dynamic head (TDH) of 3m. A flow rate was established based on capacity and the duration of the pump cycle from the SCADA information. From as-built drawings, the sump inside bottom elevation is at -1.2m geodetic. Table 9.5 summarizes the elevations of the pump station, which correspond to the water levels in the pump when the pump starts and shuts off. A copy of the pump curve and as-built drawings are provided in Appendix B.

Table 9.5 Operating conditions of Royal City Pump Station

Operating Level	Geodetic Elevation (m)
Pump Bottom	-0.7
Emergency Low Level Pump Shut Down	0.1
Min. Pump Level / Lead Pump Off	0.3
Lag Pump Off	0.45
Lead Pump On	0.7
Lag Pump On	0.85
High Level Alarm	1.3
Discharge Pipe Invert	2.2

Base Flow

To determine a base flow for the Bridgeview area, we looked at the pump cycle durations provided by the City to see how frequently a pump would turn on during a relatively dry period. If a pump did start when there was little to no rainfall occurring, this would indicate the presence of base flow entering the pump station and being pumped out. From review of the pump cycles during dry periods we established an approximate base flow of 15 L/s to 30 L/s which we distributed at various locations in the model to account for this. This equates to a unit rate of 0.07 to 0.15 L/s/ha across the pump station catchment.

Rainfall Data

Historical rainfall data was collected for the Surrey Kwantlen Park rain gauge from the Flow Works website in order to select a storm event to calibrate the model to. We wanted to select a storm event large enough that we could see how the Royal City Pump Station (RCPS) would behave, and that was relatively recent (within the past 5-7 years).

On December 1, 2006 an almost 100-year storm event occurred. However, upon looking at the RCPS SCADA data, on/off pump cycles were missing during this event. Another large storm event occurred on December 3, 2007 that reached a 50-year event. However, during this period rainfall had occurred with intermittent snowfall that would affect how the RCPS would behave. We decided to calibrate the model to the next largest storm that occurred on March 11, 2007, which reached a 10-year storm event. This event had a total of 82.6mm of rain within 24 hours. Expanding the duration and looking at the rainfall from March 10 to 14, a total of 126.2mm of rain occurred in 120 hours. Appendix E Figure 9.2 shows the rainfall distribution for this time period, and Figure 9.3 in Appendix E shows the event plotted against the Surrey Kwantlen Park IDF curve.

Outfall and Tidal Conditions

In the model, eight (8) outfalls were inputted across the study area to represent discharge outlets to the Fraser River, and are noted as follows:

- 124th Street floodbox
- Discharge pipe outlet from the Royal City Pump Station
- 128th Street floodbox
- Bolivar Creek outfall
- Southward Creek outfall
- Dingwall Creek outfall
- Alexandra Creek outfall
- Wellington Creek outfall

The City provided historical water levels at the Manson Canal Station located west of the study area south of the Pattullo Bridge from 2007 to 2012. Due to the location of this station in relation to the outfalls across the study area, we cannot simply apply the water levels directly to each outfall and assume that at a given point in time the water levels experienced across the study area are the same. Therefore, we proceeded to investigate into other historical water level data along the Fraser River to better understand the water level variation for the model.

On the Water Survey of Canada (WSC) website, historical water level data for Station ID #08MH126 near the Port Mann Bridge was available from 2010 to present. From Canadian Hydrographic Service (CHS) the New Westminster #7654 level gauge also has historical water levels dating back to 1969. Appendix E Figure 9.4 shows the location of these stations with respect to the study area and the Manson Canal station. To determine water level variation across the study area, we plotted the water levels from the Port Mann Station next to the Manson Canal station as shown in Appendix E Figure 9.7.

From this figure, the high tide levels vary by 0.3m while the low tide levels have greater variation at 0.8 to 1.0m difference. This would suggest that the bottom profile of the Fraser River drops in elevation as it flows from the Port Mann station towards the Manson station.

Since the high tide condition is what governs how the pump station behaves, and given that the Manson Canal station is closer to the RCPS, we proceeded to extrapolate the water levels from the Manson Canal station for March 10 to 14, 2007 and assign them to each outfall as their respective tidal condition. Figure 9.7 in Appendix E shows the tidal curves used in the model for each outfall.

Design Storms

The City's Kwantlen rain gauge located in Kwantlen Park is the closest rain gauge to the study area. The City of Surrey uses AES long duration type rainfall distribution as per their City Design Criteria Manual (May 2004). This distribution is representative of rainfall events occurring in the west coast of Canada. The City's Design Criteria Manual provides design storm hyetographs for areas covered by the Kwantlen Park gauge for durations of 1, 2, 6, 12, and 24 hours.

9.2.6 Model Calibration

The selected calibration event of March 10 to 14, 2007 was assessed with the model and flows from the RCPS outlet pipe were generated and plotted against the observed RCPS pump flows based on pump cycles. Both P1 and P2 pumps conveyed a flow of 1.22m^3/s in the model. Figure 9.7 in Appendix E shows the modelled versus observed pump flows along with the corresponding rainfall and tide levels.

From this figure, it is apparent that the tidal conditions strongly affect when the pump starts and shuts off. During high tide, the pump begins to cycle and continues to cycle just after the high tide begins to decrease. During low tides, the pump does not turn on with the exception of the end of March 11, 2007 when the peak rainfall intensity occurs. We then proceeded to plot the flows generated from the two floodboxes at 124th and 128th Street. This is shown in Figure 9.8 in Appendix E. As predicted, the flood boxes experience the most flows during low tide conditions when the pump station is not pumping and stormwater runoff is being discharged into the Fraser River through these structures.

9.2.7 Model Validation

We proceeded with validation by comparing the amount of stormwater volume that was being pumped in the model to the observed volume based on the pump cycle durations provided by the City. Table 9.6 shows the model generated total volume to be within less than 1% of the observed total volume.

Table 9.6 Validation of Model

Parameter	Value
Modelled Total Volume (PCSWMM)	130,383m^3
Observed Total Volume (SCADA)	131,283m^3
Difference	0.7%

9.3 Modelling Results

Utilizing the calibrated model, the hydraulic capacity of the drainage system was assessed under various design scenarios. The relationship between storm events and durations, freshet conditions, and tidal fluctuations are integral in understanding variances between winter and summer conditions. These conditions affect how the system behaves and conveys stormwater and will be the basis of determining what drainage improvement is needed.

9.3.1 Level of Service

The drainage conditions within the study area vary between winter and summer, with two different hydrologic scenarios:

- In winter months, drainage is governed by larger and longer duration rainfall events coinciding with high tidal conditions
- In summer months, drainage is governed by high tide levels that are due to freshet in the Fraser River and rainfall events are less frequent, smaller and are shorter duration

The 2011 MFLNRO Coastal Floodplain Mapping Guidelines and Specifications Report by KWL states that flood construction levels can be estimated as the sum of the following components:

- The higher high water level tide (HHWLT) elevation
- Allowance for future sea level rise (SLR), to a particular time horizon, such as 2100
- The estimated storm surge associated with the selected design storm

- The estimated wave effect associated with the design storm
- Freeboard

Based on the City's design criteria, the City requires the 5-year storm event to be managed within the drainage system and the 100-year storm event must be safely conveyed through overland flow routing. To gain a better understanding of how the existing drainage system functions under various tidal conditions and storm events, the system was analyzed under the 5, 10, and 100-year events for winter and summer seasons. This exercise provides us with an understanding of the drainage system's behaviour in which we will then apply the City's design criteria for the 5 and 100-year events.

9.3.2 Winter Conditions

Winter Tidal Conditions

For winter tidal condition we looked at the historical winter water levels at the Manson River gauge provided by the City. From this gauge, a typical tide cycle ranged from -0.9m to 2.09m geodetic. Therefore, we imported into the model a representative annual (1-year) 24-hour winter tide cycle at each outfall.

Winter Design Storms

Under winter condition, local drainage conduits such as culverts, pipes, and ditches would be sized to convey the 5-year storm event. Trunk sewers, canals, creeks, and major road culverts would be sized for the 100-year event. Flood boxes do not necessarily need to be sized for the 100-year event as long as the 100-year event is safely conveyed overland or along a major flow route. Since longer duration rainfall events occur during the winter months, the 5, 10, and 100-year, 24-hour duration design storms were inputted in the model for winter condition assessment. An example of winter design input conditions is shown in Figure 10.1 in Appendix E

The drainage system was then modelled under the following scenarios for winter conditions:

- Scenario 1: Winter condition 5-year 24-hour design event with annual winter tide
- Scenario 2: Winter condition 10-year 24-hour design event with annual winter tide
- Scenario 3: Winter condition 100-year 24-hour design event with annual winter tide

9.3.3 Summer Condition

Summer Tidal Conditions

Water levels in the Fraser River are higher in the summer due to the combination of freshet and large tides. These levels are also affected by climate change as freshet is dependent on the size of the snowpack and the rate of the snowpack melt in the Fraser watershed. Looking at the water levels recorded at the Manson gauge, observed data was only available from 2007 to present. With only 5 years of data at this station, we proceeded to look at other stations near the study area to obtain more historical records in order to determine water level frequencies.

Historical water levels were also obtained from the Canadian Hydrographic Service (CHS) website for the New Westminster gauge No.7654 from June 1969 to December 2012 (41 years). From this data, we took the maximum water level reached for each year and applied a log-Pearson type III statistical distribution to determine water level frequencies. The log-Pearson type III distribution has been recommended by the U.S. Water Resources Council (WRC) and adopted by the Natural Resources Conservation Service (NRCS) as the primary method for frequency analyses of hydrologic data in the United States. This type of distribution mainly applies to almost all natural floods and accounts for skew instead of standard deviation and mean parameters. A frequency analysis was plotted for the maximum annual water levels obtained in the 41 year period and is shown as Figure 10.5 in Appendix E.

For model purposes of the ISMP, we assigned to each outfall a constant water level (fixed stage) that reaches the higher high water level tide (HHWLT) which coincides with the peak intensity from the storm event. This in theory provides us with the worst case scenario in that the HHWLT occurs through the entire storm event. The HHWLT is defined as the highest level reached at a location by surface water in one complete tide cycle.

Summer Design Storms

The summer condition exhibits a combination of high tide levels coupled with intense, short-duration rainfall events. Therefore, the shorter duration design events would be within the 1, 2, or 6-hour timeframes. Analyzing

the drainage system under these events will also provide us with information on how the drainage system behaves under a mean annual rainfall (MAR) which is typically a 2-year storm event. Therefore, under summer conditions we must look beyond just the 5 and 100-year events.

To establish which storm duration governs we analyzed the model under a 1-year storm event for 1, 2, and 6 hours. We then determined which event the maximum flows occurred in. This identified the 6-hour duration as the governing duration. Consequently, we proceeded with the rest of the summer condition analysis with a 6-hour duration storm.

Since higher tides due to freshet occur in the summer, the Royal City Pump Station would need to meet the 100-year level of service under this condition. Accordingly, the focus was to assess the drainage system under the following scenarios for summer conditions to meet the100-year event:

- Scenario 4: Summer condition 1-year 6-hour rain + 100-year tide level
- Scenario 5: Summer condition 2-year 6-hour rain + 50-year tide level
- Scenario 6: Summer condition 5-year 6-hour rain + 20-year tide level
- Scenario 7: Summer condition 10-year 6-hour rain + 10-year tide level
- Scenario 8: Summer condition 100-year 6-hour rain + 1-year tide level

9.3.4 Hydraulic Capacity Assessment

Any pipes or ditches that experience a maximum flow greater than their flow capacity (i.e. Qmax/Qcap > 1) were highlighted in the model. Identifying these “surcharged” pipes and ditches in the model tells us where there are flow capacity restrictions in the drainage system, however it may not necessary mean that surface flooding is occurring (i.e. water levels are above the pipe obvert but below ground elevation). Therefore, we also highlighted manholes and nodes where the maximum hydraulic grade line (HGL) reaches rim or ground surface elevation, which would indicate surface flooding.

Table 9.7 summarizes the results from the hydraulic assessment. Comparing the results generated from the model for winter and summer conditions, Scenario 3 generated the most number of pipes and ditches where the maximum flow was greater than flow capacity. Scenario 3 and 8 both produced 34 manholes and nodes in which the HGL reached above ground surface.

We can also see that the area in which Surrey Operations & Maintenance Crew noted local flooding occurring at 112A Avenue and 124 Street during all rain events is also experiencing capacity and flood issues in the model.

The results shown in Table 9.7 are also mapped in Appendix E.

Table 9.7 Surcharging assets

Scenario	Storm Event	Tide Event	Pipes & Open Channels	Manholes & Nodes	Appendix E Figure Ref.
Winter Condition					
Scenario 1	5-year, 24-hour	1-year, 24-hour winter tide cycle	50	21	Figure 10.2
Scenario 2	10-year, 24-hour	1-year, 24-hour winter tide cycle	55	21	Figure 10.3
Scenario 3	100-year, 24-hour	1-year, 24-hour winter tide cycle	66	34	Figure 10.4
Summer Condition					
Scenario 4	1-year, 6-hour	100-year HHWLT* (3.86m)	36	14	Figure 10.6
Scenario 5	2-year, 6-hour	50-year HHWLT* (3.68m)	40	18	Figure 10.7
Scenario 6	5-year, 6-hour	20-year HHWLT* (3.43m)	43	23	Figure 10.8
Scenario 7	10-year, 6-hour	10-year HHWLT* (3.25m)	46	25	Figure 10.9
Scenario 8	100-year, 6-hour	1-year HHWLT* (2.64m)	55	34	Figure 10.10

*HHWLT: Higher high water level tide

9.3.5 Royal City Pump Station Capacity

The previous 1996 KWL report did not specifically state the design storm event for which the Royal City Pump Station was designed. However, large drainage pump stations in lowland areas are typically designed for the 100-year event. Therefore, the hydraulic assessment of this pump station in this study will be based on 100-year conditions.

Under summer conditions when high river levels occur, the Royal City Pump Station P1 and P2 pumps both began pumping simultaneously. Based on the model results from Scenarios 6 to 10, the longest pumping duration occurred in Scenario 8: Summer condition 100-year 6-hour rain + 1-year tide level. Under this scenario, P1 continuously pumped for over 9 hours, while within this time P2 also began pumping for 5 hours.

From industry standards, this run time length is not suitable and may cause motor burn out. In addition, suitably one of the pumps should be considered as a standby backup pump in case the lead pump malfunctions or stops working. The result from the model having both P1 and P2 pumping simultaneously is undesirable.

To determine what capacity is necessary for the Royal City Pump Station to convey the 100-year event, in the analysis it was determined that a pump flow capacity of 3.56m3/s at 3m of total dynamic head (TDH) was necessary to keep one pump cycling while the second pump remained as a standby.

9.3.6 Storage Capacity

Stormwater is relatively stagnant In the western lowland area in the Bridgeview community due to low elevations, flat slopes, and soft soils. As such, direct conveyance of stormwater runoff into the Fraser River is not easily achievable and must be stored away from residential homes, buildings, and roads. The existing open-ditch system provides important storage capacity and is an integral part of the stormwater management system.

Stormwater from these lowlands is discharged into the Fraser River via the floodboxes at 124 Street and 128 Street, and the Royal City Pump Station.

Accumulative discharge volumes were calculated at these discharge points based on the flows generated by the model for the 100yr 24hr winter condition scenario. The difference between the pump station inflows and outflows was calculated to estimate the volume of water stored in the drainage network. The results of this analysis are summarised in Table 9.8.

Table 9.8 Analysis of Total Discharge Volume

Discharge Location	Accumulative Discharge (m^3)
West Collector Canal into PS	52,7003
East Collector Canal into PS	74,8003
Total Inflow to PS (East + West)	127,498
Total Outflows from PS	128,313
Outflow - Inflow	*815*

NB: Volumes based on 100-year 4-hour winter storm event condition.

The analysis found that there was a difference of 815m^3 between the total inflows and the outflows at the PS over the 100yr 24hr event. Based on this analysis, the storage capacity in the drainage network should exceed 815m^3 to retain runoff within the system.

The City's GIS data and the 1996 KWL study show that Bridgeview area has approximately 2,000m of ditches and canals upstream of the pump station. The size of the ditches and channels vary considerably through the Bridgeview area. The modelled characteristics of these channels were similar to those in the 1996 report, where it was assumed that the majority of the ditches have dimensions 2 metres wide with 2:1 side slopes and 0.5m in depth.

The total storage volume of the ditch network was calculated for several size variations based on a typical depth of 0.5m and a total length 2000m. These calculations are shown in Table 9.9 below.

Table 9.9 Ditch Storage Capacity

Top Width (m)	Bottom Width (m)	Depth (m)	Cross-sectional Area (m^2)	Volume of Ditches (m^3)	≥ 815m^3 Storage
2.00	1.00	0.50	0.75	1,500	Yes
1.32	**0.32**	**0.50**	**0.41**	**815m^3**	**Yes**
1.00	0.00	0.50	0.25	500	No

The calculations show that if the average cross-sectional area across the 2000m of ditches is 0.75m^2, then there is sufficient storage capacity to account for the shortfall between inflows and outflows at the pump station, however if the average cross-sectional area is less than ~0.4m^2 then there will be sufficient storage capacity. Whilst this analysis is extremely approximate, it does shows that the inflow/outflow balance and the storage capacity within the system is within the same order of magnitude and that the drainage ditches are likely to provide a noticeable level of storage.

9.4 Recommendations

9.4.1 Localised Flooding in Bridgeview Area

Based on the model results, under various winter and summer condition scenarios there are some key areas that consistently have conveyance or flooding issues. These areas are mainly the western portion of the study area within the Bridgeview Community near Industrial Road and 112A Avenue, 128 Street in Bridgeview, and at the downstream end of Bolivar creek along 134 Street.

The combination of low lying land, high groundwater table, soft soil conditions, and flat grades contribute to stormwater stagnating and its inability to discharge out into the Fraser River. As such, it will be necessary to ensure that there is enough storage capacity available in the drainage system in this area to manage the large volume of stormwater at hand. We recommend that the current open-ditch concept system be maintained, which will allow for more volume capacity than a piped system. Re-grading and increasing maintenance of clearing debris and vegetation in ditches prone to flooding to increase storage capacity may help water conveyance and limit floodwaters to be within ditches and away from residential front yards. With the scarcity of available land and poor soil conditions, any means of constructing a separate detention pond or underground storage facility will be costly and not feasible.

9.4.2 Retention of Ditches

It is recommended that the open-ditch system remain so as to slow down stormwater runoff velocity, attenuate peak flow, allow for stormwater infiltration when possible and provide storage capacity. Because ditches are a critical component in the drainage servicing strategy for the study area, all efforts to ensure that un-sanctioned filling or removal of these ditches are recommended. There are a number of benefits that roadside ditches provide and opportunities to improve water quality, conveyance, and overall aesthetic appeal are discussed in Section 13 Implementation Plan.

There is an opportunity to improve drainage capacity along 124 Street when the new Pattullo Bridge is to be constructed. Current alignment plans are for the Pattullo Bridge to enter/exit from Surrey at 124 Street. The open-ditch along 124 Street is to remain open and there may be an opportunity to increase storage capacity here.

Separate to this ISMP, it is recommended that a detailed drainage study (specifically the lowland area west of Bolivar Creek within the Bridgeview community) be completed after the SFPR construction is finished. As well, the recommended study should include a comprehensive environmental assessment to re-map and classify watercourses and a topographic survey to identify street profiles, ditch cross-sections, inverts, and locations where open channels have been infilled, re-aligned, altered, or eliminated due to the SFPR construction

The implementation of BMP measures highly depends on the type of land use and what parameters we are trying to achieve (water quality, volume control, peak flow attenuation). If we look at the overall Bridgeview-North Slope land usage, we can see that there are 3 distinct regions that would require specific BMP approaches:

- West Area (124 St, Royal City, 128 St catchments): Industrial/commercial and single family residential
- Middle Area (Bolivar Creek catchment): High urban commercial and industrial downstream, single family residential
- East Area (137A St, Bedford): Mainly single family residential

The Bolivar Creek catchment which encompasses the Surrey City Centre Land Use Plan will be guided by the BMP strategy provided within the utility servicing strategy report that was completed in 2010 by AECOM. BMP strategies for the west and east areas will be looked at in more detail under Section 11.6 Best Management Practices and Section 11 Implementation Plan.

9.4.3 Royal City Pump Station

There may be an opportunity to reduce flooding by adjusting the start level of the Royal City Pump Station to begin pumping at a lower elevation. However, this would increase the duration of pump cycling and currently the model is showing that under the 100-year event the pump is on for several hours in order to keep up with the incoming flows. Currently, this pump station has two submersible propeller pumps in place with 1 m3/s capacity for each pump.

Therefore, to meet a 100-year level of service it is recommended that this pump station be upgraded to have a total capacity of 3.56m3/s at 3m total dynamic head (TDH). With this said, the pump station must also take into account future dyke elevations that will reach up to 5m. As such, it is recommended that for the upgrade a pump be selected in which, based on its pump curve, have a capacity to operate up to a 5m TDH and a flow of 3.56m3/s.

9.4.4 Flood Construction Level

The majority of the existing lot elevations within the low-lying Bridgeview area range between 1.0 to 4.6m geodetic. Previously, new homes or buildings were required to meet an elevation of 2.75m for flood proofing purposes. However, the BC Provincial regulation now mandates the flood construction level (FCL) be 4.5m above sea level.

Therefore, any re-building in this area cannot be constructed at lower elevations and filling will be required which will have impacts to drainage. Although the study area is considered to be fully built out, there are occasional re-development applications in which new buildings and structures should meet this FCL requirement.

9.4.5 Dyke Extension and Future Bolivar Creek Pump Station

Currently, the City dyke is set at 4.8m geodetic elevation (4.2m river water level plus 0.6m freeboard). Only the western portion of the study area up to 132 Street is dyke protected. The City and Provincial Government are working to extend the dyke eastward towards the Port Mann Bridge and the ultimate alignment is still yet to be established, although it is known that the new dyke will be constructed to a 5m elevation with capability to be raised in the future. With this new dyke there will be a need to provide the area with a second pump station (Bolivar Creek Pump Station) for flood protection purposes. The future pump should be constructed so as to be fish passable.

From the various scenarios, peak flows were obtained at the Bolivar Creek Outfall for the 24-hour long duration winter storm condition and is summarized in Table 9.9. The node elevation at 116 Avenue and Bolivar Creek is at 2.7m.

Table 9.10 Bolivar Creek Outfall Peak Flows

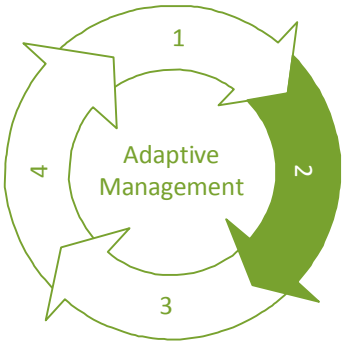
Storm Event	Peak Flow (m^3/s)	Head (m)
1-Year	3.09	4.50
2-Year	3.81	4.54
5-Year	4.07	4.57
10-Year	4.23	4.62
100-Year	4.73	4.67

It is recommended that the future Bolivar Pump Station has a capacity to operate up to a 5m TDH and a flow rate of 4.73 m3/s. This station should also have a configuration of three pumps along with one standby pump.

Stage 2

What Do We Want?

Establishes the vision for future development



10 Vision and Goals

10.1 Overview

Once a firm understanding of the opportunities and challenges of the study area was developed, the next step in the ISMP process was to answer the question "What do we want?" by defining a future vision and setting goals for the ISMP to achieve this vision. Identification of a vision and goals for the study area was performed through two methods: community engagement and workshops with internal stakeholders, such as the City's maintenance and engineering teams.

10.2 Community Engagement

From 2005 to 2007, the Bridgeview community was part of an Action for Neighbourhood Change (ANC) project initiated by the United Way of the Lower Mainland's (UWLM) perspective on community development. Since 2000, UWLM has been supporting community members in proactively bringing together residents, municipalities, agencies, and stakeholders to explore issues in high need areas.

The Bridgeview area was selected based on having an identified community already in place, immediate issues that require action and collaboration with agencies outside the community members, and the readiness and willingness of the community to adopt change in order to improve liveability.

In the 2007 report that chronicles the Bridgeview ANC project in its second year, it was evident that the defining physical features of the area were quiet residential streets without curbs or sidewalks, and large drainage ditches. Some comments and feedback collected from residents at the time are summarised below.

Figure 10.1 Community feedback from 2007 ANC Report

There was evidence that many Bridgeview residents seek to have the ditches enclosed to improve safety and aesthetic values, as the ditches reportedly accumulate garbage, debris and stagnant water which is prone to algae formation.

10.3 Internal Workshops

A workshop was held with key City staff to identify and refine the City's long-term goals for the study area. The workshop was held on October 15, 2012, and involved staff from the drainage, environment, planning and parks departments of the City, as well as project team members from AECOM and Phoenix Environmental Consultants. Minutes of the workshop are provided in Appendix C.

It was quickly identified by the workshop group that the majority of immediate issues within the study area are located within the Bridgeview community. While other watersheds in the ISMP study area had concerns such as the presence of erosion and scour in streams, creek setback encroachments, and soil stability, items of concern in the Bridgeview area were identified by City Engineering, Operation & Maintenance, and Planning Departments as the priority.

An overview of findings as well as confirmation on the key issues identified was presented to the City. Afterwards, City staff members were asked what they felt were important goals they would like see happen in the study area. Some comments that were noted in the workshop were:

- Classification of watercourses should be confirmed and updated due to the amount of disruption that the South Fraser Perimeter Road (SFPR) is having on the overall flow regime in the study area
- A new culvert at Southward Creek should be fish passable; however from Phoenix Environmental's field review it did not look passable. It was suggested that once SFPR is completed that this culvert be checked accordingly
- It was observed that a large amount of groundwater was coming off the escarpment. Therefore, it is recommended that the escarpment be kept forested so that there will be continual base flow throughout the dry summer periods and enhance the environmental conditions in this area
- City staff noted higher winter storm surges causing higher tide elevations in this area
- The City is planning to extend the dyke eastward to be constructed at a 5.0m elevation with the possibility of raising this in the future
- There are several critical ditches that must remain open for storage capacity
- Regarding the future Pattullo Bridge and impacts it may have to the Bridgeview and City Centre area. The main ditch along 124th Street is to be maintained as an open channel.
- Due to the number of major projects underway or being planned in the area, it was agreed that formalizing a public outreach strategy be re-visited at a later date so as to not confuse residents
- The group agreed that there needs to be some cohesiveness in terms of how this area transitions the land-use forms in City Centre to the industrial lands fronting the Fraser River
- Any best management practices (BMPs) promoting infiltration should be setback from the escarpment so as to not undermine the slope stability with inundation of groundwater
- The area has poor water quality due to road and garbage pollution entering the open-ditch system, as well as stagnant water in ditches heating and forming algae. Existing soil conditions and the occurrence of soil filling in the past have also attributed to poor water conditions
- The City mentioned that the streets need to be more appealing, and that residents have complained about the roadside ditches becoming overgrown and unsightly due to garbage accumulation
- The group agreed that there are some key issues that must be addressed immediately, while other key issues are more long-term goals that will take time to implement.

10.4 Findings

Several common themes were identified through both the community engagement and internal workshop processes. The themes common to both parties included:

- improving drainage
- preserving the scarce environmental value
- improving water quality and aesthetic appeal of ditches
- promoting community awareness in the Bridgeview area

The sentiment of the City staff and the community was found to differ on the issue of roadside ditches, where the community generally sought to have them removed, however the City staff appreciate the need to retain the ditches in order to maximise hydraulic storage. There is an opportunity to appease both parties through regular, effective maintenance of the roadside ditches to improve their aesthetic appeal, and improve hydraulic capacity.

10.5 ISMP Goals

The goals of the City staff and the expectations of the Community were collated and summarised into a series of goals that the ISMP shall seek to achieve. The summarised goals for the ISMP are as outlined in Table 10.1.

Table 10.1 Goals of IMSP

Discipline	Goals
Drainage	- Address local flooding - Improve conveyance and storage capacity of stormwater runoff - Properly implement BMPs to maintain base flows, attenuate peak flows, and manage the volume of stormwater runoff - Provide flood protection levels for lowland areas that will also account for climate change (New dyke extension, new drainage pump station)
Hydrogeological	- Protect the stability of the escarpment along the North Slope - Protect and maintain the forested area along the escarpment to manage base flows and provide structural slope strength - Management of settlement due to the large presence of peat
Environmental	- Protect the health of critical Class A, AO, and B watercourses - Protect riparian areas and enforce setback limits to protect fisheries habitat - Improve water quality in streams - Mitigate erosion and scouring in streams - Protect and maintain areas that have environmental value - Due to several major projects occurring or planned for in the area, a comprehensive environmental assessment and watercourse re-classification mapping should be completed
Planning	- Have a cohesive, unified, treatment of neighbourhoods and streets to improve aesthetic appeal and livability - Removal of garbage and debris, have stricter enforcement for unsightly properties - Reduce crime, theft, and vandalism in the area - Stronger boundaries between residential neighbourhoods and industrial/commercial areas

10.6 Vision Mission Statement

A vision statement was formulated based on the goals of the community and City staff. The mission statement that describes the vision of the Bridgeview – North Slope ISMP is:

> *"Create a healthy, clean and safe community environment by managing stormwater quality and quantity, protecting watercourses and natural resources that will improve liveability and appeal"*

This statement connects the concepts of proper drainage conveyance, stormwater storage capacity, water quality, and protect creeks and fish habitat in order to improve the health of the environment and sentiment in the community.

10.7 Summary

The expectations for the study area were established through community engagement and internal workshops with City staff. The two groups agreed on improving drainage, preserving remaining environmental values, improving water quality and aesthetic appeal of ditches, but differed in their preferred approach to the roadside ditches.

A list of goals for the ISMP were compiled based on the findings of the community engagement and internal workshops. The goals were further refined into a vision for the ISMP

Vision Statement

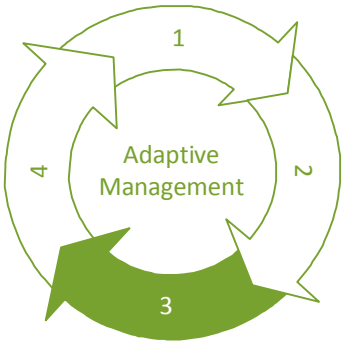
Bridgeview – North Slope
Integrated Stormwater Management Plan

"Create a healthy, clean and safe community environment by managing stormwater quality and quantity, protecting watercourses and natural resources that will improve liveability and appeal"

Stage 3

How do we put this into action?

Develops an implementation plan, with funding and enforcement strategies



11 Implementation Plan

11.1 Overview

Once the goals and expectations of the ISMP were established, the next step in the ISMP process was to answer the question "How do we put this into action?" by developing an implementation plan with the focus on delivering those goals.

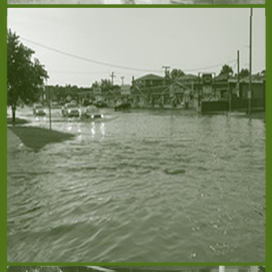
The implementation plan comprises of two main components: action plans and capital works. Action plans were typically focussed around non-tangible goals such as policy change, and capital works were identified for tangible changes such as stormwater capacity upgrades.

11.2 Action Plans

Nine (9) action plans were compiled to achieve the ISMP goals as identified in Table 10.1. Each action plan contains components as summarised in Table 11.1 below.

Table 11.1 Components of Action Plans

Component of Action Plan	Description of Component
Objectives	- Summary of the main objectives of the action plan
Participants	- Parties that will need to perform actions to achieve the objectives of the action plan. - May include City departments, external agencies, and community groups
Background	- Background information on the reasons and drivers behind the action plan
Opportunities and Constraints	- Key items to be considered during the delivery of the action plan
Recommended Actions	- Clearly stated actions that need to be implemented in order to achieve the objectives
Relevant Policies and Legalisation	- Legislation or planning documents that the action plan will need to comply with, or may be used as an instrument to support the action plan
Time Frame	- Achievable time frame for delivery from commencement of action - Classified into short-term (< 5 years), medium-term (<10 years) or long-term (>10 years)
Map	- Map of study area identifying specific areas in which to apply the implementation plan for the goal - Maps not included for Action Plans that relate to the entire study area



Action Plan 1
Manage Local Flooding

Objectives

- Protect life and property
- Mitigate local nuisance flooding, road blocks and accessibility issues
- Improve conveyance and storage of stormwater runoff and floodwaters

Participants

- Drainage & Environment Section
- Design & Construction Division
- Operations & Maintenance Division

Background

- The Bridgeview area has chronically experienced nuisance flooding in localized areas causing inaccessibility issues and safety hazards. From discussions with Surrey Operations & Maintenance staff and from AECOM works in the Bridgeview area, flooding incidences have been known to occur at:
  - 112 Avenue and 124 Street - water levels reach up to residential front yards, however to date there has been no flood damage to these buildings;
  - 125A Street Between 113B and 114 Avenue – 125A Street adjacent to property 12541 previously had an existing ditch which has now been filled in with no culvert, causing runoff from the back lane to pool and not be conveyed into the ditch along 125A Street; and,
  - 112A Avenue between 126A and 128 Street – Surface flooding here near the existing gas station is caused by road re-paving from the construction of the sanitary low pressure sewer system in the area.
- It is important to note that the large ditches running south to north along 124 Street and 125A Street continually have water present in them throughout the year; however the HGL does not reach high enough to overtop the ditch.
- Historically, City crews have had to put up road blocks due to floodwaters making their way to streets and impacting accessibility. The City receives several complaints from residents regarding inaccessibility and nuisance due to improper conveyance of floodwaters.
- There are approximately 2 kilometres of open ditches and canals that provide a significant amount of storage capacity to manage runoff volume and backwater effects. During peak rainfall events, the routing of stormwater runoff into these open channels helps attenuate peak flows by increasing time of concentration (i.e. increasing travel time) and decreasing velocity.

Opportunities and Constraints

- Challenge is to provide enough storage capacity for floodwaters in the open-ditch system and provide pedestrian and vehicle safety. Enclosing all the ditches and providing an underground drainage system with enough storage capacity is costly to construct and would require additional land acquisition. Because the Bridgeview area is well-developed with scarce open green spaces remaining, widening major collector ditches and canals or constructing an additional storage facility is difficult with the restricted land available.
- Re-grading and increasing maintenance of clearing debris and vegetation in ditches prone to flooding may help drainage conveyance and limit floodwaters to be within ditches and away from residential front yards.

- There may be an opportunity to improve flooding by adjusting the start level of the Royal City Pump Station to pump at a lower elevation. However, this would increase the duration of pump cycling and adjusting float levels in the Royal City Pump Station may only alleviate the surrounding areas and may not affect areas south of 113A Avenue and west of 125A Street where water does not have a well-defined flow route to the pump station.
- There may be locations where culvert inverts are higher than ditch inverts can be lowered to improve conveyance. However, the difference in inverts between ditches and culverts is also due to the presence of soft soils which is a challenge and continued movement is expected.
- The current alignment plan for the future Pattullo Bridge from Surrey at 124 Street is for the open-ditch along 124 Street to remain open.
- The City has experienced un-sanctioned ditch filling within the area, which affects the drainage network system and overall storage capacity. Because ditches are critical in providing drainage conveyance, storage, infiltration measures, and in some cases are classified as fisheries sensitive, it is paramount that any illegal ditch enclosure be prohibited. The City has in place a ditch enclosure/open application process in which permit application and approval is required prior to ditch filling or opening.
- Currently, BC Provincial regulation mandates the flood construction level (FCL) be 4.5m above sea level. Therefore, any re-building in this area cannot be constructed at lower elevations and filling will be required which will have impacts to drainage.

Recommended Actions

- Recommend that the current open-ditch concept system remain
- Increase maintenance of clearing debris and vegetation in ditches prone to flooding to increase storage capacity and help water conveyance and limit floodwaters to be within ditches and away from residential front yards
- Complete road re-surfacing at 112A Avenue to aid in reducing surface flooding
- Install culvert at 125A Street between 113A Avenue and 114 Avenue
- Ditch along 124 Street to remain as part of the new Pattullo Bridge project.
- Continue improvements that have been identified in the current City of Surrey 10-Year Capital Work Plan

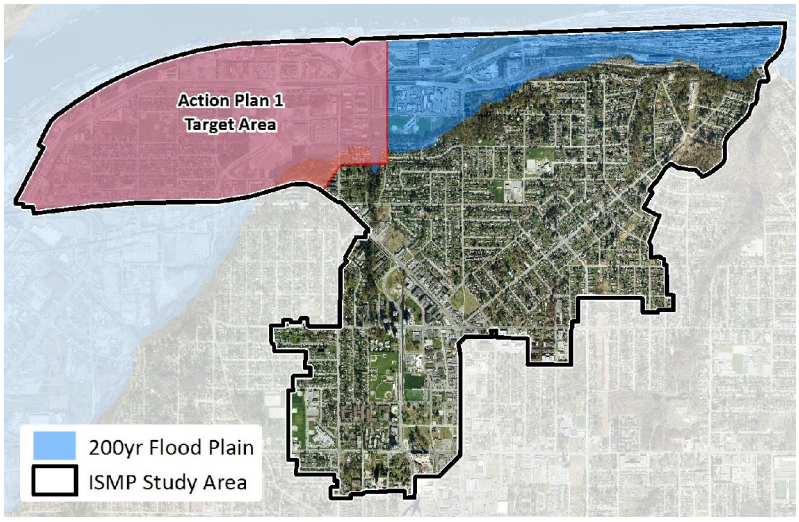
Policies and Bylaws

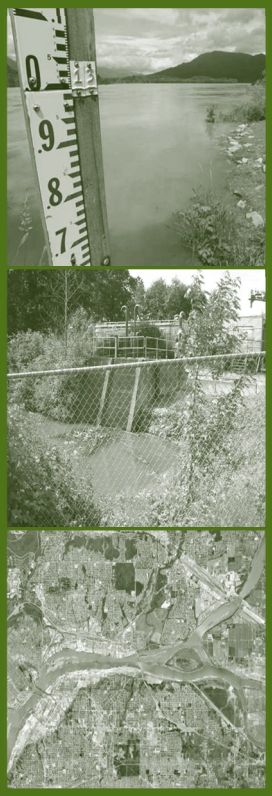
- Surrey Stormwater Drainage Regulation and Charges Bylaw 16610
- Surrey Soil Conservation and Protection Bylaw 16389
- Floodplain Policy

Time Frame

Immediate (within 5 years) if action were to be taken now

Map





Action Plan 2

Increase Fraser River Flood Protection

Objectives

- Protect life and property
- Provide flood protection to areas susceptible to flood inundation
- Manage floodwaters and the impacts of climate change on Fraser River water levels

Participants

- Drainage & Environment Section
- Design & Construction Division
- Provincial Agencies (DFO, MFLNRO)
- Businesses and stakeholders located within the new alignment

Background

- The Bridgeview-North Slope contains approximately 290 hectares of lowland area that is within the 200-year Fraser River flood plain level. Of this area, 178 hectares from the Pattullo Bridge to 132 Street are dyke protected while 112 hectares east of 132 Street that is currently not dyke protected.
- Drainage in the lowland area is currently managed via two floodboxes on 124th and 128th Street and the Royal City Pump Station. However, there may be a need to upgrade the Royal City Pump Station or to add a new pump station in order to manage flooding.
- Recently, municipalities are recognizing that there is a need to understand how climate change is impacting Fraser River tide levels. The City has observed a trend of recent winter storm surges causing higher tides in this area.
- The City is currently planning to extend dyke protection east of 132 Street for flood protection. There may also be a need to construct a new drainage pump station.

Opportunities and Constraints

- Challenges for this goal include being able to meet current Provincial requirements for dyke design. Specifically, new design criteria for seismic requirements brings forth several other issues such as securing funding to upgrade dykes and securing property needed for upgrades
- Another challenge to dyke upgrading is reviewing the servicing requirements behind the dykes and how this will affect current drainage infrastructure
- Currently, Provincial regulations set the flood construction level (FCL) to 4.5m. Therefore, any re-development in the area cannot be built below this level.

Recommended Actions

- The City is currently pursuing a new dyke extension eastward from 132 Street to provide increased flood protection to properties along the Fraser River. This new dyke would also provide protection to specific CN Rail buildings as well as the South Fraser Perimeter Road. This dyke would be built to a design elevation of 5.0m with the ability to be raised in the future
- Upgrade Royal City Pump Station from its existing capacity of 1.18 m3/s to 3.56 m3/s at a TDH = 5m to incorporate the new dyke works and provide a 100-year return period level of service.

- Depending on the alignment of the proposed dyke extension there will be a need to provide the area with a second pump station (Bolivar Creek Pump Station) for flood protection purposes since the dyke will cross Bolivar Creek. Therefore, it is recommended that the future Bolivar Pump Station be built to have a capacity of 4.73 m3/s at 5m TDH based on a 100-year return period level of service.
- Metro Vancouver is also planning for future twinning of the North Surrey Interceptor sewer within the area. As the design of the dyke extension and Bolivar Creek Pump Station progresses, it is recommended that both be constructed within the same timeframe so as to minimize any addition disturbance to the area

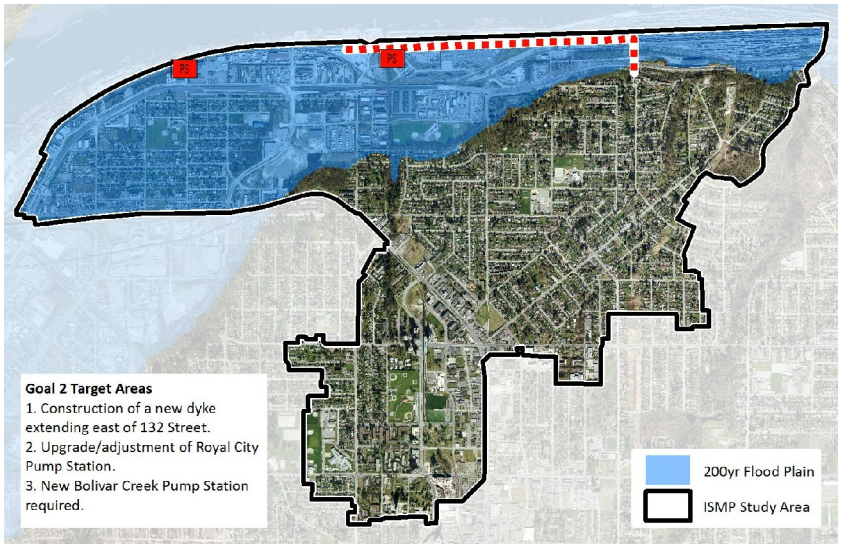
Policies and Bylaws

- Surrey Stormwater Drainage Regulation and Charges Bylaw 16610
- Ministry of Forests, Lands, and Natural Resource Operations (MFLNRO) Seismic Design Guidelines
- Floodplain Policy
- Sea Dyke Guidelines
- Lower Fraser River Study

Time Frame

Immediate (within 5 years) if action were to be taken now

Map



Action Plan 3
Protect & Enhance Water Quality

Guiding Principles

- Improve water quality in waterways and drainage systems
- Prohibit fouling and pollution
- Prevent/reduce presence of algae in ditches and streams
- Improve overall community aesthetic appeal and livability

Participants

- Drainage & Environment Section
- Operations & Maintenance Division
- Community Involvement

Description

- The Bridgeview-North Slope area has chronically experienced poor water quality. With the highly urbanized City Centre to the south, the heavily utilized industrial lands to the north, and existing peat soils, stormwater runoff picks up a plethora of contaminants and debris as it flows throughout the system. In addition, several known contaminated sites exist in the study area and are concentrated mainly within the industrial areas. The SFPR construction has also aggravated water quality issues due to construction activities and increase in vehicles and machinery. Therefore, measures to prevent or reduce the amount of pollution generated by point source and non-point source pollution are critical in the study area.
- In addition, residents and City staff have concerns over the presence of algae within the highly visible ditches. With the flatness of the lowland area coupled with high groundwater and poorly shaded ditches, stagnant water in the open-ditch systems begin to warm up causing algae growth to accelerate. While some forms of algae are natural and essential to an ecosystem, it can also have ecological, aesthetic, and human health impacts if not monitored and controlled. Overgrown algae can have nuisance effects such as foam accumulation, scum formation, and reduce the capacity for ditches to properly convey water.
- The lower elevation portions of the Bridgeview area are primarily industrial and have been for many decades. There are a number of known contaminated sites in this area and there is considerable potential for there to be more sites than those that are listed on the BC Contaminated Site Registry. From investigations into contaminated sites within the study area, it is recommended that if the City elects to thoroughly assess this item then a comprehensive study beyond the ISMP should be completed.
- Due to the significant concern expressed by residents and the City with regards to the poor water quality conditions in the industrial lands and in the highly visible ditches within the residential areas, this issue is brought forward in this ISMP as its own standing goal to ensure specific efforts are focused on improving water quality.

Opportunities and Constraints

- The three principles in improving water quality are:
  - Prevention – Avoid generating pollutants
  - Reduction – Minimize the amount of pollutant entering into the system
  - Treatment – Capturing and treating pollutants

- The easiest and most cost-effective way to improve water quality is through prevention. Increasing community awareness to eliminate littering, dumping, and polluting into the drainage system along with proper management of residential fertilizer applications may be the quickest ways to protect the water quality in streams.
- Reduction and treatment of contaminated stormwater runoff can be in forms of structural BMPs that promote source controlling such as infiltration trenches, rain gardens, and bioswales. These BMPs would capture rain immediately when it is the cleanest and direct it into the ground for base flow re-charge.
- With the Surrey City Centre Land Use Plan, AECOM completed a 2010 Surrey City Centre Land Use Plan Update Utility Servicing Strategy that included a BMP strategy for the City Centre area. Since this LUP covers the upstream portion of the Bolivar catchments, there is opportunity for improved water quality entering the downstream system if this BMP strategy is properly implemented. The strategy defined locations for water quality facilities and on-site stormwater detention to aid in runoff volume reduction as well as the Bolivar Creek diversion.
- Preventative strategies will require long-term community involvement and acceptance. As such, there must be a proactive effort to provide clear and concise information and get public buy-in for any program to be sustainable.
- Business owners, residents, and operators should be comfortable in agreeing to requirements set out in a water quality management program.
- Any structural BMP implemented must be properly maintained and a monitoring plan should be completed to gain feedback.
- Due to the high groundwater table in the lowlands and the need to protect the slope stability of the escarpment along the North-Slope, careful consideration must be provided to ensure any BMPs promoting infiltration be strategically placed away from steep sloped areas and locations where groundwater is already day-lighting

Recommended Actions

- The Bolivar Creek catchment which covers the mid-region of the study area will be guided by the Surrey City Centre BMP Strategy. Recommend implementing BMP measures identified in the 2010 Surrey City Centre Land Use Plan Update Utility Servicing Strategy by AECOM, which includes water quality facilities and on-site stormwater detention.
- The west area would require the open-ditch system to remain in place for hydraulic storage capacity purposes. However, because of public concerns regarding the look and safety of these ditches, if some of the minor ditches are to be enclosed BMP measures such as vegetated swales and rain gardens may be a viable solution in aiding water quality and slowing down stormwater runoff. Rain gardens may also provide aesthetic appeal to the community in addition to its stormwater function. As well, garbage and debris in the area can be addressed with more garbage bins and community awareness programs.
- The east area, being mainly single family residential, would have disconnected roof leaders, rain gardens, cisterns and rain barrels as potential forms of BMPs. Careful consideration must be made to BMPs that promote infiltration in this area since slope stability along the escarpment must be protected, and any additional flows to groundwater may cause undermining. To help maintain slope integrity and also provide critical environmental value to the area ,the forested buffer along the escarpment should be protected and maintained.
- Stricter enforcement to prevent/reduce polluting of watercourses and drainage systems by residents, businesses, and the industrial areas
- Implement non-structural BMPs such as public outreach programs, stewardship, and community awareness

Table 11.2 BMP Strategy by Area

Area	BMP Strategy
West (124 St, Royal City, 128 St)	Open-ditch system to be maintained Minor ditches can be replaced with curb and gutter along with vegetated swales or rain gardens Disconnected roof leaders Cleanup of garbage and debris through more garbage collection bins and public awareness programs
Middle (Bolivar Creek)	Guided by the Surrey City Centre BMP Strategy (2010, AECOM)
East (137A St, Bedford)	Disconnected roof leaders Rain gardens Rain barrels / cisterns Protection and maintenance of the forested buffer along the escarpment

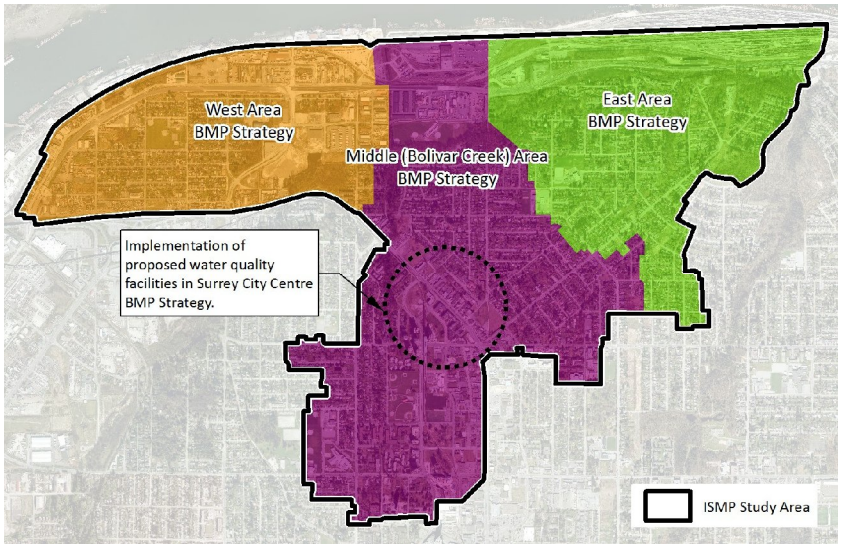
Applicable Policies and Bylaws

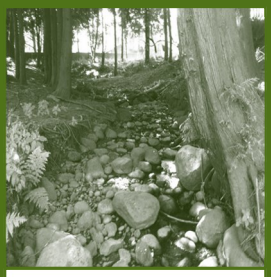
- Surrey Stormwater Drainage Regulation and Charges Bylaw 16610
- Surrey Property Maintenance and Unsightly Premises Bylaw 16393
- Surrey Nuisance Bylaw 12883
- Surrey Sanitation Bylaw 3052
- Surrey Garbage & Waste Disposal Regulation Bylaw 3495
- Surrey Sustainability Charter

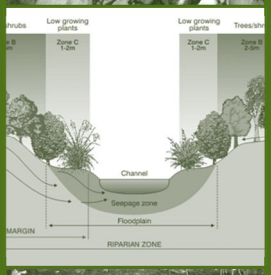
Time Frame

Immediate (within 5 years) if action were to be taken now

Map







Action Plan 4

Protect, Preserve and Enhance Stream Health and Fisheries Habitat

Guiding Principles

- Protect fisheries habitat and riparian areas to promote healthy streams.
- Mitigate creek erosion and scouring in watercourses.
- Promote fish migration and remove existing fish barriers and obstructions.
- Protect water quality in streams.
- Attenuate peak flows and maintain base flows in streams.

Participants

- Drainage & Environment Section
- Provincial and federal agencies (DFO, MFLNRO)
- Community Involvement

Background

- The ravine watercourses and most of the Class B constructed channels have been observed to provide good quality fish and wildlife habitat. However, detrimental impacts to watercourses continue to occur including: erosion and scour, fish migration barriers, damaged riparian habitat and poor water quality.
- Several “Class A” red-coded creeks are currently experiencing erosion. The Bolivar and Dingwall Creek diversions have been installed to bypass high flows around the steep slopes and ravines on the North Slope area of the study area. Field observations and long term monitoring reports indicate that the high flow bypass diversions have resulted in relatively good stream stability.
- Several barriers to upstream fish migration have existed for many years (e.g. CN Rail yard) such that all of the ravine streams are not fish accessible within the North Slope area; with the exception of Bolivar Creek, which is fish accessible to King George Boulevard. Depending on completion of the South Fraser Perimeter Road, there appear to be opportunities to restore fish access into some streams along the North Slope area (e.g. Southward Creek).
- Riparian habitat damage from refuse disposal and long-term structures built at or very close to watercourse banks and ravine crests occurs extensively throughout the study area.
- Currently there are plans to construct diversions for Alexandra Creek and Wellington Creek in order to bypass areas of known erosion occurrence.

Opportunities and Constraints

- Currently the City has plans to construct diversion sewers for Alexandra Creek and Wellington Creek which will divert high flows downstream and attenuate peak flow events to mitigate further erosion. These diversions will also direct low flows into the creek to maintain base flows and support fish habitat and nutrients.

- Several opportunities to repair riparian damage and improve water quality in streams were identified in the environmental assessment completed by Phoenix Environmental.
- Due to the large impact in which the South Fraser Perimeter Road project is having on the overall drainage flow regime, several watercourses were found during field reconnaissance that are un-mapped.
- For future major projects planned in this area, there may be opportunities to implement larger setbacks from creek top of banks or environmental compensation works.
- Because the study area is experiencing a large amount of disturbance from the South Fraser Perimeter Road construction along with several other major projects already planned for this area, it will be critical to ensure existing streams and riparian corridors are not negatively impacted.
- Several major projects (SFPR, Metro Vancouver twinning of the North Surrey Interceptor, and the Kinder-Morgan Pipeline) will cause disturbance and possible elimination of major open channels and streams which will impact the overall flow regime for the study area.

Recommended Actions

- A complete re-mapping and re-classification of all watercourses in the study area is recommended once the SFPR construction has been completed,
- Diversions for Alexandra Creek, and Wellington Creek are recommended to mitigate erosion and protect creek health.
- Remove fish barrier identified at 116A Avenue and 130 Street and fish obstruction identified at 116 Avenue and 132 Street.
- Recommend stricter enforcement to prohibit any fouling, dumping, or polluting of watercourses.
- All Class A, AO, and B watercourses shall be protected, else compensation works shall be provided.
- All Class A and AO watercourses shall have a minimum 30m setback from top of bank.
- All Class B watercourses shall have a minimum 15m setback from top of bank.
- Recommend assessing locations where setbacks from top of bank greater than 30m are necessary in order to protect aquatic habitat and stream health.

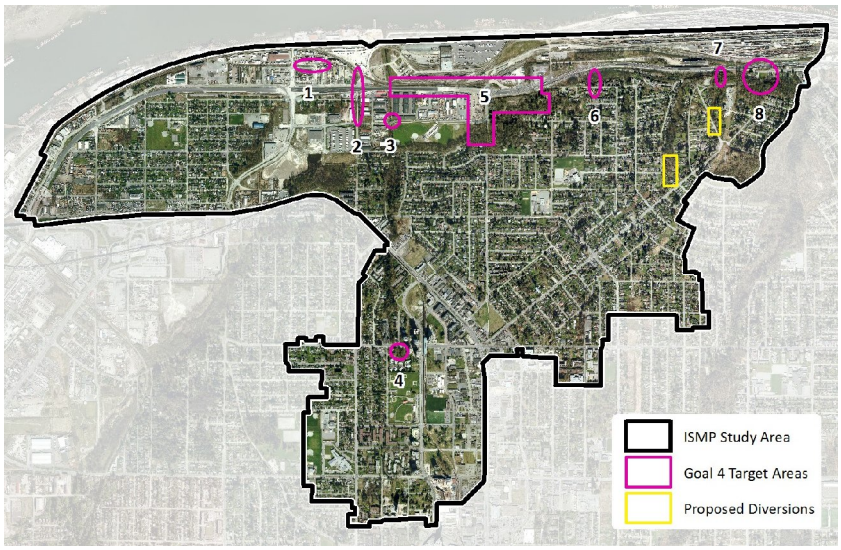
Applicable Policies and Bylaws

- Surrey Stormwater Drainage Regulation and Charges Bylaw 16610.
- Surrey Erosion and Sedimentation Control Bylaw 16138.
- Surrey's Watercourse Classification Mapping.
- Surrey's Ecological Mapping Study (EMS).
- Surrey Sustainability Charter.
- Fisheries and Oceans Canada "Land Development Guidelines for the Protection of Aquatic Habitat".
- Provincial Fish Protection Act.
- Federal Fisheries Act.
- Streamside Protection Regulation.

Achievable Time Frame

Medium range (within 10 years) if action were to be taken now

Map



Goal 4 Target Areas (Map Ref.)

1. 116A Ave. at 130 St. - Opportunity to improve riparian area and water quality. Currrently a barrier to upstream fish movement.
2. 132 St. at 116 Ave. - Potential fish obstruction at 132 St.
3. Bolivar Creek at 115 Ave. - Litter and refuse found. Opportunity to improve water quality.
4. Bolivar Creek at 108 Ave. - Evidence of stream erosion, scour, and riparian damage.
5. 116 Avenue - Tributary courses disturbed or eliminated due to South Fraser Perimeter Road.
6. 139A Watercourse - Watercourse re-mapping and re-classification required.
7. Wellington Creek West Reach - Watercourse re-mapping and re-classification required.
8. Wellington Creek East Reach - Watercourse re-mapping and re-classification required.

Unmapped watercourses at 136 Street. Watercourse re-mapping and re-classification required.

Action Plan 5
Protect Escarpment Integrity

Objectives

- Protect and maintain the integrity and slope stability of the North Slope escarpment.
- Ensure proper management of base flows through the escarpment to prevent upward hydraulic gradient at toe of slopes.
- Protect and maintain the surrounding forested area along the escarpment to control base flows and slope strength.

Participants

- Drainage & Environment Section
- Design & Construction Division

Background

- The Bridgeview lowland area has high groundwater levels that are near ground surface which limits the potential for infiltration. Increasing infiltration near the toe of steep slopes can lead to a rise in hydraulic gradients that may lead to a decrease in slope stability.
- As such, infiltration measures are limited, specifically in the lowlands, due to the need to protect the North Slope escarpment and also minimize the risk of groundwater contamination in the lower industrial areas. Therefore measures to increase infiltration should be restricted to areas that are not near steep slopes

Opportunities and Constraints:

- The need to protect the integrity of the escarpment along with surrounding forested areas will ensure a buffer exists between uplands and lowlands. Presently, there is approximately 60 to 65 ha of forested/green space area along the escarpment that is considered to be either ecosystem sites or terrestrial hubs that must be protected. (Ecosystem Management Study by HB Lanarc, April 2011)
- It is important to not over-infiltrate stormwater runoff near the escarpment. Therefore, BMPs promoting infiltration should be implemented away from steep sloped areas.

Recommended Actions

- Recommend preservation of existing forested area along the escarpment. Any BMPs promoting infiltration are to be implemented a minimum of 30m away from the escarpment setback boundary.

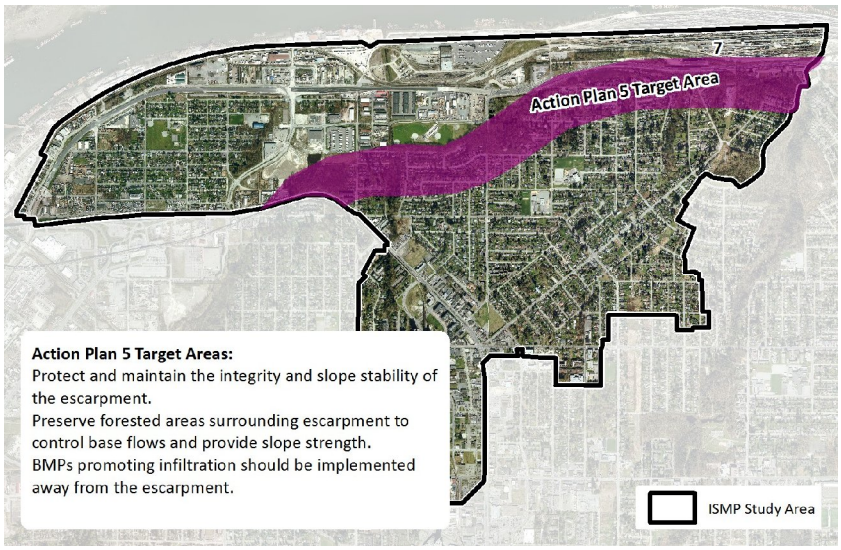
Applicable Policies and Bylaws

- Surrey Stormwater Drainage Regulation and Charges Bylaw 16610
- Surrey Soil Conservation and Protection Bylaw 16389

Achievable Time Frame

Immediate (within 5 years) if action were to be taken now

Map


Action Plan 5 Target Area
Action Plan 5 Target Areas:
Protect and maintain the integrity and slope stability of the escarpment.
Preserve forested areas surrounding escarpment to control base flows and provide slope strength.
BMPs promoting infiltration should be implemented away from the escarpment.
ISMP Study Area

Action Plan 6

Protect and Preserve Green Space and Wildlife Habitat

Objectives

- Protect and preserve green space areas and ecosystem sites, hubs, and corridors that support wildlife habitat.
- Protect and preserve forested areas located along the North Slope escarpment to help maintain slope stability and control base flows.

Participants

- Drainage & Environment Section
- Planning & Development Department
- Parks, Recreation, and Culture Department

Background

- There are few fragmented forested areas remaining that still have environmental value and must be preserved amidst the urban development and major projects underway. From Phoenix Environmental's assessment, no sensitive plant or animal species were detected during the field program, although several sensitive species such as Great Blue Heron, Trowbridge's Shrew, Pacific Water Shrew, and Streambank Lupine may be present.
- Remaining forest patches must be protected and wildlife movement corridors need to be maintained to improve the ecological integrity of the study area. These green spaces provide necessary living habitat for a number of species. Ensuring the preservation of these natural habitats will result in increased biodiversity and health in the study area.

Opportunities and Constraints

- As development continues in the study area, there may be opportunity for environmental compensation works to strengthen boundaries of forested area.
- Several of the major project underway or planned for the area cut across some of the forested hubs where tree removal may be required.

Recommended Actions

- Continue to protect sensitive and ecological corridors, sites, and hubs that are of environmental significance as identified in City's Ecosystem Management Study, and shown in action plan map
- Further protection and preservation of green space areas and locations identified as having environmental value.
- Potential for environmental compensation works as part of future major projects planned for the study area.

Applicable Policies and Bylaws

- Surrey Stormwater Drainage Regulation and Charges Bylaw 16610
- Surrey Erosion and Sedimentation Control Bylaw 16138
- Surrey's Watercourse Classification Mapping
- Surrey's Ecosystem Management Study (EMS), April 2011

- Surrey's Biodiversity Conservation Plan (BCP)
- Surrey Sustainability Charter
- Fisheries and Oceans Canada "Land Development Guidelines for the Protection of Aquatic Habitat"
- Provincial Fish Protection Act
- Federal Fisheries Act
- Riparian Areas Regulation

Time Frame

Medium range (within 10 years) if action were to be taken now

Map

Target areas shown on map over page

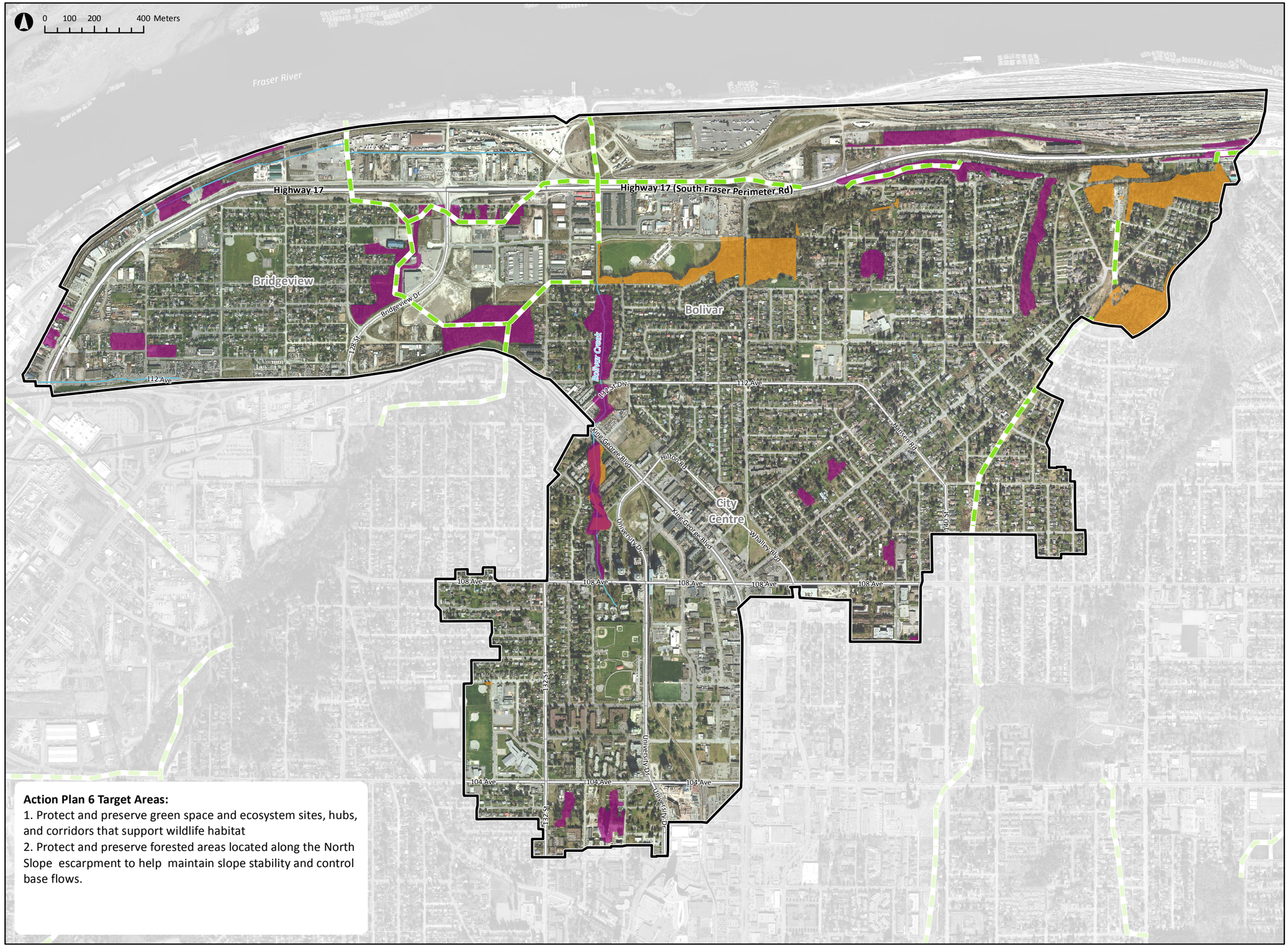
CITY OF SURREY
the future lives here.

Project
Bridgeview - North Slope ISMP

Map
Action Plan 6 Target Areas

Legend

- ISMP Study Area
- AP6 Target Ecosystem Corridor
- AP6 Target Ecosystem Site
- AP6 Target Green Space & Park
- Stream / Channel
- Highway
- Arterial Road



Action Plan 6 Target Areas:
1. Protect and preserve green space and ecosystem sites, hubs, and corridors that support wildlife habitat
2. Protect and preserve forested areas located along the North Slope escarpment to help maintain slope stability and control base flows.

Action Plan 7
Clean Up Garbage and Unsightly Properties

Objectives

- Improve community aesthetic appeal and livability.
- Support community involvement and awareness.
- Prevent future fouling and dumping into watercourses and drainage systems which affect conveyance and negatively impact water quality and the environment.

Participants

- Engineering Operations & Maintenance Division
- Park, Recreation, and Culture Department
- Bylaws and Enforcement Department
- Community Involvement

Background

- One of the most visible issues that plague the area is the presence of garbage debris along roads, walking paths, and in ditches. The neighbourhood has had a history of dilapidated houses and un-kept yards and lawns, which adds to the negative perception of the Bridgeview area.
- Residents have asked the City for more public garbage collection bins and stricter enforcement of unsightly properties that require renovation and clean up.
- Since there are many senior residents in the community who are unable to maintain their properties, community outreach may be necessary to help repair and clean up homes.
- Residents have concerns over the highly visible open-ditches in the community which attract litter and contaminated water.

Opportunities and Constraints

- Increasing community involvement and awareness will be necessary to ensure that a long-term effort is achieved. This will lower the potential for people to pollute or foul the open channel drainage system.
- Will require consistent community involvement.
- Compliance with industrial areas and businesses fronting the Fraser River.
- Stricter enforcement is needed on addressing unsightly properties.

Recommended Actions

- Provide a strategic plan to clean up garbage and debris along roads, walking paths, and in ditches.
- Provide stricter enforcement to prevent dumping, fouling, and polluting of waterways.
- Provide stricter enforcement on unsightly properties and sanitation.
- Recommend a separate detailed study regarding contaminated sites (specifically for the industrial lands) be completed to identify point-sources of pollution and to make recommendations to protect groundwater quality and reduce contamination in stormwater runoff.

Applicable Policies and Bylaws

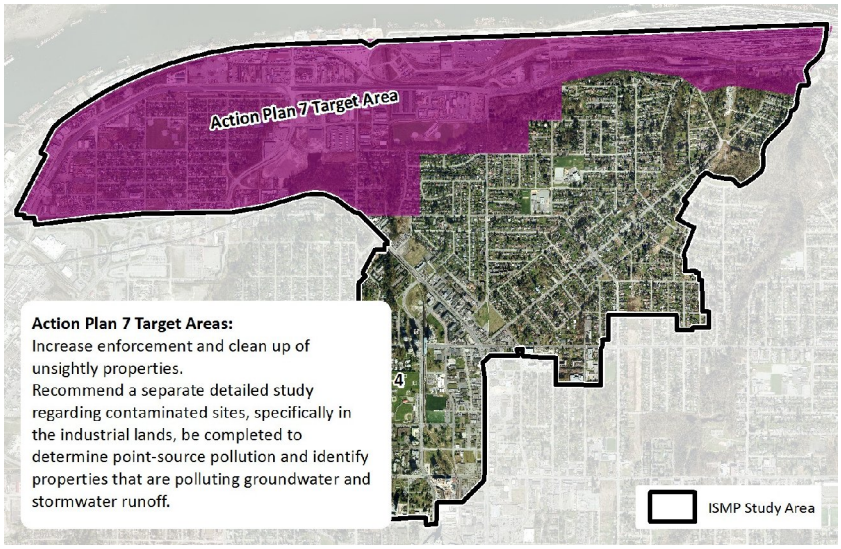
- Surrey Stormwater Drainage Regulation and Charges Bylaw 16610
- Surrey Abandoned & Vacant Properties Bylaw 16394

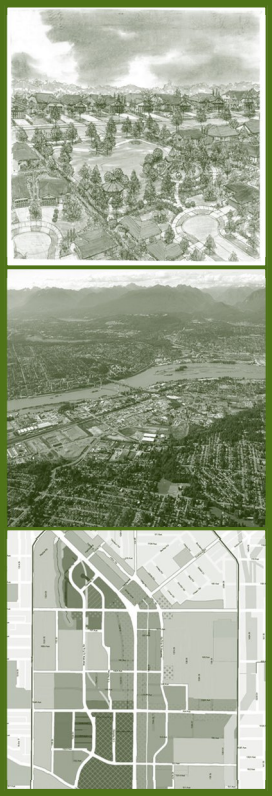
- Surrey Rental Premises Standards of Maintenance Bylaw 17686
- Surrey Property Maintenance and Unsightly Premises Bylaw 16393
- Surrey Nuisance Bylaw 12883
- Surrey Sanitation Bylaw 3052
- Surrey Garbage & Waste Disposal Regulation Bylaw 3495
- Surrey Sustainability Charter

Time Frame

Immediate (within 5 years) if action were to be taken now

Map





Action Plan 8
Establish Long-Term Cohesive Planning

Objectives

- Promote a long-term cohesive plan for the Bridgeview – North Slope area
- Establish stronger boundaries between residential communities and adjacent industrial/business areas
- Improve quality of living and aesthetic appeal

Participants

- Planning & Development Department
- Parks, Recreation, and Culture Department
- Engineering Department
- Crime Reduction Division
- Bylaws and Enforcement
- Community Involvement

Background

- Presently, the Bridgeview – North Slope study area is, essentially, built out. The City does not foresee any major land development occurring in this area other than possible lot infilling.
- Other than the Official Community Plan, there is no formalized land use plan developed for the Bridgeview – North Slope area. There has been considerable efforts focused on a strategic land use plan (LUP) to develop the City Centre downtown core which straddles King George Boulevard to the south, and there exists a neighbourhood concept plan (NCP) for the South Westminster area to the west. Therefore, it will be necessary to define how these plans transition into the study area if we are to achieve a proper uniform land use treatment.
- The City Centre LUP proposes high urban densification, which will affect the area located downstream in terms of quality and quantity of stormwater runoff being discharged. With the study area being bound by high urban land use to the south and heavy industrial areas to the north, it is extremely critical that the residential communities are not overburdened by the results of un-mitigated runoff flows, volume, and pollution.
- The South Westminster NCP proposes a network of pedestrian / bicycling routes and multi-use corridors that will cross into the Bridgeview area. As such, there is a need to plan out how these networks will be managed within Bridgeview and may be an opportunity for the City to implement amenities to improve community awareness.
- With previous public outreach programs for the Bridgeview community, there is a vital need to reduce the amount of crime, vandalism, and theft in this area. The neighbourhood has historically struggled with its overall appeal and living standard. Stricter enforcement will be needed and residents have asked for more police patrolling in the neighbourhood.

Opportunities and Constraints

- With the recent development of LUPs and NCPs adjacent to the study area, there is opportunity to lay down a strategic transition plan that is cohesive and uniform in land use treatment to guide how these plans transition into the study area.

- Opportunities to provide more amenities in the Bridgeview area may come from extending the proposed pedestrian/bicycling networks and multi-use corridors in the South Westminster NCP that cross into Bridgeview.
- Capitalize on this high profile region of Surrey which is a gateway into the City. Because the Bridgeview – North Slope area is a highly visible region from neighbouring municipalities and a gateway into the City of Surrey, there is opportunity to create a framework for high-quality developments to attract businesses and residents given the ease of accessibility being near both the Pattullo Bridge and Port Mann Bridge, Sky Train, South Fraser Perimeter Road, and capitalizing on the waterfront assets.
- With this said, what is unique in the study area is that the closest commercial hub to residents is within City Centre. As such, there are not many locations within walking distance for residents to complete daily errands. There is an opportunity to inject small, localized commercial anchor points that will attract businesses and promote community appeal.
- Achieving the goal requires a long-term implementation strategy that make take 20, 30 or 50 years to complete. As industry attitudes and leaderships change, it will be necessary to ensure long-standing consistent effort is put in by City staff, community, and stakeholders.
- Community involvement is necessary in order to have a long-term commitment in improving the overall health and aesthetic appeal of the study area. Therefore, the community must be ready to undertake changes in their neighbourhood with possible interim growing pains.
- Because of the numerous major projects currently underway or planned for the area, residents may be against any further disturbance and support may be limited to partake in a new planning process.
- For re-development to occur there must be a demand for stakeholders to invest in this area. Therefore, the challenge may be to generate interest in pursuing re-vitalization for this area which historically has struggled with its overall appeal.

Recommended Actions

- Recommend the City initiate a planning process to develop a land use plan for the Bridgeview – North Slope area
- Promote community awareness and place-making features to strengthen boundaries between residential neighbourhoods and the adjacent industrial/business areas
- Provide increased enforcement and police patrolling to reduce crime, vandalism, and theft in the area.
- Develop a long-term strategic plan to apply similar cohesive treatment to streets, buildings, residential properties, and park areas

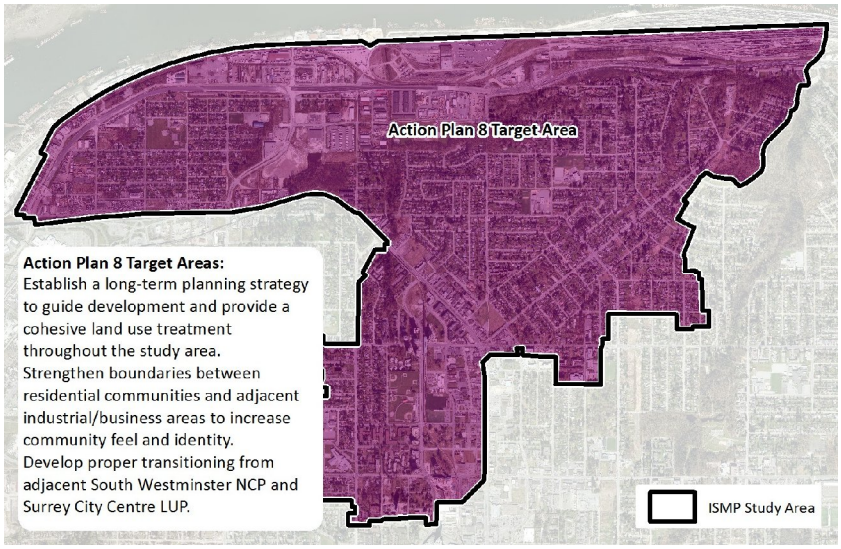
Applicable Policies and Bylaws

- Official Community Plan 12900
- Zoning Bylaw 12000
- Land Development and Subdivision Bylaw 8830
- Development Cost Charge Bylaw 17539

Achievable Time Frame:

Long range (10 or more years) if action were to be taken now

Map


Action Plan 8 Target Area
Action Plan 8 Target Areas:
Establish a long-term planning strategy to guide development and provide a cohesive land use treatment throughout the study area.
Strengthen boundaries between residential communities and adjacent industrial/business areas to increase community feel and identity.
Develop proper transitioning from adjacent South Westminster NCP and Surrey City Centre LUP.
ISMP Study Area

11.3 Existing Works Programs

Stormwater assets in the study area are already the subject of an existing renewal program. This program was reviewed to ensure that projects proposed through the ISMP would not duplicate an existing proposed project.

The City of Surrey's 2012-2021 Ten Year Servicing Plan contains a significant number of projects to be completed within the study area, some of which address goals identified in the ISMP. Projects in the servicing plan are identified to primarily address:

- Public safety
- Preserve aquatic habitat
- Avoid property damage from flooding and land erosion
- Reduce public nuisance such as localized ponding
- Climate change adaptation
- Servicing needs for new growth
- Management of downstream impacts associated with new growth

The projects identified in the servicing plan fall under one of three priority levels: Short (1 – 3 years), Medium (4 – 6 years) and Long term (7 - 10 years), and are grouped into either Drainage System Upgrades or Erosion and Ravine Stabilisation Works. A summary of the current capital works projects is provided in Table 11.2 and Table 11.3.

It is important to note that the current Ten Year Servicing Plan does not fully address drainage items that specifically pertain to water quality, base flows, and groundwater. The City therefore depends on provisions such as BMPs and source controls to manage these issues throughout the City. BMPs that fall under on-site works are also not part of the Servicing Plan and are the responsibility of the developer to implement. These on-site works are not a DCC eligible item. As such, the implementation plan for the Bridgeview-North Slope ISMP must also incorporate these previously identified works as part of the overall improvement strategy in order to provide the required level of service for the study area.

In the City's Ten Year Servicing Plan, drainage main replacement demand is largely based on the life-cycle of a pipe based on its condition and material type. The majority of the stormwater sewer network in the study area is PVC or concrete, both of which have estimated service life of 75 years, and a large proportion of the network was built in 1960s-1970s. With the information available, there is currently no critical need for storm sewer replacement based on aging storm sewer infrastructure in this area

Visit http://www.surrey.ca/city-services/3135.aspx for more information on the City of Surrey Engineering Department's Ten Year Servicing Plan.

Table 11.2 Ten Year Servicing Program (Drainage System Upgrades)

Item	Reference	Project Name	Location	Priority Term	Cost
1	1594	76m of 450mm dia. storm sewer	143 St and 109 Ave	Short	$54,320
2	6743	800m of 525mm dia. upgrade	132 St: 104 - 108 Ave	Medium	$421,000
3	6748	Wellington Drive Diversion Sewer	McBride Dr: Grosvenor Rd - 116 Ave	Medium	$145,000
4	6749	Alexandra Creek Diversion Sewer	Grosvenor Rd: 141 St – King Rd	Medium	$772,000
5	6882	134m of 600mm dia. upgrade	108 Ave: 140 – 141 St	Long	$98,266
6	6947	60m of 400mm culverts & 440m ditch	115B Ave W of 126A St	Long	$40,000
7	6950	95m of 400mm dia. culverts & 420m ditch work	115 Ave W of 126A St	Long	$40,000
8	6951	160m of 400mm culvert upgrade & 360m ditch work	114B Ave: 126A St – 129 St	Long	$100,000
9	6952	168m of 400mm dia. culvert upgrade & 508m of ditch work	114A Ave: 125A St – 129 St	Long	$80,000
10	6954	212m of 400mm culvert upgrade & 440m ditch work	114 Ave: 126 St – 129 St	Long	$120,000
11	6963	200m of 400mm culvert upgrade & 809m ditch work	115B Ave: 128 St – 132 St	Long	$90,000
12	6968	110m of 900mm dia. culvert upgrade & 700m ditch work	132 St: 114 Ave – 116 Ave	Long	$130,000
13	6987	140m of 400mm dia. culvert upgrade & 340m ditch work	113A Ave: 126A St – 128 St	Long	$80,000
14	6989	210m of 400mm dia. culvert upgrade & 670m ditch work	112B Ave: 126A St – 129 St	Long	$130,000
15	6990	80m of 400mm dia. culvert upgrade & 420m ditch work	112A Ave: 126A St – 128 St	Long	$50,000
16	7000	65m of 400mm dia. culvert upgrade & 185m ditch work	113B Ave: 125A St – 126A St	Long	$80,000
17	7002	210m of 400mm dia. culvert upgrade & 680m ditch work	113 Ave – 124 St – 126A St	Long	$100,000
18	7005	100m of 400mm dia. culvert upgrade & 1,002m ditch work	112A Ave: W of 124 St – 126A St	Long	$80,000
19	7006	60m of 400mm dia. culvert upgrade & 360m ditch work	114 Ave: 123 St – 124 St	Long	$40,000
20	7007	40m of 400mm dia. culvert upgrade & 160m ditch work	113 Ave: 124 St – 125 St	Long	$284,000
21	11640	Storm Sewer Upgrade	132 St: 104 Ave – 108 Ave	Long	$592,843
22	11653	Storm Sewer Upgrade	142 St: 108 – 106 Ave	Long	$179,745
23	11662	Storm Sewer Upgrade	111A Ave: 136 St – Brentwood Cr.	Long	$355,753
24	11677	Fraser River Dyke Improvement – VFPA Land	VFPA Land	Long	$1,200,000
25	11678	Fraser River Dyke Improvement Phase 4	130 St to E of Old Port Mann Bridge	Long	$4,000,000
26	12188	115 Ave Culvert Repair & Upgrade	13706 – 115 Ave	Short	$285,000
		Total			**$9,547,927**

Table 11.3 Ten Year Servicing Program (Erosion and Ravine Stabilization Works)

Item	Reference	Project Name	Location	Priority Term	Cost
27	9322	Ravine Erosion Repair Works	Southward Creek: 114A Ave – 137A St	Short	$93,000
28	9344	Ravine Erosion Repair Works	Bolivar Creek: 112 Ave – 133 St	Medium	$273,000
		Total			**$366,000**

11.4 Recommended Additional Works

11.4.1 Pipe Upgrades

Based on the results of the hydraulic modelling, several existing storm sewers will require upsizing in order to convey the 5-year peak flow rate. Table 11.4 below summarizes the proposed pipe upgrades to the drainage system, and includes Class D cost estimates. **Map 10 Proposed Upgrades** illustrates the locations of these upgrades along with future dyke works and pump stations. Due to the poor soil conditions within the low-lying regions, corrugated steel pipe (CSP) is the recommended material for storm sewers in this area.

Table 11.4 Recommended Pip Upgrades

Phasing	Pipe ID	Name	Location	Length (m)	Ex. Dia (mm)	Prop. Dia (mm)	Unit Cost ($/m)	Cost ($)
Short Term (1-3 yrs)	2	1000854754	Bridgeview Drive and 129 Street	15.9	750	900	$1,664	$26,524
	3	1001411086	Bridgeview Drive and 129 Street	73.3	750	900	$1,664	$121,932
	4	1000831618	128 Street and 115A Avenue	10.8	800	1500	$2,687	$28,989
	6	P39	128 Street and 114 Avenue	400.0	600	675	$1,314	$525,600
	7	P43	124 Street and Industrial Road	42.7	1200	1350	$2,384	$101,773
	8	P44	Industrial Road	103.6	300	450	$1,029	$106,635
	9	P47	124 Street and Musqueam Drive	41.0	1500	2400	$4,889	$200,449
	10	P60	115 Ave and Bridgeview Drive	80.9	1050	1200	$2,115	$171,125
	11	P49	112A Avenue and 124 Street	6.0	300	600	$1,234	$7,404
	12	1000734611	128 Street and 115B Avenue	12.2	800	1350	$2,384	$29,083
	16	1000746583	124 Street and Industrial Road	98.8	600	675	$1,314	$129,809
	17	1000746611	126A Street and 115B Avenue	104.5	1500	1800	$3,414	$356,773
	18	1000746700	Industrial Road and 112 Avenue	106.7	525	750	$1,467	$156,497
	19	1000746701	Industrial Road and 124 Street	109.7	600	750	$1,467	$160,973
	20	1000746702	Industrial Road and 124 Street	102.1	600	675	$1,314	$134,098
	21	1000746747	126A Street at Royal City PS	16.3	2155	2400	$4,889	$79,911
	22	1000746748	126A Street and 115B Avenue	20.0	1050	2400	$4,889	$97,695
	25	1000760220	128 Street and Bridgeview Drive	64.9	525	675	$1,314	$85,314
Sub-Total								**$2,520,583**
Medium Term (4-6 yrs)	1	1000852161	131 Street S of 115 Avenue	86.9	525	675	$1,314	$114,132
	5	P13	139 Street and 108 Avenue	162.0	525	675	$1,314	$212,868
	13	1000734622	King George Blvd. and 126A Street	77.2	600	675	$1,314	$101,485
	23	1000752572	Cowan Road	41.5	600	750	$1,467	$60,876
	24	1000752584	Cowan Road	14.2	525	675	$1,314	$18,661
Sub-Total (Medium Term)								**$508,022**
Long Term (7-10 yrs)	14	1000734675	116 Ave near Southward Cr. Outfall	8.8	1200	1800	$3,414	$30,043
	15	1000734676	116 Ave near Southward Cr. Outfall	6.3	1200	2100	$4,338	$27,329
	26	1000764856	King Road near Alexandra Cr. Outfall	31.3	750	1500	$2,687	$84,046
Sub-Total (Long Term)								**$141,417**
Total								**$3,170,022**

Cost estimates were prepared based on unit rates and lump sum amounts and are in 2014 dollars. These unit cost rates include installation and material costs, but does not include service connection replacement to property line. No allowance has been made for engineering or contingency. Table 11.5 summarizes the unit costs used for linear sewer upgrades.

Table 11.5 Adopted Rates for Cost Estimates

Sewer Diameter (mm)	Raw Unit Cost ($/m)*
200	$701
250	$767
300	$825
375	$927
450	$1,029
525	$1,132
600	$1,234
675	$1,314
750	$1,467
900	$1,664
1050	$1,876
1200	$2,115
1350	$2,384
1500	$2,687
1800	$3,414
2100	$4,338
2400	$4,889

* Unit cost rates are in 2014 Year dollars and include installation and material costs. These rates do not include allowance for engineering or contingency.

11.4.2 Pump Stations

Proposed Upgrade of Royal City Pump Station

It is recommended that the Royal City Pump Station is upgraded from the existing capacity of 1.18 m^3/s to 3.56 m^3/s. The estimated cost of these works is $1,500,000, excluding tax, contingency and engineering.

Proposed Bolivar Pump Station

It is recommended that the proposed Bolivar Pump Station is to have a capacity of 4.75m^3/s at 5m TDH. The estimated cost of these works is $5,000,000, excluding tax, contingency and engineering. This pump station should have three pumps and one standby pump as well as be fish passable.

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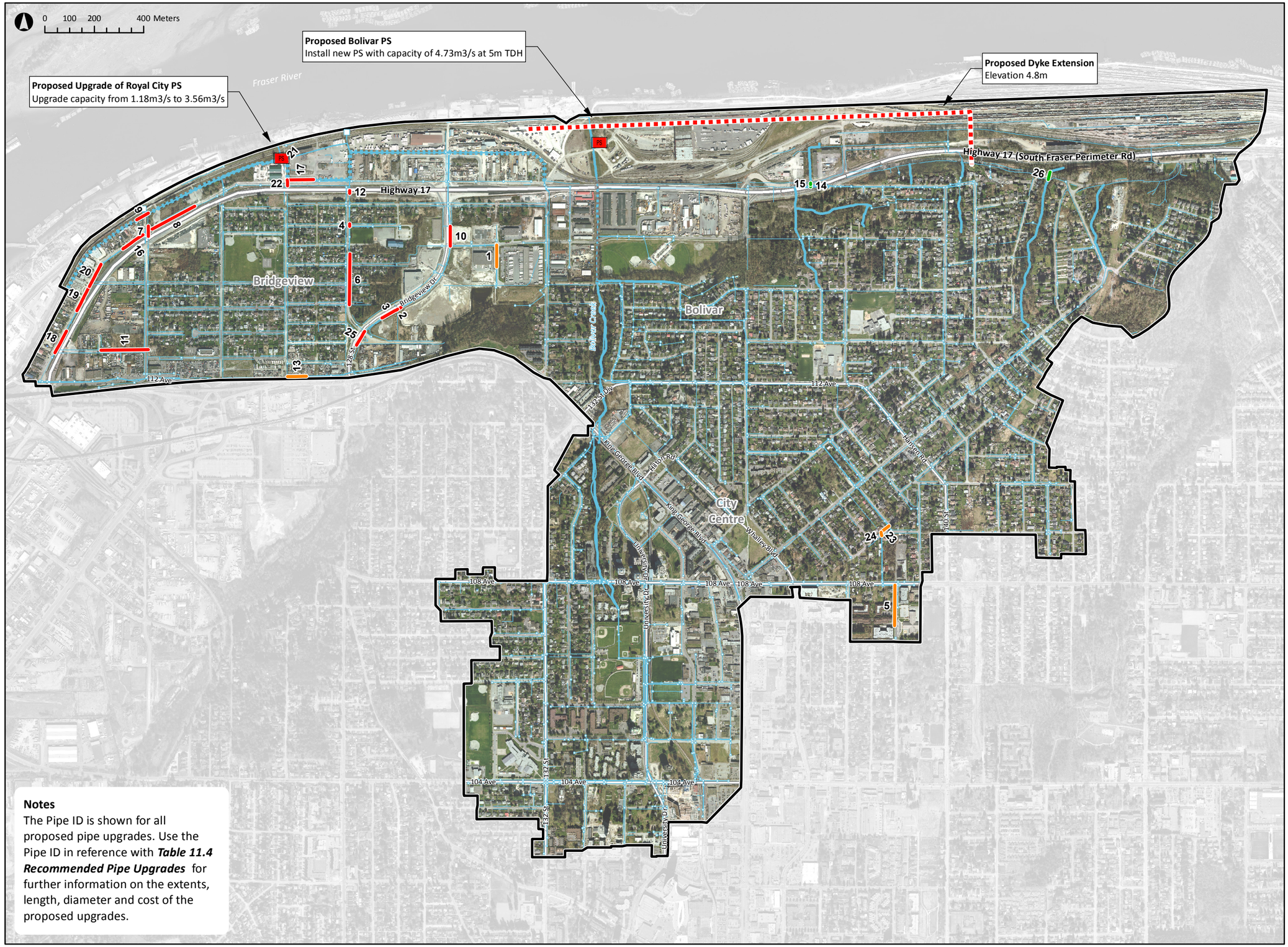
Map 10
Proposed Upgrades

Legend

Proposed Pipe Upgrade
Phasing
- Short Term (1 - 3yrs)
- Medium Term (4 - 6yrs)
- Long Term (7 - 10yrs)
- Proposed Dyke Extension
- Existing / Proposed Pump Station
- ISMP Study Area
- Existing Dyke
- Flood Box
- Manholes
- Collector Canals
- Creeks

Stormwater Sewer
Sewer Size
- Minor (<525)
- Major (≥525)
- Ditches
- Stream / Channel
- Highway
- Arterial Road



Notes
The Pipe ID is shown for all proposed pipe upgrades. Use the Pipe ID in reference with ***Table 11.4 Recommended Pipe Upgrades*** for further information on the extents, length, diameter and cost of the proposed upgrades.

11.4.3 Phasing, Investment and Funding

Pipe Upgrades

It is recommended that proposed pipe upgrade works would commence from the lowest elevation and work upstream through the study area. The phasing of the proposed pipe upgrades has planned in line with this policy, and is shown in Table 11.4 and **Map 10 Proposed Upgrades**.

The investment required to deliver the recommended pipe upgrades is summarised in Table 11.6 and Figure 11.1 below. All values are in 2012 dollars.

Table 11.6 Investmentment Summary for Pipe Upgrades

Phasing Term	Total Investment	No. of Years	Avg. Yearly Investment
Short Term (1- 3 yrs)	$2,520,583	3	$840,194
Medium Term (4 -6 yrs)	$508,022	3	$169,341
Long Term (7 - 10 yrs)	$141,417	4	$35,354
Total	**$3,170,022**	**10**	**$1,044,889**

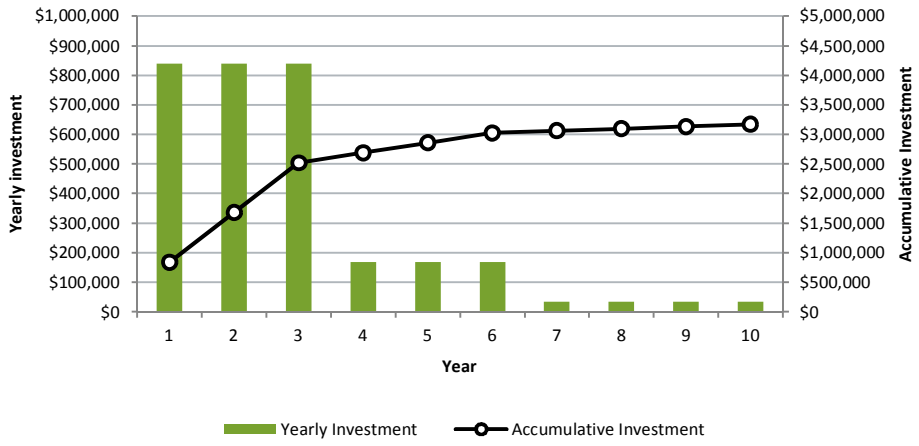


Figure 11.1 Year-by-Year Investment Breakdown for ISMP Pipe Upgrades

These upgrades are required to meet the level of service of conveying the 5-year peak flow within the pipe as stipulated in the Surrey Design Criteria Manual (May 2004). These works may be funded through means such as fitting into the current budget, a temporary stormwater utility or developer cost charges (DCCs). DCCs are collected from developers to fund the cost of providing roads, drainage, water, and sewer services for the projected growth in population. DCC rates are specified at the community and neighbourhood plan level for different land uses.

Future Pump Stations, Dyke Works, and NSI

As previously described in Section 9 Hydraulic Assessment, to meet a 100-year level of service it is recommended that the Royal City pump station be upgraded to have a total capacity of 3.56m^3/s at 3m TDH with ability to operate up to 5m TDH. This upgrade should be completed as soon as possible to relieve reliance on surrounding storage capacity within ditches and canals.

The City has plans to construct the Fraser River East Dyke as early as next year. The dyke is set at 4.8m geodetic elevation (4.2m river water level plus 0.6m freeboard). Only the western portion of the study area up to 132 Street is dyke protected. Depending on where this alignment will be there will be a need to provide the area with a second pump station (Bolivar Creek Pump Station) for flood protection purposes. Based on the hydraulic assessment it is recommended that the future Bolivar Pump Station planned for the area has capacity to operate up to a 5m TDH and a flow rate of 4.73 m3/s. This station should have three pumps and one standby pump as well as be fish passable.

Metro Vancouver is also planning for future twinning of the North Surrey Interceptor sewer within the area. As the design of the dyke extension and Bolivar Creek Pump Station progresses, it is recommended that both be constructed within the same timeframe so as to minimize any additional disturbance to the area.

The level of investment and recommended phasing for the pump stations are summarised in Table 11.7 below.

Table 11.7 Pump Station and Dyke Works Investment

Project	Total Investment	Recommended Phasing
Upgrade of Royal City Pump Station	$1,500,000	As soon as possible
Bolivar Creek Pump Station	$5,000,000	Following Fraser River East Dyke Construction Coincide with Metro Vancouver NSI Works
Total	**$6,500,000**	

11.5 Bridgeview Ditch Assessment

11.5.1 Field Inspection and Assessment

On June 14, 2013 AECOM completed a field reconnaissance of the ditches in the Bridgeview area. This site review was completed during a dry weather period in the summer but after a small rain event in order to see if any rain ponded in certain locations. Each ditch was verified in terms of their location and flow direction, and then ranked in terms of how critical the ditch was for stormwater conveyance and providing storage capacity to the overall drainage system.

Ditches were divided into three categories as described in Table 11.8.. The majority of the ditches were found to contribute significant storage capacity and provide drainage conveyance for the area. 56% of the ditches were determined to provide limited storage capacity but they were still considered important in slowing down runoff velocities. In summary, the total lengths of ditches based on priority were found to be:

- Category 1 Ditch = 1,263m Total (6%)
- Category 2 Ditch = 7,480m Total (38%)
- Category 3 Ditch = 10,960m Total (56%)

Table 11.8 Bridgeview Open-Ditch Assessment

Category	Definition	Photo of Example
1	- Ditch has depth greater than 2 feet (600mm or greater). - Medium to dense grass and/or vegetation present at surface. - Water is present during dry weather periods. - Provides critical stormwater storage capacity. - Provides critical stormwater conveyance.	

Category	Definition	Photo of Example
2	- Ditch has depth between 1-2 feet (300mm-600mm) - Low to medium grass and/or vegetation present at surface - Water may or may not be present during dry weather periods - Provides some stormwater storage capacity - Provides critical stormwater conveyance	
3	- Ditch has depth less than 1 foot (300mm or less) - Grass and/or gravel are present at surface - Water is not present during dry weather periods - Provides limited to no stormwater storage capacity - Provides some stormwater conveyance - Ability to slow down water and reduce peak flows may be limited but is greater than that of a traditional piped system (e.g. if ditch was enclosed) - Ability to facilitate infiltration may be limited during high groundwater conditions but is greater than that of a traditional piped system (e.g. if ditch was enclosed)	

11.5.2 Recommendations

Based on the hydraulic assessment completed for the study area, the open-ditch drainage system currently being utilized must be kept in order to provide sufficient storage capacity as well as proper stormwater conveyance. With the low-lying areas within the 200-year flood plain, the existing shallow groundwater table coupled with the limited land space makes any form of segregated detention facility or pond unfeasible.

Replacing the ditches in the lowlands with pipes not only reduces storage but also increases stormwater velocities and time of concentration, causing higher peak flows that put strain on the downstream creeks, floodboxes, and pump stations.

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Project
Bridgeview - North Slope ISMP

Map 11
Ditch Assessment

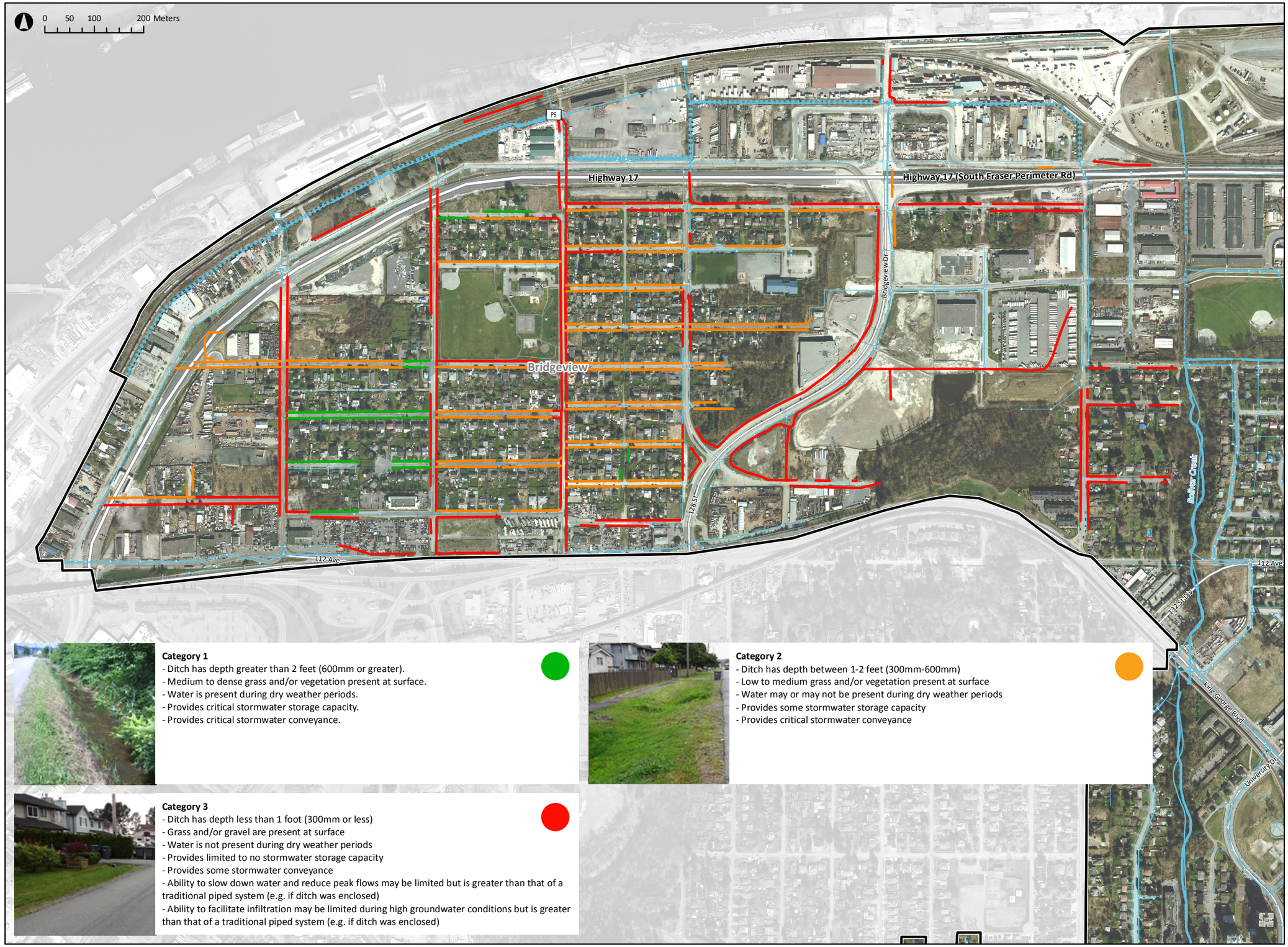
Legend

- Flood Box
- PS — Existing / Proposed Pump Station
- Category 1 Ditch
- Category 2 Ditch
- Category 3 Ditch
- ISMP Study Area
- Existing Dyke
- Manholes
- Collector Canals
- Creeks

Stormwater Sewer

Sewer Size

- Minor (<525)
- Major (≥525)
- Ditches
- Stream / Channel
- Highway
- Arterial Road



Category 1
- Ditch has depth greater than 2 feet (600mm or greater).
- Medium to dense grass and/or vegetation present at surface.
- Water is present during dry weather periods.
- Provides critical stormwater storage capacity.
- Provides critical stormwater conveyance.

Category 2
- Ditch has depth between 1-2 feet (300mm-600mm)
- Low to medium grass and/or vegetation present at surface
- Water may or may not be present during dry weather periods
- Provides some stormwater storage capacity
- Provides critical stormwater conveyance

Category 3
- Ditch has depth less than 1 foot (300mm or less)
- Grass and/or gravel are present at surface
- Water is not present during dry weather periods
- Provides limited to no stormwater storage capacity
- Provides some stormwater conveyance
- Ability to slow down water and reduce peak flows may be limited but is greater than that of a traditional piped system (e.g. if ditch was enclosed)
- Ability to facilitate infiltration may be limited during high groundwater conditions but is greater than that of a traditional piped system (e.g. if ditch was enclosed)

11.6 Best Management Practices

Stormwater best management practices (BMPs) are strategies that promote and replicate natural hydrological processes as ways to manage stormwater quantity and quality as urban development continues. Previous approaches such as detention ponds are typically end-of-pipe methods designed to manage peak rain events and flows while detaining runoff volume. Recent stormwater BMPs are now designed to manage rain where it falls, and are multi-functional in providing water quality treatment, base flow re-charge, while also attenuating peak flows and providing interim storage capacity.

Stormwater BMPs focus on three criteria that are critical to managing urban stormwater runoff:

- Peak Discharge: Reduce the maximum flow by slowing down runoff velocity and lengthening the duration of discharge.
- Volume: Reduce or delay the volume of stormwater that enters the drainage system.
- Water Quality: Improve water quality through volume reduction, filtering, and biological and chemical processes.

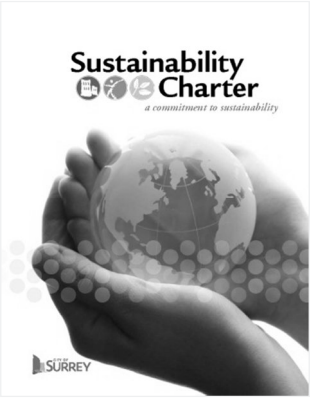
11.6.1 Structural BMPs

Structural BMPs are physically engineered built solutions to address stormwater management. These methods can be combined together to treat runoff at the source or at the point of discharge from an upstream drainage system or watercourse. Structural BMPs should, on the most part, be integrated into the surrounding site design such as within boulevards, parks, and within right-of-ways. Most of these BMP types do require some level of regular maintenance to ensure they are performing as expected.

Applications of BMPs will depend on what key performance indicators are desired (either to control volume, peak flow, or water quality parameters), available land and the type of land use that the BMP is being applied to.

Understanding that the area possesses a high groundwater table with poor soil conditions and slope stability issues along the escarpment, infiltration opportunities are limited especially within the lowlands. As such, any implementation of BMPs will more than likely occur further upstream in the Bolivar catchment or towards Bedford and 137A Street catchments. However, within these catchments BMPs promoting infiltration will need to be placed away from the escarpment.

11.6.2 Non-Structural BMPs



Non-structural BMPs involve practices and strategies that manage stormwater through planning, prevention and maintenance. These types of BMPs can also take on the form of regulatory policies and legislation. Non-structural BMPs do not require the construction of a facility, but instead focus on prevention, reduction, and enforcement to improve stormwater management. Some examples are land use planning, policy making, recycling, and educational outreach programs.

The City of Surrey has been actively involved in developing policies and guides to progress a 50-year vision for sustainable communities. The City's Sustainability Charter guides decisions and actions that will support improvement of environmental and community conditions across the City.

Homeowner pamphlets and educational materials are also ways to increase awareness to residents and underlines how small changes in and around people's homes and gardens can have long-reaching benefits on stream health. The City of Surrey has already developed guides and other literature to inform homeowners of their importance in contributing to the sustainability of the City.

It is often the case for municipalities that utilizing these two methods together will prove to be the most effective way in protecting the quality and quantity of stormwater in our systems.

11.6.3 Making the most out of BMPs

As we continue to understand that BMPs can aid in not just mitigating negative impacts of development but also supporting overall watershed health, BMPs should strive to be multi-functional in ways that conventional stormwater systems typically aren't.

Examples of ways in which BMPs can be multi-functional are:

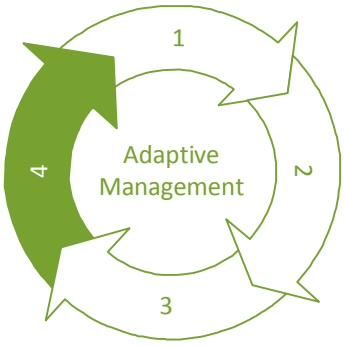
- Multi-hydrological processes: The BMP should promote several natural hydrological processes, such as increasing infiltration into soils to reduce runoff volume while also re-charging base flows and encouraging transpo-evaporation;
- Treatment Train: The BMP should combine with other BMPs to form a treatment train, which will allow for additional water quality treatment and potential back-up treatment systems.
- Site Integration: The BMP should be integrated as part of the site, such as the landscaping and infrastructure, without impeding or significantly affecting their function. Land that the BMP occupies should be able to serve purposes in addition to stormwater management, such as open space or parking;
- Storm Events: The BMP should be designed for various storm events and care must be given to manage both the large peak events as well as the smaller frequent events; and
- Source Control: The BMP should manage rain at or near where it falls, rather than at the end of the system when collection of pollutants and contamination is at its highest. It should also distribute stormwater throughout the site rather than centralize it at one collection point.

Because of the presence of heavy industrial lands in the study area, point source pollution such as discharges from factories or other industrial facilities that enter the drainage system have been a chronic problem that must be eliminated. This problem may not have an actual structural BMP solution but instead a regulatory enforcement or inspection solution. However, non-point source pollution that results from the accumulation of contaminants from land surface, erosion of soils, debris, road hydrocarbons, suspended sediments, and dissolved contaminants can be addressed with the right BMP implementation.

Stage 4

How Do We Stay On Target?

Develops a monitoring and assessment program



12 Monitoring and Adaptive Management Plan

12.1 Overview

Developing a multi-disciplinary plan for a long-term horizon is a challenge that all municipalities face. Due to economic, political, climatic, technological, and social changes as well as changes in our understanding of the watershed it is imperative that the ISMP adapt accordingly to ensure the watershed vision is met over time. As such, a key component to a successful ISMP is to develop a long-term adaptive management program that includes monitoring, operation, and maintenance strategies to verify that the vision and goals set out are met through the implementation plan.

The adaptive management approach of the ISMP encourages improvement through learned experiences and performance tracking. Recently, Fisheries Canada (formerly known as DFO) released a "Draft Urban Stormwater Guidelines and Best Management Practices for Protection of Fish and Fish Habitat", which describes the need for developments to implement BMPs in order to manage storm water through volume reduction, water quality, and detention or rate control. The recommendations identified in this report fall in line with addressing these issues and subsequently the adaptive management strategy will ensure that these goals are in fact being met.

12.2 Key ISMP Coordinator

Developing a successful adaptive management plan depends largely on the continual support of City departments and stakeholders. However, it can be at times difficult to maintain the focus of the ISMP given the substantial timeline with inevitable staff changes and daily workload demands. In order to facilitate this, we recommend that the City consider appointing one key staff member who will be responsible in moving the goals of the ISMP forward. This key ISMP coordinator will be mandated to:

- Carry out the ISMP implementation plan
- Carry out the performance monitoring and assessment of the ISMP and make recommendations on how to adapt the ISMP for future considerations
- Work with City staff to implement and change recommendations identified in the ISMP where practical and applicable
- Review and update performance targets where applicable
- Meet with inter-jurisdictional parties (MetroVancouver, DFO, MoE, etc.) to report on data results and initiatives
- Prepare reports to City Council, stakeholders, and the public on the overall health of the watershed

The Capital Regional District found that a significant factor in the success of the implementation of their Bowker Creek Urban Watershed Renewal initiative was the appointment of a key coordinator whose main focus was to constantly advance the ISMP on a regular basis.

12.3 Flood and Water Level Monitoring

The known chronic issues of local flood occurrences specifically within the low-lying areas need to be diligently monitored and recorded. Because of the close proximity to residential buildings, it is extremely important that the City document all flooding complaints from the public as well as record the extent of where water levels reach within these locations.

In addition to the localized flooding in residential neighbourhoods, it is also recommended that monitoring of tidal conditions specifically for the Bridgeview – North Slope area be performed. Currently, the nearest Fraser River tide gauges are located closer to New Westminster and the Port Mann Bridge. Although these gauges provide good indicators in overall river water levels, providing a specific gauge for the Bridgeview – North Slope

area will allow for the City to make specific assessments on long-term flood protection measures, flood construction levels, and pump station requirements.

Therefore, it is recommended that at least one water level gauge be installed along the river front to record Fraser River tides and two gauges be installed along the escarpment to monitor groundwater levels discharging from the escarpment. **Map 12 Monitoring Plan** shows recommended locations in which water level monitoring is to be performed.

12.4 Water Quality

Monitoring water quality in the open-ditch system will be necessary in determining watershed health within the area, specifically for the Bridgeview Community. It is recommended that the City establish baseline conditions and regularly compare these with conditions over time to analyze the effectiveness of the implementation plan and to provide concrete evidence to City staff and stakeholders on how water quality is improving or worsening. As such, we recommend a water quality monitoring program be part of the adaptive management process of this ISMP.

The City of Surrey already has several monitoring programs in place where baseline data can be collected, and in many ways the City is a leader in taking pro-active steps to monitor watershed health. The City already has in place the following programs:

- Flow and rainfall monitoring program
- Benthic Index of Biotic Integrity (B-IBI) monitoring program
- Ravine Erosion Assessment program
- Water quality monitoring program
- Species At Risk Assessment (SARA) program
- Sensitive Habitat Inventory Mapping (SHIM)

Since monitoring and collecting data can be time consuming and extremely expensive, the programs listed above provide a plethora of information that should be reviewed prior to determining the need for new monitoring locations and equipment.

Water quality can be effectively measured by taking discrete samples during low summer discharges to determine base flow conditions (primarily derived from groundwater), and during larger storm events in the fall or winter months where streams discharges exceed base flow rates. Samplings should be performed at least twice a year with the initial samples used to establish baseline conditions. The parameters for water quality should include:

- Total suspended solids (TSS);
- Nutrients (nitrogen and phosphorus);
- Heavy metals;
- Organics (including oil and grease); and
- Pathogens (bacteria, coliform).

Map 12 Monitoring Plan shows three recommended locations in which water quality monitoring is to be performed. These three locations correspond to each drainage catchment and are within the industrial lands in which water quality is of the most concern.

12.5 Erosion and Slope Stability Monitoring

The City has conducted regular ravine erosion assessments every two years to monitor the condition of creek erosion and bank stability. It is recommended that the City continue with this program to monitor erosion conditions, outfalls, and riparian areas for Class A and B streams and complete pre and post-development comparisons to see if erosion has been mitigated and riparian areas are being protected. Therefore, it is recommended that erosion and slope stability monitoring continue for each of the major creeks within the Bridgeview – North Slope study area, namely: Bolivar Creek, Southward Creek, Dingwall Creek, Alexandra Creek, and Wellington Creek.

12.6 Public Outreach Programs

Carrying out the long-term watershed vision must be a shared responsibility. Engaging communities, schools, and politicians to participate in the ISMP process is an important step that is at times under-emphasized or overlooked. Programs such as the ANC program described in Section 10.2 should be supported so as to strengthen community awareness and pride.

The more education and awareness that is generated about the importance of maintaining watershed health, the more likely it will be for the City to establish funding, create capital works projects, and take a pro-active approach to future planning.

12.7 Review and Adapting the ISMP

As the ISMP is carried out, issues that arise from planning, engineering, parks, and the public specific to the ISMP should be noted and filed. These issues can range from physical limitations of space to funding shortfalls and even aesthetic grievances in which the ISMP shall be re-examined as part of the adaptive management process.

CITY OF SURREY
the future lives here.

Project
Bridgeview - North Slope ISMP

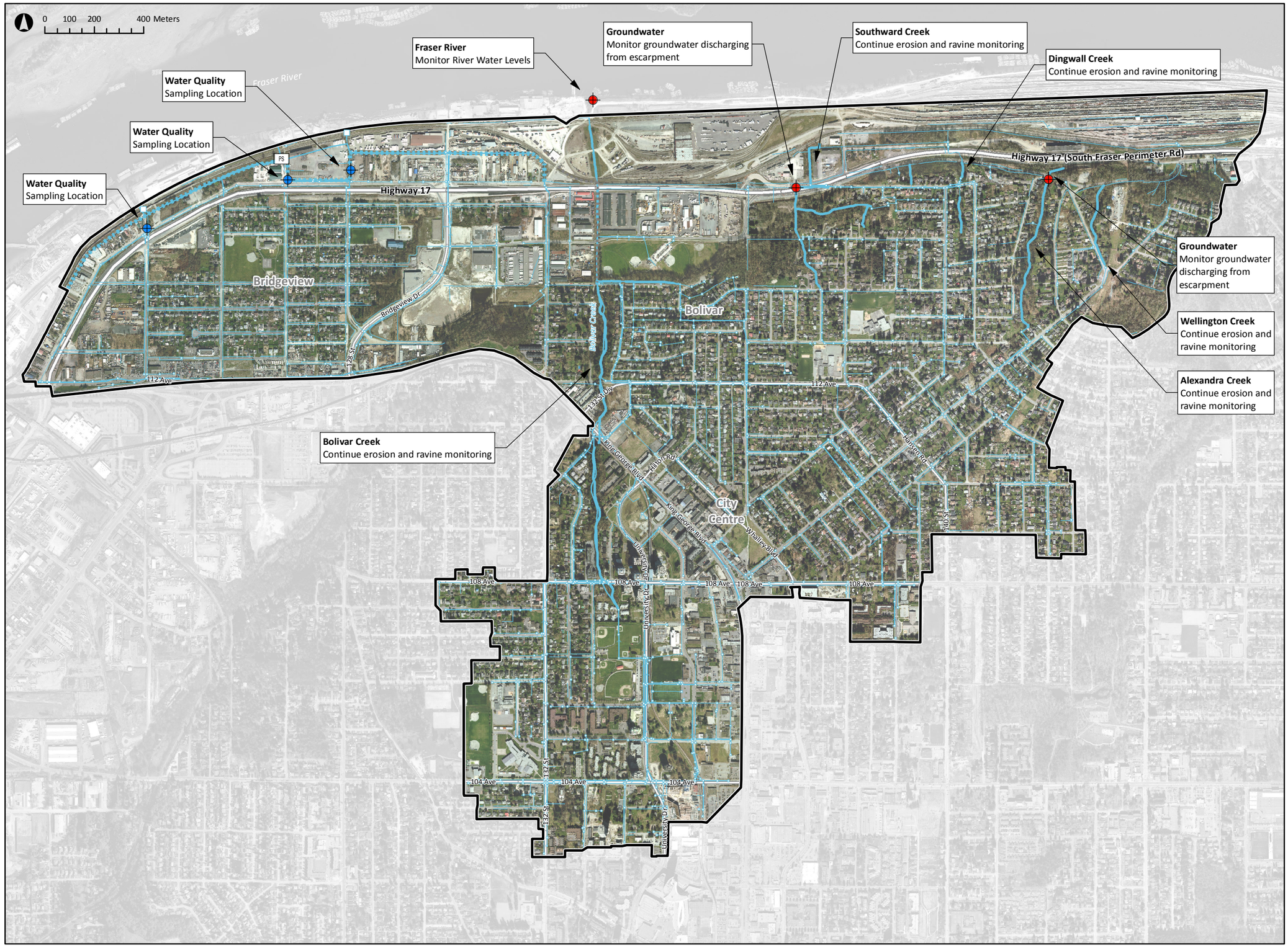
Map 12
Monitoring Plan

Legend

Monitoring / Sampling Locations
- Water Quality Monitoring
- Flow / Level Monitoring
- Existing / Proposed Pump Station
- ISMP Study Area
- Existing Dyke
- Flood Box
- Manholes
- Collector Canals
- Creeks

Stormwater Sewer

Sewer Size
- Minor (<525)
- Major (≥525)
- Ditches
- Stream / Channel
- Highway
- Arterial Road



Appendix A

Environmental Assessment

ENVIRONMENTAL ASSESSMENT REPORT

Stage 1: Bridgeview-North Slope Integrated Stormwater Management Plan

Surrey, B.C.

Prepared for:

AECOM and City of Surrey

Prepared by:

PHOENIX ENVIRONMENTAL SERVICES LTD.

August, 2012

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EXECUTIVE SUMMARY

Phoenix Environmental Services Ltd. (Phoenix), in collaboration with Gebauer and Associates Ltd. and Sartori Environmental Services, has conducted an environmental assessment of the Bridgeview-North Slope Integrated Stormwater Management Plan (ISMP) that AECOM Corporation (AECOM) has been retained to prepare for the City of Surrey Engineering Department. This report has been completed in support of Stage 1 of the formulation of the Bridgeview-North Slope ISMP (the ISMP). The objective of Stage 1 is to provide an inventory and assessment of existing terrestrial (wildlife habitats and corridors) and aquatic habitats (watercourses, wetlands) within the Study Area using available information and limited "ground-truthing" site reconnaissance. The scope of work by Phoenix has included use of existing research and reports, as well as field verification where necessary. The priority areas for protection include the Class A and Class B streams and their riparian areas, the groundwater springs and wetland areas within remaining forested areas near the base of the escarpment, and remaining forest stands along steep slopes and in the lower floodplain area.

The watercourses within the ISMP study area can be separated roughly into three categories: Ravine Streams and tributaries, Constructed Fish Habitat Drainage Watercourses, and Constructed drainage ditches (not fish habitat). Several changes in the City's online mapping (COSMOS) are proposed to address unmapped watercourses, inaccurately mapped watercourses, and to address proposed re-classifications of watercourses. These are discussed in detail in section 2.3 of this report and are shown on Figures 2-5 in Appendix A.

A number of issues relating to watercourses in the ISMP study area have been identified, including: stream erosion, fish migration barriers, riparian habitat damage and water quality. Previous sewer diversions have been installed to bypass high flows around the steep slopes and ravines on the North Slope area of the study area. Field observations and long term monitoring reports indicate that the high flow bypass diversions have resulted in relatively good stream stability. However, ravine stability assessments (2002 – 2009) indicate that numerous localized bank erosion problems persist within the North Slope ravine streams following the construction of the storm sewer diversions (ca. 2001). Several barriers to upstream fish migration have existed for many years (e.g. CN Rail yard) such that all of the ravine streams are not fish accessible within the North Slope area; with the exception of Bolivar Creek, which is fish accessible to King George Boulevard. Depending on completion of the South Fraser Perimeter Road, there appear to be opportunities to restore fish access into some streams along the North Slope area (e.g. Southward Creek). Riparian habitat damage from refuse disposal and long-term structures built at or very close to watercourse banks and ravine crests occurs extensively throughout the study area. Water quality issues are most prevalent in the lowland floodplain and industrialized areas of the ISMP study area. These issues are discussed in greater detail in section 2.4 of this report.

The relatively few and fragmented forested areas remaining in the study area have not changed substantially over many years, given the long history and density of urban development in the study area. No sensitive plant or animal species were detected during the field program, although several sensitive species are likely, including Great Blue Heron, Trowbridge's Shrew, Pacific Water Shrew and Streambank Lupine. Remaining forest patches need to be protected and

wildlife movement corridors need to be maintained or established to improve the ecological integrity of the Study Area and to provide suitable living habitats for sensitive species including Trowbridge's Shrew, Pacific Water Shrew and Western Screech-Owl, among a number of other species. Provision of natural habitats that have protected corridors will result in increased biodiversity within the Study Area.

1. INTRODUCTION

Phoenix Environmental Services Ltd. (Phoenix) has been retained by AECOM Corporation (AECOM) to provide the environmental assessment components for Stage 1 of the Bridgeview-North Slope Integrated Stormwater Management Plan (ISMP); which AECOM has been retained to prepare for the City of Surrey Engineering Department. This report has been completed in support of the formulation of the Bridgeview-North Slope ISMP.

1.1 ISMP ENVIRONMENTAL OBJECTIVES

Based on the Terms of Reference issued by the City, the Bridgeview-North Slope ISMP is intended to be a comprehensive plan to balance land use planning, stormwater engineering, flood and erosion protection, and environmental protection in order to preserve and improve the overall health of the watershed.

The environmental objectives of the ISMP include:

- to protect and enhance the overall health of the Study Area watershed consisting of 6 major drainage catchment areas,
- to protect and enhance watercourses and aquatic life,
- to prevent pollution and maintain and improve water quality
- to provide an inventory of watercourses and wildlife for the watershed, and
- to protect the environment, wildlife and wildlife habitat and corridors.

1.2 STUDY AREA

The Bridgeview-North Slope ISMP study area is characterized by predominantly urban and industrial land uses extending from commercial and high-density residential areas near the Surrey City Centre south of 108th Avenue, to single family residential areas over most of the north slope, and mixed industrial, commercial and residential within the lowland floodplain areas near the Fraser River. The study area has been largely built-out with negligible undeveloped lands, such that remaining streams, forested and environmentally sensitive areas have become a scarcity and of significant retention value, even where degraded by urban activities.

The watershed within the ISMP study area includes six (6) major drainage catchment areas including: Bedford, 137A Street, Bolivar, 128 Street, Royal City, and 124 Street, as shown on Figure 1 in Appendix A.

1.3 METHODOLOGY

The methodology for this Stage 1 ISMP Environmental Assessment (Stage 1 EA) included use of existing research and reports, as well as limited field reconnaissance, to conduct an inventory and assessment of the fish, aquatic and wildlife habitats within the ISMP Study Area.

1.3.1 Scope

The scope of work by Phoenix for Stage 1 of the ISMP has entailed:

- Confirmation of fisheries classification for key watercourses and assessment of current health conditions of selected watercourses, including associated terrestrial habitats such as ravines, riparian areas, and wetlands.
- Identification of significant terrestrial habitats including trees and forests, habitat hubs, wildlife corridors, and habitat restoration opportunities.
- Identification of sensitive environmental areas and areas of concern such as deteriorated watercourses (e.g. scour and erosion), potential sources of negative impacts to water quality, and degraded wildlife habitats.

1.3.2 Background Information Search

Prior to field visits, pertinent background information and online mapping resources (COSMOS) provided by the City was reviewed in order to focus field observations on key watercourses, identified terrestrial habitats, and those species and habitats with a high potential for occurrence. There has been an extensive collection of assessment reports previously completed for the City pertaining to the ISMP study area. Key reports reviewed for this environmental assessment include, but were not limited to: the North Bluff Drainage and Slope Stability Assessment (2000), Watercourse Bioinventories for the North Bluff Drainage and Slope Stability Assessment (2000), Ravine Slope Stability Assessments (2002, 2005, 2009), South Fraser Perimeter Road Environmental Impact Assessment reports (e.g. fish habitat, wildlife habitat), and the City of Surrey Ecosystem Management Study (2011),

Available information on provincially sensitive (i.e., Red-listed [Extirpated, Endangered or Threatened] or Blue-listed [Special Concern]) elements (i.e., plants and animals) documented as occurring in the Bridgeview-North Slope ISMP Study Area was downloaded from the Conservation Data Centre (CDC) mapping database (http://webmaps.gov.bc.ca) on July 23 2012. As well, the CDC's tracking list for sensitive element occurrences in the Chilliwack Forest District (http://a100.gov.bc.ca/pub/eswp/) was reviewed on July 23 2012 to assess the potential for other sensitive provincially-listed sensitive species to occur within the Study Area boundaries.

The Species at Risk and Local Government website (http://www.speciesatrisk.bc.ca) was also reviewed to establish the potential for federally-listed sensitive species to occur within the Study Area boundaries. Rare and endangered species are classified federally through the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and the *Species of Risk Act* (SARA). COSEWIC designates rare species as being Extinct, Extirpated, Endangered, Threatened, or Special Concern. Generally, federally-listed species are also designated provincially as either

Red or Blue; however, some exceptions occur. Moreover, not all species listed by COSEWIC are given federal protection under the SARA. Specifically, only species that have been formally added to Schedule 1 receive federal protection.

1.3.3 Field Surveys

Field observations of selected areas within the Bridgeview-North Slope ISMP Study Area have been conducted on July 11, 17 and 19, 2012 by Ken Lambertsen, R.P.Bio. (Senior Consultant) and Martin Gebauer, R.P.Bio. (Wildlife Biologist), and Stephen Sims, R.P.Bio. (Fisheries Biologist). The objectives of the field visits were to assess and classify watercourses, and to observe intact habitats and determine the potential to support wildlife, particularly rare and endangered species. Selected watercourses were observed for fish and aquatic habitat attributes and indicators of relative health (e.g. visual water quality). General habitat types, plant and wildlife species occurrences, and environmentally sensitive areas were identified during the field visits. Wildlife was identified by visual observation, calls, tracks and other sign. Utilization by wildlife not observed during the field surveys was inferred from available habitats, local information, and known distributions of wildlife.

2. WATERCOURSES

The following sections describe the types and features of watercourses in the ISMP study area, existing and proposed fisheries watercourse classifications, and key issues associated with the ecological function and health of the watercourses.

2.1 GENERAL DESCRIPTION

The watercourses within the ISMP study area can be separated roughly into three categories:

- Ravine Streams and tributaries
- Constructed Fish Habitat Drainage Watercourses
- Constructed drainage ditches (not fish habitat)

2.1.1 Ravine Streams

The ravine streams and natural creeks within the study area generally originate along the escarpment of the North Slope portion of the ISMP area and have formed ravines over the escarpment slopes. In the lower reaches within the Bridgeview lowland floodplain areas, these creeks have typically become diverted into roadside channels and enclosed in storm sewers beneath the large railway area (e.g. CN Thornton Rail Yard) along the Fraser River.

The ravine streams in the ISMP study area (see Figures 2 – 5, Appendix A) include:

- Bolivar Creek
- Southward Creek

- Dingwall Creek
- Alexandra Creek
- Wellington Creek

Bolivar Creek is the longest stream with the largest watershed within the ISMP study area, and is fish-bearing (salmonids) from its crossing at King George Boulevard north to the Fraser River.

2.1.2 Constructed Fish Habitat Watercourses

Most of the constructed drainage watercourses that are either fish-bearing, or provide flow and nutrients but are not fish-bearing, extend along the CN Railway adjacent to the Fraser River, or roads near the Fraser River in the lowland floodplain area. These include along 116A Ave., 132nd St., and 117th Avenue. However, constructed fish habitat watercourses also are present on the North Slope escarpment at 114th Ave. west of Alpen Place south of Bolivar Park, and at east side of Bolivar Park along 136 St. road allowance and 115th Avenue.

2.1.3 Constructed Drainage Ditches

These drainage ditches are typically shallow roadside drainage watercourses that primarily convey stormwater runoff for limited periods, and generally go dry quickly after rainfall ends. These ditches typically do not convey groundwater, and have insignificant fish habitat value. The majority of the 124 St., Royal City, and 128 St. drainage catchment areas contain these types of constructed roadside drainage ditches, and in some locations may intersect the high water table. The drainage ditches in the upper portions of the watersheds drain runoff only during rainfall events. The drainage ditches in the lowland floodplain portions of the watersheds provide conveyance and detention when the Fraser River water level is high. In all cases, however, these drainage ditches are not fish habitat, and are therefore classified as Class C watercourses.

2.2 WATERCOURSE CLASSIFICATIONS

The City of Surrey has classified streams according to their ability to support fish populations:

Class A – watercourses support fish populations year round or have the potential to support fish populations year round, if migration barriers are removed

Class A(O) – watercourses support fish populations generally only during the winter months; often roadside ditches that have very low flows and warm temperatures in the summer

Class B – do not support fish populations, but provide food and nutrients to downstream fish habitats and often are supported year-round by groundwater

Class C – do not support fish populations and generally only convey flows associated with rainfall events; often shallow roadside ditches in headwater areas

Based on the background data, airphotos, and limited ground truthing, a majority of the streams in the watershed have been classified correctly, as shown on the City of Surrey GIS mapping

system (COSMOS). Verification in the field consisted primarily of locating the reach breaks between Class A and Class B designations to see if fish barriers or flow restrictions were consistent with the classifications, as well as observations of flowing water during dry weather (i.e. groundwater). Fish sampling has not been conducted for this assessment, but fish have been observed at some locations during the field visits.

2.3 PROPOSED WATERCOURSE RE-CLASSIFICATIONS

Through field observations at selected locations, and with reference to background reports, several changes to watercourse classifications are proposed, including mapping corrections. These are discussed by watershed/catchment area in the following sections, and are shown on Figures 2-5. Due to the size of the ISMP study area, and for scale purposes, 4 separate figures have been prepared to show watercourse classifications, and proposed changes.

2.3.1 128 Street

2.3.1.1 116A Ave. at 130 St.

An open drainage channel east of 130th St. on the north side of 116A Ave., and previously accessible to salmonids as Class A(O) over-wintering fish habitat, had been infilled by an adjacent industrial operation. From COSMOS orthophotos, it appears this watercourse formerly extended east to 132nd St. and then south to 115th Avenue, and was infilled between April 2009 and April 2010. Phoenix has observed that the channel has been partially re-established between 130 St. and 130B Street. However, a section immediately east of 130th St. has remained infilled to operate a sump, from which drainage is pumped into a tanker truck; which poses a barrier to fish migration.

Given the potential to re-establish an overwintering fish accessible drainage channel at this location, subject to enforcement action of unauthorized fish habitat loss and appropriate design, a re-established channel is proposed to be mapped and classified as a Class A(O) watercourse at an appropriate point in the future. However, under current conditions and as currently mapped, the Class (O) classifications of upstream watercourses at 132nd St. south of 116th Ave. (South Fraser Perimeter Road) are questionable.

This location is also discussed further in section 2.4 of this report.

2.3.1.2 132 St. at 116 Ave.

Class A(O) watercourses are shown on both sides of 132nd St. south of the South Fraser Perimeter Road and north of 115th Avenue. The watercourse on the east side of 132nd St. appears to drain to a Class A(O) watercourse on the north side of 116th Ave., which has been recently modified at 116 A Ave. (as discussed in the section above). The Fish Habitat Impact Assessment for the South Fraser Perimeter Road (SFPR) by Coast River Environmental Services Ltd. (2006) recommended that the (then) Class C classification for watercourse on the east side was appropriate classified (as Class C), and due to poor water quality, the watercourse on the west side should be changed from Class A(O) to Class B. The Coast River report indicated there would be 15 m culvert extension on both the north and south sides of the SFPR.

Phoenix observed cool groundwater flows in the watercourse on the east side of 132nd St. (July 17 2012). The watercourse on the west side of 132nd St. and south of 115B Ave. appeared to be dry, which is likely attributable to the storm sewer along the west side of 132nd St. at that location cutting off flow and discharging to the watercourse on the east side of 132nd St. Subject to the outcome of culvert extensions for the SFPR, and more importantly the fate of the infilled former Class A(O) between 132nd St. and 130th St. at 116A Ave., re-classifications of these watercourses may be warranted.

If the former Class A(O) watercourse at 130 St. and 116 Ave. is re-established, with appropriate design and enhancements, then the watercourse on the east side of 132nd St. south and north of the SFPR and 116th Ave. should remain classified as Class A(O). Otherwise, the watercourse on the east side of 132nd St. should be re-classified as Class B.

The watercourse on the west side of 132nd St. is recommended to be re-classified as Class C due to storm sewer modifications and a very small drainage catchment.

2.3.2 Bolivar

2.3.2.1 116 Ave. Tributary Watercourses

A Class A watercourse is currently shown on the south side of 116th Street draining west to Bolivar Creek. This watercourse has been eliminated by the SFPR construction to date. The SFPR Fish Habitat Impact Assessment (2006) identified water quality issues considered to result in low potential for salmonid use, and assuming the watercourse would be re-constructed along the SFPR, suggested that this watercourse be re-classified as Class B.

Regarding the currently classified Class A(O) watercourse on the north side of 116th Ave./SFPR, the SFPR Fish Habitat Impact Assessment noted flows in 1999 and no flows in 2004. Suspecting that flows had be cut-off, it was concluded that this Class A(O) watercourse should be re-classified as Class C. Phoenix observed a large sand bag blocking the east end of this watercourse, and could see no evidence of flow during the July 17 site visit.

Due to the uncertainty regarding actual plans and compensation works associated with the SFPR currently under construction, the classifications of both of these Bolivar tributaries will require further investigation upon completion of the SFPR and any associated fish habitat compensation works.

2.3.2.2 Bolivar Park at 136 St.

A Class B watercourse extends along the east side of the 136th St. unopened road allowance/park trail. Phoenix observed two unmapped Class B tributaries flowing from the east (upslope) into this watercourse, both of which were still conveying groundwater in July. The southern unmapped tributary extended east and curved north following the existing trail in this Bolivar Park natural area. Refer to Figure 3 (Appendix A) for the locations of these previously unmapped Class B watercourses.

It is suspected that there are groundwater springs elsewhere along the lower steeper zone of the North Slope escarpment at this part of Bolivar Park, and can be expected elsewhere along the lower slopes of the escarpment.

There is a short watercourse along the south side of the newly constructed 115th Ave. at the intersection with 136th Street containing cattails with duckweed on the saturated silty substrates. Wetland features have been observed in the natural park area to the west of the 136 St. park trail (i.e. groundwater seeps). The watercourse appears to be intended to flow east to a culvert crossing of 115th Ave., but the channel is raised adjacent to the park trail at 115th Ave. as a result of some recent work. This can be readily rectified, and therefore this short unmapped watercourse is proposed to be shown as a Class B watercourse.

2.3.3 137A Street

2.3.3.1 136 St. North of 115 Ave.

There is a Class A(O) watercourse shown on the east side of 136th Street extending north to 116th Avenue. Due to recent construction at 136th St. and King Rd. and the SFPR, it appears uncertain that this watercourse will remain fish accessible. The SFPR Fish Habitat Impact Assessment suggested that this watercourse should be classified as Class B.

Phoenix has observed this watercourse, and current construction at the SFPR in the vicinity. The watercourse contained shallow flows draining north with in-stream cattail vegetation. Suspected habitat compensation pools and channels that have been rough-graded have also been observed between King Road and the alignment of the SFPR at 136th Street. Subject to confirmation following completion of the SFPR, it appears likely that this watercourse should be re-classified as Class B, unless the culvert connection across the SFPR is made fish-accessible.

There is a roadside drainage watercourse on the west side of 136th St. and the curve at the new 115th Ave. intersection, which is a Class C watercourse and not currently mapped.

2.3.3.2 Southward Creek

Southward Creek will need to be re-mapped on the south side of the SFPR and King Rd. upon completion of the SFPR. Currently, there is a large constructed channel extending along the south side of King Road from the 116th Ave. intersection west to the 136th St. intersection. A culvert approximately in alignment with Southward Creek on the north side of SFPR appears to be mostly plugged, possibly due to subsidence associated with surcharge preloading of the SFPR. It is considered likely that this is a temporary condition, and that there will be a new culvert crossing of King Road and the SFPR connecting the south and north reaches of Southward Creek. The large constructed channel appeared to divert flows west to a culvert at 136th St. and the SFPR; however, very minor flows were also observed draining into the subsided culvert at the original Southward Creek crossing. The appropriate classification of the new channel on the south side of the SFPR should be assessed after completion of the SFPR.

A currently mapped Class C watercourse draining west from the intersection at 116th Ave. and King Road to the Southward Creek culvert crossing has been observed to be flowing (i.e.

groundwater) in July. This watercourse should be re-classified as Class B, depending on the conditions upon completion of the SRPR in this vicinity. Likewise, the currently mapped Class C watercourses to the east of Southward Creek have been modified into the large open channel mentioned above.

2.3.3.3 Southward Creek Tributary

A Class A tributary to Southward Creek extending east from Southward Creek south of 116th Ave. is incorrectly mapped as being confluent with the Class B reach of Southward Creek to the south of King Road. Phoenix has observed that this watercourse extends further east than currently shown, and conveys substantial groundwater flows of greater volume than Southward Creek during dry weather periods (i.e. July 2012 site visits) within an apparently stable channel (i.e. no indicators of scour and erosion). This tributary of Southward Creek drains west along the slope between 115th Ave. and 116th Ave. and emanates from a 200 mm PVC pipe at the east edge of a residential yard situated at 11579 – 138B Street. Rather than flowing west into Southward Creek as currently mapped, this tributary turns north and drains along an alignment approximately the same as Southward Creek on the north side of King Rd and the SFPR. Refer to Figure 5 for the mapping changes proposed by Phoenix for this tributary of Southward Creek.

Depending on the conditions at completion of the SFPR, this tributary could be fish accessible and remain Class A. Upstream fish migration into this tributary would require a fish passable culvert crossing of the SFPR and 116th Ave. and an accessible channel from the existing large constructed channel into which this tributary currently drains. Otherwise, this tributary of Southward Creek would be re-classified as Class B.

2.3.3.4 139A Watercourse

This watercourse currently mapped as Class B to the south of King Road at the approximate alignment of 139A St. (not opened as a road at this location) has been observed to be flowing in July. However, it is unclear if it is or will be connected to the Class A(O) and Class A watercourses along 117th Ave., pending completion of the SFPR.

2.3.3.5 Dingwall Creek, north of King Road

Current COSMOS mapping shows Dingwall Creek to be Class A on the north side of King Road. Current orthophotos show a gap in the SFPR preload fill at the 140th St. alignment, which may be to protect Dingwall Creek and an adjacent Class A(O) watercourse at that location. Access to this portion of Dingwall Creek was not possible due to construction activity on the SFPR. Further assessment of the existing classification (Class A) of Dingwall Creek is required following completion of the SFPR.

2.3.4 Bedford

2.3.4.1 Wellington Creek (West Reach)

The reach of Wellington Creek draining from McBride Drive to King Road (west reach) is not shown on current COSMOS mapping as extending beyond King Road. Phoenix has observed the west reach of Wellington Creek to cross under King Road and continue flowing north in a

ravine with Victoria Park to the SFPR. Access to the SFPR at this location was not possible due to construction activity. The SFPR Fish Habitat Impact Assessment did not discuss the west reach of Wellington Creek. Older COSMOS orthophotos (2007) appear to indicate that the west reach of Wellington Creek flowed beneath the access road to the BC Hydro building and into the Class A watercourse on the south side of the CN tracks.

The unmapped portion of the west reach of Wellington Creek north of King Road appears to have had potential to be Class A (i.e. with removal of any fish passage barriers at the former BC Hydro driveway crossing). Phoenix has observed the culvert crossing of King Road to be perched, and therefore a fish access barrier. Classification of the unmapped portion of the west reach of Wellington Creek is subject to further assessment following completion of the SFPR.

2.3.4.2 Wellington Creek (East Reach)

A Class B watercourse is currently shown on COSMOS mapping within Victoria Park to the south of King Road with its headwaters to the north of the intersection of Bedford Drive and Wellington Drive. This Class B watercourse is referred to a Wellington Creek East Reach for the purposes of this assessment. Current mapping also shows a Class B roadside watercourse to the west of the east reach of Wellington Creek, and the east reach draining east along the south side of King Road to the intersection of 116A Avenue. Phoenix has observed that this Class B east reach of Wellington Creek actually crosses King Road through a wood stave culvert that has been partially infilled with debris and granular substrates, and is perched at the outlet (i.e. fish barrier). The Class B roadside watercourse currently shown to the east of the culvert crossing has not been observed. Therefore, the east reach of Wellington Creek crosses King Road and flows in a roadside watercourse on the north and west curve of King Road along the adjacent residential property (14442 – 116A Street), as shown on Figure 5 (Appendix A).

The east reach of Wellington Creek on the west side of King Road and south side of 116A Ave. has been observed by Phoenix to be unlikely to be fish accessible due to instream growth of weed vegetation and shallow depth. The SFPR Fish Habitat Impact Assessment included extensive fish sampling of this portion of the east reach of Wellington Creek, and no salmonids were present. A perched culvert crossing the driveway to the BC Hydro property was considered to be a fish migration barrier. Phoenix observed no fish passable culvert beneath the SFPR at the west end of 116A Avenue.

Phoenix also observed that a fire hydrant on the south side of 116A Ave. is leaking (chlorinated water) into the creek. The chlorinated water leak from the fire hydrant should be repaired as soon as possible.

Further assessment following completion of the SFPR is required to determine if the portion of the east reach of Wellington Creek north of King Road should remain as Class A, or be re-classified as Class B.

2.4 WATERCOURSE IMPACTS AND MITIGATION

The ravine watercourses and most of the Class B constructed channels have been observed to provide good quality fish and wildlife habitat. However, detrimental impacts to watercourses

continue to occur including: erosion and scour, barriers to fish migration, damaged riparian habitat and poor water quality.

2.4.1 Stream Erosion

The City of Surrey commissioned the North Bluff Drainage and Slope Stability study in 2000 by Stantec, which proposed high flow storm sewer diversions for Bolivar Creek, Southward Creek, Dingwall Creek and Alexandra Creek. It is apparent that these diversions were completed in the early 2000's. The diversion on Bolivar Creek extends from 108th Ave. near the crest of the escarpment slope to 114th Ave. near the base of the slope. Long term monitoring reports of the diversion sewer outfall downstream 114th Ave on Bolivar Creek by ECL Envirowest Consultants Ltd. (ECL) commencing in 2002 and onward have confirmed that the Bolivar Creek channel at the diversion outlet is largely stable. Long term monitoring reports by ECL of storm sewer diversions at Southward Creek and Dingwall Creek also indicate that the channels downstream of those diversion outlets are stable.

Phoenix has observed Bolivar Creek in several locations along the escarpment slope. The upstream section south of 108th Avenue exhibits evidence of continuing scour and erosion. However, downstream there have been signs of stream channel stability (e.g. moss on instream boulders) and the fish passable culvert at 112th Avenue. Steeper reaches of step-pool habitat within a deep and steep ravine have been observed at 112B Ave. with coarse woody debris and moss-covered instream boulders. Pool riffle habitat and channel bifurcation also appeared relatively stable at 113B Ave. Numerous juvenile coho salmon were observed by Phoenix at the fishway at the 114th Ave. crossing.

Phoenix has observed Southward Creek at the 115th Ave. crossing, at which a culvert extension downstream of 115th Ave. was constructed in 2011 to rectify erosion of the steep left (west) bank. Phoenix provided monitoring of the associated instream works. The culvert extension appears to have reduced scour along the toe of ravine slope by focusing flows into the channel instead of at the ravine bank. Further downstream near the crossing of the sanitary forcemain, Southward Creek has a lower gradient and gravel bedload deposition (i.e. bedload transport) was evident from collapsed exclusion fencing left behind in the channel. As mentioned in section 2.3.3.3, a separate tributary of Southward Creek has been observed to extend further east than currently mapped and appears to have a relatively stable, primarily groundwater-fed flow regime.

Wellington Creek (east reach) also was observed to have a relatively stable flow regime based on channel observations at King Road. Observations of Dingwall and Alexandra Creeks were limited due to access difficulties.

While observations of relatively good creek channel stability in the ravine streams by Phoenix have been limited for this assessment, it is evident that scour and erosion problems persist despite the storm sewer diversions constructed on the North Slope streams. Ravine Stability Assessments have been carried out (2002 – 2009) for the City, including the main ravine streams in the ISMP study area. Areas of continuing localized bank failure and erosion have been documented at numerous locations along Bolivar, Southward, Dingwall, and Alexandra Creeks; several of which are rated as high risk, with most erosion sites being medium to low risk sites, with respect to property and structures impacts. This suggests that further work with regard to

stormwater management BMP (e.g. volume reduction, velocity control) would be beneficial, as would relocation of various existing residential and commercial structures along and within ravine areas as re-development opportunities arise.

2.4.2 Fish Migration Barriers

In 2000, through bioinventories for the North Bluff Drainage and Slope Stability study, ECL noted that Bolivar Creek was not fish accessible upstream of 114th Ave., which has since been rectified; making Bolivar Creek the only ravine stream within the study area that is Class A along the escarpment slopes. ECL noted in 2000 that Southward, Dingwall, Alexandra and Wellington Creeks all have fish migration barriers due to culvert installations along the CN tracks or along 116th Ave. and King Road, which are also along the SFPR alignment in the study area. ECL observed that the Class B reaches of Southward, Dingwall, Alexandra and Wellington Creeks have moderate to high rearing habitat, if access barriers were to be removed.

Phoenix has observed several existing and potential fish access barriers; many of which may be temporary pending the completion of the SFPR construction, associated stream crossings and habitat mitigation and compensation works. These have been discussed more specifically in section 2.3 of this report. There appears to be potential for fish access to be provided into the currently inaccessible portions of Southward Creek and Southward Creek tributary; both of which offer moderate to high quality rearing habitat, as well as possible spawning habitat. It remains to be determined if expanding fish access into some of the ravine streams south of King Road (e.g. Southward Cr., Wellington Cr.) will be possible, or is already planned, with the completion of the SFPR. Several other barriers (e.g. Alexandra Creek) are historical and associated with the CN rail yard and tracks, which are quite difficult to correct.

Another barrier to fish migration with potential for restoration is the infilled Class A(O) drainage channel at 116A St. east of 130th Street. Although partially restored, there remains a barrier at the east side of the intersection of 130th St., and further east of the recently re-opened section extending to 130B Street. The former Class A(O) channel used to extend to 132nd St. and south of 116th Avenue.

2.4.3 Riparian Habitat Damage

Disposal of refuse along ravine banks and along and within lowland drainage watercourses has been observed by Phoenix in many locations, and is evidently quite extensive within the study area; particularly near 108th Ave. and King George Blvd. on Bolivar Creek. Discarded styrofoam and other flotsam has been observed downstream of the recently constructed portions of 115th Ave. within Bolivar Creek, where riparian habitat is limited to immediate stream banks (if present) due to current industrial buildings. While much less extensive, discarded refuse and gardening debris and invasive species has been observed where residential development has extended to the top of ravine banks along the North Slope ravine streams. Public education and establishing wider setbacks from top of ravine banks if and as re-development occurs can mitigate these impacts.

Along many of the Class A(O) and Class B open drainage watercourses, riparian vegetation is either absent or dominated by blackberry, knotweed, policeman's helmet and other invasive

plants, together with extensive refuse disposal. There is much potential to restore and enhance open channel fish habitats in the lowland areas of the study area; much of which will probably await re-development of these areas.

2.4.4 Water Quality

An assessment of water quality within the ISMP study area by Phoenix has been limited to visual indicators, and has not been supplemented by water quality testing due to the limited timeframe available for such testing (i.e. no time for replication or adjustment for seasonal effects).

2.4.4.1 North Slope Ravine Streams

Phoenix field visits have revealed generally good visual indicators of water quality within the North Slope ravine streams, where cool and clear flows were exhibited. Due to the time of year of the field visits, flows in Bolivar, Southward, Southward Tributary, Dingwall, Alexandra and Wellington Creeks appear to be primarily groundwater-fed. However, it is anticipated that during wet weather periods, stormwater contaminants from roadways, construction site siltation releases, and high flow event bank erosion result in episodes of diminished water quality. These impacts can be progressively mitigated over time by ongoing public education and stormwater quality BMP.

Salmonid observations in Bolivar Creek by Phoenix and documented in long term monitoring reports have provided further indications that the overall health of ravine streams along the North Slope is generally good. It is also clear that continued protection and potential expansion of groundwater resources to streams along the North Slope will remain very important for sustaining fish and aquatic habitat quality in the ISMP study area. For example, infiltration of source-separated stormwater, or use of utility trenches for groundwater preferential pathways to watercourses (which already occurs), are opportunities for consideration under the ISMP. Protection of springs along the escarpment slopes also should be maintained.

2.4.4.2 Artesian Flows at CN Tracks & 136 St.

Phoenix observed artesian upwelling of groundwater at the upstream end of an apparently temporary ditch draining east toward Southward Creek around a possible future or temporary cul de sac on the north edge of the SFPR. Previous COSMOS orthophotos (2007) show this area as a pond. As a cone of newly deposited sandy substrates had been formed in this pool bottom, it is apparent that this may be a seasonal condition (i.e. during Fraser River freshets), or a recent change due to SFPR construction modifications in this area. The associated groundwater flows draining to Southward Creek on the north side of the SFPR have been observed to be substantial, and should be connected to Southward Creek either directly or via the nearby apparent habitat compensation works.

2.4.4.3 Lowland Floodplain Watercourses

Many of the existing classified open channel watercourses (i.e. Class A(O) and Class B) within the ISMP study area have exhibited visual indications of poor water quality during the Phoenix field visits. However, such visual indications are not necessarily reliable and can be expected within low gradient channels in warm summer weather conditions (e.g. algal blooms). During

summer weather, it is expected that water temperatures and depressed dissolved oxygen would prevent salmonid presence that may otherwise occur during winter weather periods (e.g. Class A(O) drainage channels). In other cases, Phoenix has observed or learned of petroleum hydrocarbon contamination of some drainage watercourses within the industrial area of the ISMP (e.g. Class A(O) drainage channel at 116A Ave and 130th St). Elsewhere within the industrial area (e.g. 132nd St.), clear and cool groundwater flows were observed by Phoenix.

While there are many challenges, reduced pollution of stormwater and open channel drainage watercourses can be achieved over time through education, compliance monitoring and enforcement, and eventual re-development opportunities. Enclosing the existing open drainage watercourses in storm sewers is not a recommended approach, as geotechnical investigations for the Royal City pump station (Golder, 1996) have confirmed that maintaining open channels is advisable instead of storm sewers that are prone to subsidence in the soft, compressible soils in this part of the ISMP study area. While open drainage channels may be more susceptible to refuse accumulations and other contaminant sources, these are considered to be preferable for aquatic productivity and potential for mitigation of water quality impacts by instream vegetation biofiltration.

2.4.5 Benthic Macroinvertebrates

The City of Surrey has commissioned routine benthic invertebrate community monitoring in numerous watercourses throughout the city since 1999, which can provide indicators of aquatic health. It is understood that limited benthic invertebrate monitoring has been completed in the study area. Long term monitoring documents provided by the City for this ISMP study area have not included benthic invertebrate monitoring, and these data have not been sought out by Phoenix for the purposes of this environmental assessment.

3. TERRESTRIAL HABITATS

The ISMP study area is found in the Dry Maritime subzone of the Coastal Western Hemlock biogeoclimatic zone (CWHdm) (Green and Klinka 1994). The study area is dominated by dense residential and commercial development in the highlands and North Slope portion, and mixed industrial and residential development, including railway infrastructure and the partially completed South Fraser Perimeter Road, in the low-lying floodplain areas along the Fraser River. Natural habitats are uncommon and occur primarily along the north slope transition between the highlands and lowlands, and ravines associated with Bolivar, Southward, Dingwall and Alexandra creeks, and the east side of Bolivar Park. A relatively large and intact forested area is situated on the north side of King George Highway near 113B Ave., but is being encroached upon by industrial development. Many forested habitats are characterized by mild to severe disturbance from illegal dumping, motor bike activity, squatting and invasive plants. A more detailed description of habitat types is provided below and a complete list of plant species identified during the field visits is provided in Appendix C.

The Ecosystem Management Study has included a vegetation inventory of the City, including the Study Area (http://www.surrey.ca/files/Map1VegetationInventoryMay13.pdf), which clearly illustrates the highly modified habitats of the Study Area relative the other areas of the City (HB

Lanarc and Raincoast 2011). The vegetation inventory, terrestrial habitat hubs and existing or potential wildlife corridors within the ISMP study area (Study Area) are depicted in Figure 6.

3.1 TREES AND WOODED AREAS

3.1.1 Overview

Most forested patches in the Study Area are deciduous, dominated by Black Cottonwood (see Appendix C for scientific names), Red Alder and Bigleaf Maple with lower densities of Bittercherry and Cascara. A smaller percentage of forested area, particularly in ravine habitats, is dominated by coniferous species including Western Red Cedar, Western Hemlock and Douglas-fir with occasional Sitka Spruce. A majority of the forests have young to mature trees.

Forest stands of $\geq$ 1 hectare are rare. The largest stands included:

- deciduous-dominated forest at the northeast end of the Study Area associated with Bon Accord Creek adjacent to the east of the Study Area) and Wellington Creek;
- deciduous-dominated forests on the north slope near Southward Creek and Bolivar Creek (Bolivar Park);
- mixed coniferous forest associated with North Slope creek ravines (e.g. Bolivar Creek Alexandra); and
- the deciduous-dominated, and highly disturbed, forest along the north side of the King George Highway and south of 113B Avenue.

These sites have been identified by the City of Surrey Ecosystem Management Study as Terrestrial Hubs, Ecosystem Corridors, and/or Ecosystem Sites. The remaining forested stands, although relatively small, degraded and isolated, provide essential habitat for birds and small mammals still occurring in North Surrey, protect water quality and aquatic habitat adjacent to watercourses, and enable wildlife movement between habitat hubs.

3.1.2 Bon Accord Creek/ Wellington Creek Forest

Habitats associated with the Bon Accord Creek watershed near the northeastern end of the Study Area (but outside of the Study Area) are part of a larger forested area that is considered by HB Lanarc and Raincoast (2011) to be a Hub of high ecological significance. The forest is dominated by mature deciduous trees including Black Cottonwood, Bigleaf Maple and Red Alder, while the well established shrub understorey is dominated by Salmonberry and Indian-Plum with some Bittercherry, Beaked Hazelnut and Cascara.

3.1.3 North Slope Forests

North slope forests are dominated by deciduous tree species including Black Cottonwood, Bigleag Maple and Red Alder with occasional Western Hemlock and Western Red Cedar. Understorey vegetation is well established and characterized by Salmonberry, Thimbleberry, Indian-Plum and Red Elderberry. At the base of the slope, the occasional wetland habitats are

dominated by Lady Fern, Skunk Cabbage, Red-osier Dogwood and willow. Problematic invasive species include Policeman's Helmut and Himalayan Blackberry.

3.1.4 Ravine Forests

Ravine forests and woodlands in the steeper areas of the Study Area are dominated by mixed forest with Red Alder, Bigleaf Maple, Black Cottonwood, Western Red Cedar, Western Hemlock and Douglas-fir. Understorey shrub and herb vegetation ranges from sparse in disturbed and trampled areas to dense in relatively undisturbed areas. In more pristine areas, Salmonberry, Indian-Plum, Vine Maple, Lady Fern and Swordfern are common understorey species. In most areas, Himalayan Blackberry and English Ivy are significant invasive species, impacting primarily edge habitats, but also encroaching into central areas of ravines.

3.1.5 North King George Forest

This largely deciduous forest dominated by Black Cottonwood and Red Alder has alternating bare understorey areas (due to apparent excessive motorbike activity) and dense shrub areas dominated by Salmonberry, Indian-Plum and Beaked Hazelnut. English Ivy is particularly invasive in this area. The forest has also been disturbed by a considerable amount of refuse disposal.

3.2 Old Fields

Old field habitats were largely absent from the Study Area. Some abandoned lots, particularly in the industrial zone, had old field type habitats with some associated plant and animal species, but were generally degraded by fill and garbage.

3.3 Ponds

One small, highly disturbed pond was identified within the industrial land just southwest of the intersection of 131st Street and 114th Avenue. Despite disturbance, including dirt bike tracks and trails, efforts at draining the pond and garbage, the pond was being used by Mallard (see Section 4 for scientific names) and Belted Kingfisher, while the surrounding riparian shrub vegetation was being used by Song Sparrow, Willow Flycatcher and other bird species.

3.4 Wildlife Trees

A wildlife tree is any standing dead or living tree with special features that provides present or future critical habitats for the maintenance or enhancement of wildlife. There are nine classifications of coniferous and six classes of deciduous wildlife trees in various successions from live and healthy with no decay, to stumps and debris (Fenger et al. 2006). All of these wildlife tree stages provide important habitat, and are known to support more than 90 animal species in British Columbia, including cavity nesting birds and mammals (Backhouse 1993). Some of the uses include nesting, feeding, territoriality (i.e. bear mark trees, bird singing sites, etc.), roosting, shelter, and overwintering (Backhouse 1993).

Most of the trees observed in the study area were identified as Class 1 wildlife trees, which are live healthy trees with no decay. A few dead trees were present, but due to the relatively young ages of the forests were not common. Two raptor nests, Bald Eagle and Red-tailed Hawk, have been previously identified within the Study Area (see Figure 6).

3.5 SENSITIVE TERRESTRIAL ECOSYSTEMS

The CDC defines listed ecological communities as ecosystems identified in a Sensitive Ecosystems Inventory. These sites are generally old growth stands that are generally 500 m^2 or greater and are often the remnants of the natural ecosystems that once occupied a much larger area. Typically, mature and old growth upland ecological communities are of concern to the CDC. The listed ecological communities are classified using methodologies and nomenclature developed by Green and Klinka (1994). All forested portions within the Study Area were second to third growth stands, which are generally not considered to be Sensitive Terrestrial Ecosystems.

For the SFPR Wildlife Habitat Impact Assessment, Robertson (2006) identified habitats at the north end of 136th Street (e.g., in vicinity of Bolivar Creek) and at Bedford Creek (Wellington Creek) as blue-listed habitat. The polygon at Bolivar Creek is classified as age class 6 (i.e., mature forest) consisting of 40% Western Hemlock – Flatmoss (HM), 40% Douglas-fir – Swordfern (DF) and 20% Cottonwood - Red-osier Dogwood (CD). The blue-listed polygons (three distinct) at Bedford Creek are classified primarily as 100% Douglas-fir – Swordfern (DF). A third blue-listed polygon, in the vicinity of the King George forest, has recently been deforested and is undergoing industrial development.

3.6 SENSITIVE PLANTS

Although sensitive plant species were not identified during the July 2012 site visits, a few species are known or have the potential to occur within the study area (see Table 1).

Table 1: Federally and/or provincially listed species that occur or may occur in the study area.

Species	Federal and Provincial Status		Site Occurrence
Common/Scientific Name	**COSEWIC and SARA**	**CDC**	**Expected Onsite Habitat Use**
False-pimpernel (*Lindernia dubia* var. *anagallidea*)	-	Blue	**LOW** – According to the CDC database, False-Pimpernel is uncommon on sandbars and shoreline areas of the Fraser River near the Fraser Surrey Docks and Fraser Mills (Coquitlam). Potential for occurrence in upland wetland areas within the Study Area is low.
Pointed Broom Sedge (*Carex scoparia*)	-	Blue	**MODERATE –** According to the CDC database, Pointed Broom Sedge has been recorded on the east bank of the Fraser River near the Patullo Bridge. This species has the potential to occur in foreshore areas of the Study Area.
Streambank Lupine (*Lupinus rivularis*)	Endangered	Red	**MODERATE** – Streambank Lupine has been identified along railway tracks and in disturbed areas west of the Study Area. Similar habitats exist within the Study Area within the Fraser River floodplain; therefore the potential for occurrence within the Study Area is considered to be moderate.
Three-flowered Waterwort (*Elatine rubella*)	-	Blue	**LOW** – According to the CDC database, Three-flowered Waterwort is sparse on muddy sandbars on the east bank of the Fraser River near the Patullo Bridge. Potential for occurrence in upland wetland areas within the Study Area is low.
Vancouver Island Beggarticks *(Bidens amplissima)*	Special Concern	Blue	**LOW** – According to the CDC, Vancouver Island Beggarticks has been recorded in Surrey west of the Study Area between the Fraser River and River Road. The small wetlands located in lowland areas of the Study Area have some potential to provide habitat for this species.

4. WILDLIFE INVENTORY AND HABITAT

4.1 WILDLIFE SPECIES

Thirty-two bird species and four mammal species were recorded during the July 2012 site visits. Most species were those that have adapted to disturbed urban environments; however, some forest-interior species, such as Swainson's Thrush, Brown Creeper and Pileated Woodpecker were documented. A list of wildlife species encountered during the site visits is provided in Table 2 below.

Table 2: Wildlife species observed during 11 and 19 July 2012 site visits to the Bridgeview-North Slope ISMP Study Area.

COMMON NAME	SCIENTIFIC NAME	11 July	19 July
BIRDS			
American Goldfinch	*Carduelis tristis*	3	5
American Robin	*Turdus migratorius*	2	4
Bald Eagle	*Haliaeetus leucocephalus*		1
Belted Kingfisher	*Megaceryle alcyon*		2
Bewick's Wren	*Thryomanes bewickii*	2	
Black-capped Chickadee	*Poecile atricapillus*	6	13
Black-headed Grosbeak	*Pheucticus melanocephalus*		3
Black-throated Gray Warbler	*Setophaga nigrescens*	1	
Brown Creeper	*Certhia americana*		2
Bushtit	*Psaltriparus minimus*		3
Caspian Tern	*Hydroprogne caspia*		1
Cedar Waxwing	*Bombycilla cedrorum*	3	4
Downy Woodpecker	*Picoides pubescens*		1
European Starling	*Sturnus vulgaris*		6
Golden-crowned Kinglet	*Regulus satrapa*		2
House Finch	*Carpodacus mexicanus*	3	2
Mallard	*Anas platyrhynchos*		12
Merlin	*Falco columbarius*		1
Northern Flicker	*Colaptes auratus*		1
Northwestern Crow	*Corvus caurinus*	2	3
Pacific Wren	*Troglodytes pacifica*	1	
Pileated Woodpecker	*Dryocopus pileatus*		1
Red-tailed Hawk	*Buteo jamaicensis*		2
Savannah Sparrow	*Passerculus sandwichensis*		2
Song Sparrow	*Melospiza melodia*	4	5
Spotted Towhee	*Pipilo maculatus*	2	1
Swainson's Thrush	*Catharus ustulatus*	4	4
Warbling Vireo	*Vireo gilvus*		
Western Wood-Pewee	*Contopus sordidulus*		1
White-crowned Sparrow	*Zonotrichia leucophrys*		1
Willow Flycatcher	*Empidonax traillii*		2
Wilson's Warbler	*Cardellina pusilla*	1	
Total Species	**32**	**13**	**27**

Table 2 (continued):

MAMMALS			
Black-tailed Deer	*Odocoileus hemionus*	1	
Coyote	*Canis latrans*		tracks
Gray Squirrel	*Sciurus carolinensis*	1	
Raccoon	*Procyon lotor*	tracks	

4.2 FEDERALLY AND PROVINCIALLY LISTED SPECIES OF CONCERN

Based on a review of existing literature and an assessment of suitable habitats, a number of federally and/or provincially-listed wildlife species may occur within the Bridgeview-North Slope ISMP Study Area. These species are listed in Table 3.

Table 3: Federally and/or provincially listed species that occur or may occur in the study area.

Species	**Federal and Provincial Status**		**Site Occurrence**
Common/Scientific Name	**COSEWIC and SARA**	**CDC**	**Expected Onsite Habitat Use**
BIRDS			
Band-tailed Pigeon (*Patagioenas fasciata*)	Special Concern	Blue	**LOW** – Mixed coniferous and deciduous forests, which are the preferred nesting habitats of Band-tailed Pigeons, are not widespread in the Study Area. As well, berry-producing shrub-dominated areas, which are important foraging habitats, are also not common.
Barn Owl (*Tyto alba*)	Special Concern	Blue	**LOW** – Barn Owls are solitary nesters that prefer agricultural areas. Nests are usually situated in man-made structures including barns and old buildings (Campbell et. al 1990). With agricultural and old-field habitats being rare in the Study Area, Barn Owl is not expected to occur regularly.
Great Blue Heron (*Ardea herodias fannini*)	Special Concern	Blue	**MODERATE** - Foraging habitat does not appear to be a limiting factor for this subspecies as not all available habitat is used by herons each year. Heron colonies have not been documented within the Study Area, although a large colony is present on the north bank of the Fraser River just east of the Port Mann Bridge. Herons from this colony are expected to occasionally feed along the Fraser River foreshore, ditches and other wetlands within the Study Area.
Green Heron (*Butorides striatus*)	-	Blue	**LOW** - Green Herons use a variety of habitats, including sloughs, rivers, lakes, ponds, reservoirs, estuaries and beaches in British Columbia. Important habitat components for Green Herons include slow-moving or shallow water for foraging and nearby dense trees or tall shrubs for nesting (Fraser 1996). The occurrence of these habitat features is limited in the Study Area.
Olive-sided Flycatcher (*Contopus cooperi*)	Threatened	Blue	**LOW** – Olive-sided Flycatchers occur at low densities in urbanized areas. They are more likely to occur briefly during the spring and fall migratory periods.
Peregrine Falcon (*Falco peregrinus* ssp. *anatum*)	Special Concern	Red	**MODERATE** – Peregrine Falcons are known to have nested on both the Patullo and Port Mann Bridges in the past; therefore, some foraging likely occurs over the site. Nesting habitat is not available within the Study Area.
Short-eared Owl (*Asio flammeus*)	Special Concern	Blue	**LOW** – Old-field habitats preferred by Short-eared Owls are sparse within the Study Area; therefore, the likelihood of occurrence is very low.
Western Screech-Owl (*Megascops kennicottii* ssp. *kennicottii*)	Threatened	Blue	**MODERATE** – Western Screech-Owls are unlikely to nest in the smaller disturbed ravines and woodlots within the Study Area. A possible moderate suitability nesting and living habitat is the forest associated with Bon Accord Creek at the northeast end of the Study Area.

Table 3 (continued):

MAMMALS			
Pacific Water Shrew (*Sorex bendirii*)	Endangered	Red	**MODERATE** - The majority of Pacific Water Shrew captures have been within 25 m of streams (Nagorsen 1996; Craig 2003). In BC, capture sites appear to be primarily associated with coniferous or deciduous forest, characterized by Red Alder, Bigleaf Maple, Western Hemlock and/or Western Red Cedar that border riparian areas, streams and Skunk Cabbage marshes (Nagorsen 1996). Pacific Water Shrews have also been captured in more open habitat, with dense marsh vegetation that includes Reed Canarygrass vegetated roadside ditches and water bodies. Suitable habitats for Pacific Water Shrew exist along Bon Accord Creek (documented water shrew record), Bolivar Creek ravine, and wetland-type habitats at the base of the north slope.
Snowshoe Hare (*Lepus americanus* ssp. *washingtonii*)	-	Red	**LOW** - This primarily nocturnal species favours moist semi-open forests with clearings and thickets (McTaggart-Cowan and Guiguet 1965). There are very few records of this species in recent years, but forested habitats and ravines within the Study Area may provide habitat (e.g., Bon Accord Creek watershed).
Trowbridge's Shrew (*Sorex trowbridgii*)	-	Blue	**HIGH** - Trowbridge's Shrew uses both riparian and non-riparian forest (Zuleta and Galindo-Leal 1994). In non-riparian forests, the Trowbridge's shrew has shown a preference for areas with a high moisture regime, rich soils, and abundant decaying CWD and leaf litter on the forest floor (Nagorsen 1996). Relatively intact forests associated with the north slope and Bon Accord Creek are expected to provide remnant habitat for this species.
AMPHIBIANS			
Red-legged Frog *(Rana aurora*)	Special Concern	Blue	**LOW** - Red-legged frogs in BC are found in moist forests and in forested wetlands (Corkran and Thoms 1996). Adults will often wander far from standing water to forage on small insects or forest invertebrates (Nussbaum et al. 1983 in Ovaska and Sopuck 2004). Generally, they breed in cool, shaded temporary ponds where they attach their eggs to submerged woody debris or vegetation (Corkran and Thoms 1996). Wetland breeding habitats are very sparse within the Study Area; therefore, the probability of occurrence is low.
INVERTEBRATES			
Oregon Forestsnail *(Allogona townsendiana)*	Endangered	Red	**LOW** – According to the CDC and Forsyth (2004), most Oregon Forestsnail occurrences are in the Fraser Valley from Langley eastward. As well, preferred habitat, characterized by Bigleaf Maple and Stinging Nettle, does not appear to be prevalent in the Study Area.
Pacific Sideband *(Monadenia fidelis)*	-	Blue	**MODERATE** - Pacific sidebands live in deciduous, coniferous or mixed forests as well as in open forests and grassy areas (Forsyth 2004). Moderate habitat suitability is available in the Bon Accord watershed and north slope forested areas.

4.3 WILDLIFE CORRIDORS

Wildlife corridors exist between remaining forested and shrub-dominated habitats within the Study Area. The presence of Coyote and Black-tailed Deer suggests that adequate linkages still exist between some of the more significant natural environments within the Study Area (e.g., creek ravines and north slope forests).

4.4 RAPTOR NEST SITES

Raptor nests sites have been previously recorded by other studies (e.g., South Fraser Perimeter Road Environmental Assessment – Robertson 2006; HB Lanarc and Raincoast 2011) within the Study Area. The Bald Eagle nest previously recorded is indicated on the attached Figure 6. A raptor nest survey was not conducted as part of the current investigation.

5. SENSITIVE ENVIRONMENTAL AREAS

5.1 WATERCOURSES AND RIPARIAN HABITATS

The priority areas for protection include the Class A and B streams and their riparian areas and remaining forest stands of $\geq$ 1 hectare (refer to Figure 6). Watercourses and their riparian areas in the City are currently protected by the Land Development Guidelines for the Protection of Aquatic Habitat. Under this regulation, setbacks for streams range from 15-30 meters from the high water mark or from the top of ravine (if slopes steeper than 3:1 exist) depending on the density of development at a site. Most of the existing development around streams in the Study Area occurred prior to the application of setbacks.

5.2 INTERIOR FOREST HABITAT

Interior forests have special habitat conditions that enable them to support different wildlife species than forest edge habitats. Interior forest habitats are not present in the ISMP Study Area, and appear limited to the adjacent Bon Accord Creek forest and ravine.

6. CONCLUSIONS

This Stage 1 ISMP Environmental Assessment (Stage 1 EA) has included use of existing research and reports, as well as limited field reconnaissance, to conduct an inventory and assessment of the fish, aquatic and wildlife habitats within the ISMP Study Area. The Bridgeview-North Slope ISMP study area is characterized by predominantly urban and industrial land uses extending from commercial and high-density residential areas near the Surrey City Centre south of 108th Avenue to single family residential areas over most of the north slope and mixed industrial, commercial and residential within the lowland floodplain areas near the Fraser River. The study area has been largely built-out with negligible undeveloped lands, such that remaining streams, forested and environmentally sensitive areas have become a scarcity and of significant retention value.

The watercourses within the ISMP study area can be separated roughly into three categories: Ravine Streams and tributaries, Constructed Fish Habitat Drainage Watercourses, and Constructed drainage ditches (not fish habitat). The City of Surrey's Fisheries Watercourse Classification system has been applied to assess and classify watercourses in the study area. Several changes in the City's online mapping (COSMOS) are proposed to address unmapped watercourses, inaccurately mapped watercourses, and to address proposed re-classifications of

watercourses. These are discussed in detail in section 2.3 of this report, and are shown on Figures 2 - 5 in Appendix A. Numerous potential re-classifications of watercourses require further assessment after completion of the SFPR, as the nature of culvert crossings and habitat compensation works have not been determined during this assessment.

A number of issues relating to watercourses in the ISMP study area have been identified, including: stream erosion, fish migration barriers, riparian habitat damage and water quality. Previous sewer diversions have been installed to bypass high flows around the steep slopes and ravines on the North Slope area of the study area. Field observations and long term monitoring reports indicate that the high flow bypass diversions have resulted in relatively good stream stability. However, ravine stability assessments (2002 – 2009) indicate that numerous localized bank erosion problems persist within the North Slope ravine streams following the construction of the storm sewer diversions (ca. 2001). Several barriers to upstream fish migration have existed for many years (e.g. CN Rail yard) such that most of the ravine streams are not fish accessible within the North Slope area; with the exception of Bolivar Creek, which is fish accessible to King George Boulevard. Depending on completion of the South Fraser Perimeter Road, there appear to be opportunities to restore fish access into some streams along the North Slope area (e.g. Southward Creek). Riparian habitat damage from refuse disposal and long-term structures built at or very close to watercourse banks and ravine crests occurs extensively throughout the study area. Water quality issues are most prevalent in the lowland floodplain and industrialized areas of the ISMP study area. These issues are discussed in greater detail in section 2.4 of this report.

The relatively few and fragmented forested areas remaining in the study area have not changed substantially over many years, given the long history and density of urban development in the study area. No sensitive plant or animal species were detected during the field program, although several sensitive species are likely, including Great Blue Heron, Trowbridge's Shrew, Pacific Water Shrew and Streambank Lupine. Remaining forest patches need to be protected and wildlife movement corridors need to be maintained or established to improve the ecological integrity of the Study Area and to provide suitable living habitats for sensitive species including Trowbridge's Shrew, Pacific Water Shrew and Western Screech-Owl, among a number of other species. Provision of natural habitats that have protected corridors will result in increased biodiversity within the Study Area.

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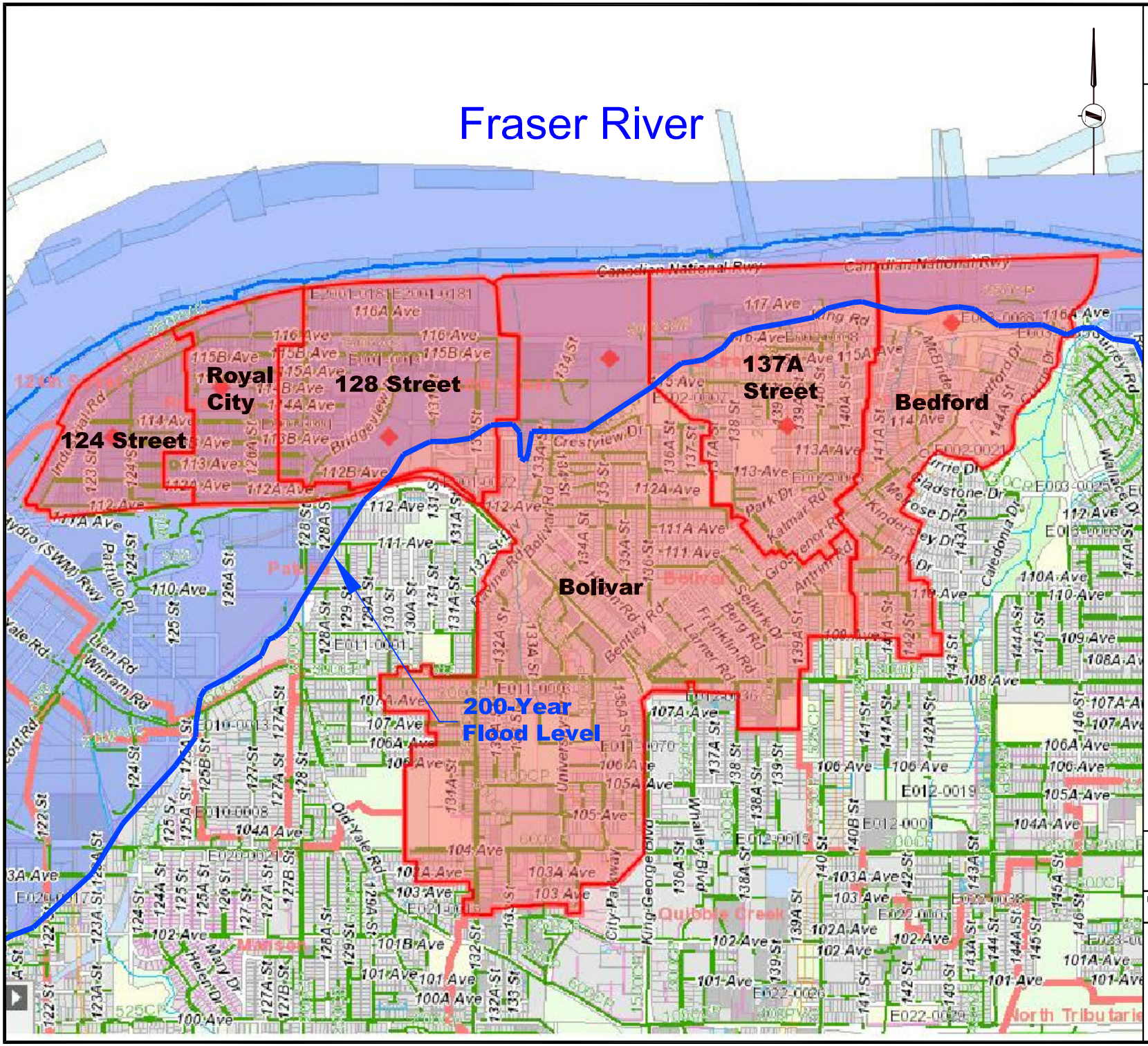
APPENDIX A

Figures



CITY OF SURREY
the future lives here.

Bridgeview - North Slope ISMP

Scale: N.T.S.

AECOM

Project No.	Date
	May 18, 2012

Study Area and Watersheds

Figure 1

124th Street Catchment

116A Ave. at 130 St.

- Partially restored channel *(infilled between April 2009 & April 2010).*
- *Water quality issues and opportunities for riparian improvements.*
- *Current barrier to upstream fish movement.*

132 St. at 116 Ave.

- *Re-classification of watercourse north of SFPR dependent on appropriate design and enhancements at 130 St. and 116A Ave.*
- *Potential obstruction to upstream fish movement at 132 St. SFPR crossing.*
- *Further investigations are required following completion of SFPR to reclassify watercourse on the east side of 132 St. south of SFPR.*
- *Phoenix recommends re-classification of the ditch of the west side of 132 St. south of 115B Ave. from Class A(o) to Class C.*

Royal City Catchment

128th Street Catchment

Bolivar Creek

Class "A" Watercourse

Class "A(o)" Watercourse

Class "B" Watercourse

Class "C" Watercourse

Assessment & Potential Habitat Enhancement Location

Unknown Watercourse Classification

Note .DWG base layers courtesy of City of Surrey COSMOS mapping (2012)

Bridgeview - North Slope ISMP

Watercourse Classification Map

Figure 2. 124th Street, Royal City & 128th Street Catchments

DATE July 2012		REV 00
DRAWN BY S. Sims	SCALE 1:7500	DRAWING NO. BridgeviewISMP-WCM_F2.dwg

116 Ave. Tributary Watercourses

- Class A watercourse currently shown on the south side of 116 St. that drains west to Bolivar Creek has been eliminated as part of SFPR construction.
- Class A(o) watercourse on north side of SFPR has been previously re-classified as Class C in the 2006 SFPR Habitat Impact Assessment.
- Phoenix recommends further investigation for both watercourses once SFPR construction is complete.

Bolivar Creek at 115 ave.

- Likely Class A subject to confirmation upon completion of SFPR.
- Styrofoam and other refuse observed downstream of 115 Ave. crossing. Water quality issues should be further investigated

Artesian upwelling observed

Bolivar Park at 136 St.

- Unmapped watercourse (Class B) along the south side of newly constructed 115 Ave at intersection with 136 St. Downstream connection requires improvements.
- Two unmapped tributaries on the east side of the existing Class B watercourse.

Bolivar Catchment

Class "A" Watercourse

Class "A(o)" Watercourse

Class "B" Watercourse

Class "C" Watercourse

Assessment & Potential Habitat Enhancement Location

Unknown Watercourse Classification

Note .DWG base layers courtesy of City of Surrey COSMOS mapping (2012)

Bridgeview - North Slope ISMP

Watercourse Classification Map

Figure 3. Bolivar Catchment (North)

DATE July 2012		REV 00
DRAWN BY S. Sims	SCALE 1:7500	DRAWING NO. BridgeviewISMP-WCM_F3.dwg

Bolivar Creek

Bolivar Creek south of 108 Ave.

- *Evidence of scour and erosion.*
- *Riparian habitat impacts*

Bolivar Catchment

Class "A" Watercourse

Class "A(0)" Watercourse

Class "B" Watercourse

Class "C" Watercourse

Assessment & Potential Habitat Enhancement Location

Unknown Watercourse Classification

Note .DWG base layers courtesy of City of Surrey COSMOS mapping (2012)

Bridgeview - North Slope ISMP

Watercourse Classification Map

Figure 4. Bolivar Catchment (South)

DATE July 2012		REV 00
DRAWN BY S. Sims	SCALE 1:7500	DRAWING NO. BridgeviewISMP-WCM_F4.dwg

136 St. North of 115 Ave

- Due to SFPR construction the class A(0) watercourse on east side of 136 St. now flows into the roadside ditch on the south side of 116 Ave. Phoenix recommends further investigation and potential re-classifcation following SFPR completion.
- Unmapped Class C roadside drainage on west side of 136 Ave is conveyed into the southside SFPR watercourse.

139A Watercourse

- The watercourse currently mapped as Class B has been observed to be flowing during site investigations (July 2012), however, it is unknown if it will connect to Class A and Class A(0) watercourses along 117 Ave. Phoenix recommends further investigations upon SFPR completion.

Wellington Creek (west reach)

- Phoenix recommends further assessment after completion of SFPR to confirm the location and classification of un-mapped watercourse north of King Rd.

Southward Creek

- Watercourse on south side of the King Road alignment extending along 116 Ave west to 136 St. intersection will require re-mapping and potential re-classification upon SFPR completion.
- Phoenix recommends that the currently mapped Class C watercourse east of the Southward Creek crossing of the SFPR be re-classified as Class B pending further investigations upon completion of the SFPR.

Wellington Creek (East reach)

- Watercourse alignment has been adjusted to reflect the observed woodstave culvert crossing of King Rd.
- The currently mapped Class B east of culvert crossing on the south side of King Rd. does not exist.
- Phoenix recommends further investigation and potential re-classifcation of Wellington Creek (East Branch) on the west side of King Road, south side of 116A Ave, and upstream of the SFPR.
- Leaking hydrant flowing into watercourse on south side of 116A Ave. was observed.

Southward Creek Tributary

- A Class A tributary to Southward Creek extending east from Southward south of 116 Ave. has been re-mapped.
- Phoenix recommends further investigation and potential re-classifcation upon completion of the SFPR.

137A Street Catchment

Bedford Catchment

Class "A" Watercourse

Class "A(0)" Watercourse

Class "B" Watercourse

Class "C" Watercourse

Assessment & Potential Habitat Enhancement Location

Unknown Watercourse Classification

Note .DWG base layers courtesy of City of Surrey COSMOS mapping (2012)

Bridgeview - North Slope ISMP Watercourse Classification Map Figure 5. 137A and Bedford Catchments

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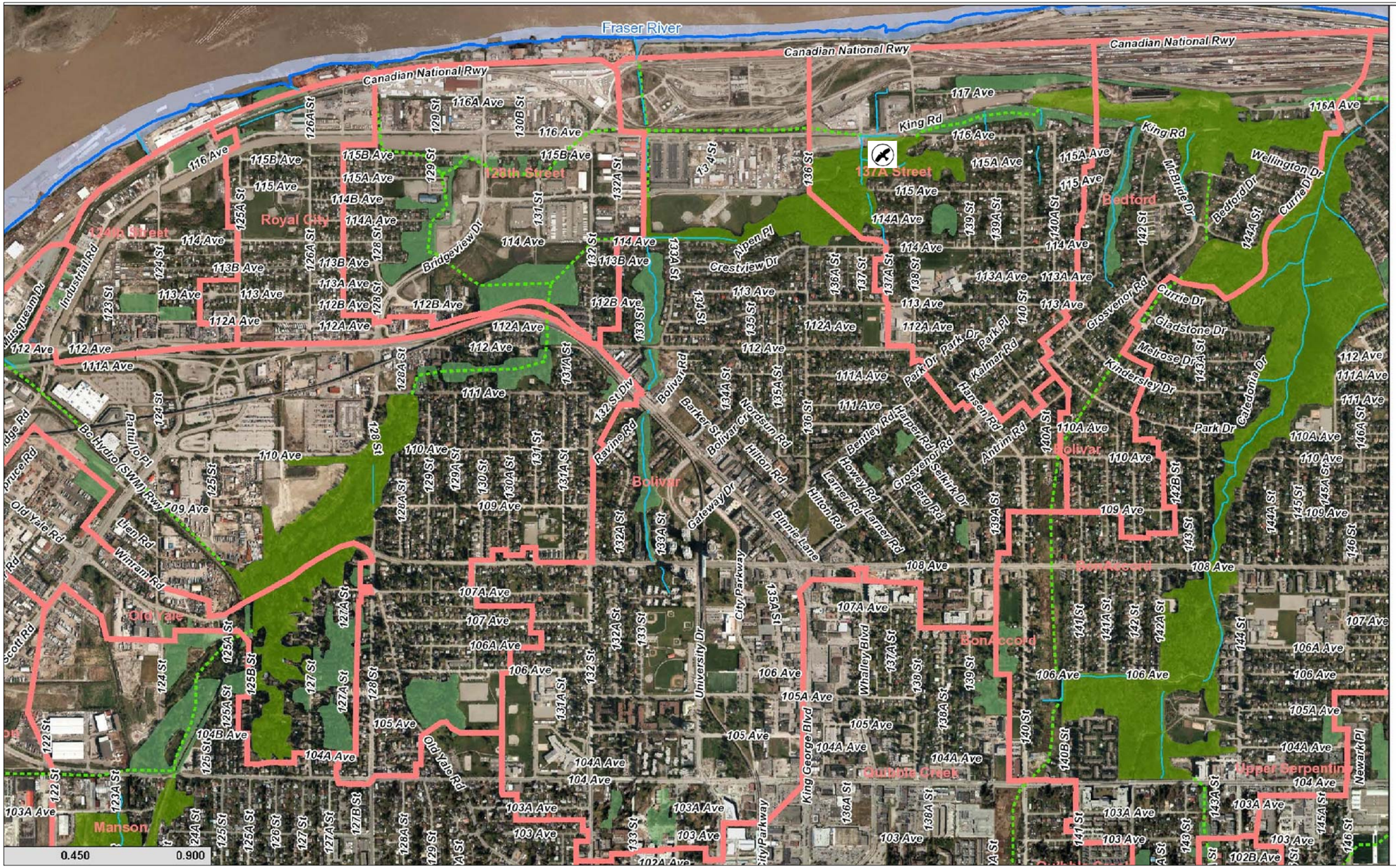

Legend

- Road Names4000_25000
- Water Courses
  - Creek
  - River
- Drainage Major Catchments
- Drainage Major Catchments (label
- Ecosystem Corridors
- Ecosystem Sites
- Terrestrial Hubs
- Aquatic Hubs
- Aerial Photo April/May 2011
  - Red: Band_1
  - Green: Band_2
  - Blue: Band_3

Existing BAEA Nest (Robertson Environmental Services Ltd, 2006)

Note Othrophotos and layers courtesy of City of Surrey COSMOS mapping (2012)

Bridgeview - North Slope ISMP
Figure 6. Wildlife Habitat Map

DATE July 2012		REV 00
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APPENDIX B

Photographs

Photo 1: Bolivar Creek south of 108th Avenue

Photo 2: Bolivar Creek fishway at 112 Ave. looking downstream (North).

Photo 3: Step pools in Bolivar Creek near 112B Ave. looking upstream.

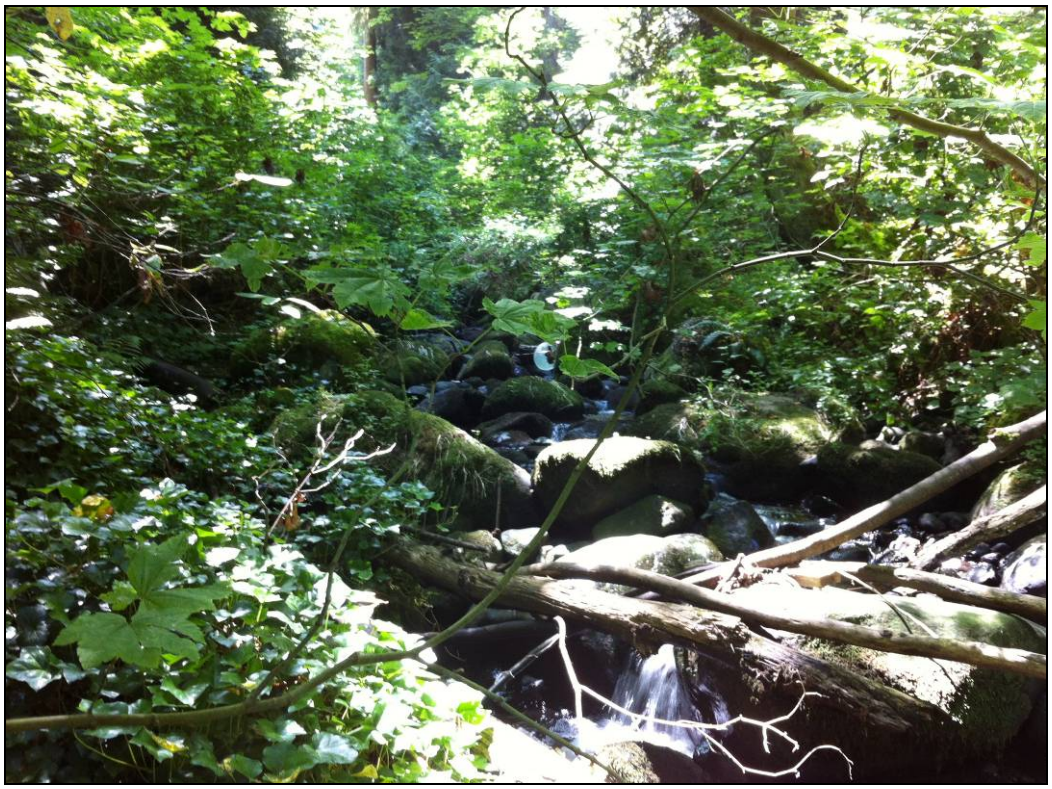


Photo 4: Bolivar Creek fishway at 114th Ave. looking upstream

Photo 5: Flotsam in Bolivar Creek north of 115th Avenue.

Photo 6: Large constructed channel south of 116 Ave. & SFPR at 136 St looking East

Photo 7: Southward Creek at large constructed channel south of 116th Ave. & SFPR.

Photo 8. Southward Creek north of SFPR looking North (downstream)

Page 9: Infilled channel/ fish migration barrier, 116A Ave. & 130 St. looking West

Photo 10: Partially restored channel, 116A Ave. & 130B St. looking West

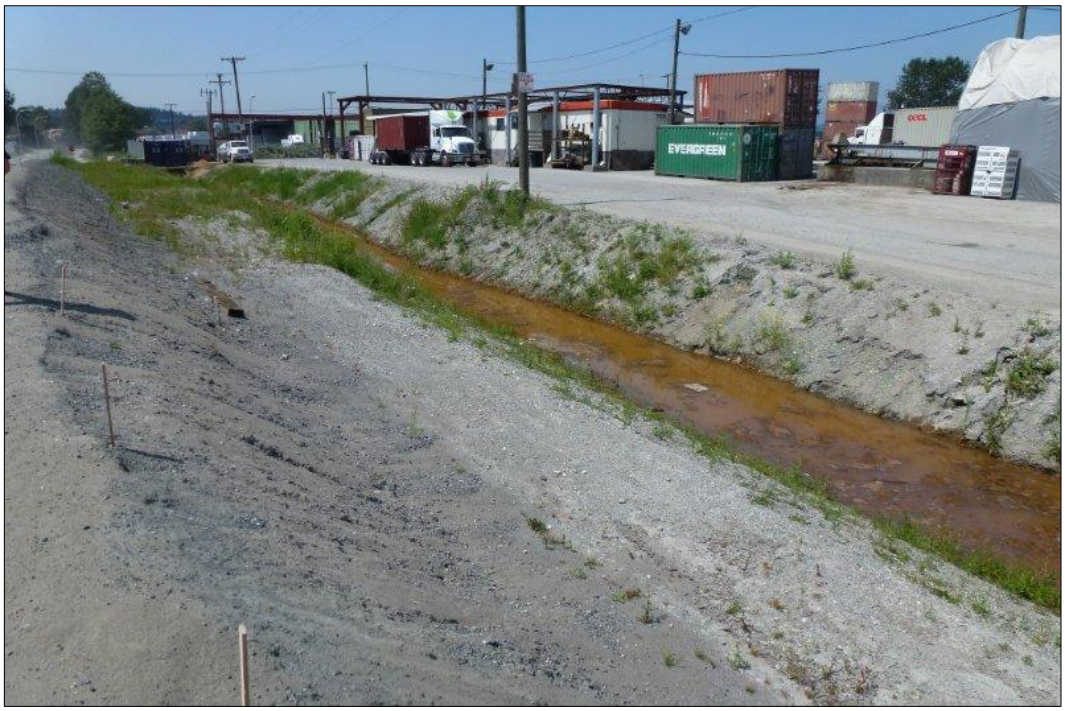


Photo 11: Infilled former Class A watercourse South side (116 Ave.) of SFPR looking West

Photo 12: Artesian upwelling in pond, CN tracks at 136 St.

Photo 13: Alexandra Creek looking North from King Rd

Photo 14: Dingwall Creek at culvert inlet beneath 14026 – 116 Ave. residence & 116 Ave.

Photo 15: Wellington Creek East Reach, perched woodstave culvert at King Rd.

Photo 16: Wellington Creek East Reach at 116A Ave. looking West

APPENDIX C

Plant species observed during field visits

Plant species identified during July 2012 field visits to the Bridgeview-North Slope ISMP Study

Common Name	Scientific Name
Trees	
Black Cottonwood	*Populus balsamifera*
Black Locust	*Robinia pseudo-acacia*
Bigleaf Maple	*Acer macrophyllum*
Bittercherry	*Prunus emarginata*
Cascara	*Rhamnus purshiana*
Domestic Cherry	*Prunus serotina*
Douglas-Fir	*Pseudotsuga menziesii*
Grand Fir	*Abies grandis*
Red Alder	*Alnus rubra*
Rowan Tree	*Sorbus aucuparia*
Sitka Spruce	*Sitka sitchensis*
Western Hemlock	*Tsuga heterophylla*
Western Red Cedar	*Thuja plicata*
Shrubs	
Beaked Hazelnut	*Corylus cornuta*
Butterfly Bush	*Buddleia davidii*
Common Snowberry	*Symphoricarpos albus*
Devil's Club	*Oplopanax horridus*
English Ivy	*Hedera helix*
English Hawthorn	*Crataegus laevigata*
English Holly	*Ilex aquifolium*
English Laurel	*Prunus laurocerasus*
Hardhack	*Spiraea douglasii*
Himalayan Blackberry	*Rubus discolor*
Hydrangea	*Hydrangea* sp.
Indian-Plum	*Oemleria cerasiformis*
Pacific Willow	*Salix lucida*
Periwinkle (Variegated)	*Vinca major*
Red Elderberry	*Sambucus racemosa*
Red-osier Dogwood	*Cornus stolonifera*
Salmonberry	*Rubus spectabilis*
Scotch Broom	*Cytisus scoparius*
Stink Currant	*Ribes bracteosum*

Table continued:

Common Name	Scientific Name
Shrubs Continued	
Thimbleberry	*Rubus parviflorus*
Vine Maple	*Acer circinatum*
Willow sp.	*Salix sp.*
Herbs	
American Brooklime	*Veronica beccabunga*
Black Medick	*Medicago lupulina*
Canada Goldenrod	*Solidago canadensis*
Cattail	*Typha latifolia*
Cleavers	*Galium aparine*
Clover sp.	*Trifolium sp.*
Common Burdock	*Arctium minus*
Common Dandelion	*Taraxacum officinale*
Common Foxglove	*Digitalis purpurea*
Common Horsetail	*Equisetum arvense*
Common Plantain	*Plantago major*
Common Rush	*Juncus effusus*
Common St. John's Wort	*Hypericum perforatum*
Common Tansy	*Tanacetum vulgare*
Creeping Buttercup	*Ranunculus repens*
Curled Dock	*Rumex crispus*
Dock sp.	*Rumex sp.*
European Bittersweet	*Solanum dulcamara*
False Lily-of-the-Valley	*Maianthemum dilatatum*
Field Bindweed	*Convolvulus arvensis*
Fireweed	*Epilobium angustifolium*
Giant Hogweed	*Heracleum mantegazzianum*
Grasses	*Graminae*
Hairy Cat's-Ear	*Hypochaeris radicata*
Hairy Vetch	*Vicia hirsuta*
Herb-Robert	*Geranium robertianum*
Hooker's Fairybells	*Disporum hookeri*
Japanese Knotweed	*Fallopia japonica*
Large-leaved Avens	*Geum macrophyllum*
Oxeye Daisy	*Leucanthemum vulgare*

Table continued:

Common Name	Scientific Name
Herbs Continued	
Pacific Bleeding Heart	*Dicentra formosa*
Pacific Water-Parsley	*Oenanthe sarmentosa*
Pineapple Weed	*Matricaria discoidea*
Policeman's Helmut	*Impatiens glandulifera*
Purple Loosestrife	*Lythrum salicaria*
Purple-leaved Willowherb	*Epilobium ciliatum*
Red Clover	*Trifolium pratense*
Reed Canary Grass	*Phalaris arundinacea*
Ribwort	*Plantago lanceolata*
Siberian Miner's -Lettuce	*Claytonia sibirica*
Skunk Cabbage	*Lysichiton americanum*
Small-flowered Bulrush	*Scirpus microcarpus*
Thistle sp.	*Cirsium sp.*
Wall Lettuce	*Lactuca muralis*
White Clover	*Trifolium repens*
White Sweet-Clover	*Melilotus alba*
Yellow Evening-Primrose	Oenothera vollisa
Yellow Sweet-Clover	Melilotus officinalis
Ferns	
Bracken Fern	*Pteridium aquilinum*
Lady Fern	*Athyrium felix-femina*
Spiny Wood Fern	*Dryopteris expansa*
Swordfern	*Polystichum munitum*

Appendix B

Royal City Pump Station Information

FLYGT

PERFORMANCE CURVE

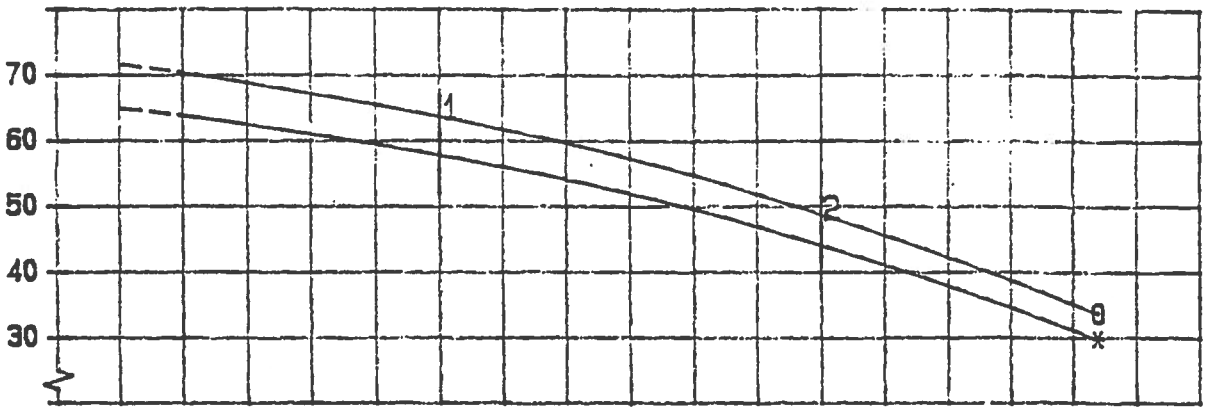
DATE	PROJECT	ISSUE	PROD
1994-06-29	ROYAL CITY DRAINAGE P.S.	3	7081

NO. OF BLADES	4	TOT.MOM.OF INERTIA	3.09 KGM²	POLES	10	FREQ 60 HZ	CURVE NO 63-705 B4
IMPELLER THROUGHLET	570	RATED SPEED	710 RPM	VOLTAGE	600 V		IMPELLER DIAMETER 14
	150			MOTOR SHAFT POWER	63 KW		MOTORTYPE 43-30-10A/6
				STARTING TORQUE	1035 NM		GEARTYPE / RATIO
				MAX TORQUE	1925 NM		
				RATED CURRENT	95 A		
				STARTING CURRENT	440 A		

	1/1-LOAD	3/4-LOAD	1/2-LOAD
MOTOR PF	0.71	0.65	0.53
MOTOR EFFICIENCY	90.5%	90.5%	88.5%
GEAR EFFICIENCY			

POWER

PP04.J (KW)



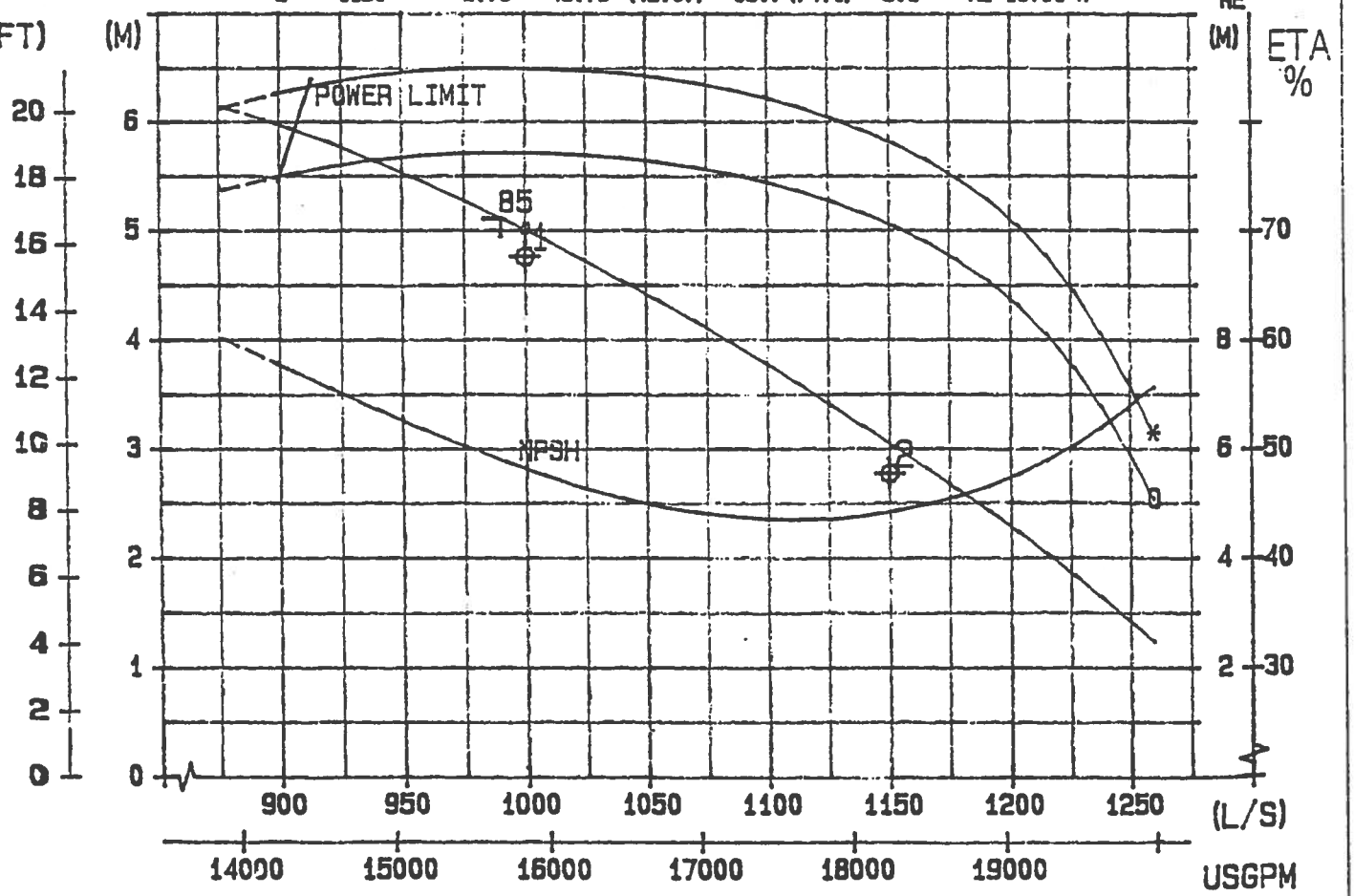
DUTY-POINTS:	FLOW (L/S)	HEAD (M)	POWER (KW)	ETA (%)	NPSH (M)	GUARANTY
1	1000	4.75	62.17 (56.41)	75.0 (82.6)	5.7	HI level A
2	1150	2.76	46.76 (42.07)	66.7 (74.1)	5.3	HI level A

HEAD

(FT) (M)

NPSH$_{RE}$ (M)

ETA %

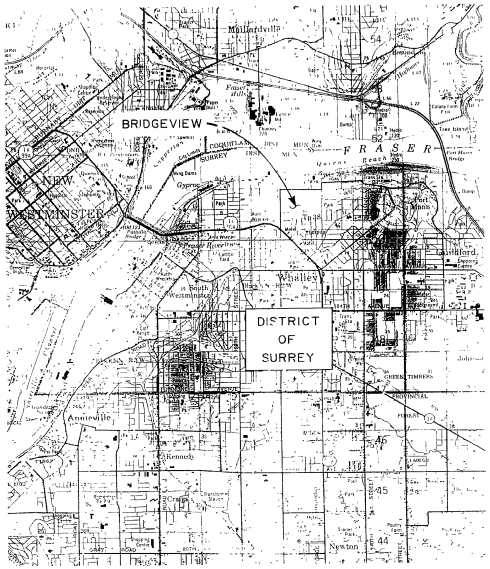


CURVES SHOW PERFORMANCE WITH CLEAR WATER AND NPSH$_{AV}$ > NPSH$_{RE}$

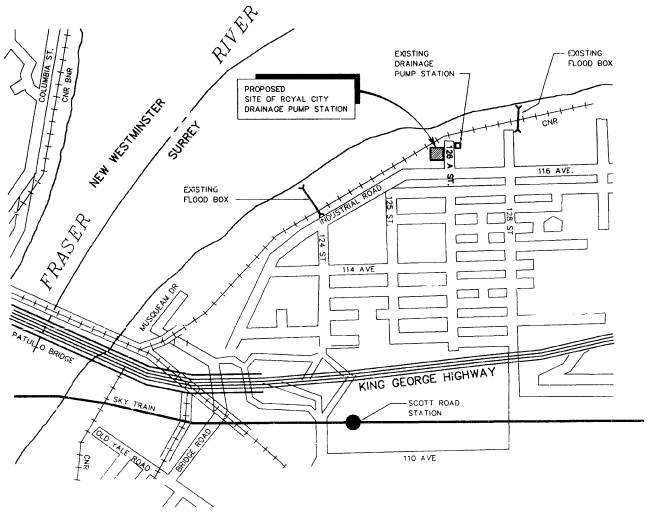
* : PUMP EFFICIENCY/SHAFT POWER

0 : OVERALL EFFICIENCY/INPUT POWER

ALL HYDRAULIC LOSSES UP TO 500 MM.ABOVE THE TOP OF THE PUMP/MOTOR ARE INCLUDED



KEY PLAN
N.T.S



LOCATION PLAN
N.T.S

CITY OF SURREY
CONTRACT No. M.S. 643402-02
FOR CONSTRUCTION OF
THE ROYAL CITY DRAINAGE PUMP STATION

INDEX TO DRAWINGS

SS-000-528(P) D-3402

REVISIONS	ISSUE	DATE	DR'N	CH'D	APP'D	DESCRIPTION
	B	94/05/18	DHA			ISSUED FOR TENDER
	C	14/07/19	DHA			ISSUED FOR CONSTRUCTION
	D	95/06/23	DM			RECORD DRAWING

ISSUE	DATE	DR'N	CH'D	APP'D	DESCRIPTION
E	96/03	AB			A.B. PLOTTED

DESIGNED AEB
DRAWN DHA
CHECKED

KERR WOOD LEIDAL ASSOCIATES LTD.
CONSULTING ENGINEERS

CITY OF SURREY
ROYAL CITY PUMP STATION
KEY PLAN, LOCATION PLAN
AND INDEX TO DRAWINGS

SCALE AS SHOWN
DRAWING No 471-002
SHEET 1 OF 18 ISSUE D

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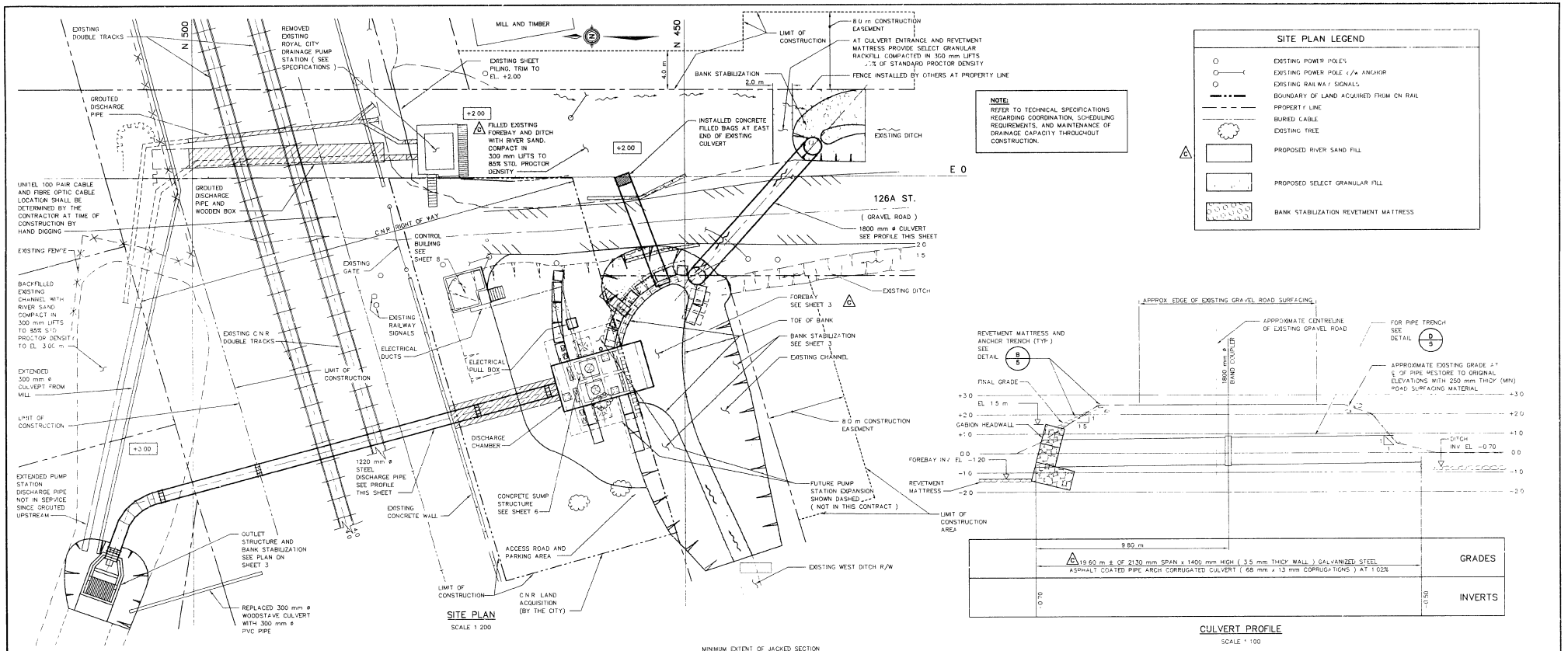


SITE PLAN

SCALE 1 200

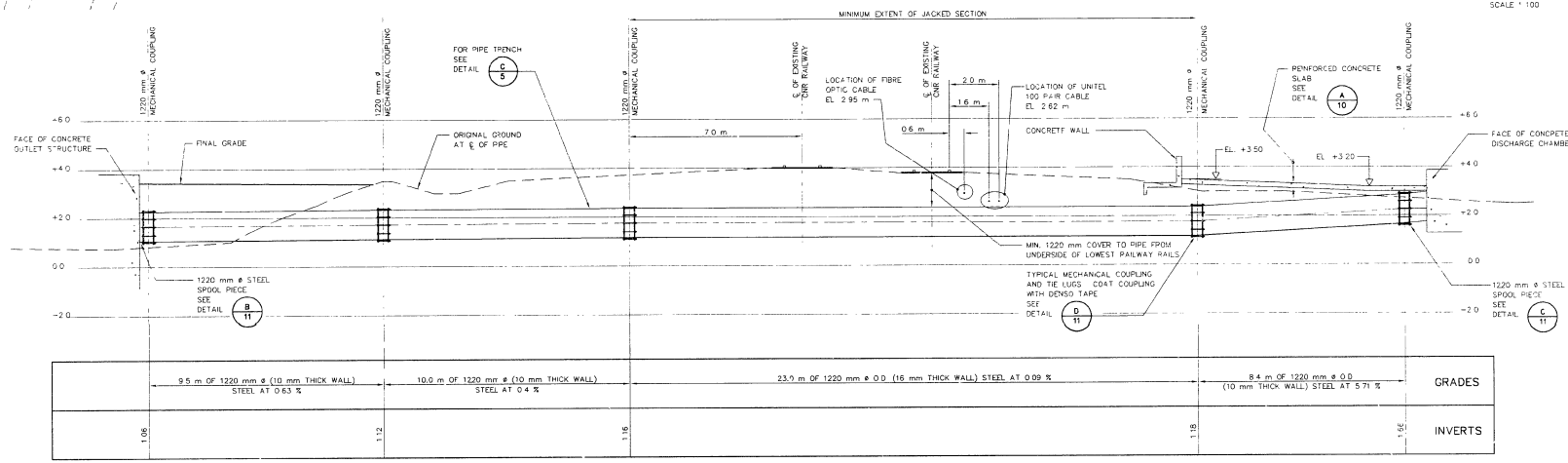
NOTE:
REFER TO TECHNICAL SPECIFICATIONS REGARDING COORDINATION, SCHEDULING REQUIREMENTS, AND MAINTENANCE OF DRAINAGE CAPACITY THROUGHOUT CONSTRUCTION.

SITE PLAN LEGEND

- EXISTING POWER POLES
- EXISTING POWER POLE c/w ANCHOR
- EXISTING RAILWAY SIGNALS
- BOUNDARY OF LAND ACQUIRED FROM CN RAIL
- PROPERTY LINE
- BURIED CABLE
- EXISTING TREE
- PROPOSED RIVER SAND FILL
- PROPOSED SELECT GRANULAR FILL
- BANK STABILIZATION REVETMENT MATTRESS

CULVERT PROFILE

SCALE 1:100



DISCHARGE PIPE PROFILE

SCALE 1:100

NOTES:

1. FOR CLEARING AND STRIPPING LIMITS SEE SPECIFICATIONS
2. REFER TO SPECIFICATIONS FOR GEOTECHNICAL REPORT
3. HYDROSEED ALL AREAS DISTURBED BY CONSTRUCTION REUSE STRIPPING MATERIAL FOR HYDROSEED BASE
4. CORPORATION TO SUPPLY HUB AND BENCH MARK FOR REFERENCE
5. PROVIDE SNOW FENCE (ORANGE) AROUND EXCAVATION REMOVE AND DISPOSE OF UPON PROJECT COMPLETION
6. ASSUME REMOVAL OF 0.5 m DEPTH OF WEATHERED SURFACE SOIL PRIOR TO INSTALLATION OF ANY FILL MATERIAL
7. PROVIDE COFFER DAMS, SHEET PILING AND MISCELLANEOUS SHORING AS REQUIRED FOR CONSTRUCTION

NOTES RE. C.N.R. CROSSING

1. PUMP STATION DISCHARGE PIPE TO BE INSTALLED USING HORIZONTAL JACKING METHOD THROUGH NATIVE AND RAILROAD BED MATERIALS
   VERTICAL TOLERANCE ± 100 mm
   HORIZONTAL TOLERANCE ± 100 mm
2. LOCATION OF THE C.N.R. FIBRE OPTIC CABLE MUST BE IDENTIFIED PRIOR TO INSTALLATION OF PIPELINE.
3. 72 HOURS PRIOR-NOTICE OF START OF CONSTRUCTION MUST BE GIVEN TO C.N.R. AND THE NECESSARY REPRESENTATIVE IS REQUIRED ON SITE DURING ANY PART OF THE CONSTRUCTION WITHIN THE RAILWAYS OPERATED RIGHT OF WAY.

D-3402

SS-000-511(P)

REVISIONS	ISSUE	DATE	DR'N	CH'D	APP'D	DESCRIPTION
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	C	94/07/14	DHA			ISSUED FOR CONSTRUCTION
	D	95/06/02	JL			RECORD DRAWING
	E	96/09	GB			AB PLOTTED

DESIGNED AEB
DRAWN PL/DHA
CHECKED

KERR WOOD LEIDAL ASSOCIATES LTD.
CONSULTING ENGINEERS

CITY OF SURREY
ROYAL CITY PUMP STATION
SITE PLAN AND PIPING PROFILES

SCALE AS SHOWN
DRAWING No. 471-002
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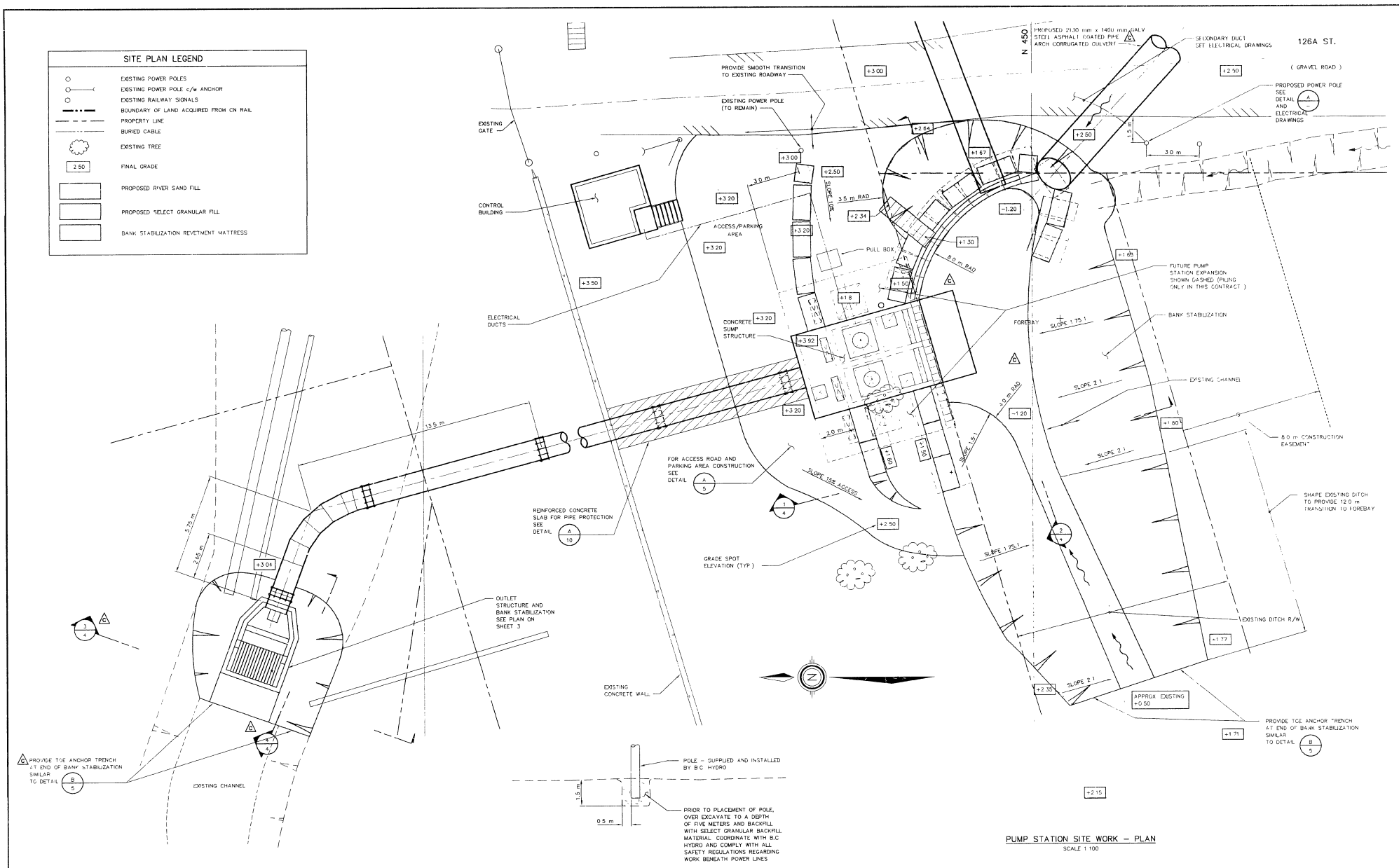

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DESIGNED AEB
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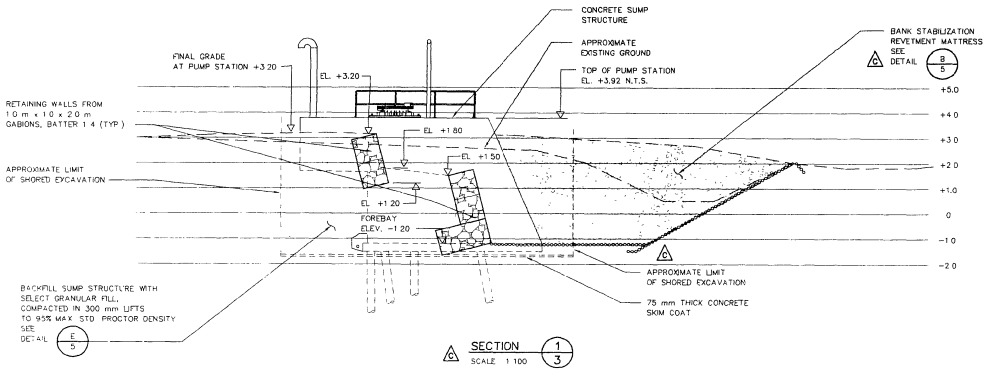
CHECKED

KERR WOOD LEIDAL ASSOCIATES LTD.
CONSULTING ENGINEERS

CITY OF SURREY
ROYAL CITY PUMP STATION
STATION AND OUTLET STRUCTURES
SITE PLANS

SCALE AS SHOWN
DRAWING No 471-002
SHEET 3 OF 18 ISSUE D



SECTION 1/3
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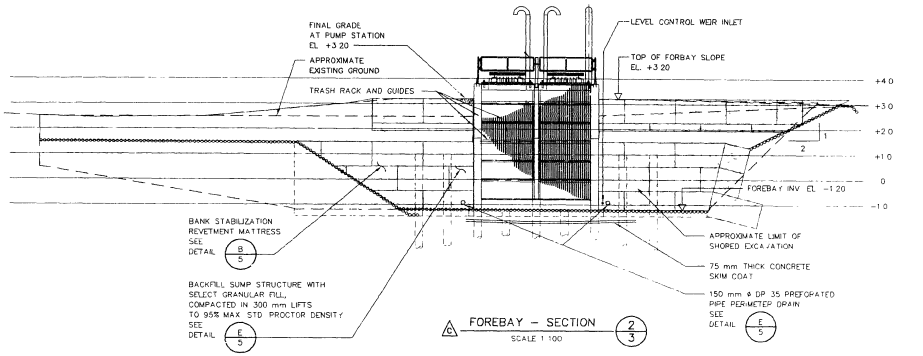
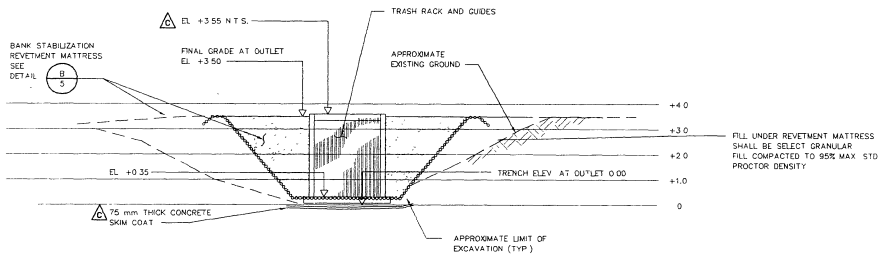
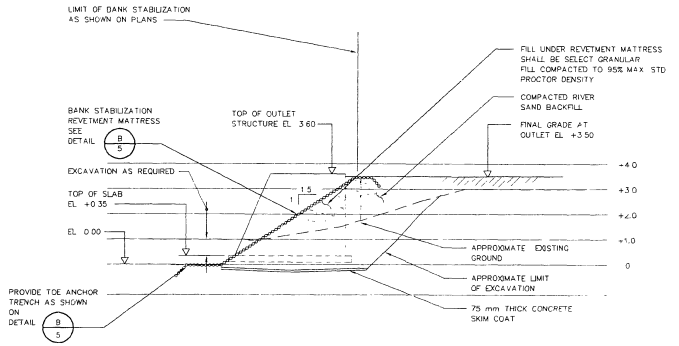


FOREBAY – SECTION 2/3
SCALE 1:100



DISCHARGE CHANNEL – SECTION 3/3
SCALE 1:100



DISCHARGE CHANNEL – SECTION 4/3
SCALE 1:100

D-3402

SS-000-513(P)

ISSUE	DATE	DR'N	CH'D	APP'D	DESCRIPTION
B	94/05/18	DHA			ISSUED FOR TENDER
C	94/07/14	DHA			ISSUED FOR CONSTRUCTION
D	95/05/06	JL			RECORD DRAWING

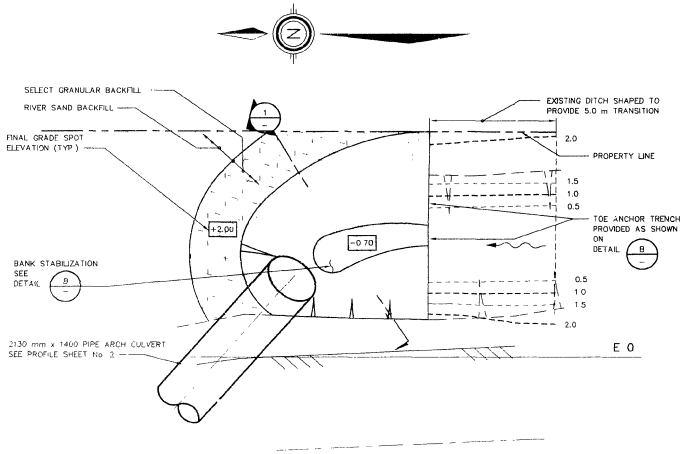
ISSUE	DATE	DR'N	CH'D	APP'D	DESCRIPTION
E	96/09	GS			A.B. PLOTTED

DESIGNED AEB
DRAWN DHA
CHECKED

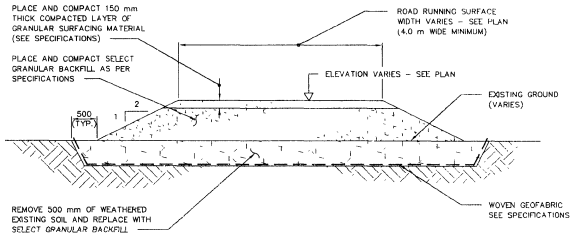
KERR WOOD LEIDAL ASSOCIATES LTD.
CONSULTING ENGINEERS

CITY OF SURREY
ROYAL CITY PUMP STATION
SUMP AND OUTLET STRUCTURES
SITE SECTIONS

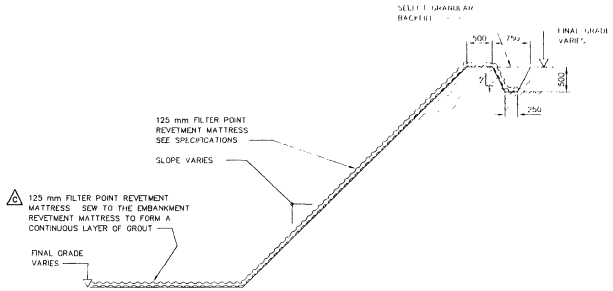
SCALE AS SHOWN
DRAWING No 471-002
SHEET 4 OF 18 ISSUE 0



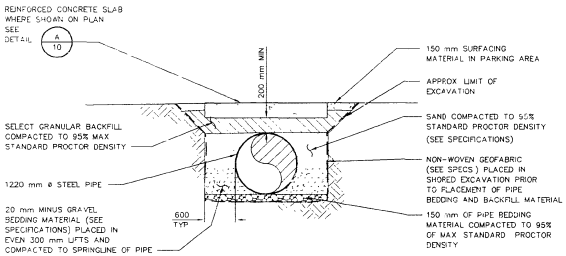
CULVERT ENTRANCE SITE WORK PLAN
SCALE 1:100



TYPICAL ACCESS ROAD AND PARKING AREA CONSTRUCTION – DETAIL A/3
SCALE 1:100

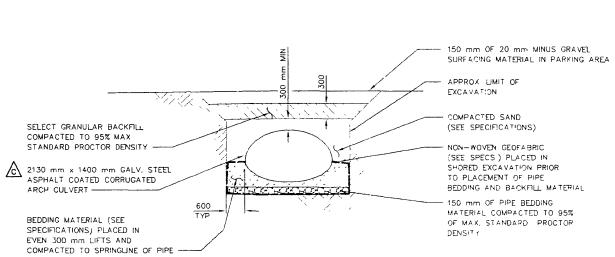


BANK STABILIZATION – DETAIL B/– B/2 B/3 B/4
SCALE N.T.S

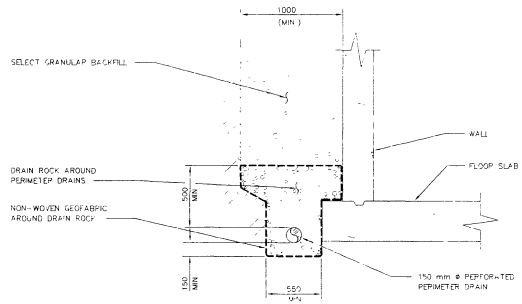


(NON-JACKED SECTIONS)

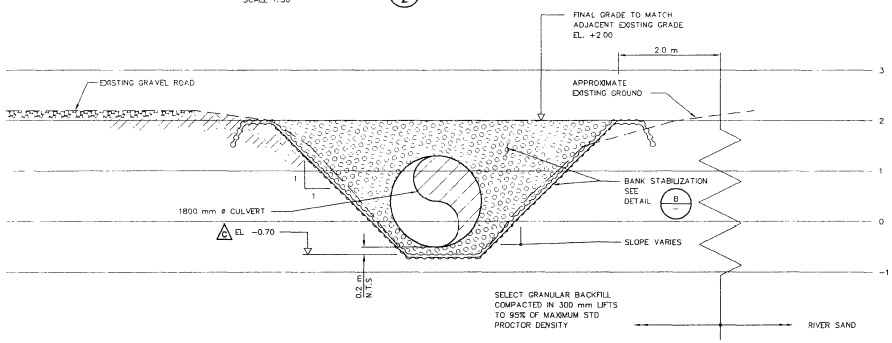
DISCHARGE PIPING TRENCH – DETAIL C/2
SCALE 1:50



CULVERT TRENCH – DETAIL D/2
SCALE N.T.S



A PERFORATED DRAIN – DETAIL E/4 E/6 E/7
SCALE 1:25



CULVERT ENTRANCE – SECTION 1/–
SCALE 1:50

D-3402

SS-000-514(P)

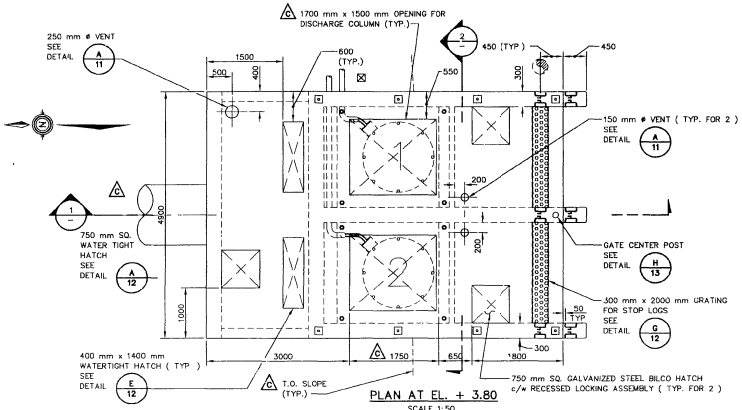
REVISIONS	ISSUE	DATE	DR'N	CH'D	APP'D	DESCRIPTION	ISSUE	DATE	DR'N	CH'D	APP'D	DESCRIPTION
	B	94/05/18	DHA			ISSUED FOR TENDER	E	96/03/28				A.B. PLOTTED
	C	94/07/14	DHA			ISSUED FOR CONSTRUCTION						
	D	95/05/06	JL			RECORD DRAWING						

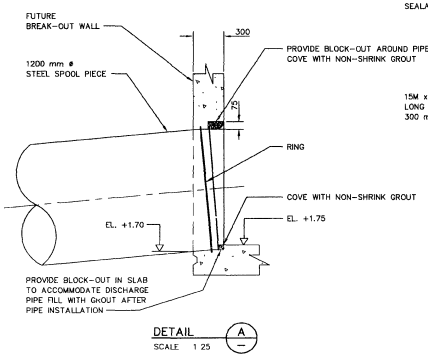
DESIGNED AEB
DRAWN DHA
CHECKED

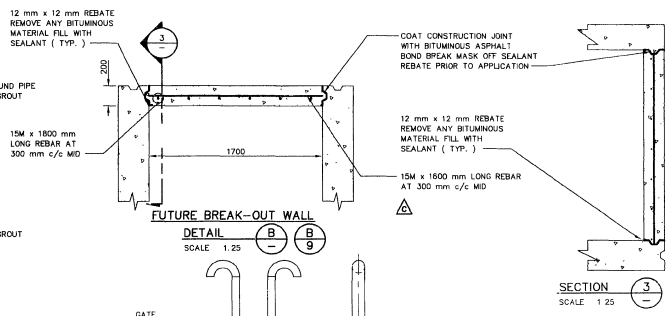
KERR WOOD LEIDAL ASSOCIATES LTD.
CONSULTING ENGINEERS

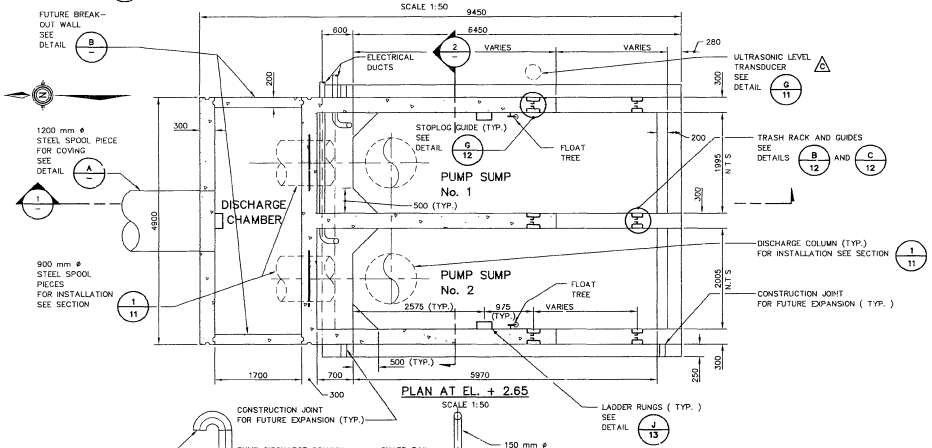
CITY OF SURREY
ROYAL CITY PUMP STATION
CULVERT INLET PLAN AND SECTIONS
AND MISCELLANEOUS SITE DETAILS

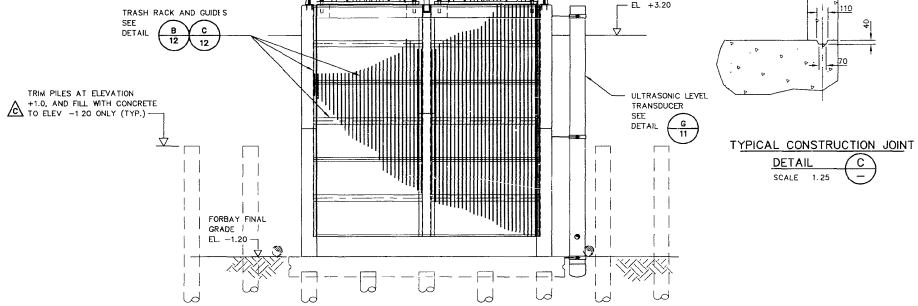
SCALE AS SHOWN
DRAWING No. 471-092
SHEET 5 OF 18 ISSUE D

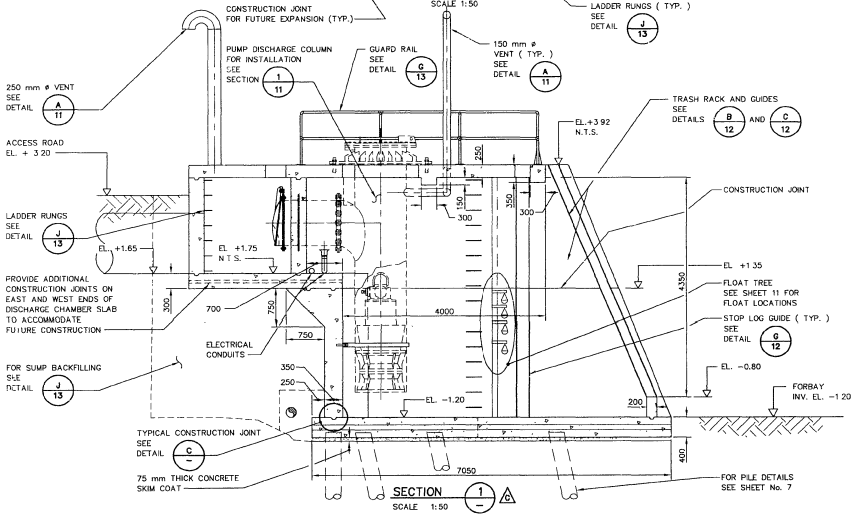


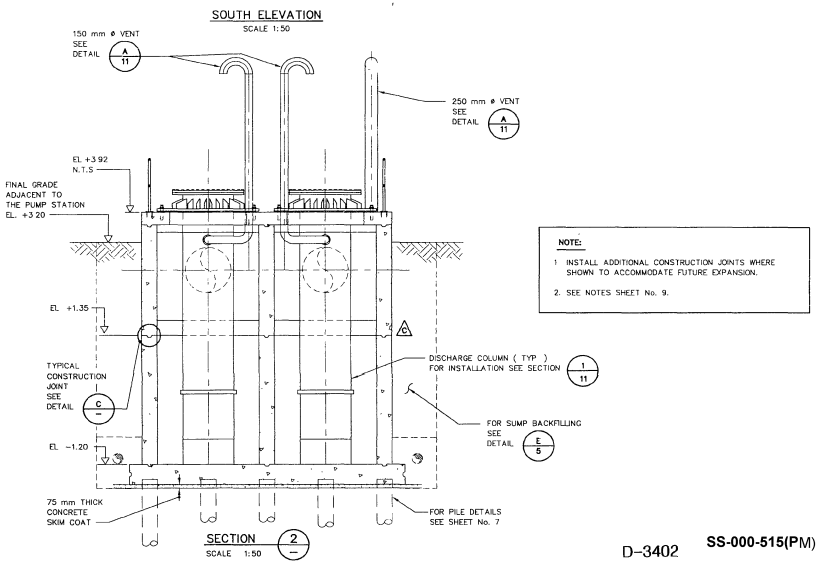












NOTE:

1. INSTALL ADDITIONAL CONSTRUCTION JOINTS WHERE SHOWN TO ACCOMMODATE FUTURE EXPANSION.
2. SEE NOTES SHEET No. 9.

D-3402 **SS-000-515(PM)**

REVISIONS	ISSUE	DATE	DR'N	CH'D	APP'D	DESCRIPTION
	B	94/05/18	DHA			ISSUED FOR TENDER
	C	94/07/14	DHA			ISSUED FOR CONSTRUCTION
	D	95/05/06	JL			RECORD DRAWING
	E	96/07	GB			A & B PLOTTED

471-002\CONCRETE.DWG 95/05/12

DESIGNED AEB
DRAWN PL
CHECKED

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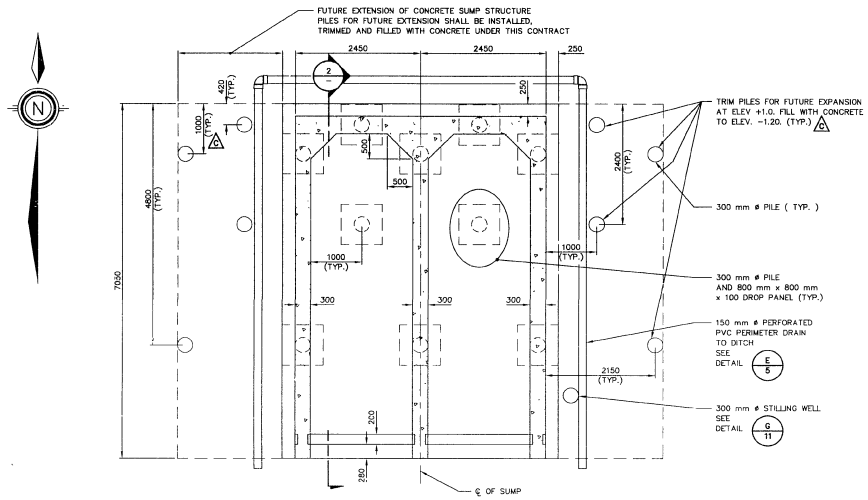
CONSULTING ENGINEERS

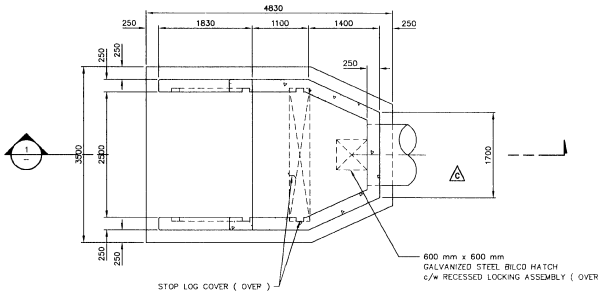
CITY OF SURREY
ROYAL CITY PUMP STATION
SUMP CONCRETE OUTLINE

SCALE AS SHOWN
DRAWING No. 471-002
SHEET 6 OF 19 ISSUE D



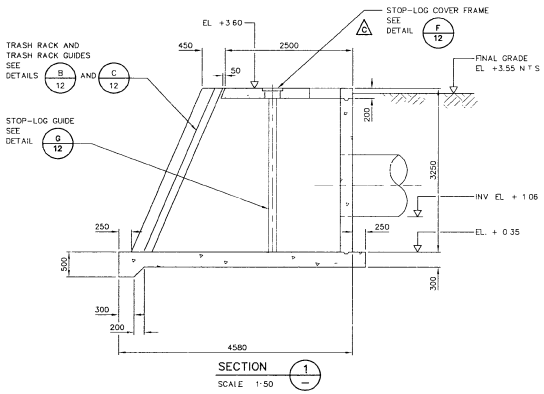
SUMP FOUNDATION & PILING PLAN

SCALE 1:50



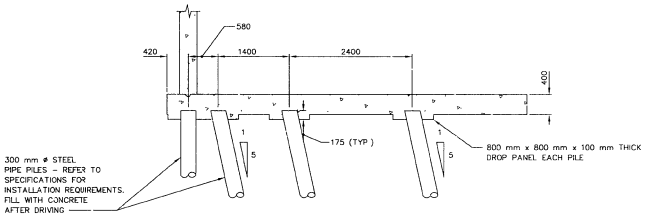
OUTLET STRUCTURE – FOUNDATION PLAN

SCALE 1 50



SECTION 1

SCALE 1:50



NOTES:

1 FOR CONTROL BUILDING PILES SEE SHEET No. 8

2 ESTIMATED PILE DEPTH VARIES 20.0 m TO 22.0 m

PILING SECTION 2

SCALE 1 50

SS-000-516(P)

D-3402

REVISIONS	ISSUE	DATE	DR'N	CH'D	APP'D	DESCRIPTION
	B	94/05/18	DHA			ISSUED FOR TENDER
	C	94/07/14	DHA			ISSUED FOR CONSTRUCTION
	D	95/05/08	JL			RECORD DRAWING
	E	96/03	GB			AS PLOTTED

DESIGNED AEB

DRAWN DHA/PL

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CONSULTING ENGINEERS

CITY OF SURREY

ROYAL CITY PUMP STATION

CONCRETE OUTLINE – OUTLET STRUCTURE AND MISCELLANEOUS PLANS, SECTIONS AND DETAILS

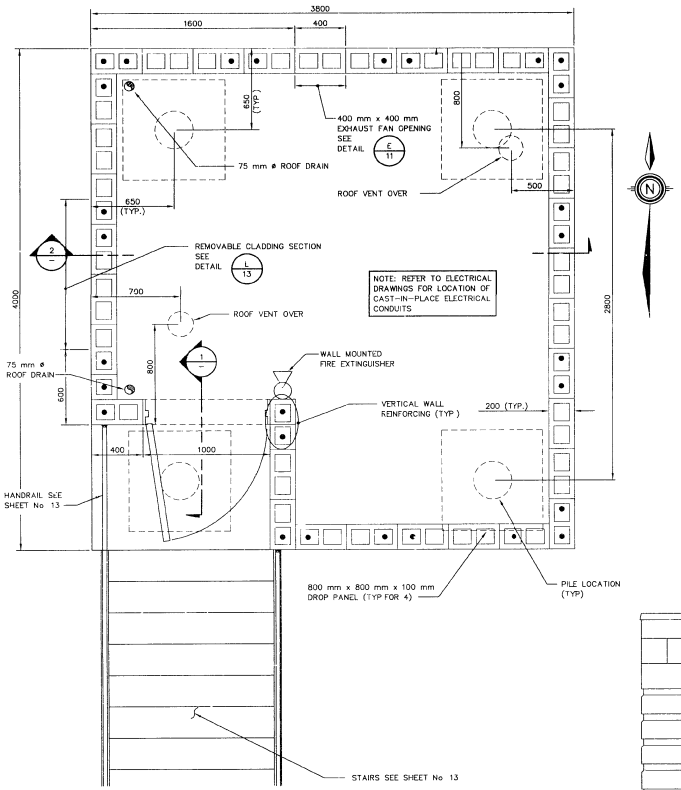
SCALE AS SHOWN

DRAWING No 471-002

SHEET 7 OF 18 ISSUE D

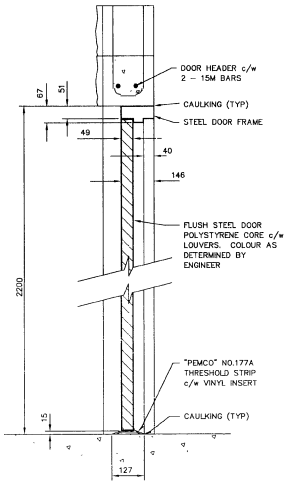
95/05/08

471-002\OUTLET.DWG



CONTROL BUILDING – PLAN

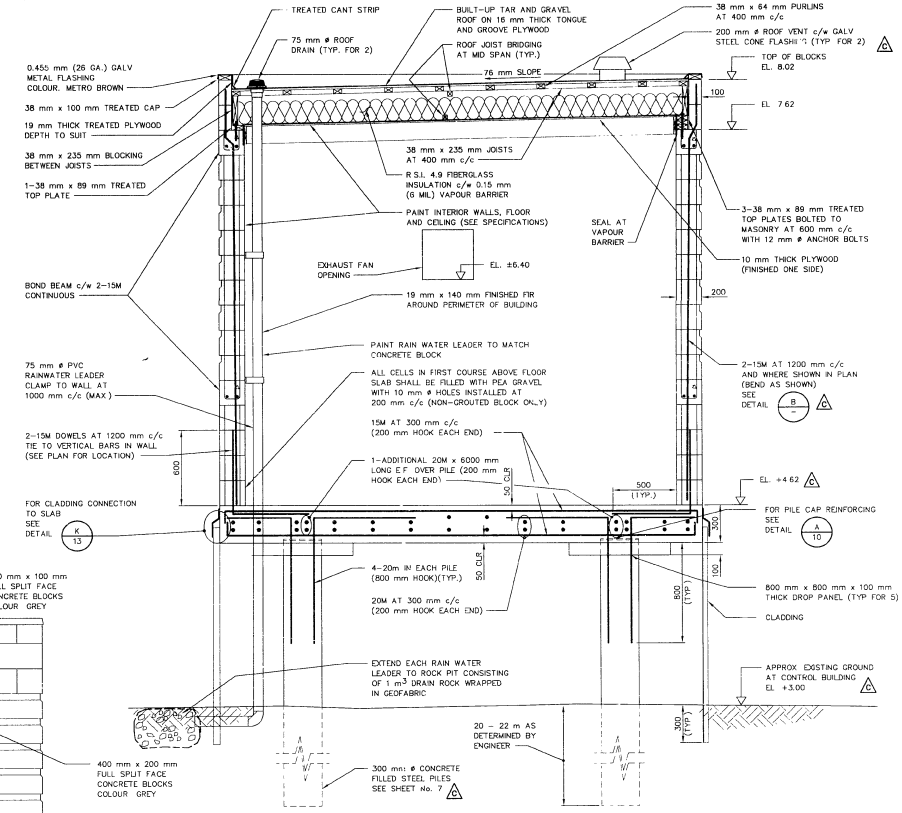
SCALE 1:20



DOOR DETAIL

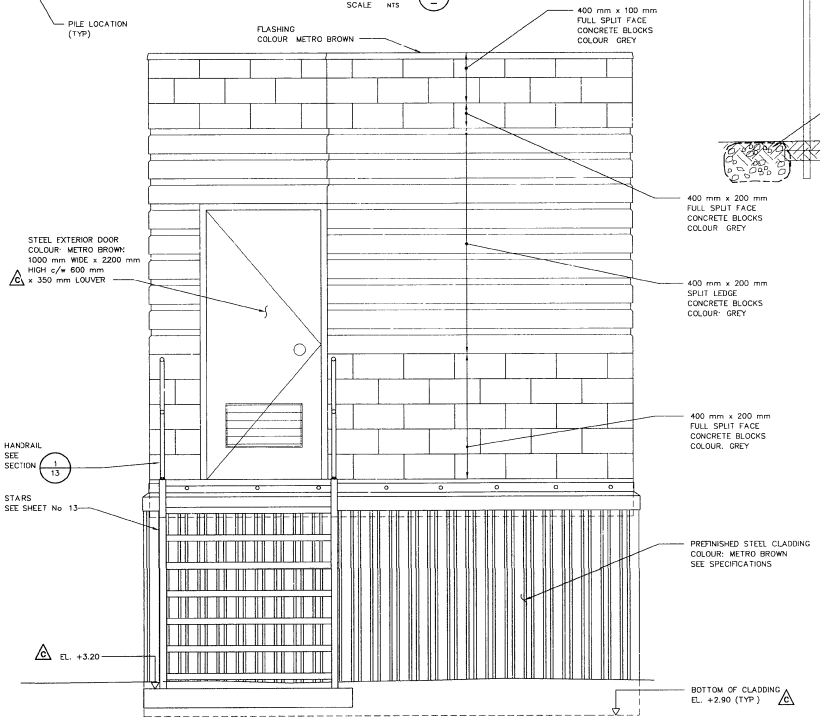
SECTION 1 / –

SCALE NTS



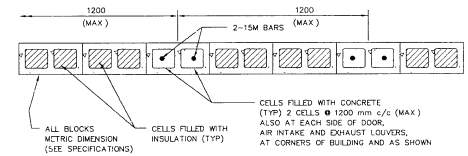
SECTION 2 / –

SCALE 1:20



CONTROL BUILDING – SOUTH ELEVATION

SCALE 1:20



MASONRY – DETAIL B / –

NTS

REINFORCED MASONRY NOTES

CONCRETE FILL TWO VOIDS EVERY 1200 mm c/c AND REINFORCE WITH 2 – 15M BARS

PROVIDE 4 mm (9 GAUGE) LADDER TYPE REINFORCING HORIZONTALLY AT 400 mm c/c

ADD ONE EXTRA 15M BAR AND CONCRETE FILL AT ENDS OF WALL AND EACH SIDE OF DOORS

MINIMUM BAR SPLICE TO BE 30 BAR DIAMETERS.

CONCRETE FILL TO BE 20 MPa AT 28 DAYS.

MORTAR TO BE TYPE 'S'.

PROVIDE DOWELS FORM FLOOR SLAB TO MATCH ALL VERTICAL BARS.

PROVIDE HORIZONTAL BOND BEAM AT TOP AND MID-HEIGHT OF ALL WALLS AS SHOWN. REINFORCE BOND BEAM WITH 2 – 15M BARS

VERTICAL BARS TO RUN THROUGH BOND BEAMS WITH 2 – 15M BARS.

FOR LINTEL OVER DOOR AND LOUVER OPENING, FILL ONE COURSE WITH CONCRETE AND REINFORCE WITH 2 – 15M BARS.

MASONRY BLOCKS SHALL BE WATERPROOFED OUTSIDE, AND CELLS FILLED WITH GRANULAR INSULATION, VERMICULITE OR APPROVED EQUAL.

NOTE:
SEE ELECTRICAL DRAWINGS FOR LOCATION OF CONCEALED CONDUIT AND WIRING

D-3402

SS-000-517(P)

REVISIONS	ISSUE	DATE	DR'N	CH'D	APP'D	DESCRIPTION
	B	94/05/18	BP	TS		ISSUED FOR TENDER
	C	94/07/14	DHA			ISSUED FOR CONSTRUCTION
	D	95/05/06	JL			RECORD DRAWING
	E	96/03/	GB			A.B. PLOTTED

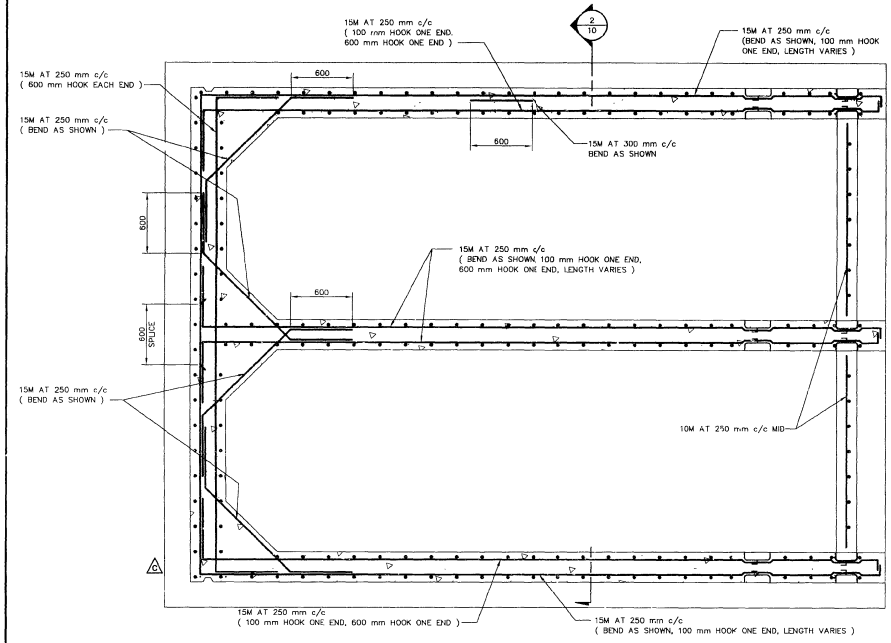
DESIGNED AEB
DRAWN DHA
CHECKED

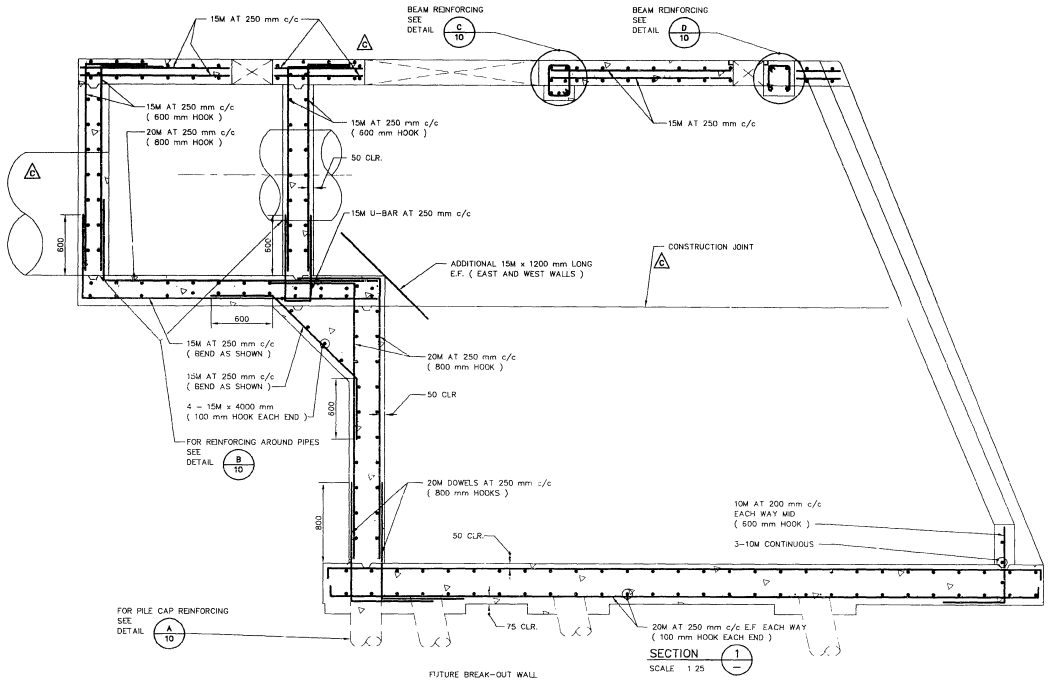
KERR WOOD LEIDAL ASSOCIATES LTD.
CONSULTING ENGINEERS

CITY OF SURREY
ROYAL CITY PUMP STATION
CONTROL BUILDING – ARCHITECTURAL, CONCRETE OUTLINE AND REINFORCING

SCALE AS SHOWN
DRAWING No 471-002
SHEET 8 OF 18 ISSUE D

471-000\CONTROL\DWG 95/05/06

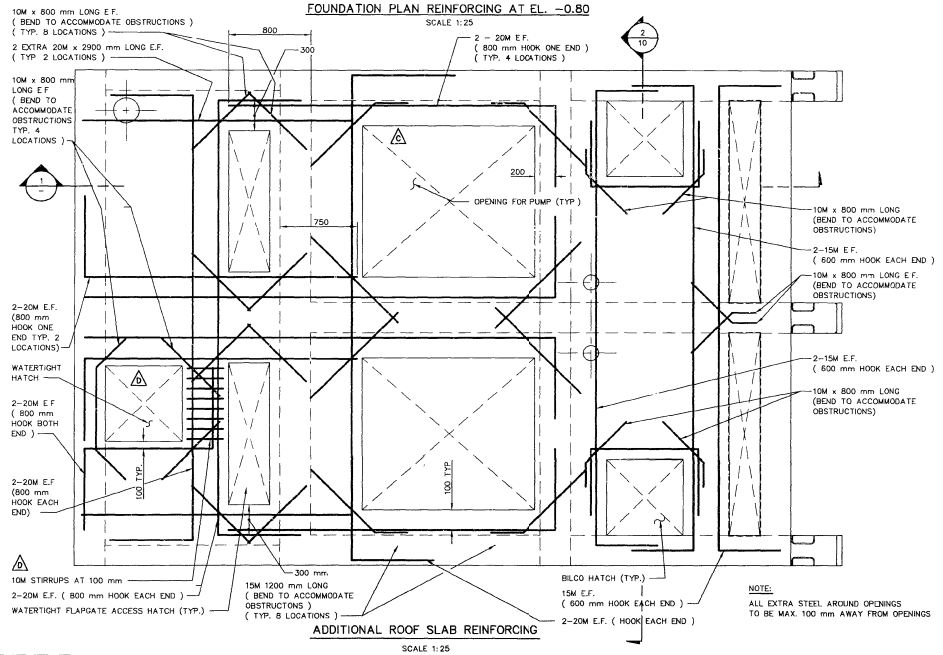




SECTION 1 / —
SCALE 1:25

FOUNDATION PLAN REINFORCING AT EL. -0.80

SCALE 1:25



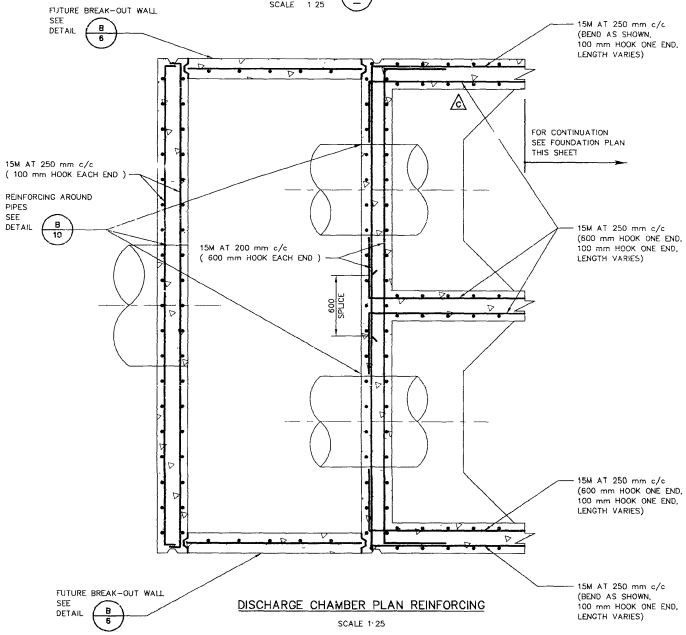
ADDITIONAL ROOF SLAB REINFORCING

SCALE 1:25

NOTE:
ALL EXTRA STEEL AROUND OPENINGS
TO BE MAX. 100 mm AWAY FROM OPENINGS

REINFORCING NOTES

1. ALL STRUCTURAL CONCRETE SHALL CONFORM TO CSA CAN 3A23.1
2. CONCRETE CHARACTERISTICS AS FOLLOW:
   - 28 DAY COMPRESSION STRENGTH (MIN.) 35 MPa
   - SLUMP 80 mm
   - MAXIMUM WATER CEMENT RATIO 0.45
   - AIR CONTENT 6.5 %
   - TYPE 10 PORTLAND CEMENT
3. ALL EXPOSED EDGES OF CONCRETE SHALL BE CHAMFERED 20 mm
4. REINFORCEMENT SHALL BE GRADE 400 CONFORMING TO CSA G30.12
5. REINFORCEMENT SHALL HAVE COVER AS FOLLOWS:
   - 75 mm CONCRETE CAST AGAINST SOIL
   - 50 mm ELSEWHERE
6. BAR SPLICES SHALL BE MIN. 40 x BAR DIAMETER
7. ALL CONCRETE WORK SHALL CONFORM TO CSA 3A23.1 AND TESTING OF SAME TO CSA CAN 3A23.2 M77
8. ALL OPENINGS IN WALLS GREATER THAN 250 mm AND WHERE NOT SHOWN IN DRAWINGS SHALL HAVE 2 x 15M DIAGONALLY PLACED BARS AT EACH CONCRETE FACE AND EACH CORNER. MINIMUM LENGTH 1200 mm.
9. ALL REINFORCEMENT OTHER THAN DIAGONAL BARS SHALL BE PLACED TO RESULT IN A REINFORCEMENT MAT OF TWO BAR THICKNESS
10. SEE CONCRETE OUTLINE, ARCHITECTURAL, ELECTRICAL AND MECHANICAL DRAWINGS FOR LOCATION OF EMBEDDED MATERIALS AND EQUIPMENT.
11. SEE CONCRETE OUTLINE AND ARCHITECTURAL DRAWINGS FOR DIMENSIONS OF STRUCTURE



DISCHARGE CHAMBER PLAN REINFORCING

SCALE 1:25

D-3402 SS-000-518(P)

REVISIONS	ISSUE	DATE	DR'N	CH'D	APP'D	DESCRIPTION	ISSUE	DATE	DR'N	CH'D	APP'D	DESCRIPTION
	B	94/05/18	DHA			ISSUED FOR TENDER	E	96/05	GB			A.B.PLOTTED
	C	94/07/14	DHA			ISSUED FOR CONSTRUCTION						
	D	95/05/06	JL			RECORD DRAWING						

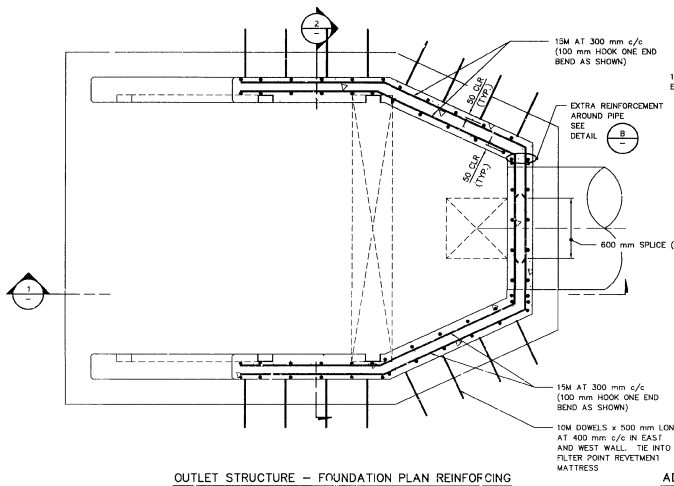
DESIGNED IG/AEB
DRAWN PL/DHA
CHECKED

KERR WOOD LEIDAL ASSOCIATES LTD.
CONSULTING ENGINEERS

CITY OF SURREY
ROYAL CITY PUMP STATION
SUMP REINFORCING -
PLAN, SECTIONS AND DETAILS

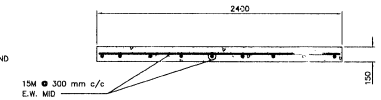
SCALE AS SHOWN
DRAWING No 471-002
SHEET 9 OF 18 ISSUE D

471-002(REINF.DWG) 95/05/06



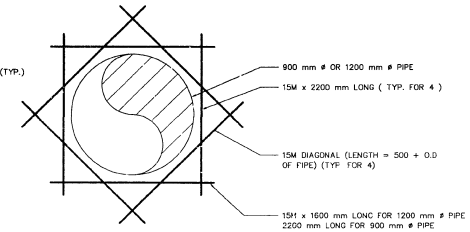
OUTLET STRUCTURE – FOUNDATION PLAN REINFORCING

SCALE 1:25



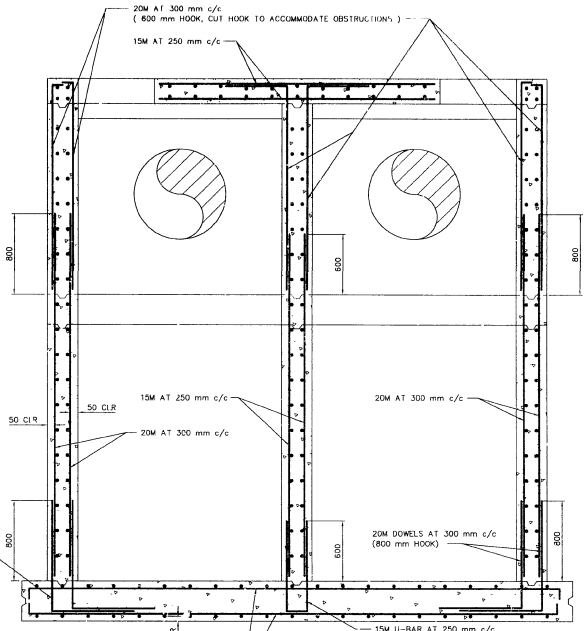
DISCHARGE PIPE PROTECTION DETAIL A 2 / A 3 / A 5

SCALE 1:25



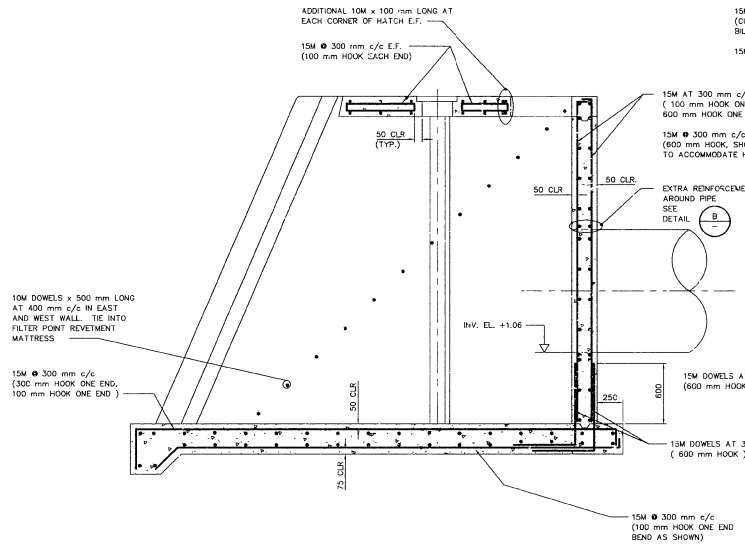
ADDITIONAL REINFORCING AROUND PIPE – DETAIL B – / B 6 / B 9

SCALE 1:25



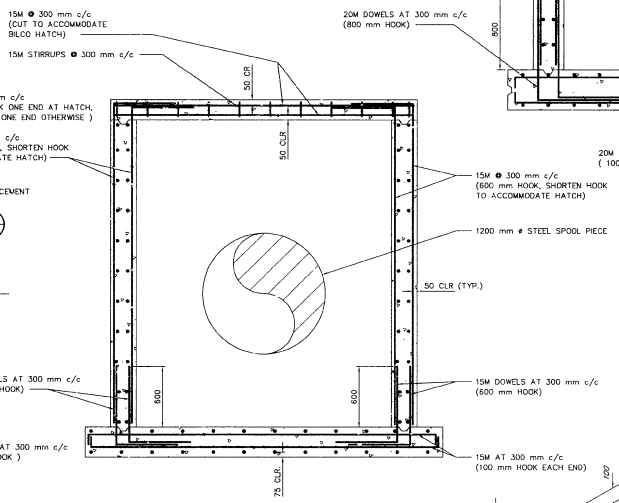
SECTION 2 / 9

SCALE 1:25



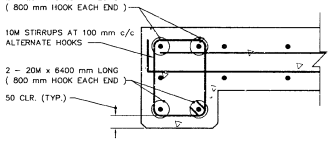
SECTION 1 / –

SCALE 1:25



SECTION 2 / –

SCALE 1:25

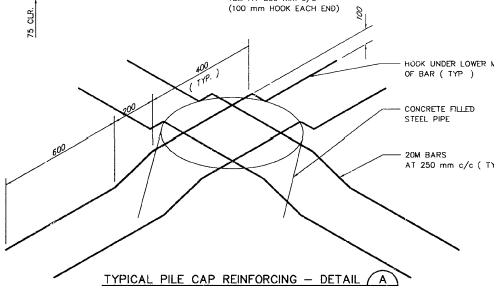


NOTE:

HORIZONTAL STEEL IN BEAM SHALL BE CONTINUOUS FROM THE EXTERIOR FACE OF THE EAST WALL TO THE EXTERIOR FACE OF THE WEST WALL.

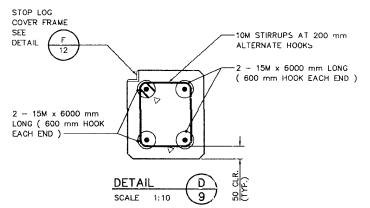
DETAIL C / 9

SCALE 1:10



TYPICAL PILE CAP REINFORCING – DETAIL A / 8

N.T.S.



DETAIL D / 9

SCALE 1:10

NOTE

HORIZONTAL STEEL IN BEAM SHALL BE CONTINUOUS FROM THE EXTERIOR FACE OF THE EAST WALL TO THE EXTERIOR FACE OF THE WEST WALL

D-3402 SS-000-519(P)

REVISIONS	ISSUE	DATE	DR'N	CH'D	APP'D	DESCRIPTION	ISSUE	DATE	DR'N	CH'D	APP'D	DESCRIPTION
	B	94/03/18	DHA			ISSUED FOR TENDER	E	96/03	KS			A.B. PLOTTED
	C	94/07/14	DHA			ISSUED FOR CONSTRUCTION						
	D	95/05/06	JL			RECORD DRAWING						

DESIGNED AEB

DRAWN DHA/PL

CHECKED

KERR WOOD LEIDAL ASSOCIATES LTD.

CONSULTING ENGINEERS

CITY OF SURREY

ROYAL CITY PUMP STATION

REINFORCING – OUTLET STRUCTURE AND MISCELLANEOUS DETAILS

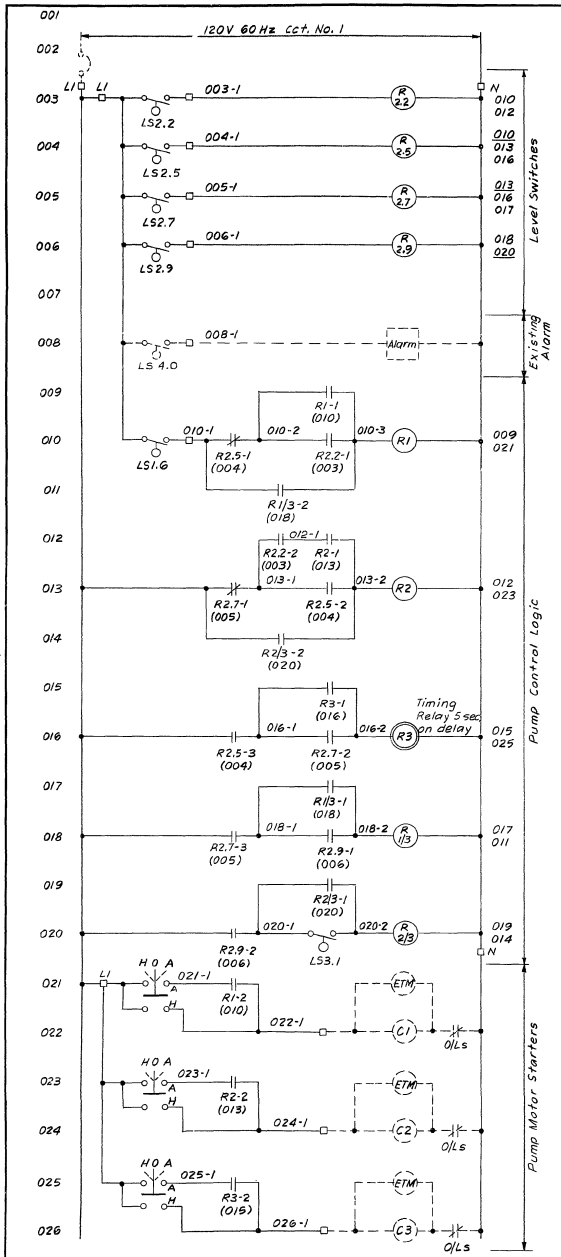
SCALE AS SHOWN

DRAWING No 471-002

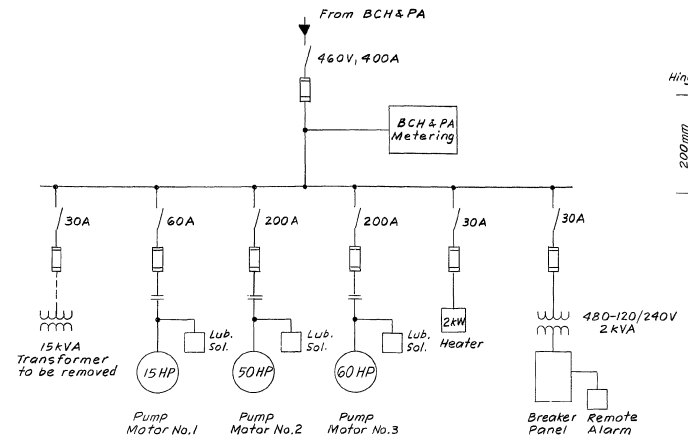
SHEET 10 OF 18 ISSUE D

95/05/06

471-002\OUTRDWG.DWG



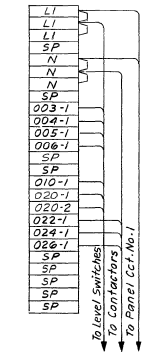
SCHEMATIC
(Components shown with broken lines are existing)



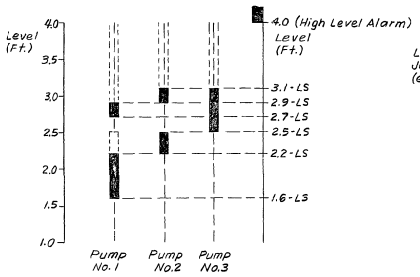
SINGLE LINE DIAGRAM
(All components shown are existing)

Out-lets	Function	Bkr. A	Circuit No.	Bkr. A	Function	Out-lets
	Controls	15	1 2	15	Heater	1
2	Lights	15	3 4	15		
1	Receptacle	15	5 6	15	Remote Alarm	1
	Space		7 8		Space	

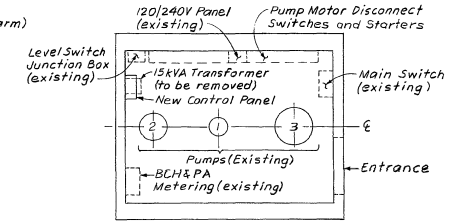
120/240V PANEL
(Existing)



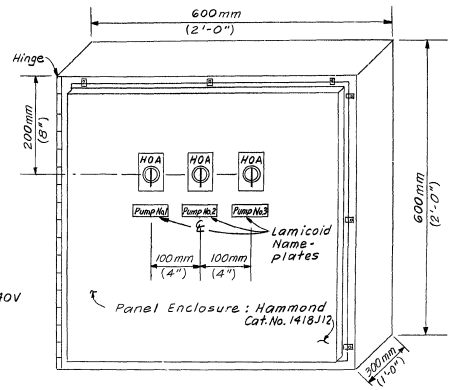
DETAIL A-TERMINAL BLOCKS
Scale N.T.S.



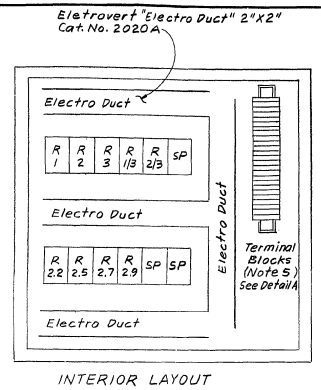
PUMP OPERATING LEVELS (FT)
Scale N.T.S.



PUMPHOUSE - LAYOUT
N.T.S.



CONTROL PANEL
N.T.S.



INTERIOR LAYOUT

NOTES

1. Before submitting his tender, the Contractor shall examine the site and familiarize himself with the existing conditions and installation.
2. The entire installation shall comply with all rules and regulations of all inspection authorities having jurisdiction, specifically the Canadian Electrical Code CSA C22-1-1978 and any local amendments thereto.
3. Work shall consist but not necessarily limited to, the supply of all labour and materials to completely install, test and commission the electrical installation required to make operational the pumphouse in the manual and automatic mode. This will include: Permits and inspection fees. Removal of the 15kVA transformer and H-O-A switches in starter covers. Sealing of all openings left open by removal of equipment. Manufacture, installation and connection of the control panel. Removal, inspection, cleaning and re-installation to the satisfaction of the Engineer, of the level switches, to operate at levels as shown on the drawing. All conduit, fittings, conductors, connectors, covers, hardware etc, neccessary to complete the work.
4. Control relays shall be Allen Bradley N-type Cat. No. 700-N400-A1. Timing relays shall be Agastat Series SCC-LA-01-2-A-B-A on-delay 0.5 to 15 sec., DPDT, 120V coil c/w socket.
5. Terminal blocks shall be Electrovert "Wiba" series 9700 B/6 c/w end plates, mounting rails and hardware.
6. Selector switches shall be Allen Bradley, 3 position maintained, Cat. No. 800T-J17A c/w contact block and legend plate Type 13, Cat. No. 800T-X511.
7. Interconnections between the control panel and existing devices shall be RWU No. 14 AWG conductor in EMT conduit.
8. Wire markers shall identify all conductors installed under this contract by wire numbers in agreement with the schematic and shall be Electrovert Z type.

NO.	DESCRIPTION	BY	CH'D	APPR.	DATE
	REVISIONS				
4.	As constructed				4-10-82
3.	APPROVED FOR CONSTRUCTION				15-7-82
2.	Removed bar scales, changed layouts to N.T.S. and added imperial dimensions				11-3-82
1.	Revised schematic, Note 4, defined R3 and deleted R3.1				18-2-82

PROJECT D-180

CORPORATION OF THE DISTRICT OF SURREY

BRIDGEVIEW PUMPSTATION MODIFICATION
ELECTRICAL - PUMP CONTROLS

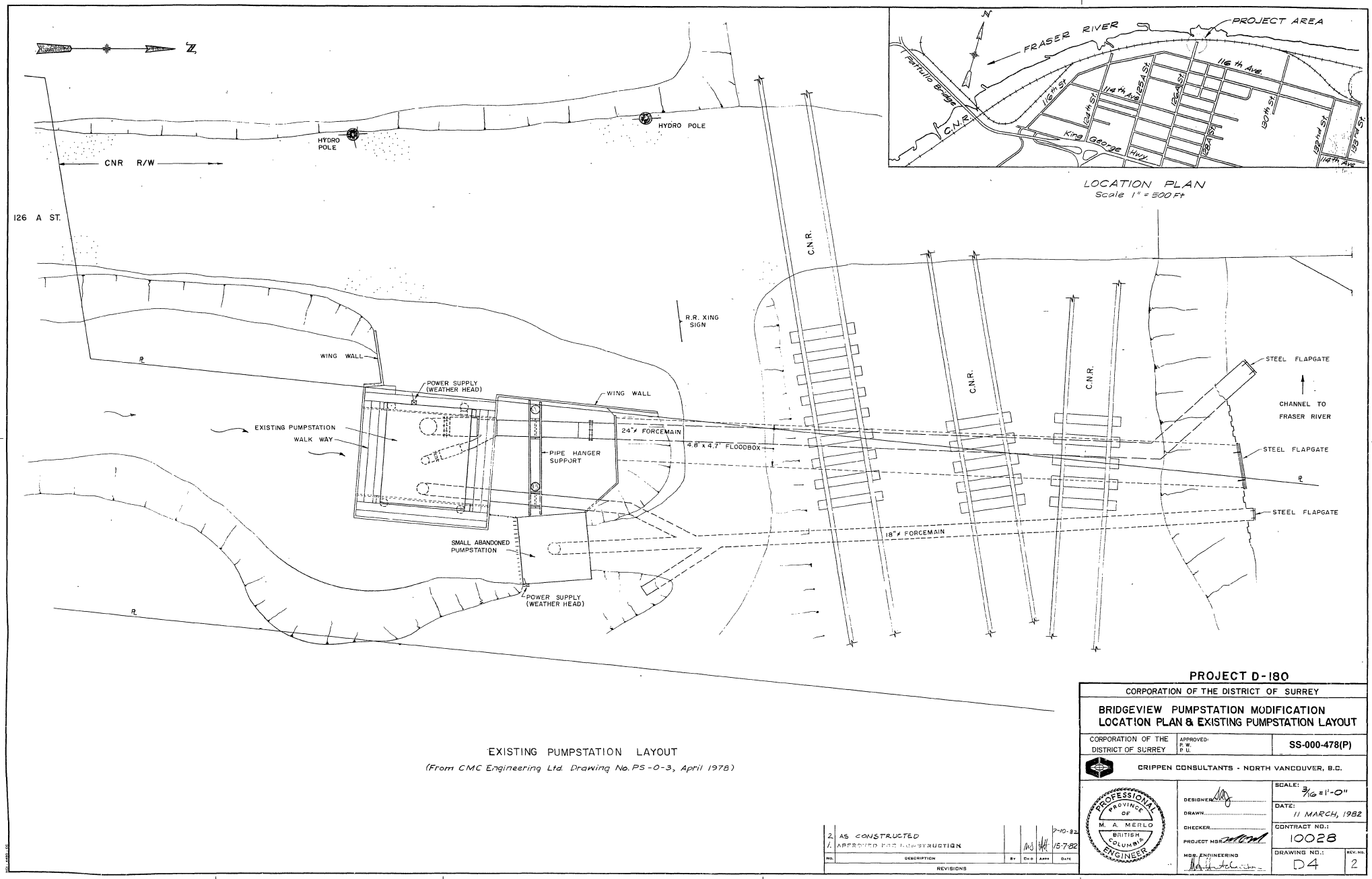
CORPORATION OF THE DISTRICT OF SURREY | APPROVED P.W. P.U. | SS-000-476(PE)

CRIPPEN CONSULTANTS - NORTH VANCOUVER, B.C.

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA W. HUMER

DESIGNER N.A.
DRAFTSMAN Y. JANG
CHECKER N.A.
PROJECT MGR.
MGR. ENGINEERING

SCALE: N.T.S.
DATE: 6 NOV., 1981
CONTRACT NO.: 10028
DRAWING NO.: 10028-D2
REV. NO.: 4



EXISTING PUMPSTATION LAYOUT

(From CMC Engineering Ltd. Drawing No. PS-0-3, April 1978)

LOCATION PLAN
Scale 1" = 500 Ft

PROJECT D-180

CORPORATION OF THE DISTRICT OF SURREY

BRIDGEVIEW PUMPSTATION MODIFICATION
LOCATION PLAN & EXISTING PUMPSTATION LAYOUT

CORPORATION OF THE DISTRICT OF SURREY	APPROVED: P. W. / P. U.	SS-000-478(P)
CRIPPEN CONSULTANTS - NORTH VANCOUVER, B.C.		

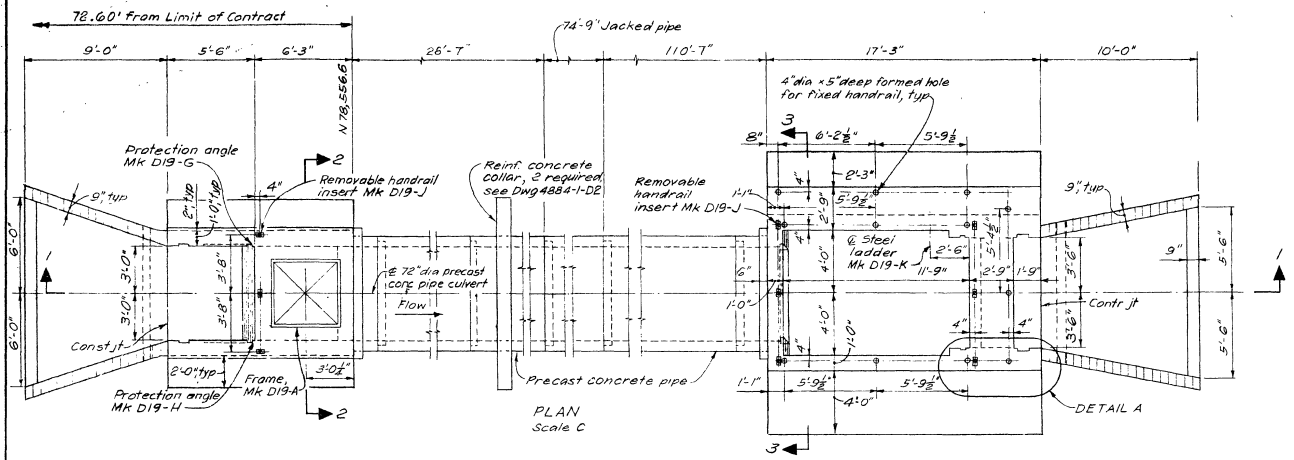
PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — M. A. MERLO

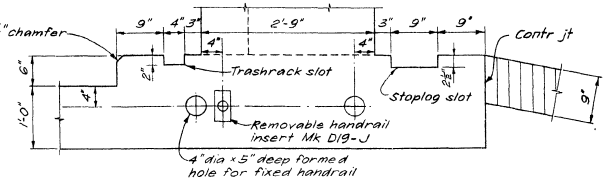
DESIGNED: MAM
DRAWN:
CHECKER:
PROJECT MGR.:
MGR. ENGINEERING:

SCALE: 3/16" = 1'-0"
DATE: 11 MARCH, 1982
CONTRACT NO.: 10028
DRAWING NO.: D4
REV. NO.: 2

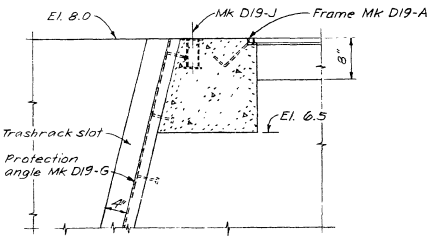
NO.	DESCRIPTION	BY	CH'D	APP'D	DATE
2.	AS CONSTRUCTED				7-10-82
1.	APPROVED FOR CONSTRUCTION		MAM		15-7-82

REVISIONS

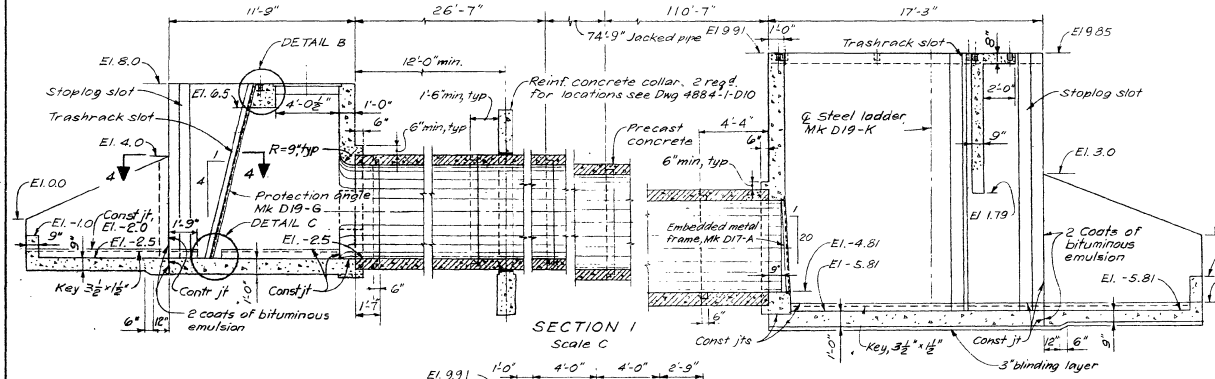


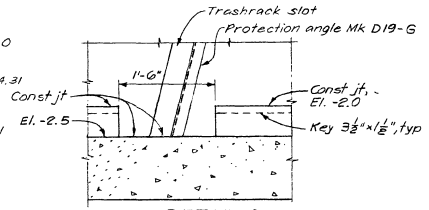


DETAIL A
Scale B

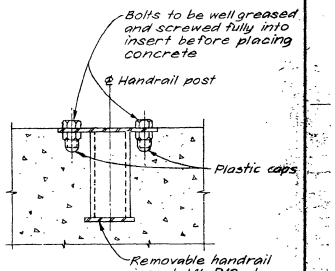


DETAIL B
Scale B

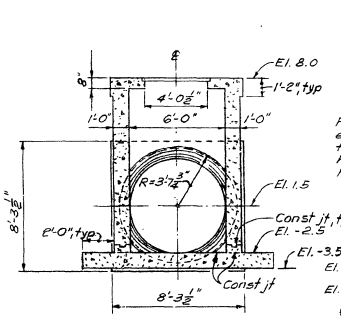




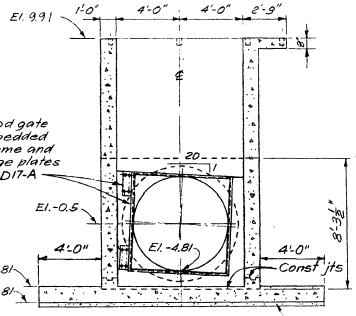
DETAIL C
Scale B



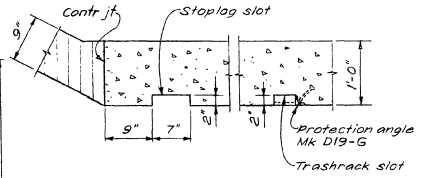
INSERT FOR REMOVABLE HANDRAIL
Scale A



SECTION 2
Scale C



SECTION 3
Scale C



SECTION 4
Scale B

NOTES

1. For general arrangement see Dwg D 10.
2. For seepage collars see Dwg D2.
3. For reinforcement see Dwg D14.
4. Concrete shall be Class 1.
5. Precast concrete 72" internal diameter culvert sections with exposed reinforcement to be embedded in in-situ inlet and outlet as shown.

Scale C 5 0 5 10 15 20 FT.
Scale B 1 0 1 2 3 4 5 FT.
Scale A 1 6" 0 1 FT.

F/W SS-O-481 105779

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA M. A. MERLO

CRIPPEN ENGINEERING LTD.
NORTH VANCOUVER, B.C.
PROJECT NO. 1040S
DEPARTMENT HEAD
PROJECT ENGINEER
CHIEF ENGINEER

2. As built.
1. Outlet structure inverts revised.

APPROVED FOR CONSTRUCTION MAY 17 1979

NO	DESCRIPTION	BY	CHD	APPR	DATE
	REVISIONS				

RECOMMENDED PROJECT MANAGER
DATE Aug 30 1978.
APPROVED DIRECTOR, WATER INVESTIGATIONS
DATE Sept 8/78

BRITISH COLUMBIA
MINISTRY OF THE ENVIRONMENT
WATER INVESTIGATIONS BRANCH
CANADA-BRITISH COLUMBIA
FRASER RIVER FLOOD CONTROL 1968 AGREEMENT

PROJECT NO. & CONTRACT NO.:
SOUTH WESTMINSTER FLOOD CONTROL WORKS
128 TH STREET FLOODBOX
CONCRETE OUTLINE

DESIGNED	SURVEYED
DRAWN FL	DATE
CHECKED	FILE NO. 0281550-C120-1
SCALE As shown	DATE 29 Aug 1978
DWG. NO. 4884-1-D13 R2	SHEET 16 OF 20 SHEETS

Appendix C

Internal Workshop Notes & ANC Reports

AECOM
3292 Production Way, Floor 4
Burnaby, BC, Canada V5A 4R4
www.aecom.com
604 444 6400 tel
604 294 8597 fax

Minutes of Meeting

Date of Meeting	October 15, 2012	Start Time	10:00 am	Project Number	#4812-707 (60270841)
Project Name	Bridgeview – North Slope ISMP				
Location	Surrey City Hall – Parks and Recreation Boardroom				
Regarding	Stage 1 Meeting & Internal Workshop #1				
Attendees	**City of Surrey** – Carrie Baron (CB), Jeannie Lee (JL), Stephen Godwin (SG), Lee-Anne Pitcairn (LP), Doug Merry (DM) **AECOM** – May Phang (MP), Scott Neuman (SN) **Phoenix Environmental** – Ken Lambertsen (KL)				
Distribution	Same as above				
Minutes Prepared By	May Phang				

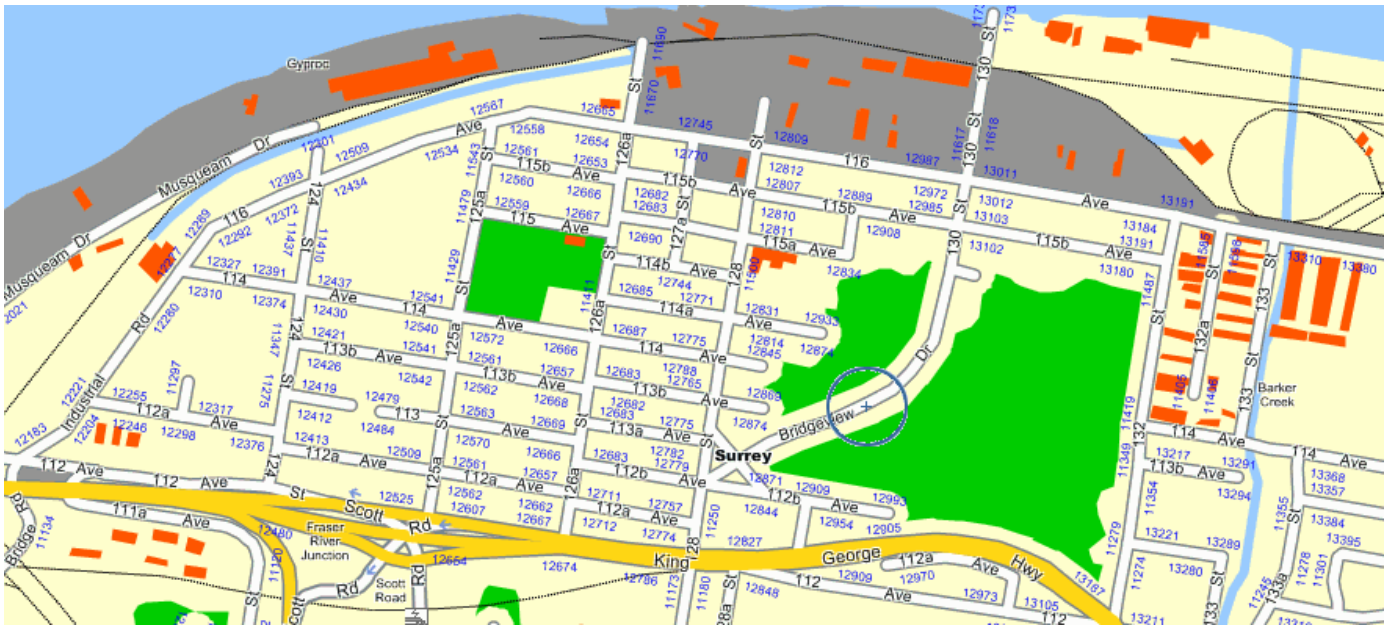
PLEASE NOTE: If this report does not agree with your records of the meeting, or if there are any omissions, please advise, otherwise we will assume the contents to be correct.

	Action
• May began the meeting with a presentation summarizing Stage 1 of the ISMP.	
Study Area, Land Use, and Major Projects	
• May summarized the study area, land use based on OCP, adjacent NCP and GLUP, and major projects that are underway for the area.	
• Carrie mentioned that the South Fraser Perimeter Road (SFPR) portion from 144 Street to 130 Street is planned to be completed by 2013, however west of 130 Street may be delayed until 2014.	
• The latest sketch showing the proposed alignment section A, B, and C for the new dyke extension east of 130 Street was shown. The City noted that the Ministry has verbally approved this alignment and that the City is currently working with CN Rail for go ahead and in general they are in agreement with it. However, dyke route B may be pushed closer to the Fraser River.	
• The new dyke alignment will provide flood protection to SFPR, properties upland, and areas of CN property.	
Environment	
• Ken from Phoenix talked about watercourse classification issues existing within the study area. Specifically, the group talked about Southward Creek and SFPR. There is a new culvert in place that should be fish passable (Carrie noted that this was part of DFO approval for this project), however Ken mentioned from his field review it did not look fish passable. The group agreed that a key note to add into the ISMP is that this culvert be fish passable	MP – Add key note for this culvert and Southward Creek to report.

• Ken also stated that there are two parallel watercourses upstream of Southward Creek that should be mapped and have their classification confirmed. The group discussed that because the environment is constantly changing in this area due to SFPR and other major projects, one of the ISMP recommendations should be to recommend all watercourses and environmental conditions be re-mapped and classified after the SFPR contractor is out of the area.	MP – Add recommendation in report.
• Ken and Stephen discussed updating the City's watercourse classification map. Ken to send Stephen GIS/CAD files for updating purposes.	KL – Send SG GIS/CAD data.
• Ken noted that there is a large amount of groundwater and base flow coming off the escarpment. The key is to keep the escarpment forested which will result in continual base flow potentially through July as well as enhance environmental conditions in downstream areas.	MP – Add to report.
Drainage	
• May gave an overview of how the study area drains and spoke about the two floodboxes and Royal City Pump Station.	
• Carrie noted that there has been a trend recently of winter storm surges causing higher tides to be experienced in this area. Jeannie is to provide AECOM with Manson gauge data (river and upland side).	JL – Provide Manson gauge data to AECOM
• May discussed sea level rise (SLR) and showed a projection chart of SLR up to year 2300 from BC MOE Sea Dyke Guidelines, January 27, 2011. Carrie noted that this is more for sea dykes but will not be directly applied to the dyke extension design along Fraser River.	
• Carrie stated that the new dyke elevation will be built to 5.0m and are being designed such that they can be raised in the future to allow for climate change.	
• Carrie also stated that a new pump station will be required in this area. AECOM will need to identify the location of this future pump station along with sizing requirements (capacity and total dynamic head) once the new dyke is constructed.	MP, SN – Analyze in next stages.
• Carrie mentioned that in previous reports it was identified that some ditches were more critical to be kept open (for example, all ditches running north/south to be kept while ditches running east/west were not so critical). AECOM is to identify which drainage ditches should be left open and which drainage routes should be "opened up".	MP, SN – Analyze in next stages.
• The group discussed the plan for the new Pattullo Bridge and that 124th Street ditch must be maintained as an open channel.	
• The City is currently working on the Bolivar Creek diversion with Web Engineering. The City is to provide AECOM with the latest design drawings for this diversion and AECOM is to incorporate this into their model as the base scenario.	JL – Coordinate design drawings.
• Metro Vancouver's design drawings show sewer adjacent to and within the setback of Bolivar Creek (Stantec design). Jeannie to provide AECOM with a copy of these drawings.	JL – Coordinate design drawings.
• Ken mentioned to the City that south side of 115 Avenue there is a house that has filled in a critical watercourse and pipe currently runs through property (Dingwall creek area).	

Stakeholder and Public Consultation Strategy	
• The group discussed that with the Metro Vancouver (MV) North Surrey Interceptor (NSI) twinning project under way, we should have a representative at those meetings.	MP – to attend future MV NSI meetings
• Involvement of CN Rail stakeholders should be after the new dyke alignment is finalized.	
• City Planning do not envision any significant change in this area, and that currently they have only seen sparse re-development.	
• May asked the group what their initial thoughts were on involving the public. The group discussed the potential for confusion due to the number of major projects in this area. It was agreed that at this point in time, AECOM will continue with the next stages of the ISMP and at a later point in the project we will re-visit public outreach once recommendations are more finalized.	
Stage 2 Visioning Workshop: "What Do We Want?"	
• Doug asked how this area is to be treated with respect to City Centre and the Quibble Creek ISMP. The group discussed how these two areas are to be treated separately. Uplands in Bolivar and Bedford Catchments will be developed and BMPs will be incorporated, however we will need to ensure BMP setbacks are away from the escarpment so as to not undermine the slope stability.	
• For lowland areas within the 200-year floodplain, AECOM is to come up with a plan but most likely it will be an open-ditch concept with water quality BMPs and drainage improvements.	
• The group discussed how to make the area and streets more appealing, address the drainage issues, and provide water quality improvements.	
• AECOM is to look into groundwater recharge areas and to also identify within the uplands where development should be concentrated in to protect recharge locations. Doug noted that AECOM should look into setbacks on Bolivar Creek that may be larger than 30m.	
• May noted that this area sits between City Centre (urban and commercial) and the industrial lands fronting the river. Perhaps the long-term vision for this area may be to provide a cohesive well-planned community that connects these two areas together.	
• Carrie and Lee-Anne discussed that crime needs to be addressed. We may have a short-term vision to address the existing issues in this area and then also have a long-term vision to focuses on a larger community appeal.	
• May concluded the meeting and will provide Jeannie with an updated schedule for the project.	MP – Update schedule

Bridgeview



Language Spoken at Home
Count- Bridgeview 2005

Number	Language
1	Arabic
1	Blank code
4	Chinese
1	Czech
5	Cantonese
100	English
2	French
13	Hindi
2	Japanese
2	Korean
1	Other
2	Other Malayo-Poly
2	Persian
6	Pilipino
2	Polish
19	Punjabi
1	Russian
7	Spanish
6	Tagalog
1	Tamil
19	Vietnamese
Total: 197	

2001 Census Profile by specified are (see maps)	**Bridgeview**	**Surrey**
Total Population	1,895	347,825
Total Visible Minorities	830 (43%)	127,015 (36.5%)
Two Largest Visible Minority	South Asian (38.6%) South East Asian (28.3%)	South Asian (59.6%) Chinese (13%)
% who lived at different address 5 years ago (movers)	46.5%	48.9%
Average Household Income	$41,607	$63,197
Incidence of Low Income	35.7	18.3
Gov't Transfer payments %	15.9	10.9
Largest % age group	30-39 (20.3%)	40-49(16.1%)
EDI score	44.6%	23.5%

Community Services in Area (or close by)
Bridgeview Community Centre

Elementary School	Bridgeview	SURREY CITY
% Single Fam Hhlds	60.1%	72.2%
Av Fam Income (2001)	$50,244	$63,954
% Income Assis (age 5-12)	14.0%	unknown
Lone female Parent (child at home)	15.0%	15.5%
% Unemp with children	9.2%	unknown
% Rented Dwellings	28.0%	29.0%
Abor as % of total pop	4.5%	2.0%
% New Immigs (1996-2001)	2.0%	21.0%
% Home Lang not English	13.0%	33.6%
Transiency(moved in previous year)	13.0%	16.7%
Transiency (Moved in previous 5 yrs)	48.0%	48.9%
% children vulnerable on any scale of EDI	44.6%	23.5%
(EDI area name)	(Bridgeview)	

Action for Neighbourhood Change | Quartiers en essor

community stories

October 2005

ISBN #1-55382-149-1

ANC in BC Selects Bridgeview

The Action for Neighbourhood Change project (ANC) may be complex but its purpose is clear. The initiative is about real people helping one another to make their neighbourhoods better places to live. Since the project began in February 2005, it has generated optimism and hope among community members. The partners are excited that the program is having the desired results: Citizens are becoming involved in changing their neighbourhoods and government is hearing the feedback it needs to support them effectively. This series of stories presents each of the five ANC neighbourhoods as they existed at the start of the initiative. A second series will be published at the end of the ANC's 14-month run to document the changes and learnings that have resulted from the effort. For more information about ANC, visit: www.anccommunity.ca

Uncharted waters

United Way of the Lower Mainland (UW LM) serves a population of 2.25 million people in a part of British Columbia which blends rural, suburban and downtown areas. Land masses are divided by water and mountains, so geography plays an important role in service location decisions. UW LM stretches north to Pemberton, winds along the Sunshine Coast to encompass Whistler, Squamish and Bowen Island, and ends in Vancouver and its surrounding communities. The latter include Richmond, Delta, Surrey, New Westminster, The Langley's, Coquitlam, Port Coquitlam, Maple Ridge and the North Shore communities of North Vancouver, West Vancouver and North Vancouver District. Of these, Surrey is growing at the fastest rate – 1,500 people move into the city each month. Its population (roughly 350,000) will soon rival Vancouver's (550,000).

A participant in the pan-Canadian learning community known as Vibrant Communities,

TAMARACK An Institute for Community Engagement

CALEDON INSTITUTE OF SOCIAL POLICY

ONF NFB

Funding provided in part by Canada

UW LM is one of three convenor organizations for Vibrant Surrey.[1] It also piloted a "Communities in Action" program, a four-year community issues identification and action plan initiative aimed at improving the quality of life at the community level. When the federal government selected Surrey as one of the cities to be included in Action for Neighbourhood Change (ANC), UW LM was well-positioned to identify several likely sites for the project and work with the community.

Over the last 20 years, the United Way movement in Canada has expanded its core mission of funding community and charitable services. It now emphasizes its role as a community builder whereby it invests resources into communities in order to help residents build their own capacity to address social issues. UW LM and several other local United Ways across the country are exploring the concept of "community impact." Within ANC, this will involve considering both the type of work UW LM will do through the project as well as the impact that United Way-funded agency services can have at the neighbourhood level.

Site selection – Surrey-style

The Surrey neighbourhood selection process was driven by two UW LM guiding principles: first, community building is about building capacity for communities, organizations and the nonprofit sector; and second, it must be community-driven. UW LM's earlier experience with the Communities in Action process underlined the importance of asking for stakeholder input on selection criteria and being aware that agencies will support ideas that are financially and programmatically sustainable. Because Surrey is growing quickly and has a diverse population, ANC was attractive to Surrey City Council members who were looking for help in dealing with

United Way of the Lower Mainland's perspective on community development

Over the last 20 years, UW LM has gradually moved from being a federated fundraiser to a community builder. In 1995, UW LM staff members attended a conference in the US where they learned of the various ways United Way organizations in that country were building communities. Says Linda Western, UW LM Planning Consultant: "What that means is that we began investing resources – staff, dollars, networks – into communities in a way that strengthened their capacity to address social issues. We have had staff working with United Way-funded and other agencies and partners for the past 15 years. We have been working closely with members of the Surrey community for more than five years."

Since 2000, UW LM has been responsive to the spontaneous efforts of community members who want to address an issue. It also has worked proactively, bringing together agencies and issue stakeholders to explore issues in high growth and high need areas. (The task of detailing local concerns has been accomplished through a program called "Communities in Action," in which the first phase is the creation of a community profile developed using indicators chosen by residents.) Profiles provide a snapshot of the current facts and directions as a basis on which to set goals, directions and strategies.

A second preference is for UW LM to be involved in the early phase of an initiative, but to relinquish leadership to the community as soon as possible. Says Linda: "Our organization continues to provide support until the capacity is there to assume leadership. We work to be transparent and collaborative and to build on a community's assets. Our projects are designed and operated in a way that improves the likelihood that they can be sustained over time."

the challenges of change. UW LM made a commitment to continue working in the Surrey neighbourhood beyond the ANC's 14-month mandate.

Says Linda Western: "Our experience working in Surrey had taught us that they like to find their own solutions, and because the federal government had pre-selected Surrey for involvement, it was important that we establish an open, transparent and collaborative selection process with United Way acting as a facilitator. We were clear that it would be the community – not United Way – that would select the neighbourhood." Representatives from 45 Surrey-focused organizations were invited to an initial meeting. These included the school board, a crime prevention society, a poverty advocacy group, immigration services, multi-service societies, an Aboriginal society, police, library, City Parks and Recreation and planning departments, and a community group (Surrey Association for Sustainable Communities). Participants were given a list of qualitative and quantitative criteria suggestions and asked if they would help to choose a neighbourhood.

Over a two-month, four-meeting period, a core group of invitees continued to come together, each adding important selection information as the process moved forward. People who were unable to attend meetings were kept informed of the process and progress. The proposed criteria were grouped under four themes: community makeup and well-being, availability of services, levels of resident activism and readiness, and the presence and interest of outside partners. Between the first and second meetings, UW LM staff met with researchers in education, health and local government and agreed that it would be most useful to start with elementary school catchments areas as a means of defining neighbourhood boundaries. By the second meeting, the number of potential neighbourhoods had fallen from 70 to eight. More information was gathered from principals and parent advisory committees in the eight possible neighbourhoods, along with social housing information and information from local agencies.

At the third meeting, the neighbourhoods were further shortlisted to five. A group exercise was held to summarize everyone's collective knowledge about the five remaining neighbourhoods. Certain criteria were emerging as important, particularly community readiness, neighbourhood assets and whether it was felt ANC could have an impact. Group members were encouraged to visit the communities to get a physical sense of them.

At the fourth meeting on June 14, maps were put up to help participants visualize the sites and neighbourhood information was summarized on flip charts. Group members walked among the displays and discussed the issues informally. When all agreed it was time to vote, Bridgeview easily rose to the top of the list. Says Linda: "We kept the criteria and the values of the project in front of us throughout the process. We wanted a neighbourhood which was representative of the rest of Surrey and where we could make an impact within a short time frame. In the end, we chose Bridgeview based on two deciding factors: it met all the criteria of balance between asset and need, and already had a sense of community. One of the key indicators was the report on school readiness of kindergarten children."

The Early Development Indicator is a screening instrument used by teachers across BC to assess kindergarten-aged children on a neighbourhood-by-neighbourhood basis. In 2004, it showed that Bridgeview children rated

at the extreme lower end of the scale. In all areas – gross and fine motor skills, sociability, language, ability to relate to others – their results were similar to those achieved by children in isolated northern communities. Staff members at the local elementary school have suggested that Bridgeview's status as a forgotten, isolated neighbourhood ultimately affects the development of young children.

By the time UW LM held a meeting to announce Bridgeview's selection, word of the project had spread to the managers of departments and organizations that were involved in the selection process and they, too, attended the opening. Says Linda: "Selection committee members had shared their excitement about the opportunity ANC presents, not only to help one neighbourhood, but to share the learning that it generates throughout the wider community."

Approval and acceptance by the residents was seen as the next step in the neighbourhood selection process. A meeting was held with the Bridgeview Hall Community Association and the elementary school parent advisory committee, many of whom serve on both committees. Initially, they were hesitant about being selected as an ANC neighbourhood because it implied that their community would again be portrayed in a negative light. This perception was soon laid to rest and they became enthusiastic about the potential benefits offered by involvement with ANC.

As the final step in the selection process, United Way held a media launch to announce Bridgeview's selection. An invitation was extended to all who had been initially involved as well as those who had been added during the process. Says Linda: "Although intended as an opportunity to inform the media of the launch of the project, word of mouth had spread to the residents."

On July 25, more than 50 people, including newly-elected MLA Bruce Ralston, who lives in a nearby Surrey neighbourhood, responded to the invitation. Bridgeview residents, city staff, members of the selection process committee and some of their managers and members of the media came to the event. Initial fears and reservations expressed by residents about having something done "to them" were quickly overcome. Residents were assured that the only action taken to date had been the selection of Bridgeview, and they soon understood that it would have created false expectations among unsuccessful neighbourhoods to involve them any sooner in the project.

Says local ANC coordinator Gill Redfern: "One elderly woman came to our opening event angrily demanding to know why residents had not been invited into the selection process. By the end of the meeting, she apologized for her outburst and told us that she thought our process had been exactly right and that Bridgeview was exactly the right location for ANC. Though we are only beginning to get to know the people in this community, they have impressed on us their appreciation of Bridgeview's history, strengths and opportunities. Harnessing that community spirit is an exciting prospect."

Bridgeview – out of sight, out of mind

Bridgeview lies at the bottom of a valley on a flat, largely open piece of land bounded by the four-lane Pattullo Bridge, the four- and six-lane King George Highway, the Fraser River and an industrial park. A 1976 National Film Board video entitled, "Some People Have to Suffer" documented Bridgeview's 24-year struggle (1953 to 1977) with the municipality of Surrey to replace open sewage ditches with a sewer system.[2] The

neighbourhood's distinct geography and sense of community were key factors in its selection for involvement.

Early agricultural settlement in the area dates back to the 1860s. The Pattullo Bridge opened in 1937, linking New Westminster with Surrey, and the area began to develop both as an industrial and suburban area. Modern Bridgeview was established during the 1940s when small homes were constructed on the east side of the bridge to house the wives and families of men incarcerated in the penitentiary across the river (the penitentiary was closed in 1980). There are plans to establish an industrial park to serve the growing lumber industry.

Other structures within the neighbourhood today include the Bridgeview Community Hall (situated on a large park space), a mixture of old and new houses on wide, ditch-lined streets, one temple, one elementary school, a convenience store and a small trailer court. The drainage ditches have the effect of dividing properties into rural-looking lots and they overflow and flood footpaths during rainy weather. Warehouse and industrial facilities run along the river-front boundary, with a used car and parts lot, workshops and one hotel situated along the highway. In order to buy goods, visit a doctor or dentist, attend high school, go to work and access social programs, residents must travel "up the hill." Transit service is available, though limited, skirting around Bridgeview. In order to reach the nearest transit station, people have to walk over the highway on a walkway that becomes impassable in bad weather. Students must take the Sky Train and a bus to reach the high school.

Surrey is divided into six town centres. The Whalley area, of which Bridgeview is only a small part, has received resources to establish youth, employment and seniors programming; a limited number of these services have made it "down the hill" to Bridgeview.

Isolated by its very boundaries, with virtually no retail stores, no library, limited transit service and only a community centre to provide a variety of community services, Bridgeview has nevertheless managed to forge a community identity. Bridgeview Days, an annual community party, was celebrated for the 61st time in late June, coinciding with the Bridgeview Residents' Association's 61st anniversary.

The people of Bridgeview

Bridgeview has a population of 1,895. The proportion of visible minorities is higher in Bridgeview than in Surrey (43.8 percent versus 36.5 percent). Of the 830 visible minority community members, South Asians and South East Asians represent 38.6 and 28.3 percent respectively. Punjabi (5.2 percent), Hindi (5.2 percent), Tagalog (2.2 percent) and Chinese (1.6 percent) are the most commonly spoken languages after English (60.6 percent).

Among the 720 households, the average income is $41,607, compared with the Surrey average of $63,197. More than two-thirds (67.6 percent) of residents own their homes, while 32.4 percent are renters [Statistics Canada 2001]. The majority (70.8 percent) live in single family homes. A small trailer court makes up part of the community. House prices are affordable, which makes the neighbourhood attractive to low-income workers, recently-settled immigrants and first time home buyers. Rental housing stock varies in upkeep and appearance. Residents have expressed interest in labour swap arrangements where people trade house improvement services with one another.

The neighbourhood's isolation has had the positive effect of knitting the 53.6 percent of permanent dwellers tightly together. Bridgeview residents keep a close eye on one another's homes and children. This concern may act as a well-spring for involvement in ANC.

Community assets

Bridgeview Elementary School is a brightly coloured, modern facility. It serves 190 students and has an active parent advisory council. Its former principal, Marcia Hogan, worked in Bridgeview for nine years, leaving in December 2004. During her tenure, she instituted many programs aimed at improving literacy, numeracy and social responsibility skills. New principal Michael Gordon has continued Marcia's efforts to link school programs with community centre activities (e.g., before- and after-school and summer programs) and has plans to further develop this work after the new school year begins.

Bridgeview Community Hall acts as the community hub and is open 12 hours a day from Monday to Friday. Weekend programming generally is reserved for groups that rent the facility (e.g., Scouts, Air Cadets, weddings and private functions). Surrey's parks and recreation department recently expressed interest in establishing new programs at the centre. Until now, the centre's offerings have included exercise and craft classes, a preschool program, a family resource centre, an Industry Canada Community Access Program site, summer day camps and annual community events. The Bridgeview Community Association has had to raise funds from local business and donors to cover reduced municipal operations funding.

At this year's Bridgeview Days, residents could participate in a parade, craft display, games and activities, a softball challenge and a family dance. Gill Redfern used the opportunity to begin meeting members of the community, introducing them to ANC and asking them to list what they liked about their community and what they felt needed improvement.

Says Gill: "People expressed a great deal of affection for, and identification, with their community. There is a tangible spirit that is manifested in a 'can do' attitude. There is a definite perception that Bridgeview is a forgotten and neglected suburb which has helped bring residents together to get things done. Besides Bridgeview Days, there are several community events that run throughout the year which keep people connected with one another, but there are still many people who remain isolated. The neighbourhood has evolved a small-town, rural feel where people notice change immediately. Because of its geographical position, people do not happen upon Bridgeview by accident, nor are its streets used as thoroughfares to get to another part of Surrey. If a strange car is driving around or parked in someone's driveway, people tell one another about it and look out for each other's safety."

When asked which aspects of their community needed attention, residents were quick to identify physical and structural improvements they wished to see made. In particular, they wanted equivalence in service delivery to other parts of Surrey. Municipal council representatives in BC are selected based on their affiliation with a political party. Currently, only one member of City Council, Penny Preddy, currently lives in North Surrey. She is aware of the United Way's activities in the rest of Surrey and will be kept informed of Bridgeview's ANC project.

The way forward

Now that UW LM has concluded its neighbourhood selection process, it will begin engaging community members in the process of envisioning change. This process will include building connections between residents and community support organizations and encouraging community capacity building at the neighbourhood level. The lessons learned during the first stages of the work will be shared with other community members in Surrey and throughout the Lower Mainland.

As a first step after the selection process, the staff of United Way of the Lower Mainland is committed to finding as much accurate information as possible about the area under study. Thorough research will be followed by planning, implementation and monitoring activities. UW LM generally plays a planning consultant role; that is, it invests funds, assembles stakeholders and facilitates process. Ultimately, the goal of ANC is to allow neighbourhoods to lead this process, but initially, the local United Ways will provide a model for future work undertaken by the community. UW LM also is committed to making its role transparent and to ensuring that the work done by ANC is driven by the Bridgeview community and that all parties work collaboratively.

Anne Makhoul

Anne Makhoul coordinates the 'community stories' series for the Caledon Institute of Social Policy.

Endnotes:

1. For more information on Vibrant Communities, visit: *www.vibrantcommunities.ca*

2. National Film Board video, "Some People Have to Suffer," directed by Chris Pinney. Copyright 1976, available at: *www.nfb.ca*

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1. Statistics Canada. (2001). *Census*.

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Action for Neighbourhood Change | Quartiers en essor

community stories

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ANC in Surrey: Bridgeview is Still in Motion

Action for Neighbourhood Change (ANC) was a two-year action research project which ran from February 2005 to March 2007. It operated in five cities – Surrey, Regina, Thunder Bay, Toronto and Halifax.[1]

This paper is the third in a series of community stories which chronicle the path of ANC in the five sites. Series one introduced each neighbourhood and the process by which it was selected for participation. The second provided a mid-process snapshot of involvement and activity. The third summarizes the work accomplished over two years, including project staff and resident perceptions of ANC and its impact on the neighbourhood.[2]

Neighbourhood history

Bridgeview is a small part of a very large city. Surrey is one of Canada's fastest-growing municipalities. Its population is currently estimated at 388,000 and it is expected shortly to overtake Vancouver as the largest city in British Columbia.

Bridgeview (population 1,895) has often been overlooked by municipal and other officials as but a small piece of Whalley – one of Surrey's six municipal centres. Isolated behind barriers of water, bridges, expressways and heavy industry, its defining physical features include quiet residential streets without curbs or sidewalks and large drainage ditches, which help carry away the storm water that inevitably finds its way to this low-lying location. Residents fought long battles with municipal officials in the 1970s to finally secure federal government funds to build an adequate – though expensive and experimental –

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sewage system, but the fight over curbs and safe walkways continues. A new four-lane expressway called the Gateway will soon carve a path along Bridgeview's northern perimeter. The community is divided over whether the increased noise and vehicle pollution balances the demolition of some badly neglected properties that were cleared to make room for the expressway.

Over the course of ANC's two years of operation, United Way of the Lower Mainland's ANC Manager Linda Western was pleased to see a high level of interest and participation in Bridgeview by members of a group of 40 government and agency representatives that she originally had assembled to help select a neighbourhood for participation. Though there were many points of comparison by which to choose a possible location for the project, it was the low scores on a provincial kindergarten readiness test that tipped the balance in Bridgeview's favour. Scores obtained were similar to those of children living in isolated northern regions of BC.

Bridgeview's physical isolation has a positive side, however. It helped create strong bonds among residents who learned to devise homemade remedies to the challenges they faced. They established traditions and routines that made community life enjoyable. Not having a strong municipal presence also meant that they did not have to worry too much about outside accountabilities. Says long-time resident Linda Isaac: "People feel that we have a great community here in Bridgeview. Isolation works to our advantage, particularly our sense of safety with our youth. Our only public space is the Community Hall – we don't have the congregating structures like malls and theatres that draw in negative influences."

Close relationships can also appear exclusive. Bridgeview residents may purchase annual memberships at the Community Hall for $5 but, in recent years, many residents had been unaware either of the Hall's existence or its programs and activities. In order to generate revenue to cover the Hall's operating expenses, the board of directors of the Bridgeview Hall Community Association has to strike a balance between renting out space to large organizations like Scouts Canada and Alcoholics Anonymous and resident-requested programming which may generate smaller revenues. To some people in the neighbourhood, this arrangement has made the Hall appear less responsive to resident inquiries or suggestions.

When ANC staff arrived in the summer of 2005, they were initially invited into the Hall, but soon relocated to Bridgeview Elementary School. Space and privacy were at a premium at the Hall, but principal Michael Gordon found a spot for ANC in his school. The move did not go unnoticed. ANC Bridgeview staff would have to spend a lot of time working at relationships with Hall members over the course of the project. Says Linda Western: "The association has a 62-year history of activity, and change is rarely easy. Having a new process operating was exciting for some and disturbing for others."

"When ANC first arrived, we thought it would bring in specific programs like English as a Second Language training for parents and grandparents," says Hall coordinator Rhonda Hanley. "It hasn't worked out the way I thought it would."

A different way of working

ANC's resident and relationship focus brought a different element to Bridgeview community practices. Over the first year, Linda Western and ANC site manager Gill Redfern spent

a great deal of time engaging individuals and small groups in discussing their perceptions of the neighbourhood and the challenges they faced. Slowly but surely, a core group of volunteers emerged that by year's end had formed a new, eight-member neighbourhood association called Bridgeview in Motion. Members considered either eventually merging their structure with the Bridgeview Hall Community Association or arriving at a comfortable coexistence in which each group would pursue separate but complementary activities. By March 2007, both organizations were continuing to operate side by side; three individuals serve on both committees.

In the spring of 2006, Gill Redfern returned to her home in New Zealand and Jamie MacKay was hired as the new ANC Bridgeview site manager. Says Jamie: "Whenever a person takes over the reins from someone else, there is a certain amount of adjustment required. My skills were different from Gill's, but the job of hearing resident voices and providing support for their efforts have continued as the central pieces of my work."

In the summer of 2006, Bridgeview in Motion members felt it was time for ANC to move back to the Community Hall. In September, ANC hired WeiHsi Hu, a musically and artistically talented community development worker whose language skills helped attract members of Bridgeview's Chinese community to the work of ANC.

Brian Brubaker has lived in Bridgeview for 19 years and chaired the Hall Association for 15 years. In board elections held in March 2007, he moved over to the treasurer position. Brian and two other board members also belong to Bridgeview in Motion. Says Brian: "ANC has encouraged more people to become active in the community. Some are older residents who have been less involved, others are new. Though I may not agree with everything they say, they have the right to voice their opinions. I'm hoping that more new families will become members of the Hall Association board, because they're the ones who need to help design programs and activities for their children. Some of the older board members forget how much change we dealt with 20 or so years ago. We've gotten comfortable with our routines, but now we need fresh people and fresh ideas."

The recent board elections provided a reason for many Bridgeview residents to join the Hall Association. Elections in past years had attracted less than 20 voters; this year approximately 80 people turned out. One group of residents chose to boycott the election, expressing their concerns that the Hall Association's policies and procedures were unclear. Says Jamie MacKay: "The good news is that more Bridgeview residents are interested in how the Hall operates. Once people begin to ask questions about how voices are heard and projects are chosen, it's important to earn their trust by making sure that structures are sound and procedures are enforced. Association members are aware that their charter is old and their policies and procedures need to be updated. This is an important learning opportunity for Hall board members. As they attend to procedural details, their association is becoming a more equitable, open structure that is responsive to all the residents of Bridgeview."

It is clear that ANC has brought to the fore a conflict between established relationships and traditions, and the needs of the entire neighbourhood. Getting through the rough patches takes a significant amount of time. Fortunately, United Way of the Lower Mainland has agreed to continue funding Jamie's position for another year. Says Brian Brubaker: "It's been good having Jamie here to help with mediation and meeting operation. I have found it hard to deal with the

divisions that have surfaced in the last year and I really appreciated the information and support he provided. In some ways, I think it would be good if more initiatives like ANC arrived in Bridgeview because it might speed up the changes we need to make in our organizations and the ways we interact with one another."

Bridgeview in Motion successes

Bridgeview in Motion (BIM) members chose their name partly to reflect the action orientation adopted early in their involvement with ANC. They were instrumental in reviving regular community cleanups and in getting more people to participate in Surrey's Adopt-a-Street campaign. Cleanup sessions were followed by potluck lunches in the Hall, and the pride and relationships that resulted from this work have continued to generate new ideas and activities.

Persistent, unanswered requests to City bylaw officials to deliver trash cans for Bridgeview led BIM to purchase its own cans with funds that eventually were reimbursed by ANC's Action Grants. BIM members decided to offer children and youth the chance to paint the cans – partly as a way of getting them involved in beautifying their neighbourhood and also as a deterrent to graffiti artists. At the 2007 Bridgeview Days annual community celebration in the summer of 2007, BIM will unveil the results of a trash can art design project. They are hoping Adopt-a-Street participants will also adopt a can, and that local businesses will do the same during a proposed later phase of the project – especially if they are offered a receptacle that has been embellished with their company name and an appropriate graphic.

Says Linda Isaac: "Bridgeview has a long history of pestering bylaw enforcement officers, and it takes a lot of time before our requests get a response. ANC has continued to encourage our efforts and we've been pleased to see some movement. For example, a few buildings that had almost disappeared behind piles of garbage are now cleaned up, and a pathway that joins the neighbourhood to the Skytrain has been cleared of shrubs. The safety issues surrounding curbs and sidewalks, however, have never received serious attention. The City feels that the project is too expensive, but with the construction trucks that will soon move into Bridgeview to build the Gateway, I'm even more concerned about pedestrian safety. I hope this is an issue which BIM can move forward by harnessing the influence of the United Way of the Lower Mainland and others."

BIM also initiated a movie matinée event for children and their families. The positive response has led to plans for a second and subsequent screenings. Though BIM meetings take place at the Hall, its community activities can be bumped by paying customers who might wish to book the facility.

WeiHsi Hu worked with BIM to design and implement a neighbourhood survey tool in October 2006, which was later supplemented by an ANC-led Neighbourhood Vitality Index[3] (NVI) survey undertaken in February 2007. Results from the NVI process are pending, but the data collected in October confirmed that the majority of respondents approved of the projects and direction BIM was taking. It also confirmed earlier BIM perceptions that most residents like to help carry out events, but that planning and procedures work is attractive to only a few. Says WeiHsi: "We held a Chinese New Year celebration in February that confirmed this finding. Two volunteers and I planned the entire event, but as people began to arrive, they pitched in and helped us get everything done." About 300 people attended the celebration.

Action Grant achievements

literacy gets support

Bridgeview Elementary School principal Michael Gordon is aware of the tensions swirling around the Community Hall, but feels that the necessary discomfort felt by the adult community pales in comparison to the benefits being enjoyed by Bridgeview children as a result of ANC's arrival. Thanks to Linda Western's efforts to create a circle of supporting organizations – which are referred to as the Friends of Bridgeview – he now has direct access to people and programs that will make significant positive changes in his students' lives.

Says Michael: "ANC really helped us with a push for programming that would encourage early literacy. Our school has been chosen as the site for the provincial government's literacy pilot project, 'StrongStart,' and we landed it by virtue of ANC's groundwork. It operates five mornings a week in a dedicated room and allows caregivers – many of whom are grandparents – to connect with one another and participate with the children in pre-literacy activities that include play, socializing and instruction. Year two ANC Action Grant funds were secured by a partnership between BIM and the school's parent advisory committee to establish an on-site community library for children aged 0 to 6. A new partnership forged with Surrey Public Library sends us books on a rotational basis. A large part of the library's function is to provide books and materials in languages other than English to serve the needs of Bridgeview's non-English speakers."

One of ANC staff member WeiHsi Hu's tasks was to ask what Bridgeview could do as a community to help children live healthy lives. He visited groups of older children in the elementary school to get their input and, in turn, they have consulted children in younger grades. The results of these enquiries will be fed into policy and program plans for Bridgeview Elementary's re-installation as a community school – one of ten new sites recently announced by the Surrey school board. (This designation had been terminated in the 1980s as a result of diminished board funding.) The input will also form the basis of a community presentation in April with representatives from Friends of Bridgeview in attendance. WeiHsi's background in youth engagement has allowed him to turn the final product for the presentation over to the children – a leap of faith that is the best foundation for engaging trust and creativity.

ANC's resident-focused process trusts that neighbourhoods can identify areas of need and ways to address them. The approach puts the process of engagement first and outcomes second. It requires its own particular leap of faith from government funders whose departmental mandates emphasizes outcomes which must be achieved within specific time frames. As the Bridgeview experience demonstrates, it can take a long time to work out differences in vision and approach. Says Michael Gordon: "ANC gave the community a chance to talk about itself and listen to other voices. The waters at the Hall may still be rough, but people remain active through the storms."

WeiHsi also helped organize a large event at Bridgeview Elementary in November 2006 where residents came out to meet representatives from community organizations, visit information booths and talk about issues of concern around child rearing and child care. Arts activities were provided for children and the event also reinforced and extended new connections and relationships.

supporting partners

Sahra-Lea Tosdevine-Tataryn has worked in Bridgeview for eight years as a Surrey Parks, Recreation and Culture liaison officer. Though the neighbourhood is only a small part of her area of responsibility, she has worked diligently to build partnerships and support Hall Association members in their programming and events. She also was involved in establishing a kindergarten readiness program at the elementary school, and is particularly happy to see youth activities in the Hall become more prominent. Says Sahra-Lea: "ANC's grant funding has brought together a lot of people to work in new ways. It's allowed me to meet new residents and the face-to-face exposure helps them relate to Parks, Recreation and Culture in a different way. I think the relationship building has created awareness and improved communication links to our department and other City services."

focus on youth

ANC's first year brought a new nonprofit organization to Bridgeview. Pacific Community Resources Society (PCRS) operates in partnership with the Ministry of Child and Family Development, designing programs for youth at risk between ages 13 and 19. ANC paid the salary of a part-time PRCS youth worker named Rebecca Wykes to engage Bridgeview teens. When the ANC money ran out in late 2005, PCRS decided to continue funding the position, splitting the cost with Surrey Parks and Recreation.

As a way to demonstrate its responsiveness to youth requests heard by Rebecca and ANC, the Hall's youth lounge was refurbished with year one ANC Action Grant funding. Chris Weekes took over for Rebecca in September 2006. Says Chris: "When I arrived, some of the youth would tell me that they needed this or that on the assumption that I would make things appear. Gradually a shift occurred and now they ask how we – collectively – are going accomplish something."

In the summer of 2006, several youth were paid by the Hall Association to set up and take down booths and materials for Bridgeview Days, the community's July celebration. In October, they created a wildly popular haunted house for the Halls' Halloween event. In recent years, both of these tasks had been contracted out by the Hall Association, often to non-residents. This time, fees remained with the youth group – now called the Youth Council – which deposited the money into an account for new equipment purchases. They followed the haunted house project with a successful penny drive. Weekly Youth Council meetings now regularly attract between five to ten members.

The Youth Council inspired Pacific Community Resources Society to submit an Action Grant proposal in partnership with the Hall Association to beautify the neighbourhood. Called the "All in a Day's Work" project, 50 youth will contribute 24 hours each to do street and yard cleanup and prepare a community garden. Individuals will earn a maximum $240 over the course of 12 weeks, beginning each work session with a healthy breakfast prepared by Hall Association members.

Chris' PCRS supervisor, Michel Pouliot, is a member of Friends of Bridgeview. Says Michel: "ANC was the catalyst that helped our organization build stronger ties to Surrey Parks and Recreation. Bridgeview's youth represent only three percent of the youth in Surrey as whole, so we could not have justified working at this level without ANC's programmatic support. We plan to continue our partnership with the City,

and if possible, expand services to include teens younger than 13."

In addition to partnering with PCRS for the All in a Day's Work project, the Hall Association secured Action Grants to retrofit the Hall's kitchen, build a walking track for seniors and parents with children, and establish sports and cultural activities for children that will provide opportunities for their parents to socialize.

Concluding remarks

"Everyone has the sense that ANC has just moved in," says Linda Western, ANC Manager for United Way of the Lower Mainland. "In the year ahead, we look forward to residents developing an even deeper understanding of how they can shape and influence the changes happening in their community. Relationships and trust are the basis of this work and they take time to build."

Sarah-Lea Tosdevine-Tataryn agrees: "Even five years is very short for this type of renewal initiative and ANC Bridgeview definitely needs more time. Things are now really getting going, but this work is like a business – it takes two years to lay the groundwork, and then you start to enjoy the rewards."

Says Chris Weekes of PCRS: "This neighbourhood is used to handling challenges on its own – which is good. Like the old McGyver television character, however, they often had to make do with what they had on hand, rather than locate the best possible tool for the job. There are now better linkages to services, and residents can see for themselves the type of resources that can be brought into Bridgeview."

The tension experienced among Bridgeview's residents as they work through the issue of empowerment must run its course. Integrating and acting upon the ideas and problems expressed by new and newly-raised voices is challenging. This work is typical of neighbourhood and community revitalization efforts. How well Bridgeview can mediate its various groups, acknowledge differences and continue on a path of revitalization is yet to be seen.

In mid-March, youth from the All in a Day's Work project spent the weekend removing blackberry brambles that had completely overtaken a house in the neighbourhood. The dwelling had been hidden for as long as Linda Isaac's husband could remember – and he has lived in Bridgeview for all of his 56 years. Says Linda: "Whenever we drive into the neighbourhood, we remark on that house. Bridgeview may have been overlooked by Surrey in the past, but we ourselves have contributed to some of the problems we are experiencing."

Like a structure freed from the tangle of old habits, Bridgeview is demonstrating its resilience and ability to adapt. Its residents are beginning to see that they have the capacity to build a neighbourhood where all can feel welcome.

Anne Makhoul

Endnotes

1. The purpose of ANC was to work at a neighbourhood level, providing funds and partnership opportunities to help residents effect positive change. ANC also presented a structure for building collaboration across five key federal government sponsors, United Way of Canada-*Centraide Canada*, five local United Way agencies, Tamarack – An Institute for Community Engagement, the Caledon Institute of Social Policy and the National Film Board. The lessons learned by the national partners are captured in *Final Reflections from the Action for Neighbourhood Change Research Project* [Gorman 2007].

2. Two previous ANC stories about Bridgeview can be found on the Caledon Institute and ANC websites:

ANC in BC Selects Bridgeview (October 2005).

A Return to ANC in Surrey: Bridgeview in Motion (April 2006).

3. ANC has been engaged in an ongoing effort to create an index to measure neighbourhood vitality. Its Neighbourhood Vitality Index (NVI) was released and tested in the five ANC sites in February 2007. Further information on the index can be found on the project website: *www.anccommunity.ca*

Reference

Gorman, C. (2007). *Final Reflections from the Action for Neighbourhood Change Research Project.* Ottawa: Caledon Institute of Social Policy, May.

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Website: *www.caledoninst.org*

What do we have in Bridgeview that we value and like?

Bridgeview is a great place to live because …

Great community support

The hall, school, flea market, scouting, summer fun, great neighbours, fun … Christmas parties, Easter egg hunt, Bridgeview Days, yeah!

Parents that care

My school

The community is very welcoming

Quiet community!

Great community

Parents that talk and care about the future of the next generation

Bridgeview is the place to be!

New to area: Awesome, so far. Lots of kids. Wonderful.

It's a small place with lots of people

We feel like we live in a small community where everyone cares about each other

Nice, small community

Great friends, and Bridgeview people are great for welcoming new people in the neighbourhood

Lots of people to hang out with!

Everyone is so close

Hardworking volunteers!

The most caring, open and welcoming community in Surrey!! (I will never leave.)

Bridgeview is a good place to have fun

Community spirit

Love the community

Bridgeview is a blessing!!!

Sense of community

Free computer time

Lots of great kids!

Great community and events

Lots a kool things to do!

We have good community support

Lots of fun for all. Bridgeview is a really cool neighbourhood.

Quiet neighbourhood

Bridgeview is friendly

A basketball court

I like that you are cleaning up the streets and sidewalks

Very quiet with good people

Like the park

Hall

People

Community

Community Hall to celebration community functions. Doing annual events that give people and kids in the community times to appreciate our very unique community. The kids grow up very

respectful of their community and school and their neighbours. The closeness of people I have worked with on community projects. Home projects.

The people are close to each other

The school and the community centre are close by

Close knit community, school, people

Community Centre, C.A.P. (computers), Scouting

People, school, community

What do we have in Bridgeview that we would like to change or be different?

Bridgeview would be better if we could change …

Store, small mall that works, pre-school upgrade

Fill in the ditches

Ditches to be filled in

A pool down here

Skate park

Speed bumps

Sidewalks fixed

A skate park for the older kids

The ditches filled in and sidewalks

Speed bumps around our park and school

Help to clean up some of the old houses

Skateboard park

Ice walkway and clean when snow

Sidewalks

Speed bumps

Clean pathway to Skytrain

Change the image of some properties, help older homeowners clean up and fix up their properties

Have more community people involved with the functions of the Community Hall

Get better response from City as other parts of Surrey; get the same benefits – as in roads, transportation, clean ditches

Make it easier to build a new house in the neighbourhood

Put back the cleanup

Blockwatch

Safe place for kids to play!

Yards cleaned up and no more dumping. Safe place for families.

Clean up area, more community awareness, city involvement, no dumping. Togetherness!

More police patrol during midnight to 6:00 a.m.

Swimming pool

More activities for different age groups

More clean and safe more family outings

Have swimming pool

More community events

Great park – expand the playground, more trees in the park

Great program, hope next time

Ring and monkey bars

Cleaning ditches! More Trees!

A pool to swim in

Cover the sidewalk ditch

Better sidewalks

More clean area for kids to play (get rid of junkies)

We need a Superstore; we need a Walmart; we need direct connection to the Scott Road Skytrain station

Put a clock outside

A gym at King George 125A would be nice

A gym

Skate park in the park

Needs a community swimming pool to enjoy

Bumpers close to school area

Put a better playground

Traffic slowdowns (add)

Less industrial, more retail

Stop cutting down trees

Less theft (Liberal gov't policy, desperate people more desperate, stealing out of yards)

Community garden and/or garden sharing

Help with home improvement projects

More recycling

Other people's misconceptions

Changing the negative attitude towards the people living in Bridgeview

Changing the negative attitude from other communities towards the residents of Bridgeview

Mow the grass in the park

Get the mess out of the yards

Rock wall

Cleaner habitat

Get rid of drug houses

Help the grade 7 graduates get to their new high school (community carpooling)

A pool

Change attitude about kids and adults; respect

A lot of dogs are running here and there without leashes

Renovate

A skate park

A pool

A pool

Pool

A pool

Pool

Skate park

A skate park

Pool tables

A skate park

More cops around, especially at night; too much theft around the neighbourhood

Drain the clogged drainpipes

Make all of the bullies go away

The ditches, and people's upkeeping of property and vehicles

Please improve the sides of the roads and ditches; ditches are the worst looking part of this area.

They don't cut the grass on time and properly

Ice skating rink; skate park; pool tables

When you enter this are from New Westminster, this is the first area of Surrey, but it doesn't look good. It's a bad introduction to Surrey. The should remove the junk-yard of cars and other junk-yards. Please make it livable and beautiful.

Please make this area looking good and beautiful

All the gossip

Appendix D

Site Inspection Findings

CITY OF SURREY
the future lives here.

Bridgeview-North Slope ISMP

Legend

1. Royal City Pump Station looking northwest at 126A Street
2. East collector ditch along 126A Street looking north
3. East collector ditch at 126A Street and 116 Avenue showing 800mm, 900mm, and 1050mm CMP culverts
4. West collector ditch at Royal City Pump Station looking west
5. 126A Street east ditch at 115A Ave. looking north
6. 126A Street west ditch at 115Ave. looking north
7. South Fraser Perimeter Road at 125A Street, pre-load and 900mm concrete culvert looking northeast
8. West ditch along 125A Street and Sout Fraser Perimeter Road

AECOM

SCALE 1:750

Project No.	Date
60270841	August 2012

Field Reconnaissance Photos (July 13, 2012)

Figure 5.7

Photos from Inspection 2012-07-13


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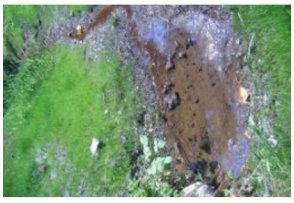
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Photos from Inspection 2013-06-14


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Appendix E

Detailed Hydraulic Modelling Results

Figure 9.7 Model Calibration

(Note: PCSWMM model calibration to Royal City Pump Station discharge outflows corresponding to historical level data provided by the City of Surrey, Dec.2012)

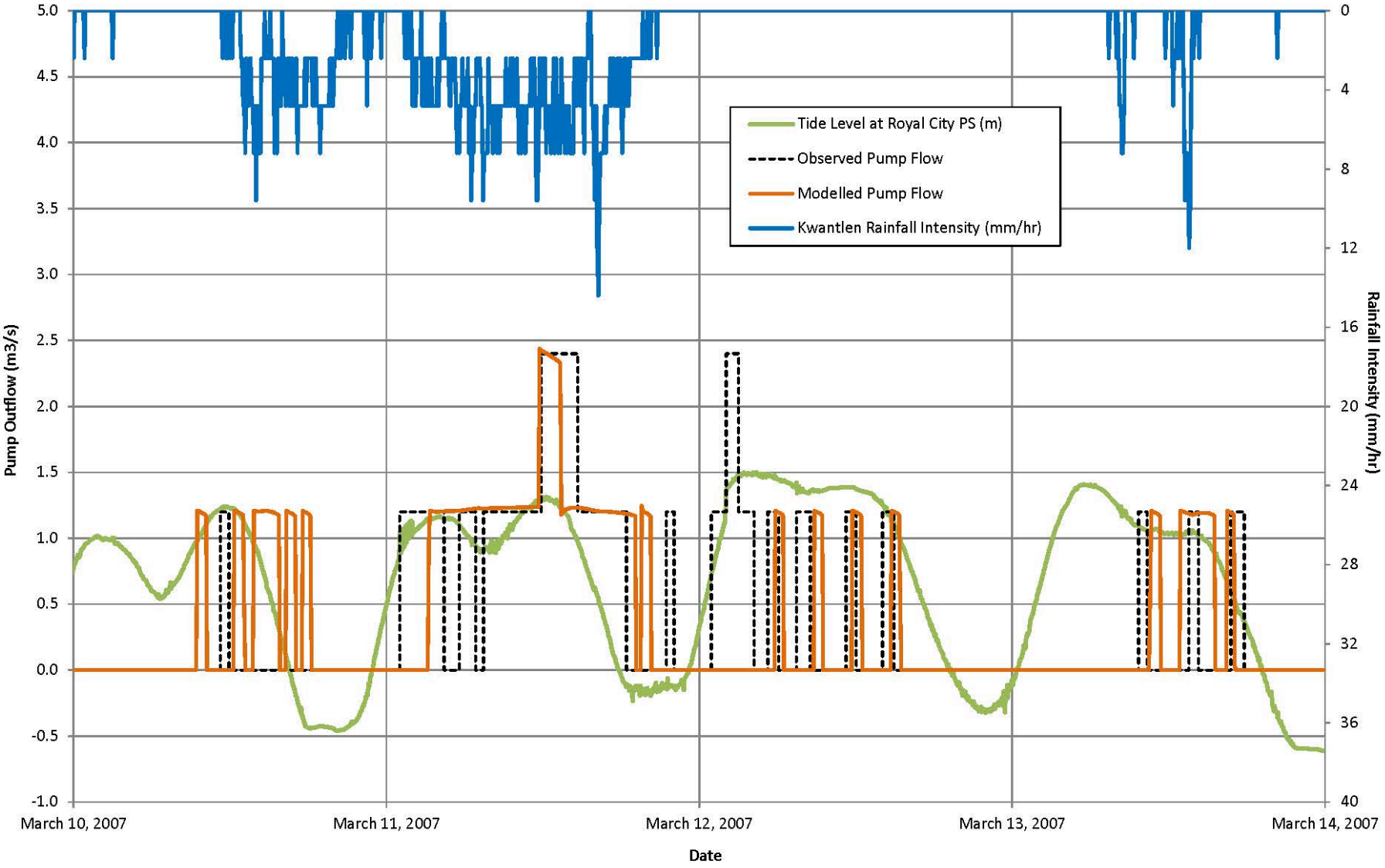


Figure 9.8 Model Results For Royal City Pump Station and Floodboxes

(Note: PCSWMM model calibration to Royal City Pump Station discharge outflows corresponding to historical level data provided by the City of Surrey, Dec.2012)

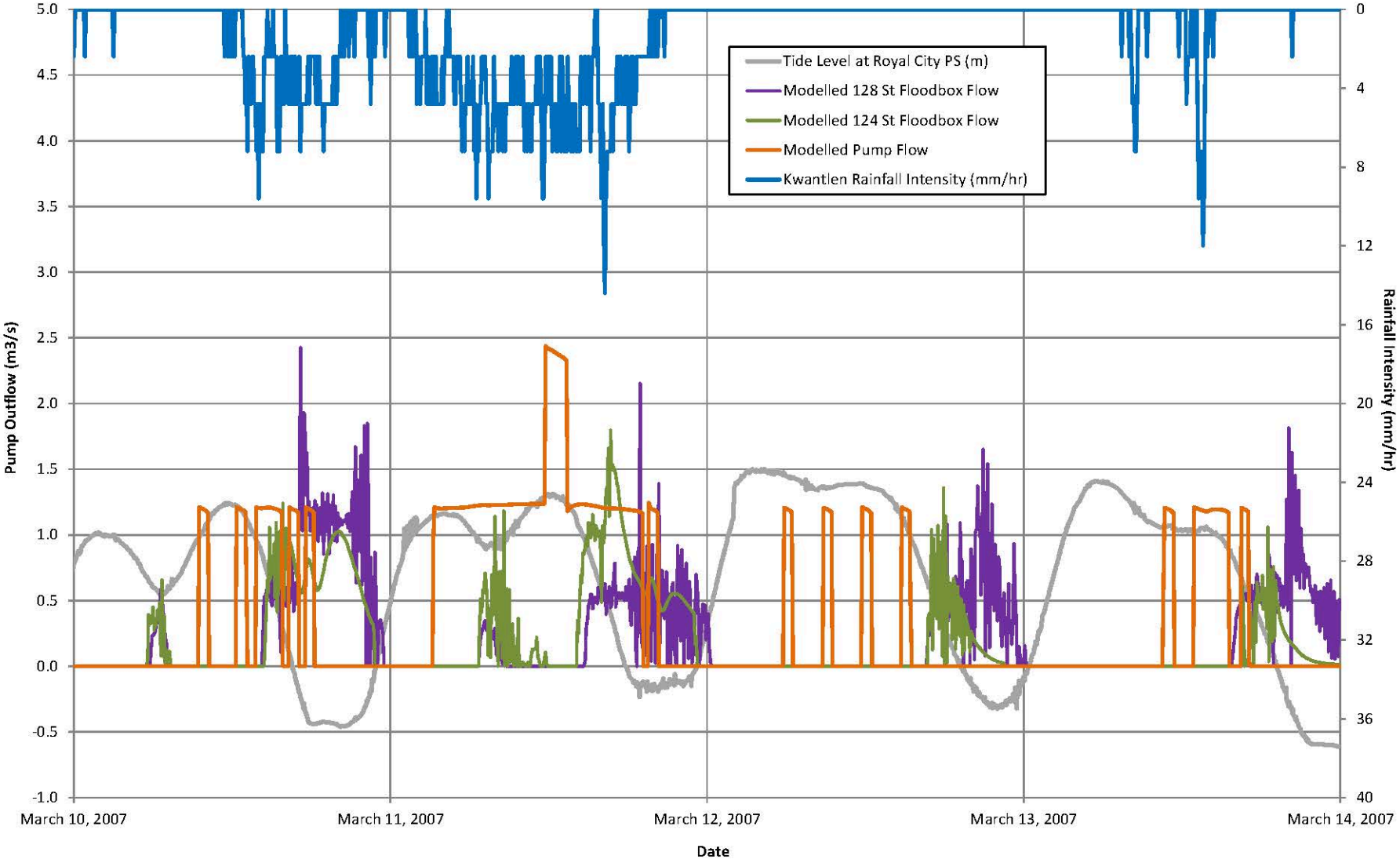
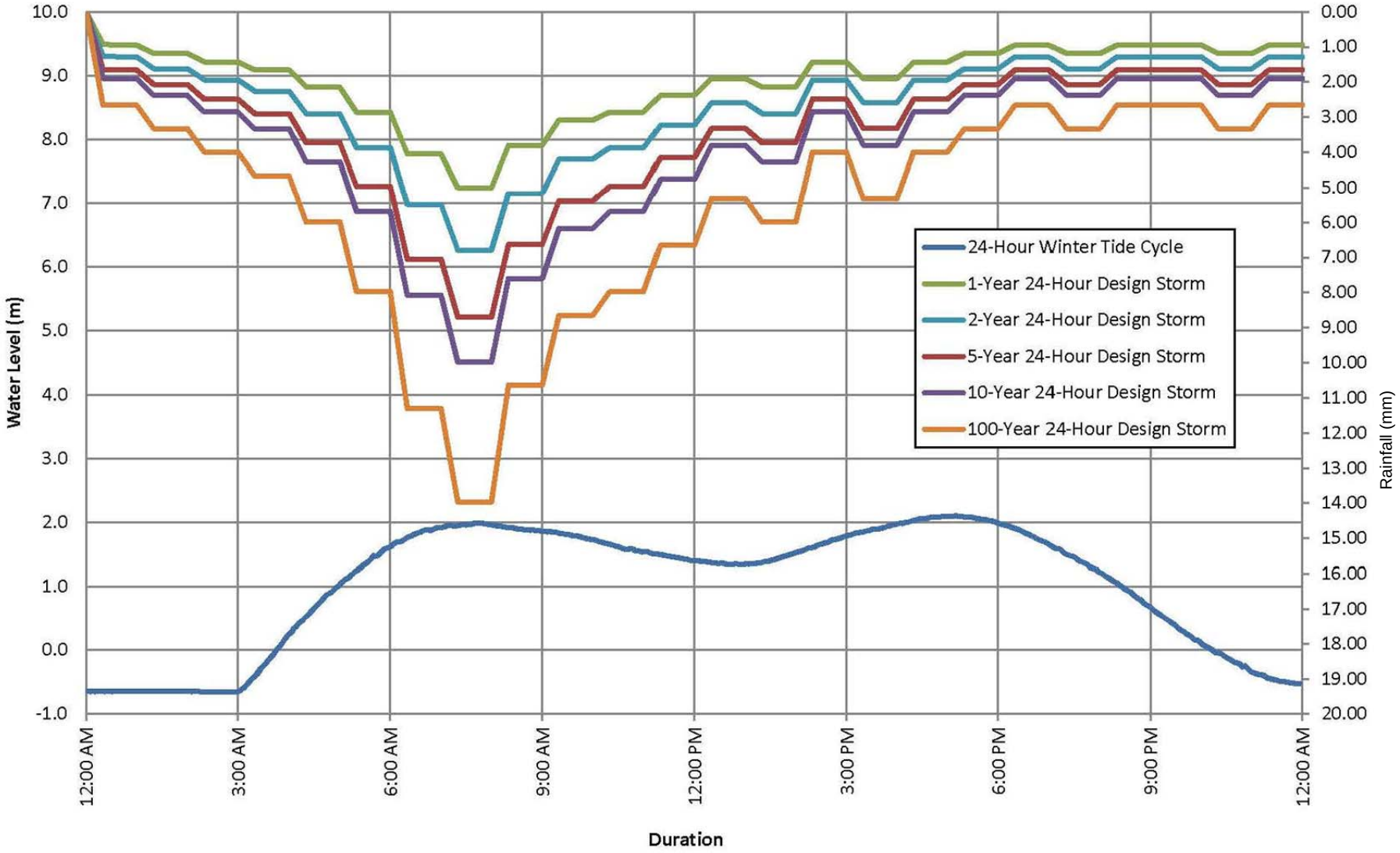


Figure 10.1 Winter Design Conditions



Fraser River

CN Railway

Royal City Pump Station Outlet

128 St. Flood Box

124 St. Flood Box

PS

Bolivar Creek Outfall

Southward Creek Outfall

Dingwall Creek Outfall

Alexandra Creek Outfall

Wellington Creek Outfall

116 Ave

114 Ave

113 Ave

112 Ave

108 Ave

104 Ave

102A Ave

112A Ave

114A Ave

Industrial Road

124 Street

125A Street

126A Street

128 Street

130 Street

132 Street

136 Street

140 Street

Bridgeview Drive

King George Blvd

Grosvenor Road

McBride Drive

Bedford Drive

University Drive

King George Blvd

Bridgeview-North Slope ISMP

Legend

Manhole or Node

- HGL < Ground Surface
- HGL > Ground Surface

Pipe or Open Channel

- Qmax/Qcap < 1
- Qmax/Qcap > 1
- Outfall
- PS Royal City PS
- Study Area
- CN Railway
- Existing Dyke
- Subcatchment
- Waterbody

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300 150 0 300 Meters

Project No.	Date
60270841	October 2013

Scenario 1:
Winter Condition
5-Year 24-Hour

Figure 10.2

Fraser River

CN Railway

Royal City Pump Station Outlet

128 St. Flood Box

124 St. Flood Box

PS

Bolivar Creek Outfall

Southward Creek Outfall

Dingwall Creek Outfall

Alexandra Creek Outfall

Wellington Creek Outfall

116 Ave

114 Ave

112 Ave

112A Ave

113 Ave

108 Ave

104 Ave

102A Ave

124 Street

125A Street

126A Street

128 Street

130 Street

132 Street

136 Street

140 Street

Industrial Road

Bridgeview Drive

King George Blvd

Grosvenor Road

McBride Drive

Bedford Drive

114A Ave

University Drive

King George Blvd

Bridgeview-North Slope ISMP

Legend

Manhole or Node

- HGL < Ground Surface
- HGL > Ground Surface

Pipe or Open Channel

- Qmax/Qcap < 1
- Qmax/Qcap > 1
- Outfall
- PS Royal City PS
- Study Area
- CN Railway
- Existing Dyke
- Subcatchment
- Waterbody

300 150 0 300 Meters

Project No.	Date
60270841	October 2013

Scenario 2:
Winter Condition
10-Year 24-Hour

Figure 10.3

CITY OF SURREY
the future lives here.

Bridgeview-North Slope ISMP

Legend

Manhole or Node

- HGL < Ground Surface
- HGL > Ground Surface

Pipe or Open Channel

- Qmax/Qcap < 1
- Qmax/Qcap > 1
- Outfall
- Royal City PS
- Study Area
- CN Railway
- Existing Dyke
- Subcatchment
- Waterbody

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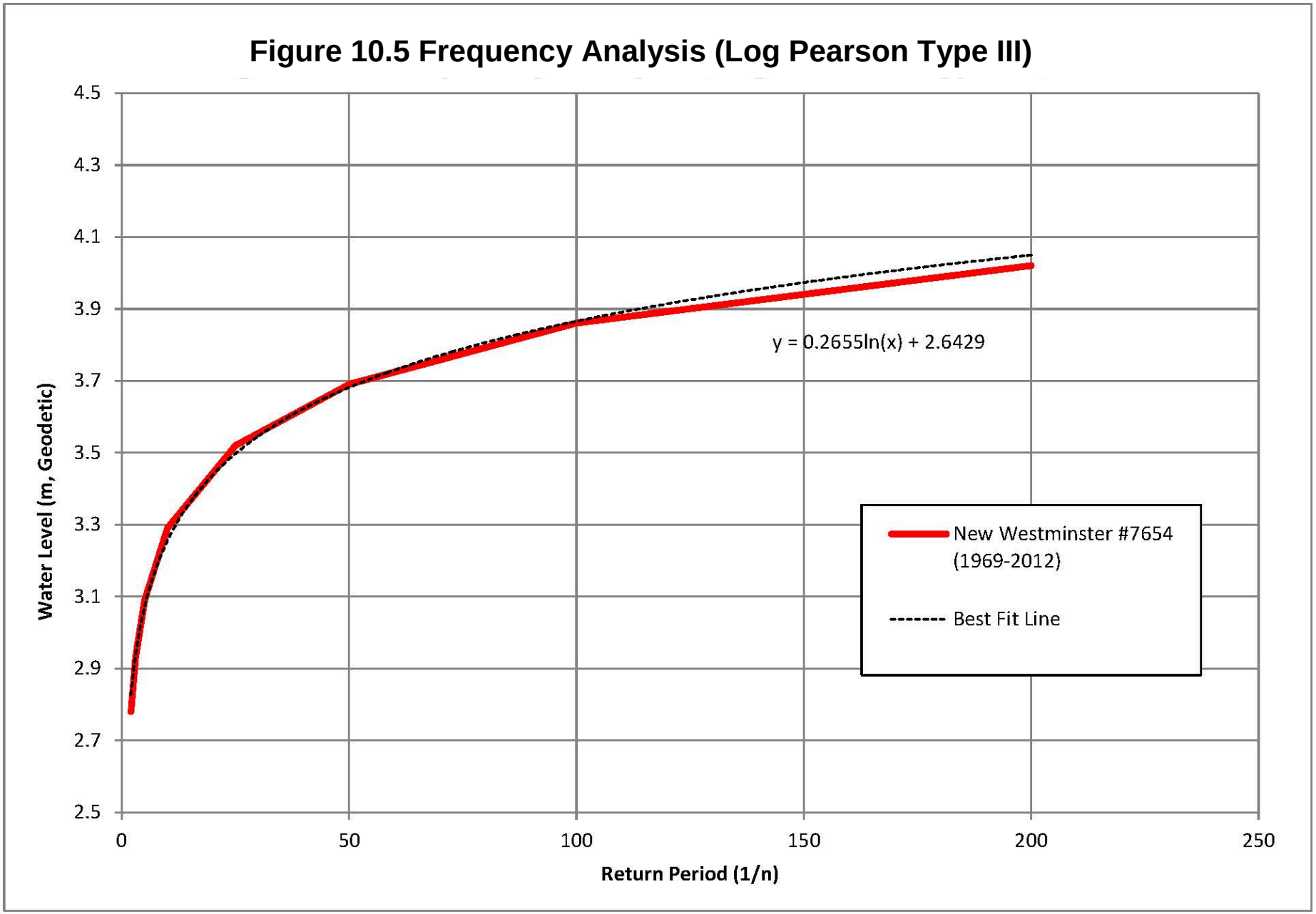
300 150 0 300 Meters

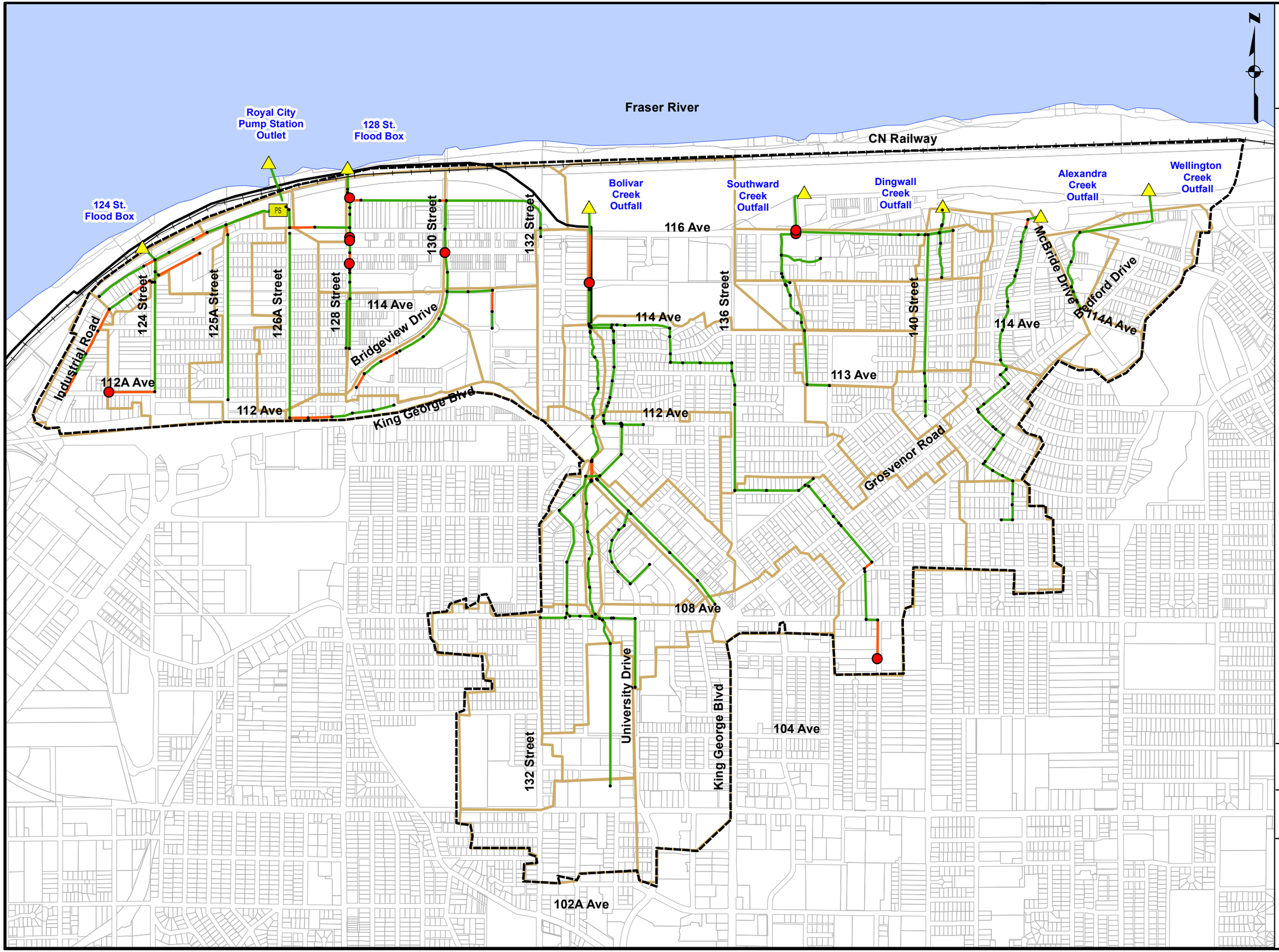
Project No.	Date
60270841	October 2013

Scenario 3:
Winter Condition
100-Year 24-Hour

Figure 10.4

Figure 10.5 Frequency Analysis (Log Pearson Type III)





CITY OF SURREY
the future lives here.

Bridgeview-North Slope ISMP

Legend

Manhole or Node

- HGL < Ground Surface
- HGL > Ground Surface

Pipe or Open Channel

- Qmax/Qcap < 1
- Qmax/Qcap > 1
- Outfall
- Royal City PS
- Study Area
- CN Railway
- Existing Dyke
- Subcatchment
- Waterbody

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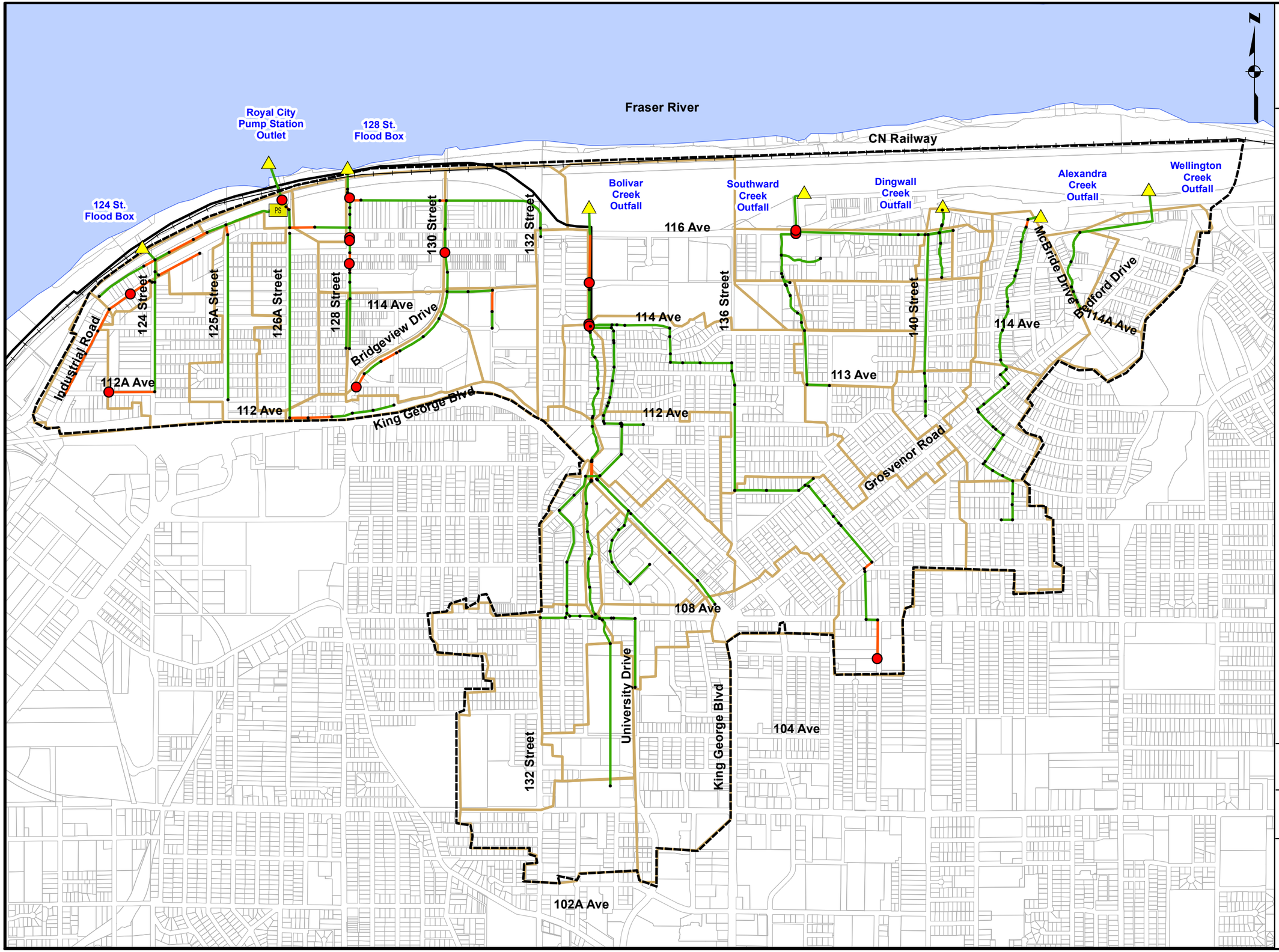
300 150 0 300 Meters

Project No.	Date
60270841	October 2013

Scenario 4:
Summer Condition
1-Yr Rain + 100-Yr Tide
Figure 10.6



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the future lives here.

Bridgeview-North Slope ISMP

Legend

Manhole or Node

- HGL < Ground Surface
- HGL > Ground Surface

Pipe or Open Channel

- Qmax/Qcap < 1
- Qmax/Qcap > 1
- Outfall
- PS Royal City PS
- Study Area
- CN Railway
- Existing Dyke
- Subcatchment
- Waterbody

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300 150 0 300 Meters

Project No.	Date
60270841	October 2013

Scenario 5:
Summer Condition
2-Yr Rain + 50-Yr Tide
Figure 10.7

Fraser River

CN Railway

Royal City Pump Station Outlet

128 St. Flood Box

124 St. Flood Box

Bolivar Creek Outfall

Southward Creek Outfall

Dingwall Creek Outfall

Alexandra Creek Outfall

Wellington Creek Outfall

PS

Industrial Road

124 Street

125A Street

126A Street

128 Street

130 Street

132 Street

136 Street

140 Street

McBride Drive

Bedford Drive

Bridgeview Drive

King George Blvd

Grosvenor Road

University Drive

116 Ave

114 Ave

113 Ave

112 Ave

112A Ave

114A Ave

108 Ave

104 Ave

102A Ave

Bridgeview-North Slope ISMP

Legend

Manhole or Node

- HGL < Ground Surface
- HGL > Ground Surface

Pipe or Open Channel

- Qmax/Qcap < 1
- Qmax/Qcap > 1
- Outfall
- Royal City PS
- Study Area
- CN Railway
- Existing Dyke
- Subcatchment
- Waterbody

300 150 0 300 Meters

Project No.	Date
60270841	October 2013

Scenario 6:
Summer Condition
5-Yr Rain + 20-Yr Tide

Figure 10.8

CITY OF SURREY
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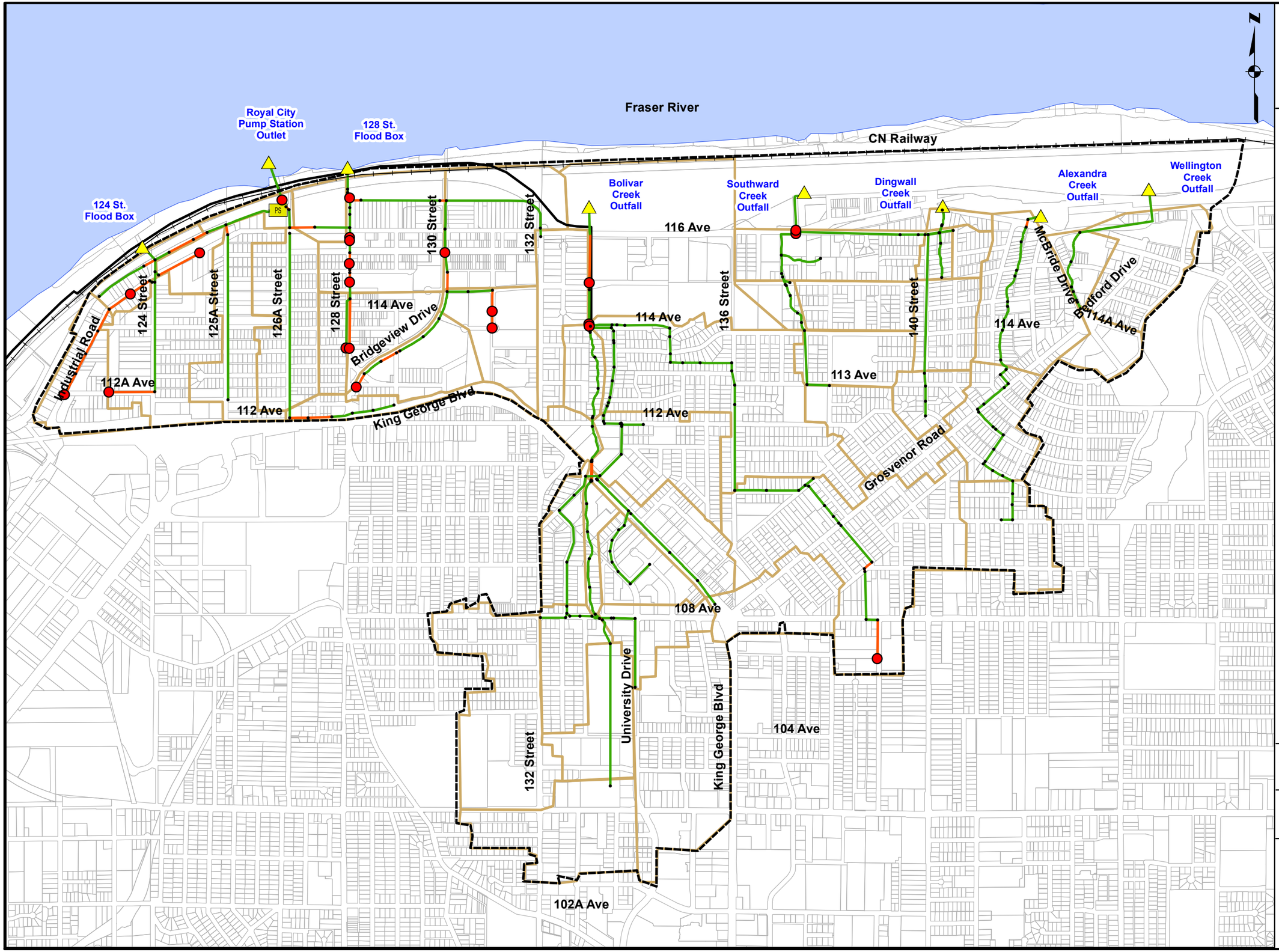
Bridgeview-North Slope ISMP



Legend

Manhole or Node

- HGL < Ground Surface
- HGL > Ground Surface

Pipe or Open Channel

- Qmax/Qcap < 1
- Qmax/Qcap > 1
- Outfall
- PS Royal City PS
- Study Area
- CN Railway
- Existing Dyke
- Subcatchment
- Waterbody

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300 150 0 300 Meters

Project No.	Date
60270841	October 2013

Scenario 7:
Summer Condition
10-Yr Rain + 10-Yr Tide

Figure 10.9

Fraser River

CN Railway

Royal City Pump Station Outlet

128 St. Flood Box

124 St. Flood Box

PS

Bolivar Creek Outfall

Southward Creek Outfall

Dingwall Creek Outfall

Alexandra Creek Outfall

Wellington Creek Outfall

116 Ave

114 Ave

112 Ave

112A Ave

108 Ave

104 Ave

102A Ave

113 Ave

Industrial Road

124 Street

125A Street

126A Street

128 Street

130 Street

132 Street

136 Street

140 Street

Bridgeview Drive

King George Blvd

Grosvenor Road

McBride Drive

Bedford Drive

114A Ave

University Drive

King George Blvd

132 Street

N

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Bridgeview-North Slope ISMP

Legend

Manhole or Node

- HGL < Ground Surface
- HGL > Ground Surface

Pipe or Open Channel

- Qmax/Qcap < 1
- Qmax/Qcap > 1
- Outfall
- Royal City PS
- Study Area
- CN Railway
- Existing Dyke
- Subcatchment
- Waterbody

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Project No.	Date
60270841	October 2013

Scenario 8:
Summer Condition
100-Yr Rain + 1-Yr Tide

Figure 10.10

Surrey is the 2nd largest city in BC and the 12th largest city in Canada with a population of over 468,000. And we're still growing. We're set to become the most populated city in Metro Vancouver by 2020, as people from around the world continue to move to one of the youngest and most culturally diverse cities in Canada.

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