Latimer Creek Watershed Integrated Stormwater Management Plan

September 2015

ASSOCIATED ENGINEERING
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Executive Summary

1 INTEGRATED STORMWATER MANAGEMENT PLANNING

The fundamental purpose of an Integrated Stormwater Management Plan (ISMP) is to maintain and enhance the overall health of a watershed while allowing for future development. An ISMP is a comprehensive planning document that addresses a wide variety of components related to watershed health while considering economic growth. The ISMP process encompasses stormwater management under existing development conditions; consideration of future development and climate change, as well as the potential hydrologic and hydraulic impacts; terrestrial and aquatic environmental assessments; public consultation; stakeholder engagement; overall watershed health assessment; development of an implementation plan, including funding strategies and enforcement strategies; as well as monitoring and assessment strategies.

2 STUDY AREA DESCRIPTION

The Latimer Creek study area extends across the municipal boundary between the City of Surrey and the Township of Langley. The municipal divide is located along 196 Street. Within the City's portion of the project area, the objectives of the current study are typical of a comprehensive ISMP. Within the Township of Langley, stormwater management planning has already been completed through the various Neighbourhood Community Plans that are being conducted under the Willoughby Community Plan. We understand that stormwater management planning within the Township has generally progressed in accordance with the recommendations from the 2003 Latimer Creek Master Drainage Plan. As a result, there is no requirement for this ISMP to evaluate the hydrologic and hydraulic conditions within the Township under existing or future conditions. Rather, the focus of this ISMP within the Township of Langley is on the environmental components, with a particular emphasis on the terrestrial and aquatic assessments.

Township of Langley

Within the Township, the southern limit of the watershed extends to 73A Avenue. The eastern limit of the study area is bounded approximately by 204 Street, while the northern limit of the study area within the Township extends to just north of the 200 Street and Highway 1 Interchange. In general, the portion of the watershed within the Township is a gently sloped upland area with elevations between 100 m and 15 m, which drains in a northwest direction. This area is dominated by Residential land use, with some Commercial areas and pockets of Institutional.

City of Surrey

Within the City, the upland portions of the study area extend a short distance north of Highway 1, with the western limit of the study area generally following the alignment of Harvie Road. The southern limit of the study area within the City is bounded by the main channel of Latimer Creek. Within the City's portion of the study area, the land is predominately developed as One Acre Residential, with portions of the study area zoned as General Agricultural. This portion of the study area transitions from gently sloped upland areas with elevations between 35 m and 5 m, into lowland areas at the upstream end of the City's Serpentine River system. The City's dyking system extends only a short distance into the current study area – there is approximately 200 m of dyke along the main channel of Latimer Creek immediately upstream of Harvie Road near the limit of the study area.

The surface soils and surficial sediments within the City's portion of the study area are variable in their capacity to support infiltration-based facilities. On the west side of Harvie Road, north of 88 Avenue, the ground conditions show moderate infiltration potential. The remainder of the study area (within the City of Surrey) exhibits low potential for infiltration, with some areas demonstrating no potential for infiltration due to artesian conditions.

3 WATERSHED GOALS AND OBJECTIVES

The overall goals identified by the City of Surrey and the Township of Langley for the study area are to:

- Protect and enhance the overall health and natural resources of the study area;
- Promote participation from all stakeholders to achieve a common future vision of the watershed;
- Minimize risk to life and property associated with flooding, and provide strategies to attenuate peak flows;
- Protect and enhance watercourses and aquatic life;
- Prevent pollution and maintain/improve water quality;
- Prepare an inventory of watercourses and wildlife for the watershed study area;
- Protect the terrestrial environment, wildlife, and habitat corridors;
- Identify areas of existing and future industrial, residential, commercial, agricultural, and recreational land uses;
- Assess the potential impact of climate change on the ISMP area;
- Develop a cost effective and enforceable implementation plan; and
- Establish a monitoring and assessment strategy to ensure goals are achieved, maintained, and enforced.

In consideration of these goals, the vision statement developed for the Latimer Creek ISMP is presented as follows:

The vision for the Latimer Creek ISMP is to hold paramount public safety and the protection of the environment while accommodating community growth, in a way that enhances watershed health and aesthetics, and promotes the existing strategies aimed at conserving biodiversity. This ISMP will present a strategy for implementing stormwater best management practices and environmental enhancement opportunities that can balance the City's and Township's long-term environmental and economic goals.

4 IMPLEMENTATION, FUNDING, AND ENFORCEMENT

Location Specific Terrestrial Enhancement Opportunities

In addition to documenting the existing terrestrial network throughout the Latimer Creek watershed, we also identified a number of potential enhancement opportunities. The intent is to maintain habitat connectivity within the watershed (across municipal boundaries), and to identify areas not yet recognized for environmental protection.

Within the City of Surrey, we identified these enhancement opportunities as potential hubs, sites, or corridors, consistent with the City's GIN. Within the Township of Langley, we identified enhancement opportunities as potential conservation areas, consistent with the approach taken in the various neighbourhood plans. The potential terrestrial enhancement opportunities are identified on Map 4-2, and presented below in Table ES-1.

Table ES-1
Potential Terrestrial Enhancement Opportunities

Site Label	Municipality	Habitat Description	Ecological Value	Connectivity	Disturbance	Proposed Green Infrastructure
A	Surrey	Mature mixed wood forest dominated by conifers. Provides high valued habitat to passerines, small mammals including the Trowbridge shrew (*Sorex trowbridgii*) for forage, shelter, and breeding opportunities and connects to the Latimer Creek Conservation Area.	High	Medium	Medium	Hub
D*	Surrey	This area is a combination of an upland forest and a larger low lying wetland that is connected to Port Kells Park and Latimer Creek. Part of this area is an existing Hub while the other portion is a proposed Hub. This area would provide a diverse amount of habitat and movement opportunities to a range of species including amphibians, such as the red-legged frog, what has been recorded in the area, passerines, and small mammals including the Pacific water shrew, muskrats, beavers, passerines, and raptors including the barn owl or the red	High	High	Low	Site

Site Label	Municipality	Habitat Description	Ecological Value	Connectivity	Disturbance	Proposed Green Infrastructure
		tailed hawk (*Buteo jamaicensis*) for forage, shelter, and breeding and hunting opportunities. This area may also provide overwinter habitat for amphibians.				
E	Langley	This area is mainly comprised of a mature deciduous forest providing a large amount of habitat for small mammals, raptors, and passerines such as the American robin or dark-eyed junco. This area is directly adjacent to a commercial space along the west but is otherwise surrounded by a suburban residential development that is connected to the Yorkson conservation area.	Medium	High	Medium	Conservation Area
Corridor 1	Surrey	Riparian habitat and creek (Bartesko Brook) providing high valued habitat to amphibians, such as the red-legged frog, fish, passerines, and small mammals. Local and regional connections from the existing Green Infrastructure Network from the City of Surrey and provides a connection for southward movement into the Township of Langley through the proposed network.	High	High	Medium	Corridor
Corridor 3	Surrey and Langley	Latimer Creek and tributary are a riparian forested area that extends north to south and east to west. This area not only provides a diverse structure of habitat for amphibians, such as the red-legged frog, passerines, and small mammals including the Pacific water shrew, muskrats, and passerines, for forage, shelter (summer and winter), and breeding and hunting opportunities, but also provides a movement corridor locally and regionally between watersheds (i.e. Upper Serpentine and Clayton watersheds).	High	High	Medium	Conservation Area

*Note – Proposed Site D is already identified as a proposed site within the City's BCS.

Stream Classification

During our aquatic assessment, we identified a discrepancy in the watercourse classification mapping near the municipal boundary. The watercourse in question is the Unnamed Tributary 1, west of 196 Street to its confluence with Latimer Creek (approximately 75 m in length). The City's watercourse mapping identifies this portion as Class B. However, east of 196 Street (upstream), this creek is designated as a Class A watercourse within the Township's mapping. We recommend that this portion of creek by designated as a Class A watercourse within the City of Surrey's watercourse classification mapping.

Location Specific Drainage and Environmental Improvement Projects

Based on the constraints identified during our aquatic assessment, as well as the identified drainage infrastructure deficiencies and storage requirements, Table ES-2 outlines the proposed drainage and environmental upgrades within the study area. The proposed culvert upgrades take into account the potential benefits that would be provided by the recommended storage ponds. These location specific improvements are shown on Map 4-4.

Table ES-2
Recommended Drainage and Environmental Improvements

ID / Municipality	Location	Item	Reason for Upgrade	Description	Cost
1 – Surrey	Old Sawmill Creek at 86 Ave	Culvert (31)	Undersized for 100-year flow; overtops road.	Replace 1120 mm x 1630 mm CSP Arch with 1520 mm x 2060 mm CSP Arch	$100,000
2 – Surrey	86 Ave east of188 St	Culvert (51)	Undersized for 100-year flow; overtops road.	Replace 450 mm Wood Stave with 800 mm CSP.	$100,000
3 – Surrey	Harvie Rd south of 90 Ave	Culvert (61)	Undersized for 100-year flow; floods adjacent property.	Replace 750 mm Conc with 1350 mm Conc	$100,000
4 – Surrey	Old Sawmill Creek at 90 Ave	Culvert (33)	Existing culvert in poor condition; invert corroded through.	Replace 750 mm CSP with new 800 mm CSP	$100,000
5 – Surrey	West of Harvie Rd, north of 90 Ave	Pond	Control peak flows.	10,600 m^3 storage pond.	$8,276,000[1]
6 – Surrey	East of 192 St, north of 90 Ave	Pond	Control peak flows.	3,800 m^3 storage pond.	$2,964,000[2]
7 – Surrey	West of 196 St, north of 88 Ave	Pond	Control peak flows.	2,200 m^3 storage pond.	$1,716,000[2]

ID / Municipality	Location	Item	Reason for Upgrade	Description	Cost
8 – Langley	Latimer Creek at 200 St	Culvert	Barrier to upstream fish passage.	Replace hanging culvert with fish passable culvert.	$175,000[3]
9 – Langley	Latimer Creek north of 80 Ave	Channel	0.4 m falls are an obstacle to fish passage.	Modify channel to establish step-pool feature.	$25,000
10 – Langley	Latimer Creek between 200 St and 80 Ave	Debris	Obstruction to fish passage.	Remove debris.	$10,000
11 – Surrey/Langley	Latimer Creek at 196 St	Culvert	Barrier to upstream fish migration.	Replace hanging culvert with fish passable culvert.	$100,000
12 – Surrey	Bartesko Brook, east of 192 St	Channel	0.4 m falls are an obstacle to fish passage.	Modify channel to establish step-pool feature.	$25,000
13 – Surrey	Bartesko Brook, east of 192 St	Debris	Obstruction to fish passage.	Remove debris.	$10,000
14 – Surrey	Old Sawmill Creek at 88 Ave	Debris	Obstruction to fish passage.	Remove debris.	$10,000
15 – Langley	Unnamed Tributary 1, north of 86 Ave	Culvert	Barrier to upstream fish migration.	Replace hanging culvert with fish passable culvert.	$60,000[4]
16 – Langley	Unnamed Tributary 1, south of 86 Ave	Debris	Obstruction to fish passage.	Remove debris.	$15,000
17 – Surrey	Unnamed Tributary 2 at 78 Ave	Culvert	Barrier to upstream fish migration.	Replace hanging culvert with fish passable culvert.	$100,000
18 – Surrey	Bartesko Brook at 192 St.	Culvert (41)	Undersized for 100-year flow with climate change.	Replace 600 mm CSP with 1000 mm CSP	$80,000

Notes:
1. Cost taken directly from City of Surrey Ten Year Servicing Plan.
2. Pond cost estimated at $780/m^3, based on reported cost of pond within Anniedale-Tynehead NCP, and the previously reported volume requirement ($3,279,000 / 4200 m^3).
3. The higher cost at this location is due to the crossing be located under 200th Street. Installation would require trenchless methods and/or significant Traffic Management with an open excavation method.
4. The lower cost at this location is due to the crossing being located under a driveway rather than a public road.
5. Culverts within the Township of Langley are to be Concrete or HDPE.
6. CSP culverts within the City of Surrey are to have an Aluminized Type 2 coating.

Source Control Implementation

In order to mitigate the negative hydrologic and hydraulic impacts of development within the study area, source controls should be implemented within the watershed. The focus of these measures is on stormwater management. Within the Township of Langley, stormwater management planning has already been completed through various Neighbourhood Plans; as such, the recommended source controls are geared towards the City's portion of the study area. Table ES-3 presents the recommended BMPs for the specific land uses that coincide with the anticipated future development within the City's portion of the study area.

Table ES-3
Applicable Source Controls by Land Use

Land Use	Applicable Source Controls
One Acre Residential & Urban Residential	• Absorbent soils to capture and attenuate runoff; absorbent soil depth to be 450 mm. • Disconnection of roof leaders from the storm drains (for older houses being redeveloped). • Pervious pavements used for walkways, driveways and patios.
Business Centre (Commercial Development)	• Absorbent soils to capture and attenuate runoff; absorbent soil depth to be 450 mm. • Pervious pavements for walkways, parking areas and storage pads. • Bioswales, rather than below-grade piped systems to drain parking lots. • Rain gardens to collect, treat, and attenuate runoff from parking lots and/or rooftops. • Green roofs to attenuate runoff. • Structural treatment devices to improve water quality before discharging flows from site.
Roadways	• Absorbent soils and landscaping trees to intercept, capture and attenuate runoff; absorbent soil depth to be 450 mm. • Pervious pavements for sidewalks and low-traffic parking areas. • Rain gardens to capture, treat and attenuate runoff. • Bioswales / enhanced ditches.

Funding Strategy

Successful implementation of the ISMP's recommendations will rely on the ability of the City and the Township to secure the necessary funding, and for private land owners, community groups, and environmental groups to become involved. As noted, the Township of Langley has completed a number of Neighbourhood Plans. As part of these existing Neighbourhood Plans, financial strategies have already been developed within the Township. As such, the funding strategy for the Latimer Creek ISMP focuses on the portion of the study area located within the City of Surrey. Table ES-4 lists options to cover the financial aspects of the ISMP recommendations.

Table ES-4
Funding Strategy Summary

Funding Recommendations	
1.	Incorporate source controls and stormwater Best-Management Practices in all municipal road projects to maximize cost-effectiveness.
2.	Revise the Drainage Parcel Tax fee structure to reflect the relative impact of developments, including parcel area and impervious coverage.
3.	Encourage land owners and private developers who undertake source controls in support of watershed health through recognition and incentive programs, specifically: • DCC 'Front Ender' as a financing mechanism to fund construction of LIDs and BMPs. • Potential Drainage Parcel Tax reduction based on reduction in burden on the drainage system through proper rainwater management. (Economic feasibility would need to be confirmed). • A Stormwater Management Rebate Program offering one-time rebates through the City of Surrey Planning and Development Department. • Salmon Marshall Certification Program (existing program).
5.	Incorporate source controls and stormwater Best-Management Practices in major infrastructure projects sponsored by the New Building Canada Plan.
6.	Encourage community and environmental groups to undertake identified environmental enhancement projects and facilitate application for funding by the EcoAction Community Funding Program.
7.	Apply for funding through the Green Municipal Fund for projects with a significant rainwater management component.
8.	Apply for funding through the Infrastructure Planning Grant Program for further studies recommended in this ISMP.

Enforcement Strategy

The City of Surrey's and Township of Langley's ability to enforce the recommendations of this ISMP is critical to the successful implementation of the plan.

The recommended regulatory changes identified as part of this ISMP are summarized in Table ES-5.

Table ES-5
Enforcement Strategy Summary

Regulatory Amendment Recommendations		
1.	Surrey	Update City of Surrey Engineering Design Criteria Manual: • Define design criteria to account for the impacts of climate change. • Include maximum acceptable runoff rates by land use. • Define source control design criteria.
2.	Langley	Update Township of Langley Subdivision and Development Servicing Bylaw – Schedule B Design Criteria – Section D Drainage: • Define design criteria to account for the impact of climate change. • Include maximum acceptable runoff rates by land use. • Define source control design criteria.
3.	Surrey	Amend City of Surrey Zoning Bylaw, 1993, No. 12000: • Refine special building setbacks to include watercourses, GIN hubs and corridors, wetlands, ponds, and areas of environmental significance. • Explicitly reference source control requirements for parking areas, One-Acre Residential and Light-Impact Industrial sections. • Revise minimum front yard setback for One-Acre Residential.
4.	Langley	Amend Township of Langley Zoning Bylaw 1987 No. 2500: • Revise Section 107 – 'Parking and Loading Requirements' to specifically mention permeable pavement. • Revise Section 111 – 'Landscaping, Screening, and Fencing' to specify a minimum 450 mm thick layer of absorbent landscaping. • Revise minimum front lot line setback in Section 400 – 'Residential.'
5.	Surrey	Amend the Drainage Parcel Tax Bylaw to reflect the fee structure discussed in the funding strategy. Rates would be assessed on a per-area basis, rather than a per-lot basis. The overall drainage parcel tax collected on a City-wide basis would not change with this re-structuring; rather, the rates for each parcel would be weighted based on hydrologic considerations.
6.	Surrey	Amend the Stormwater Drainage Regulation and Charges Bylaw: • Revise the requirements for stormwater management facilities to include redeveloped parcels. • Prescribe specific consequences for discharge of pollutants of concern to the stormwater drainage system, ditches, watercourses or other water bodies, and specifically reference ISMP stormwater quality and quantity targets. • Make reference to stormwater quality and quantity performance targets described within the City's ISMPs.

Regulatory Amendment Recommendations		
7.	Surrey	Expand Schedule B of the Erosion and Sediment Control Bylaw to include provisions for common components of source control stormwater best management facilities.
8.	Surrey	Develop specifications and standard drawings for this ISMP's recommended source control strategies for incorporation into the City's Supplementary Master Municipal Construction Documents.
9.	Surrey	Develop and pass a formal Riparian Areas Regulation Bylaw.
10.	Surrey	Develop and implement a City-wide Invasive Species Management Plan.
11.	Surrey	Require the following for residential development and building permit applications: • Landscaping plans showing tree and/or shrub plantings, and enhanced growing media • Site plans showing the locations and extents of pervious pavement.
12.	Surrey	Require the following for industrial / commercial development and building permit applications: • Landscaping and site plans showing the location and extent of source controls. • Summary of hydrologic calculations used to prove that source control measures meet the performance targets described in this ISMP. Summary of calculations and methodology used to design and locate any detention/retention storage facilities to meet the performance targets described in this ISMP.
13.	Langley	Revise Bylaw 4825 – 'Jericho Sub-Neighbourhood Plan' to: • Specifically reference the Township's Drainage Design Criteria, including the changes noted above in item 2. • Specify a minimum topsoil depth of 450 mm in Section 4.6 Landscape Components.
14.	Langley	Revise Bylaw 4995 – 'Carvolth Neighbourhood Plan' to include specific stormwater source control targets: • Design rainfall event for infiltration-based source controls. • Design rainfall event for water quality treatment features. • Target particle size for TSS removal. • Target removal efficiencies for water quality.

5 MONITORING AND ASSESSMENT

Performance indicators and targets are required to evaluate whether the goals and objectives of the ISMP are being achieved. The hydrometric monitoring, water quality monitoring, and benthic invertebrates monitoring components should generally adhere to Metro Vancouver's Monitoring and Adaptive Management Framework (AMF). We recommend monitoring additional metrics, subject to available resources. These metrics have the capability to improve proactive identification of potential problems across the watershed.

Primary performance metrics to be monitored are listed in Table ES-6.

Table ES-6
Recommended Performance Indicators

	Performance Indicator	Estimated Cost	Monitoring Program
Land Use Metrics			
Metric 1	**Percent Tree Cover**	$1,500 per investigation	Supplemental
Metric 2	**Percent Total Impervious Area**	$2,000 per investigation	Supplemental
Metric 3	**Percent Effective Impervious Area**	$5,000 - $7,500 per investigation (where flow monitoring data is available)	Supplemental
Metric 4	**Percent Riparian Forest Integrity**	$4,000 per investigation	Supplemental
Flow Regime Metrics			
Metric 5	**Number and Condition of Erosion Sites**	Part of overall Ravine Stability Assessment budget (Surrey – existing / Langley – recommended).	Ravine Stability Assessments
Metric 6	**Hydrometric Monitoring (Water Level and Flow)**	$30,000 for setup (per site) $5,000 annually for data collection (per site)	AMF
Environmental Metrics			
Metric 7	**Water Quality Monitoring**	$8,000 per site per sampling period	AMF
Metric 8	**Benthic Invertebrates (B-IBI)**	$3,500 per site	AMF
Metric 9	**Fisheries Habitat Assessment**	$8,000 per watercourse	Supplemental
Metric 10	**Spill Reporting**	$500 per incident Additional costs to analyze and remediate problem areas	Supplemental

The timing and triggers of each performance indicator vary, and for maximized value should be integrated into existing City of Surrey and Township of Langley programs where feasible.

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1 Introduction

1.1 PROJECT OVERVIEW

The City of Surrey and the Township of Langley engaged Associated Engineering to develop an Integrated Stormwater Management Plan (ISMP) for the Latimer Creek Watershed.

The Latimer Creek Watershed extends across the municipal boundary between the City of Surrey and the Township of Langley. Completed in 2003, the Latimer Creek Master Drainage Plan was the result of a joint initiative between the City and the Township, and provided a framework for both municipalities to accommodate future development while protecting the overall health of the watershed. Since that time, development has proceeded in both municipalities in accordance with the recommendations of the Master Drainage Plan.

More recently, the Township of Langley has completed a number of neighbourhood servicing plans for portions of the watershed contained within the Township. These servicing plans address stormwater management and land use issues. As a result, within the Township the scope of work under this current ISMP focuses on watershed health and environmental values.

Within the City of Surrey, the study area includes the main channel of Latimer Creek, as well as the contributing areas located north of Latimer Creek, extending approximately from Harvie Road to 196 Street. The scope of work within the City's portion of the study area includes a comprehensive assessment to cover all aspects of an Integrated Stormwater Management Plan. The study area is discussed in further detail in Section 2.

1.2 BACKGROUND INFORMATION

A significant amount of work has been completed within the Latimer Creek Watershed to assess various components of stormwater management within both the City of Surrey and the Township of Langley. As noted above, the scope of work under this current ISMP is focused, so as not to duplicate work that has been completed recently as part of these various studies. Key documents utilized in support of this ISMP are outlined in Table 1-1.

Table 1-1
Existing Documentation on the Study Area

Document Title	Author	Date
Latimer Creek Master Drainage Plan	Associated Engineering	May 2003
Plan Surrey 2013: Official Community Plan	City of Surrey	October, 2014
2012 – 2021 Ten-Year Servicing Plan	City of Surrey	January 2012
2014 – 2023 Ten-Year Servicing Plan (Draft)	City of Surrey	January 2014
Biodiversity Conservation Strategy	Diamond Head Consulting	January 2014

Document Title	Author	Date
City of Surrey Ecosystem Management Study	HB Lanarc / Raincoast	April 2011
Clayton ISMP	AECOM	July 2012
2002 City of Surrey Ravine Stability Assessment	Urban Systems	May 2003
2005 City of Surrey Ravine Stability Assessment	Associated Engineering	March 2006
2009 City of Surrey Ravine Stability Assessment	WEB Engineering, Ltd.	June 2009
2012 City of Surrey Benthic Invertebrate Sampling Program	Raincoast Applied Ecology	2012
2013 City of Surrey Benthic Invertebrate Sampling Program (Draft Results)	Raincoast Applied Ecology	October 2014
Bylaw 3800 – Willoughby Community Plan	Township of Langley	
Bylaw 3911 – South West Gordon Neighbourhood Plan	Township of Langley	
Bylaw 4013 – Routley Neighbourhood Plan	Township of Langley	
Bylaw 4030 – Yorkson Neighbourhood Plan	Township of Langley	
Bylaw 4825 – Jericho Sub-Neighbourhood Plan	Township of Langley	
Bylaw 4995 – Carvolth Neighbourhood Plan	Township of Langley	

1.3 PROJECT PARTICIPANTS

The study team is comprised of personnel from Associated Engineering and our Environmental Sciences division, Summit Environmental. Key team members involved in the development of this ISMP are:

- Jamie Fitzgerald — Project Manager
- Josh Thiessen — Technical Lead
- Jenna Lee — Water Resources Engineer
- Lyndsey Johnson — Aquatic Biologist
- Nicole Basaraba — Terrestrial Biologist
- Christopher Homes — Hydrogeologist
- Aaron Deane — GIS Specialist

The City of Surrey and Township of Langley also played a crucial role in the development of this ISMP. The key contributors from these municipalities include:

- Jeannie Lee — City of Surrey Project Manager
- Art Kastelein — Township of Langley Project Manager

2 Study Area Overview

2.1 PHYSIOGRAPHY

The Latimer Creek study area extends across the municipal boundary between the City of Surrey and the Township of Langley. The municipal divide is located along 196 Street.

Within the Township, the southern limit of the watershed extends to 73A Avenue. The eastern limit of the study area is bounded approximately by 204 Street, while the northern limit of the study area within the Township extends to just north of the 200 Street and Highway 1 Interchange.

Within the City, the upland portions of the study area extend a short distance north of Highway 1, with the western limit of the study area generally following the alignment of Harvie Road. The southern limit of the study area within the City is bounded by the main channel of Latimer Creek.

The study area is approximately 776 ha. We delineated the catchment area for the study based on the City of Surrey's and Township of Langley's GIS data. Map 2-1 provides a general overview of the study area for the Latimer Creek ISMP.

The main channel of Latimer Creek originates in the southern portion of the overall study area within the Township of Langley. It drains in a northwest direction, and crosses the municipal boundary near 84 Avenue.

The north arm of Latimer Creek originates just south of 86 Avenue within the Township of Langley. It drains north under Highway 1, then west under 200 Street, before turning south and draining back under Highway 1 and into the City of Surrey just north of 88 Avenue.

Bartesko Brook and Old Sawmill Creek both originate near the height of land along Highway 1 within the northern portion of the study area in the City of Surrey. Bartesko Brook drains into Old Sawmill Creek north of 88 Avenue. Old Sawmill Creek continues south, eventually discharging into the main channel of Latimer Creek north of 84 Avenue near 188 Street.

In general, the portion of the watershed within the Township is gently sloped upland area between elevation 100 m and elevation 15 m, which drains in a northwest direction. This area is dominated by Suburban Residential land use, with some Commercial areas and pockets of Institutional.

Within the City's portion of the study area, the land is predominately developed as One Acre Residential, with portions of the study area zoned as General Agricultural. This portion of the study area transitions from gently sloped upland areas between elevation 35 m and elevation 5 m, into lowland areas at the upstream end of the City's Serpentine River system. The City's dyking system extends only a short distance into the current study area – there is approximately 200 m of dyke along the main channel of Latimer Creek immediately upstream of Harvie Road near the limit of the study area.

2.2 CLIMATE

As with much of Metro Vancouver, the climate of the study area is relatively warm and averages approximately 1600 mm of rainfall per year. The largest annual rainfall events tend to occur between November and January as a result of cyclonic, frontal storms that often last as long as three days. During the summer, short-duration convective storms also contribute to the total annual rainfall. July and August tend to be the driest months, often presenting prolonged dry periods.

As indicated by the City of Surrey's Master Drainage Plan and Rainfall Boundaries (Engineering Design Criteria Manual), the nearest long-term climate station to the study area is Surrey Kwantlen Park.

The 1971 to 2000 climatic normal data (precipitation) for the Surrey Kwantlen Park Station is summarized in Table 2-1.

Table 2-1
Canadian Climate Normals Station Data, 1971 – 2000; Surrey Kwantlen Park

Surrey Kwantlen Park	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
Precipitation (mm)	202.2	158.5	146.3	116.4	92.3	73.6	52.9	50.7	71.7	152.5	239.9	228.9	**1585.9**
Rain (mm)	179.4	147.3	143.2	116.2	92.3	73.6	52.9	50.7	71.7	152.3	235.5	212.7	**1527.9**
Snow (mm) (Snow-water equivalent)	22.7	11.2	3.1	0.1	0	0	0	0	0	0.2	4.4	16.3	**58.1**

2.3 EXISTING DRAINAGE

As noted, the stormwater management component of this ISMP is limited to the area within the City of Surrey, located north of Latimer Creek. There are three major watercourses:

- North Latimer Creek
- Bartesko Brook
- Old Sawmill Creek

Drainage within this area is predominately conveyed by ditches and culverts into these three watercourses, which discharge into Latimer Creek. There are limited portions of enclosed drainage within the study area:

- 600 mm diameter concrete storm pipe along 88 Avenue near 196 Street
- 300 mm diameter concrete storm pipe along 88 Avenue between 192 Street and Harvie Road
- 250 mm diameter concrete storm pipe along 87A Avenue between 188 Street and 192 Street

Each of these storm drains provides local drainage for the road rights-of-way only.

2.4 CITY OF SURREY RAVINE ASSESSMENTS

On semi-regular intervals, the City of Surrey engages consultants to perform assessments of ravines in order to identify high-risk erosion sites, debris blockages and other problem areas. In general, these assessments provide important detail on key drainage features throughout the City.

As part of the background data provided by the City, we received the 2002, 2005 and 2009 City of Surrey Ravine Assessments. Based on our review of this data, no instability sites have been identified within the current study area.

2.5 HYDROGEOLOGICAL CONDITIONS

2.5.1 Surficial Geology

There are six main surficial geologic units (exposed or at depth) in the study area as shown in Table 2-2. Map 2-2 shows the distribution of surficial materials within the study area.

Table 2-2
Summary of Surficial Geology Units

Unit	Identifier	Age	Description
Modern Sediments		10,000 – present	Recent fluvial and colluvial deposits present in the draws along the streams
Salish Sediments	SAb	10,000 – present	Bog, swamp, and shallow lake deposits. Lowland peat up to 14 m thick, overlying Fraser River sediments. Salish Sediments include all post glacial terrestrial or marine sediments deposited when the sea was within 15 m of present sea level.
Capilano Sediments (post-glacial)	Cb	11,000 – 13,000	Raised beach medium sand to coarse sand 1 – 5 m thick containing fossil marine shell casts.
	Cd		Marine to glaciomarine stony to stone-less silt loam to clay loam with minor sand and silt, between 3 – 60+ m thick often containing marine shells.
	Ce		Marine silt loam to clay loam with minor sand, silt, and stony glaciomarine material, up to 60+m thick.
Vashon Drift (Fraser Glaciation)	Va	13,000 – 18,000	Lodgement till (with sandy loam matrix) and minor flow till containing lenses and interbeds of glaciolacustrine laminated stony silt

A geological type-section for surficial materials near the study area (Armstrong and Hicock 1976, Map 1484A, Section D-D') shows the Vashon Drift sediments lie conformably above Quadra Sand (18,000 - 26,000 years old) horizons. These Quadra Sand sediments comprise the lower, confined aquifers beneath the study area, and these sediments are not found at surface within the study area.

2.5.2 Surface Soils

There are 12 soil types classified as being a dominant or secondary soil material within the study area. Table 2-3 provides descriptions for the study area soil types, and Map 2-3 displays their spatial distribution across the study area.

Table 2-3
Summary of Surficial Soil Types

Soil Name	Symbol	Soil Material	Drainage	Classification
Annis	AN	15 to 40 cm of organic material over medium textured, mixed floodplain deposits	Poor to very poor; high groundwater table	*Rego Gleysol*
Bose	BO	30-160 cm of gravelly lag or glacial outwash deposits over moderately coarse textured glacial till and some moderately fine textured glaciomarine deposits	Well to moderately well; telluric seepage.	*Rego Humic Gleysol*
Cloverdale	CD	Moderately to fine-textured marine deposits	Poor; perched water table	*Humic Luvic Gleysol*
Gibson	GN	40 – 160 cm of partially decomposed organic material over floodplain deposits	Very poor; high groundwater table	*Terric Mesisol*
Glen Valley	GV	More than 160 cm of decomposed organic material, mainly reeds, sedges and grasses	Very poor; high groundwater table	*Typic Fibrisol*
Heron	HN	Coarse textured littoral deposits over moderately coarse textured glacial till or moderately fine textured glaciomarine deposits	Poor; perched water table	*Rego Humic Gleysol*

Soil Name	Symbol	Soil Material	Drainage	Classification
Judson	JN	40 to 160 cm of well-decomposed organic material underlain by moderately fine textured glaciomarine deposits	Very poor; perched water table	*Terric Humisol*
Lumbum	LM	More than 160 cm of partially decomposed organic material	Very poor; high groundwater table	*Typic Mesisol*
Milner	MR	Fine to moderately fine textured marine deposits	Moderately well	*Luvisolic Humo-Ferric Podzol*
Scat	SC	Moderately fine textured glaciomarine deposits	Poor; perched water table	*Ortho Humic Gleysol*
Ross	RS	Medium to moderately fine textured local stream deposits	Very poor; subject to flooding	*Rego Gleysol*
Sunshine	SS	Sandy Littoral and glacial outwash deposits	Well to moderately well	*Orthic Humo-Ferric Podzol*

Source: Luttmerding 1980a, b.

Many of the soils are classified as either Organic soils or Gleysols, indicating that they were developed under mostly saturated conditions. From the desktop review, those soils appear to be moderate to well drained (BO, MR and SS), indicating they may be potentially suitable for infiltration of stormwater. The soils rated as having poor to very poor drainage are unlikely to be suitable for traditional enhanced drainage methods.

2.5.3 Hydrogeology

The assessment of hydrogeological parameters within the study area relied heavily on data available on the B.C. Water Resources Atlas. Three aquifers are present underlying portions of the study area, as shown on Map 2-4, and as described in Table 2-4.

Table 2-4
Aquifers within the Study Area

Aquifer No.	0058	0059	0061
Aquifer Name	58 IIC (11)	59 IIC (11)	61 IIIC (11)
Aquifer materials	Sand and Gravel	Sand and Gravel	Sand and Gravel
Productivity	Moderate	Moderate	High
Vulnerability	Low	Low	Low

Aquifer No.	**0058**	**0059**	**0061**
Demand	Moderate	Moderate	Low
Aquifer Classification	IIC	IIC	IIIC

Source: B.C. Water Resources Atlas

There are 44 wells identified within the study area, but none of those wells is identified as a B.C. MoE observation well. None of the wells logs indicate that bedrock was encountered at depth.

One well (MoE Well Tag No. 47966) is identified as being a high producing well, rated for up to 250 US gallons per minute (USgpm). This is in contrast to the majority of the wells in the area, which tend to range from 4 to 30 USgpm in well logs where estimated well yield has been recorded.

Available water well records indicate that the wells are widely dispersed in the study area, and completed to two different categories of depth (<9 m and >60 m below ground surface, [mbgs]). Several of the wells are older, shallow wells (<9 mbgs) which target the overlying sediments on top of the low permeability silts and clays. These surface water wells tap into the surface water in the surficial sediments, which mounds above the till contact. As the study area is primarily serviced by the municipal water system, it is inferred that there were many of these shallow dug wells before the municipal water system was constructed. The other category of wells is drilled through this till, and encounters underlying sands and gravels. The top of the underlying aquifer is encountered at 64 to 104 mbgs, which correlate with the underlying Quadra Sands.

No specific infiltration rate or hydraulic conductivity values for the upper sediments in the study area were obtained from the literature review; although studies in nearby and similar surface sediments provide values from sites with similar soils (Table 2-5). Based on these published values, the estimated infiltration rate in the weathered surface soil subsoil likely ranges from approximately 0.2 to 2.5 mm/hour. The limited local data; however, suggests that the infiltration rates in clay could be at the lower end of this range.

Table 2-5
Summary of Local Soil Infiltration Rates

Location	**Soil Type**	**Estimated Infiltration Rate (mm/hr)**
From Kerr Wood Leidal (2006)		
East Clayton, east central Surrey	Till, Observed Values	0.9 (with interflow) 1.6 (without interflow)
	Clay, Observed Values	0.7
Range of Values in Cited Literature	Till	0.5 – 2.5
	Clay	0.2 – 2.5

2.5.4 Field Investigation

We completed a field investigation on November 2, 2014 to supplement the results of our desktop review. The hydrogeological field investigation was limited to the City of Surrey's portion of the study area. The results of this hydrogeological field investigation are outlined below.

2.5.4.1 Surficial Deposits

The field observations were consistent with the soil mapping, discussed earlier, and as presented in Map 2-2 and Map 2-3. The surficial soils observed were characterized by a surficial topsoil horizon, nominally 10-20 cm thick, overlying clays, silts and silty sands. The surficial soils were observed to drain freely in select locations, but extremely poorly in others, and ponded water was observed in many land parcels within the study area at the time of inspection. Flooded conditions were especially prevalent in areas toward the southwest of the study area, where the land is at a topographic low. This area is historically prone to seasonal flooding, and the watercourses in this area (near the limit of the study area) are controlled by a dyke network, which extends downstream from this point.

2.5.4.2 Hydrogeological Observations

During the site inspection, no areas of marked groundwater upwelling were noted. As the inspection took place within 72 hours of a heavy rainfall event, soils were predominantly saturated.

In the southern, lower elevation portions of the study area, the vegetation and saturated soils indicated a shallow groundwater table, ground saturation for long durations, and potential for artesian conditions where slopes were present. The soggy, organic-rich soils at surface and undercut clayey banks also suggest elevated water levels during the wetter months.

Moving northeast, the topographic relief remains relatively flat along North Latimer Creek and Bartesko Brook as they approach Highway 1. In the flatter areas as viewed from the highway, water was not observed to be ponded at the time of inspection, but from a review of historical air photos of the area, the fields adjacent to the highway do pond water on occasion.

Toward the northwest, the ground steepens appreciably past Harvie Road (along 189 Street), and the break in slope allows for groundwater seepages and springs. However, none were observed at the time of inspection.

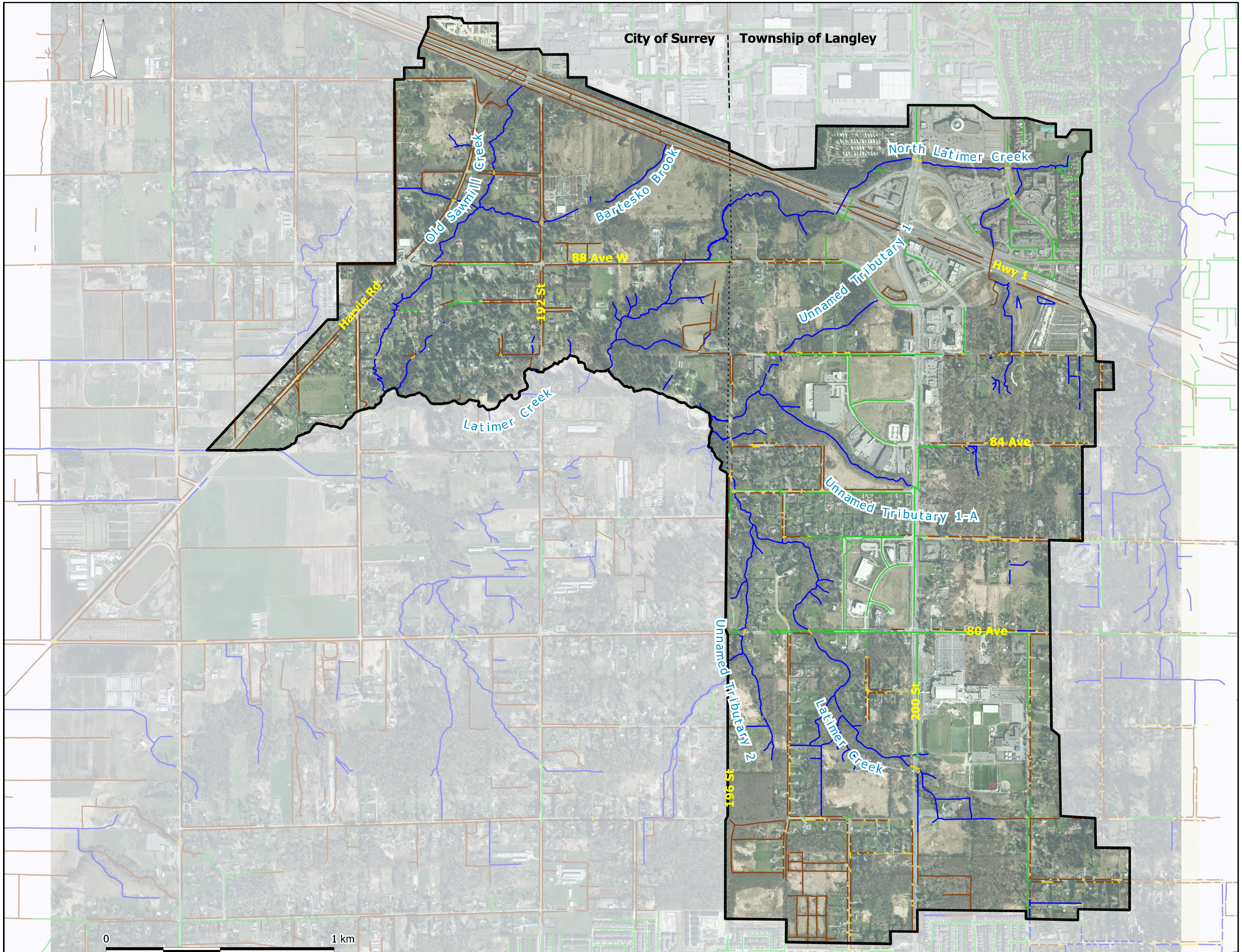
2.5.5 Implications for Stormwater Management

As noted, the overview hydrogeological assessment was limited to the City of Surrey's portion of the study area. The surface soils and surficial sediments in this portion of the study area appear to be variable in their capacity to drain. In some instances, this variability is a result of proximity to modern watercourses (modern fluvial sediments adjacent to Latimer Creek, Bartesko Brook and Old Sawmill Creek). In other cases, it is a result of topography, and those areas toward the southwest of the study area are often in a state of flood, as evidenced by sections of Latimer Creek being constrained by earthen dykes, and flood closure gates along Harvie Road.

In some of the more upland areas within the City's portion of the study area (toward the north, closer to the highway), there appear to be free-draining soils to at least a minimal depth (0.6 to 1.0 m below ground surface, at location 7). This was consistent with the surface soils map which indicates the presence of well to moderately well-drained Sunshine soils at this location. However, any enhanced stormwater infiltration applications would require detailed drainage information for the underlying soils, to at least 3 m. Site-specific investigations will be required to achieve this.

The sediments underlying most of these surface soils are predominately comprised of fine textured materials (silt and clay) to an appreciable depth (from the well logs, in places up to 75-100 m below ground). As such, any infiltration from the upper soils would be limited in duration, as the water would tend to mound above these low-permeability materials. Consequently, any site-specific investigation into the use of surface soils as an infiltrative medium should also map the depth to the clay contact, and where the stormwater moves after infiltration. If the surface soils were observed to thin in a downslope position, any infiltrated stormwater could "daylight". In addition, for residential homes located down-gradient from a potential infiltration facility, sub-basements and perimeter drains could be affected by heavy rains.

Map 2-5 indicates the areas within the City of Surrey's portion of the study area where there is potential for application of infiltration-based facilities, subject to site specific investigations.



LEGEND

- CULVERT
- STORM MAIN
- WATERCOURSE
- DITCH
- STUDY AREA
- STUDY AREA DIVISION

SCALE:	1:16,000		
PROJECT NO.	2014-2768	INITIAL	DATE
DRAWN		JT	15-09-04
DESIGNED			
CHECKED			
APPROVED			
PROJECTION:	UTM ZONE 10N NAD 83		

Associated Engineering GLOBAL PERSPECTIVE. LOCAL FOCUS.

CITY OF SURREY the future lives here.

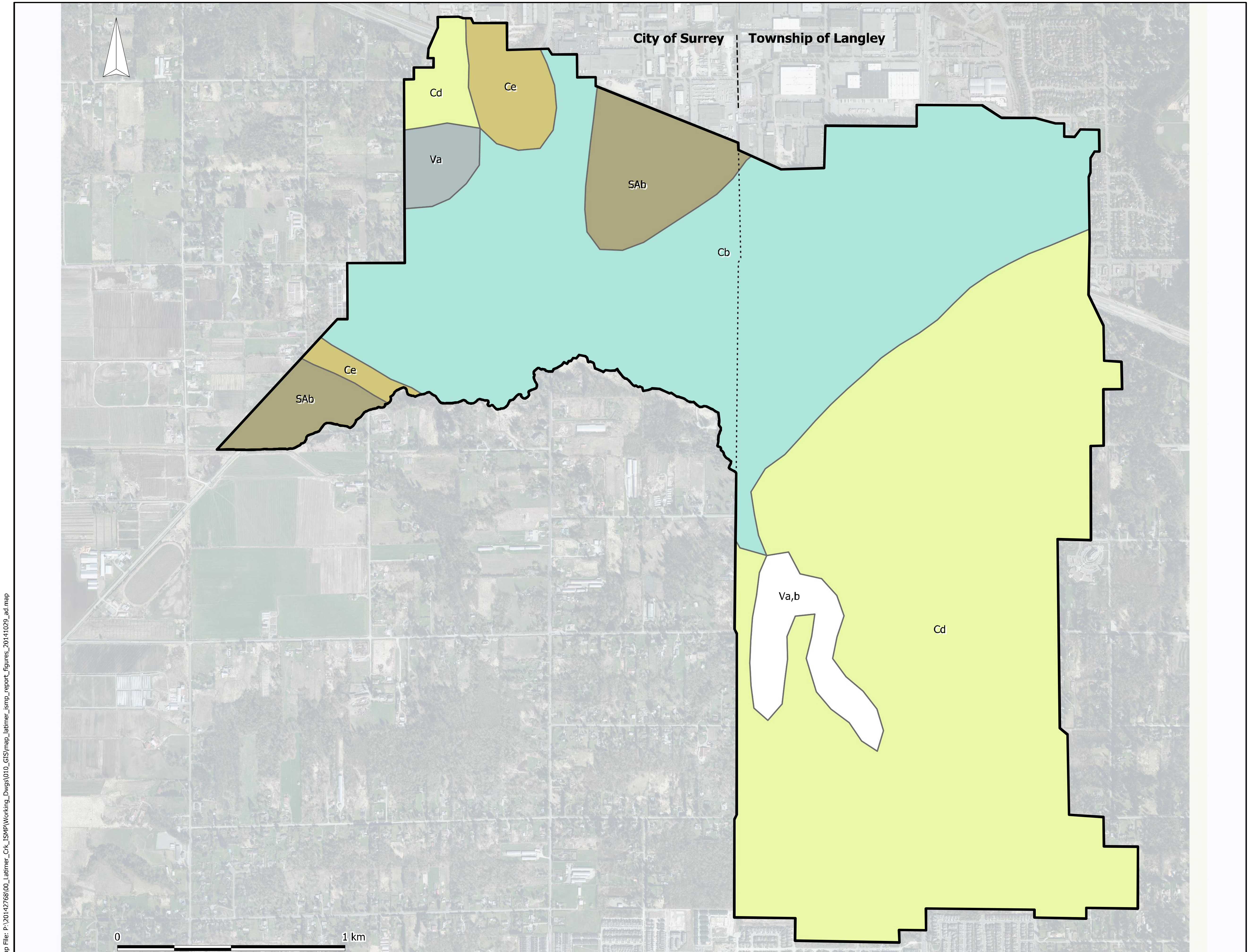
Township of Langley Est. 1873

LATIMER CREEK ISMP

STUDY AREA OVERVIEW

DRAWING NUMBER	REV. NO.	SHEET
MAP 2-1		

Map File: P:\20142768\00_Latimer_Crk_ISMP\Working_Dwgs\010_GIS\map_latimer_ismp_report_figures_20150326_jl.map



LEGEND

SURFICIAL GEOLOGY TYPE

- Cb
- Cd
- Ce
- SAb
- Va
- Va,b

REFER TO TABLE 2-2 FOR DETAILS REGARDING SURFICIAL GEOLOGY UNITS

SCALE:	1:16,000		
PROJECT NO.	2014-2768	INITIAL	DATE
DRAWN		JT	15-09-04
DESIGNED			
CHECKED			
APPROVED			
PROJECTION:	UTM ZONE 10N NAD 83		

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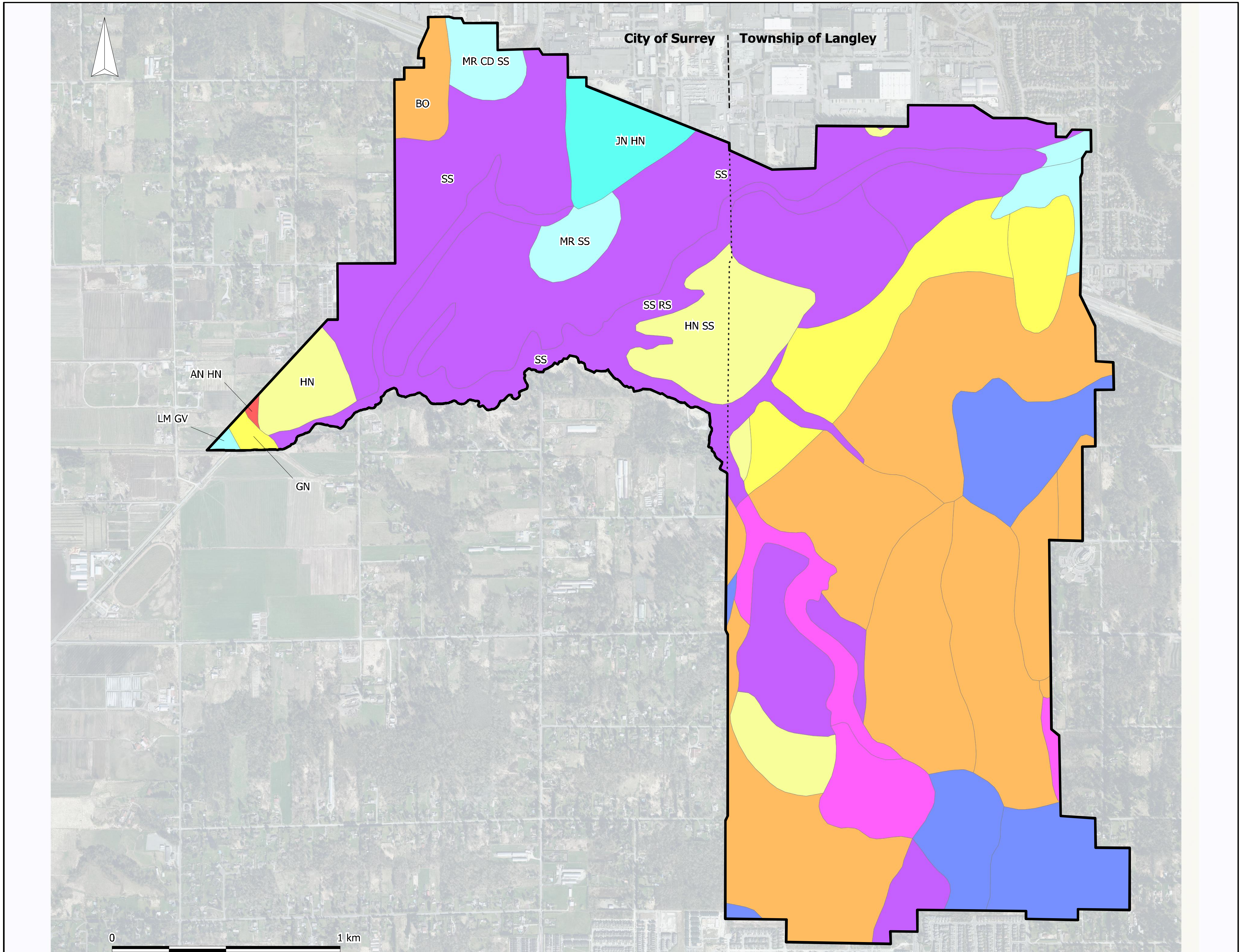
LATIMER CREEK ISMP

SURFICIAL GEOLOGY

DRAWING NUMBER	REV. NO.	SHEET
MAP 2-2		



LEGEND

SOIL TYPE

- AN - ANNIS
- BO - BOSE
- CD - CLOVERDALE
- GN - GIBSON
- HN - HERON
- JN - JUDSON
- LM - LUMBUM
- MR - MILNER
- SC - SCAT
- SS - SUNSHINE
- W - WHATCOM

REFER TO TABLE 2-3 FOR DETAILS REGARDING SURFICIAL SOIL TYPES

NOTE:
COLOUR CODING BASED ON DOMINANT SOIL CLASS

SCALE:	1:16,000		
PROJECT NO.	2014-2768	INITIAL	DATE
DRAWN		JT	15-09-04
DESIGNED			
CHECKED			
APPROVED			
PROJECTION:	UTM ZONE 10N NAD 83		

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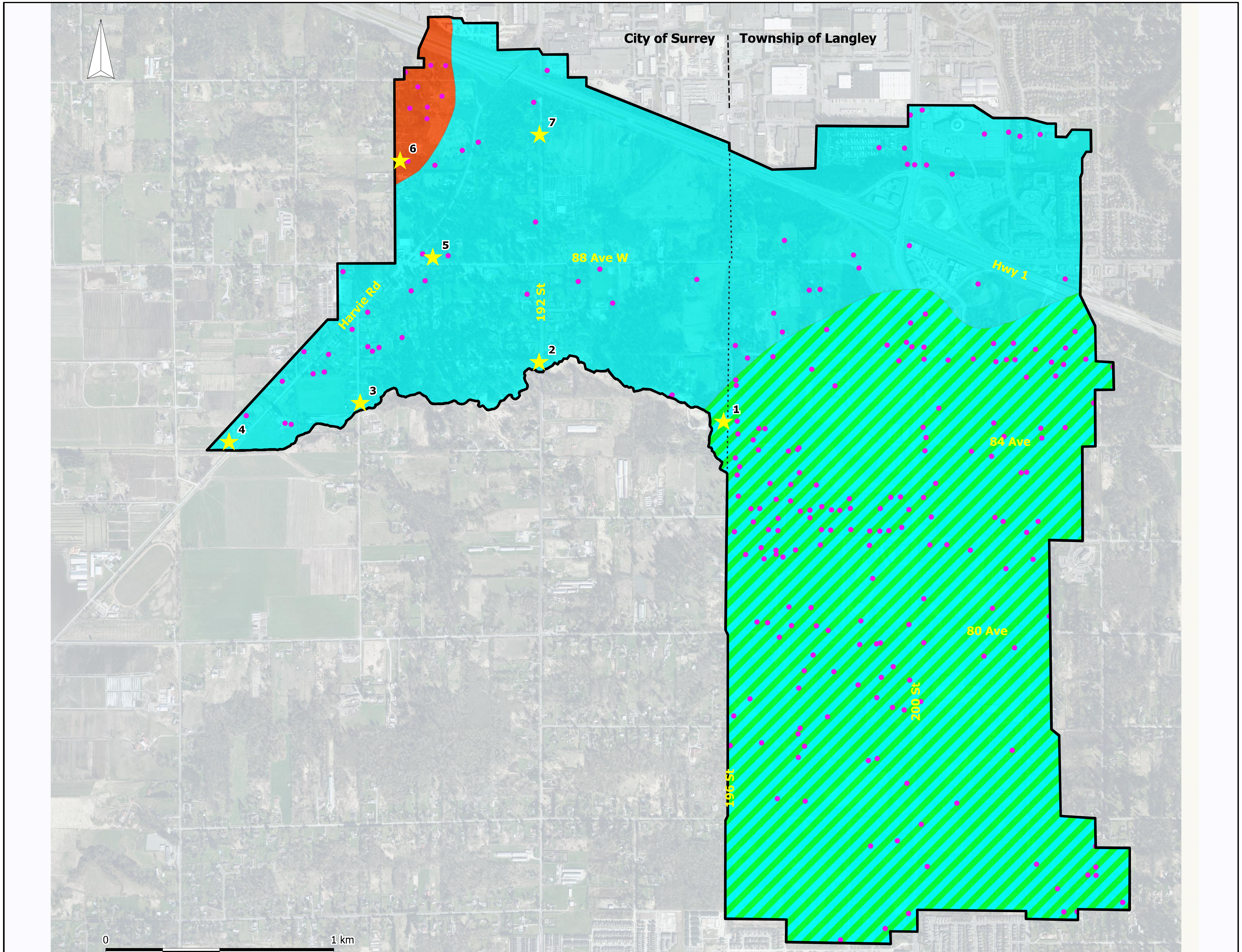
LATIMER CREEK ISMP

SOIL TYPES

DRAWING NUMBER	REV. NO.	SHEET
MAP 2-3		



Map File: P:\20142768\00_Latimer_Crk_ISMP\Working_Dwgs\010_GIS\map_latimer_ismp_report_figures_20141029_ad.map

LEGEND

FIELD INVESTIGATION SITE

WELL

AQUIFER

58 IIC

59 IIC

61 IIIC

OVERLAPPING AQUIFERS

REFER TO TABLE 2-4 FOR DETAILS REGARDING AQUIFERS

SCALE:	1:16,000		
PROJECT NO.	2014-2768	INITIAL	DATE
DRAWN		JT	15-09-04
DESIGNED			
CHECKED			
APPROVED			
PROJECTION:	UTM ZONE 10N NAD 83		

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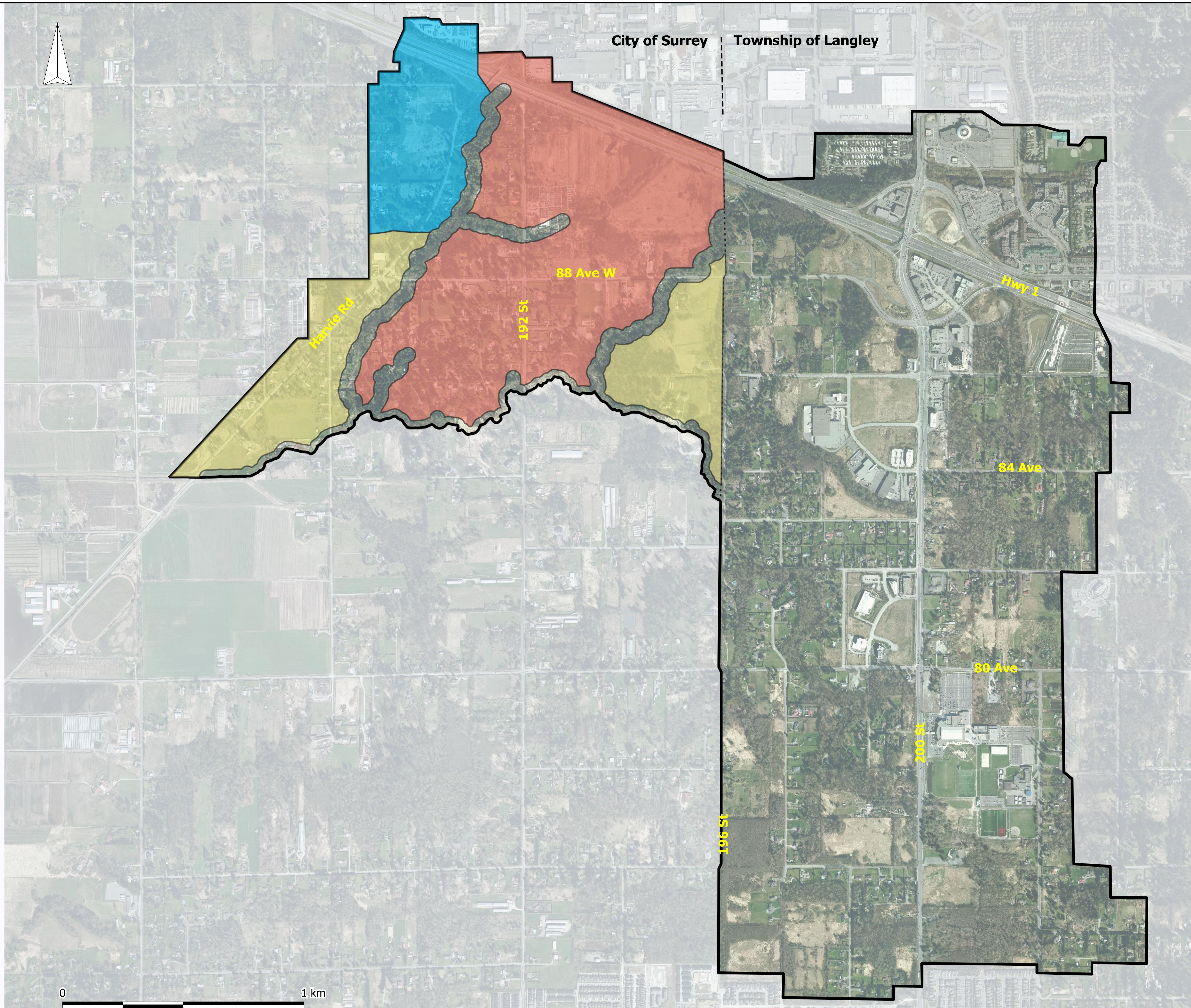
LATIMER CREEK ISMP

AQUIFERS

DRAWING NUMBER	REV. NO.	SHEET
MAP 2-4		



LEGEND

INFILTRATION POTENTIAL

- MODERATE INFILTRATION
- LOW INFILTRATION
- HIGH WATER TABLE OR ARTEESIAN AREAS NO INFILTRATION

SCALE:	1:16,000		
PROJECT NO.	2014-2768	INITIAL	DATE
DRAWN		JT	15-09-04
DESIGNED			
CHECKED			
APPROVED			
PROJECTION:	UTM ZONE 10N NAD 83		

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LATIMER CREEK ISMP

INFILTRATION POTENTIAL

DRAWING NUMBER	REV. NO.	SHEET
MAP 2-5		

Map File: P:\20142768\00_Latimer_Crk_ISMP\Working_Dwgs\010_GIS\map_latimer_ismp_report_figures_20141029_ad.map

3 Goals and Objectives

The fundamental purpose of any ISMP is to maintain and enhance the overall health of a watershed while allowing for future development; this is true for the current Latimer Creek ISMP.

We note that the current study differs from a typical ISMP due to the fact that the study area extends into both the City of Surrey and the Township of Langley.

Within the City's portion of the project area, the objectives of the current study are typical of a comprehensive ISMP, and include a wide variety of ISMP components: stormwater management, accounting for future development and climate change; terrestrial and aquatic environmental assessments; public consultation; stakeholder engagement; watershed health assessment; developing an implementation plan; and, establishing a monitoring and assessment strategy.

Within the Township of Langley, stormwater management planning has already been completed through the various Neighbourhood Community Plans that are being conducted under the Willoughby Community Plan. As a result, there is no requirement for this ISMP to evaluate the hydrologic and hydraulic conditions within the Township under existing or future conditions. Rather, the focus is on the environmental components of the ISMP within the Township of Langley, with a particular emphasis on the terrestrial and aquatic assessments. Aside from the stormwater management components of this ISMP which apply only to the City, the general objectives apply to the entire study area.

As outlined in the Terms and References for this Latimer Creek ISMP, which were developed jointly by the City of Surrey and the Township of Langley and presented prior to the onset of the project, the overall goals for the study area are to:

- Protect and enhance the overall health and natural resources of the study area;
- Promote participation from all stakeholders to achieve a common future vision of the watershed;
- Minimize risk to life and property associated with flooding, and provide strategies to attenuate peak flows;
- Protect and enhance watercourses and aquatic life;
- Prevent pollution and maintain/improve water quality;
- Prepare an inventory of watercourses and wildlife for the watershed study area;
- Protect the terrestrial environment, wildlife, and habitat corridors;
- Identify areas of existing and future industrial, residential, commercial, agricultural, and recreational land uses;
- Integrate the potential impact of climate change on the ISMP area;
- Develop a cost effective and enforceable implementation plan; and
- Establish a monitoring and assessment strategy to ensure goals are achieved, maintained, and enforced.

To achieve these goals, the specific measures to be implemented as part of the ISMP should include:

- Preserve existing green space and undeveloped lands.
- Consider the impact of development within the City's portion of the watershed on the tributaries to and main channel of Latimer Creek.
- Establish measurable indicators of the health of Latimer Creek to identify concerns and be able to implement restorative measures, as required.
- Modify existing rainfall data in accordance with the City's Climate Adaptation Strategy to evaluate the impacts of climate change.
- Restore riparian corridors where redevelopment opportunities allow.
- Maintain and improve watershed biodiversity by supporting the maintenance and enhancement of terrestrial movement corridors in accordance with the recommendations in the City's BCS.
- Extrapolate the terrestrial movement corridors into the Township of Langley in line with the methodology set out in the City's BCS.
- Reduce the overall Effective Impervious Area (EIA) by hydraulically disconnecting impervious areas from watercourses through the use of source controls.
- Enhance fisheries habitat through the mitigation of aquatic constraints and the restoration of degraded habitat through considering fish presence, fish potential, and inputs to downstream fish habitat.
- Define and enforce stormwater quality management objectives.
- Promote the management of rainfall at the source to improve the hydrologic characteristics of the study area.

In consideration of the overall goals and specific measures identified above, the vision statement developed for the Latimer Creek ISMP is presented below.

The vision for the Latimer Creek ISMP is to hold paramount public safety and the protection of the environment while accommodating community growth, in a way that enhances watershed health and aesthetics, and promotes the existing strategies aimed at conserving biodiversity. This ISMP will present a strategy for implementing stormwater best management practices and environmental enhancement opportunities that can balance the City's and Township's long-term environmental and economic goals.

4 Terrestrial Ecology and Aquatic Habitat

We conducted an environmental assessment based on desktop studies supplemented by field investigations. The key objectives of this environmental assessment were to establish the baseline terrestrial and aquatic conditions within the Latimer Creek study area. This helps to better understand the existing state of the watershed, and to establish watershed-scale goals along with appropriate methods to achieve these goals.

4.1 TERRESTRIAL ASSESSMENT

The terrestrial assessment included a desktop review, as well as a field assessment. The desktop review included the following background information from both the City of Surrey and the Township of Langley:

- City of Surrey's Biodiversity Conservation Strategy (Diamond Head 2014);
- City of Surrey's Ecosystem Management Study (HB LANARC and Raincoast 2011).
- Wildlife Habitat Conservation Strategy (Township of Langley and LEPS 2008);
- Instances of rare or at risk wildlife and plant occurrences and potential in the Study Area (BC Conservation Data Centre 2014 and City of Surrey 2014);
- Ortho-imagery of the watershed; and
- GIS information provided by the City of Surrey and the Township of Langley.

We conducted a field assessment on October 23 and 24, 2014 of the Latimer Creek watershed to characterize habitats for wildlife, including potential for species at risk. The field assessment focused on visiting areas with riparian and forest vegetation, wildlife corridors, habitat features (ponds, wildlife trees, evidence of wildlife), and included 33 assessment points, as indicated on Map 4-1. During the assessment no rare plants or wildlife species were detected.

4.1.1 Terrestrial Habitat in the Latimer Creek Watershed

4.1.1.1 Vegetation

The Latimer Creek watershed is mainly classified as urban suburban low- to moderate-density development (Diamond Head 2014), with four broad vegetation classes:

- Forest
- Riparian
- Wetlands; and
- Agricultural

The majority of the natural vegetation occurs in the riparian areas along watercourses such as Latimer Creek, and in upland forests surrounded by developed parcels.

Forest habitats are structurally diverse, and includes both young and mature (>80 years old) conifers or mixed forest stands. Dominant conifers include western red cedar (*Thuja plicata*), Douglas-fir (*Pseudotsuga menziesii*), and western hemlock (*Tsuga heterphylla*); often associated with deciduous big leaf maple (*Acer macrophylum*), trembling aspen (*Populus tremuloides*) and red alder (*Alnus rubra*). The understory is mainly composed of salmonberry (*Rubus spectabilis*), thimbleberry (*Rubus parviflorus),* vine maple (*Acer circinatum*), and salal (*Gaultheria shallon*) (Pojar et al. 1991), with piggyback plant (Tolmiea menziesii), vanilla leaf (*Achlys triphylla*)*, ferns* (sword fern [Polystichum munitum] and b*racken fern [Pteridium aquilinum]) and* stair step moss (*Hylocomium splendens*).

Riparian habitats are associated with continuous or ephemeral streams, and ponds. Vegetation is comprised of mixed forest communities, often of western red cedar with Douglas fir, black cottonwood (*Popular balsamifer balsamifer*), devil's club (*Oplopanax horridus*), thimbleberry (*Rubus parviflorus), salal,* salmonberry, and lady fern (*Athyrium filix-femina*).

Wetlands and associated low lying areas have standing or fluctuating water levels, creating saturated soil conditions. These areas are typically dominated by skunk cabbage (*Lysichiton americanus*), horsetail (*Equisetum arvense* and *E. fluviatile*), cattails (*Typhaceae* spp.) and bulrushes (*Cyperaceae* spp.).

Agricultural habitats include actively cultivated areas and old fields that have been managed in the past. Agricultural areas are often bordered by riparian areas, either drainage ditches or channelized watercourses, remnant vegetated corridors, or urban development. Agricultural edge habitats are often dominated by reed canary grass (*Phalaris arundinacea*), alder (*Alnus* ssp.), Douglas maple, and Himalayan blackberry (*Rubus discolour*), which is prevalent throughout the watershed.

4.1.1.2 Wildlife

The majority of wildlife in the watershed is likely small- and medium-sized mammals, birds, reptiles and amphibians. Large areas of land required by larger mammals (e.g., mule deer, black bears) are limited, so it is likely that those species occurring in the watershed are transient rather than resident individuals.

Forested habitat provides food resources that include fruits and seeds, or hunting opportunities, shelter, and nesting for resident birds, small- and medium-sized mammals such as mice, voles, skunks (*Mephitis mephitis*) raccoons (*Procyon lotor*) or coyotes (*Canis latrans*). Migrant species, especially birds, may breed or take refuge in forested habitats during seasonal use. Wildlife trees and coarse woody debris are important features for a range of wildlife in forested habitat.

Riparian areas provide shelter, and cover for mammals, birds including waterfowl, reptiles, amphibians and invertebrates. These might include species at risk, such as the Pacific water shrew (*Sorex bendirii)*, red-legged frog (*Rana aurora*), and Oregon Forest snail (*Allogona townsendiana*), particularly when the habitat is close to a permanent water source (BC CDC 2014). Wildlife trees are found throughout the watershed, in young to mature forests. These trees provide forage for insectivorous bird species, such as brown creepers (*Certhia americana*) and woodpeckers, as well as nesting cavities for primary and secondary cavity nesters.

Core wetland areas are associated with Latimer Creek, south of the Colossus Langley Cinemas near 200 Street and 88 Avenue, which connects to Yorkson Creek to the east, and the wetland and habitat conservation area for Latimer Creek at Port Kells Park. These areas provide a unique ecosystem and connect habitat particularly within urban suburban areas of the watershed. Wildlife found in these areas may include muskrats (*Ondatra zibethicus*), beavers (*Castor canadensis*), Pacific water shrews (*Sorex bendirii*), northern red-legged frogs (*Rana aurora*), Pacific chorus frogs (*Pseudacris regilla*), long-toed salamanders (*Ambystoma macrodactylum*), red winged blackbirds (*Agelaius phoeniceus*), and numerous invertebrates. Areas such as these provide high value foraging, breeding, and over wintering habitat for amphibians, small mammals, passerines, and raptors.

Agricultural fields and other open areas provide ample hunting opportunities for raptors and coyotes as they support abundant small mammal populations and songbirds. Ungulates, like the mule deer (*Odocoileus heminous*) may also be found in these areas as they provide feed and tall grass for bedding down. Waterfowl are often found in these areas and can be considered a pest because they can cause damage to agricultural crops.

4.1.1.3 Species at Risk

The Latimer Creek watershed provides habitat for a potential 33 plant species and 63 wildlife species at risk, that includes 4 amphibian, 1 reptile, 1 turtle, 23 bird, 11 mammals, and 23 invertebrate species with the potential to occur in the watershed (refer to Appendix A). Of these, 17 wildlife species and 12 plant species have been detected within a 10 km radius (based on the intersection of 200 Street and 80 Avenue) of the Latimer Creek watershed, as summarized in Table 4-1 and Table 4-2 (BC CDC 2014b). In particular, the City of Surrey has recorded the red-legged frog, Trowbridge's Shrew (*Sorex trowbridgii*) and barn owl at various locations in the watershed.

Table 4-1
Plant Species at Risk Detected within 10 km of the Latimer Watershed

Common Name	Scientific Name	BC[1] Status	COSEWIC[2]	SARA[3]	Habitat Type	Potential to Occur in the Project Area
Blue vervain	*Verbena hastata* var. *scabra*	Blue			Wetland, marsh, grassland, shrub, and meadow	Moderate
Chaffweed	*Anagallis minima*	Blue			Terrestrial, roadside	High
Mountain sneezeweed	*Helenium autumnale* var. *grandiflorum*	Blue			Grassland, shrub, and meadows.	low
Nuttall's waterweed	*Elodea nuttallii*	Blue			Lakes, ponds, open water, streams and riparian areas	High

Common Name	Scientific Name	BC[1] Status	COSEWIC[2]	SARA[3]	Habitat Type	Potential to Occur in the Project Area
Roell's brotherella	*Brotherella roellii*	Red	E (NOV 2010)		Mixed forest areas with course woody debris	High
Slender-spiked mannagrass	*Glyceria leptostachya*	Blue			Wetlands, swamp, marsh, bog, fen, mudflats, lakes, ponds, and open water	High
Small spike-rush	*Eleocharis parvula*	Blue			Intertidal marine, mudflats, wetlands, lakes, ponds, and open water	Low
Small-flowered bittercress	*Cardamine parviflora*	Blue			Habitat unknown however, a known occurrence at the Mark Hill Port, Coquitlam B.C.	Moderate
Streambank lupine	*Lupinus rivularis*	Red	E (Nov 2002)	1	Streams, rivers, urban, suburban, mudflats, and meadows.	Moderate
Three-flowered waterwort	*Elatine rubella*	Blue			Wetlands, bogs, fens, lakes, ponds, open water, mudflats, and estuaries.	High
Ussurian water-milfoil	*Myriophyllum ussuriense*	Blue			Lakes, and riparian areas.	High
Vancouver Island beggarticks	*Bidens amplissima*	Blue	SC (Nov 2001)		Tidal shores of Fraser River, mudflats, estuary, beaches, wetlands, and marshes.	High

Notes:

1) The red-listed includes any ecological community, and indigenous species and subspecies that is extirpated, endangered, or threatened in British Columbia. The blue-list includes any ecological community, and indigenous species and subspecies considered to be of special concern (formerly vulnerable) in British Columbia.
2) The Committee on the Status of Endangered Wildlife in Canada is a committee of experts that assesses and designates which wildlife species are in some danger of disappearing from Canada. E = Endangered, T = Threatened, SC = Special Concern, DD = Data Deficient.
3) The *Species at Risk Act* establishes Schedule 1, as the official list of wildlife species at risk. It classifies those species as being either extirpated, endangered, threatened or a special concern. Once listed, the measures to protect and recover a listed wildlife species are implemented.

Table 4-2
Wildlife at Risk Detected within 10 km of the Latimer Watershed

Species Group	Common Names	Scientific Name	BC Status	COSEWIC	SARA	Habitat type	Potential to Occur in the Project Area
Mammals	Pacific Water Shrew	*Sorex bendirii*	Red	E (Apr 2006)	1	Mixed forests, and riparian areas	High
	Trowbridge's Shrew	*Sorex trowbridgii*	Blue			Mixed forests, creeks and riparian	High
Birds	American Avocet	*Recurvirostra americana*	Blue			Lakes, ponds, open water, and wetland areas	Low
	American Bittern	*Botaurus lentiginosus*	Blue			Palustrine, and herbaceous wetland areas	Low
	Green Heron	*Butorides virescens*	Blue			Estuarine	Low
	Barn Owl	*Tyto alba*	Blue	T (2010)	1	Agricultural fields, riparian and forested areas	High
Turtle	Painted Turtle - Pacific Coast Population	*Chrysemys picta pop. 1*	Red	E (Apr 2006)	1	Lacustrine, ponds	Moderate
Amphibians	Northern Red-legged Frog	*Rana aurora*	Blue	SC (Nov 2004)	1	Riparian areas, riverine areas, creek and ponds	High
	Oregon Spotted Frog	*Rana pretiosa*	Red	E (2011)	1	Riparian, and wetland areas (*i.e.* bogs, fens, or lakes)	High
Invertebrate	Audouin's Night-stalking Tiger Beetle	*Omus audouini*	Red	T (Jul 2011)		Marine: beach, intertidal	Low
	Autumn Meadowhawk	*Sympetrum vicinum*	Blue			Lacustrine areas	Low

Species Group	Common Names	Scientific Name	BC Status	COSEWIC	SARA	Habitat type	Potential to Occur in the Project Area
	Beaverpond Baskettail	*Epitheca canis*	Blue			Palustrine; pond; roadside	High
	Blue Dasher	*Pachydiplax longipennis*	Blue			Riverine areas, and shallow water areas	High
	Dun Skipper	*Euphyes vestris*	Red	T (Apr 2013)	1	Terrestrial: shrubland	Moderate
	Emma's Dancer	*Argia emma*	Blue			Riverine; creek; moderate gradient	High
	Grappletail	*Octogomphus specularis*	Red			Riverine; mixed forested areas	High
	Oregon Forest snail	*Allogona townsendiana*	Red	T (Apr 2013)	1	Riverine, and riparian areas	High

4.1.1.4 Invasive Species

Invasive species occur in the watershed, and can limit productivity, biodiversity, reduce soil stability and water quality, destroy habitat in the area and out compete native flora and fauna (Ministry of Agriculture 2013). Invasive plant species occur along ditches, in unmanaged agricultural areas and other disturbed sites. Nuisance species observed included creeping buttercup (*Ranunculus repens*) and Scotch broom (*Cytisus scoparius*), while other invasive species included Himalayan blackberry (*Rubus discolour*), English ivy (*Hedera helix*), reed canary grass (*Phalaris arundinacea)*, and false lamium (*Lamium* spp. *L. galeobdolon*). Blackberry is particularly prevalent in the watershed.

The City of Surrey also identifies American bullfrogs (*Rana catesbeiana*) as an invasive species in the Latimer watershed. This species competes for natural resources with native species and are highly predacious, eating native frogs, including the listed red legged frog and Oregon spotted frog (B.C. Frogwatch 2013).

4.1.2 Existing Terrestrial Network

As part of the terrestrial assessment, we identified important habitat for wildlife, movement corridors, wetlands and environmentally sensitive areas that are related to the conservation of terrestrial habitat and life within the watershed.

Within the City of Surrey, this follows the approach taken in the Green Infrastructure Network, which identifies corridors, hubs, and sites to maintain and increase habitat conservation and connectivity between habitats. These components are outlined as follows in the City's GIN:

- **Hubs** - areas greater than 10 ha in size with a diverse habitat structure;
- **Sites** - areas less than 10 ha in size, which may support fewer species; and
- **Corridors** - linear habitat areas that encourage the movement of species between fragmented hubs and sites, including riparian areas with 30 m setback from the high water mark.

As documented in the GIN, the City's approach follows three core principles of biodiversity conservation:

- Preserving large core habitat areas;
- Ensuring connectivity between habitat areas; and
- Providing a diversity of habitat features throughout the City.

We recognize that the identification of hubs, sites, and corridors is limited to the City's portion of the study area.

Within the Township of Langley, we identified environmentally valuable areas in a more general sense. We identified existing parks, as well as areas that have been designated for conservation within the existing neighbourhood plans. In addition, we also identified areas with significant environmental value which have not yet been designated for conservation.

The existing network of hubs, sites, corridors, parks, and conservation areas is shown on Map 4-1.

4.1.3 Location-Specific Terrestrial Network Enhancement Opportunities

In addition to documenting the existing terrestrial network throughout the Latimer Creek watershed, we also identified a number of potential enhancement opportunities. The intent is to maintain habitat connectivity within the watershed (across municipal boundaries), and to identify areas not yet recognized for environmental protection.

Within the City of Surrey, we identified these enhancement opportunities as potential hubs, sites, or corridors, consistent with the City's GIN. Within the Township of Langley, we identified enhancement opportunities as potential conservation areas, consistent with the approach taken in the various neighbourhood plans. We evaluated each of the enhancement opportunities based on the following:

- Level of connectivity
- Ecological Values
- Relative Disturbance (roads, noise, proximity to existing development)

Table 4-3 outlines the criteria used to describe each of these considerations. This simplified approach is adapted from, and generally consistent with, the City of Surrey's GIN; however, it does not replicate the more rigorous methodology of the Ecosystem Management Study or the Biodiversity Conservation Strategy implemented by the City.

Table 4-3
Criteria Used to Evaluate Terrestrial Network Enhancement Opportunities

Criteria	Rating	Description
Connectivity	High	Connectivity to major Hubs, Sites, and Corridors already designated in the Green Infrastructure Network (City of Surrey), Conservation Areas and Park as designed by the Township of Langley, or other proposed Hubs, Sites or Corridors that are naturalized and designed to provide movement for a wide range of species.
	Medium	Connectivity to Conservation Areas and Parks as designed by the Township of Langley, or to proposed Hubs, Sites, and Corridors that are naturalized and designed to provide movement for a wide range of species.
	Low	Connectivity between Hubs and Sites or smaller Conservation Areas or Parks that provide movement for species more adapted to urban habitat.
Ecological Value	High	Important habitat that is considered a component of the Green Infrastructure Network. Connectivity, locally and regionally, wildlife sightings (particularly species at risk), and the potential to support significant wildlife communities.
	Medium	Important habitat that enhances connectivity and supports significant wildlife communities.
	Low	Moderately important habitat that supports the GIN and can benefit from enhancement opportunities.
Disturbance	High	Areas surrounded by moderate to high-density suburban and urban areas with consistent traffic or industrial noise
	Medium	Areas surrounded by low-density suburban to urban areas with consistent traffic noise.
	Low	Areas surrounded by low-density suburban to urban areas and parks, or conservation areas with consistent or irregular traffic noise.

Source: Adapted from Diamond Head 2014

The potential terrestrial enhancement opportunities are identified on Map 4-2, and presented below in Table 4-4.

Table 4-4
Potential Enhancement Opportunities

Site Label	Habitat Description	Ecological Value	Connectivity	Disturbance	Proposed Green Infrastructure
A	Mature mixed wood forest dominated by conifers. Provides high valued habitat to passerines, small mammals including the Trowbridge shrew (*Sorex trowbridgii*) for forage, shelter, and breeding opportunities and connects to the Latimer Creek Conservation Area.	High	Medium	Medium	Hub
D*	This area is a combination of an upland forest and a larger low lying wetland that is connected to Port Kells Park and Latimer Creek. Part of this area is an existing Hub while the other portion is a proposed Hub. This area would provide a diverse amount of habitat and movement opportunities to a range of species including amphibians, such as the red-legged frog, what has been recorded in the area, passerines, and small mammals including the Pacific water shrew, muskrats, beavers, passerines, and raptors including the barn owl or the red tailed hawk (*Buteo jamaicensis*) for forage, shelter, and breeding and hunting opportunities. This area may also provide overwinter habitat for amphibians.	High	High	Low	Site
E	This area is mainly comprised of a mature deciduous forest providing a large amount of habitat for small mammals, raptors, and passerines such as the American robin or dark-eyed junco. This area is directly adjacent to a commercial space along the west but is otherwise surrounded by a suburban residential development that is connected to the Yorkson conservation area.	Medium	High	Medium	Conservation Area
Corridor 1	Riparian habitat and creek (Bartesko Brook) providing high valued habitat to amphibians, such as the red-legged frog, fish, passerines, and small mammals. Local and regional connections from the existing Green Infrastructure Network from the City of Surrey and provides a connection for southward movement into the Township of Langley through the proposed network.	High	High	Medium	Corridor

Site Label	Habitat Description	Ecological Value	Connectivity	Disturbance	Proposed Green Infrastructure
Corridor 3	Latimer Creek and tributary are a riparian forested area that extends north to south and east to west. This area not only provides a diverse structure of habitat for amphibians, such as the red-legged frog, passerines, and small mammals including the Pacific water shrew, muskrats, and passerines, for forage, shelter (summer and winter), and breeding and hunting opportunities, but also provides a movement corridor locally and regionally between watersheds (i.e. Upper Serpentine and Clayton watersheds).	High	High	Medium	Conservation Area

**Note – Proposed Site D is already identified as a proposed site within the City's BCS.*

4.1.3.1 Limitations on Location-Specific Terrestrial Enhancement Opportunities

As noted, the Township of Langley has prepared a number of Neighbourhood Plans as part of the Willoughby Community Plan. These Neighbourhood Plans have already established land use and development plans within the Latimer Creek Study Area. In particular, the Carvolth Neighbourhood Plan (Bylaw 2013 No. 4995) covers roughly half of the Township's portion of the study area for the current ISMP.

While our Terrestrial Habitat Assessment identified Area 'E' as an area with high environmental value, this area has been designated for residential development under the Integrated Area Concept Plan for Carvolth. As such, the Carvolth Neighbourhood Plan precludes the establishment of a dedicated conservation area at this location. Nevertheless, it is important to include Area 'E' within the current assessment in order to identify the impacts of future development within the study area. While there may be no opportunity to designate a conservation area, it is important to understand and document the potential development impacts within the Latimer Creek ISMP study area.

4.1.4 General Terrestrial Enhancement Opportunities

In addition to the location-specific enhancement opportunities noted above, the general recommendations of the City of Surrey's Biodiversity Conservation Strategy should be extended beyond the City's boundary, and should be applied over the entire study area to the extent possible. Some of the main recommendations of the BCS that should be incorporated into this ISMP include:

- The creation of a Green Infrastructure Network (GIN) to support wildlife movement,
- Improved invasive species management,
- The implementation of strategies to speed the growth of young forests,
- The enhancement of shrub/herb/grass habitat through strategic planning.

The BCS provides a significant level of detail on the general constraints and enhancement opportunities for the Latimer Creek ISMP (specific to the City's portion of the study area). The current ISMP is not intended to duplicate the efforts of the BCS; rather, the intent is to incorporate the recommendations from the BCS into the ISMP to support enhancement of watershed health.

The BCS breaks the City of Surrey into Biodiversity Management Areas and discusses general constraints and enhancement opportunities for each area. The Biodiversity Management Areas which are relevant to the Latimer Creek ISMP Study Area (both the City's portion, and by extension the Township's portion) include:

- Tynehead
- Serpentine Nikomekl
- Cloverdale

The successful enhancement of the health of the Latimer Creek Study Area must take into account the recommendations of the BCS in these Biodiversity Management Areas.

4.2 AQUATIC ASSESSMENT

The Latimer Creek ISMP Study Area includes Latimer Creek and several major tributary streams including:

- Latimer Creek
- North Latimer Creek
- Old Sawmill Creek
- Bartesko Brook
- Unnamed Tributaries to Latimer Creek.

South Latimer Creek is another major tributary of Latimer Creek, but is not part of the Latimer Creek ISMP study area; it is in the Clayton watershed, south of the Study area.

These major streams generally flow through low-density residential neighbourhoods and agricultural areas, with the exception of the northeast portion of the watershed, which is located in a highly-developed commercial area. The downstream limit of the watershed is located at Harvie Road near the 84 Avenue right-of-way. Further downstream, Latimer Creek drains west and flows through a series of constructed linear channels to the Serpentine River, which in turn drains southwest to its confluence with Mud Bay.

The aquatic habitat of these streams in the study area includes man-made drainage channels, highly modified and disturbed channels and riparian areas, and undeveloped, high-value, natural corridors and stream habitats. Land development in the study area has resulted in habitat degradation through channel re-alignment, flow alteration and water quality degradation. Natural stream channels and associated riparian corridors are present mainly within low-density residential developments, and several areas that back onto ravines, which provide protection to natural features of the streams.

4.2.1 Stream Classifications

The City of Surrey has developed a classification system for watercourses, tributaries and ditches within the City (City of Surrey 1995). The classification provides an overall fish habitat value rating based on fish presence, duration of water flow and water source and surrounding vegetation potential. The term "fish" refers to both salmonids and regionally significant fish. Four classifications were established in 1995 and are summarized in Table 4-5.

Table 4-5
City of Surrey Watercourse Classification System

Classification	Map Symbol	Description
Class A	Solid red line	Inhabited by or potentially inhabited by fish year round if migration barriers are removed.
Class A (O)	Dashed red line	Inhabited by or potentially inhabited by fish, if migration barriers are removed, primarily during the over-wintering period.
Class B	Solid yellow line	Significant food and/or nutrient value, no fish present.
Class C	Solid green line	Insignificant food and/or nutrient value or road-side ditches.

The Township of Langley uses a similar classification system for watercourse, tributaries and ditches (Township of Langley 1998). Six classifications were established in 1998 and are summarized in Table 4-6.

Table 4-6
Township of Langley Watercourse Classification System

Classification	Map Symbol	Description
Class A	Red line	Inhabited by or potentially inhabited by fish year round if migration barriers are removed.
Class A (OD)	Orange line	Watercourses with intermittent water supply. Inhabited by or potentially inhabited by fish primarily during the over-wintering period. May dry up in summer months. (OD = Overwintering habitat, dries up)
Class A (OW)	Magenta line	Watercourses with fish presence year round. Inhabited by or potentially inhabited by salmonids during over-wintering period; non-salmonid species are generally present year round. (OW = Overwintering habitat, wet all year)
Class B	Yellow	Non-fish bearing. Provide a significant source of food, nutrient and cool water supplies to downstream fish populations.

Classification	Map Symbol	Description
Class C	Green	Non-fish bearing. Insignificant source of food and nutrients. These watercourses dry up soon after rainfall.
Unclassified	Blue	Watercourses for which no detailed information exists.

Most major streams within the study area are classified as year-round or seasonal fish-bearing habitat (Class A, A(O), A(OD), or A(OW)), with the remaining major streams not included under the various "A" classes, and several other minor watercourses classified as significant sources of food and nutrients to downstream fish populations (Class B).

Stream classification mapping is available online on the City of Surrey's Online Mapping System (COSMOS; City of Surrey 2014a), the City of Surrey's Fish Classification Map (City of Surrey 2014b), the Township of Langley's Online Mapping System (Geosource; Township of Langley 2014a), and the Township of Langley's Watercourse Classification Map (Township of Langley 1998). Stream classifications for the Study area are provided in Map 4-3.

A summary of the classifications for the named streams and other major unnamed streams in the Study area is provided in Table 4-7.

Table 4-7
Stream Classifications for Significant Streams in the Study Area

Stream	Description	Classification
Latimer Creek	Tributary to the Serpentine River	Class A
North Latimer Creek	Tributary to Latimer Creek	Class A
Old Sawmill Creek	Tributary to Latimer Creek	Class A
Bartesko Brook	Tributary to Old Sawmill Creek	Class A
Unnamed Tributary 1*	Tributary to Latimer Creek	Class A
Unnamed Tributary 1-A*	Southeast branch of Unnamed Tributary 1 Confluence west of 196 Street, south of 86 Avenue	Class A
Unnamed Tributary 2*	Tributary to Latimer Creek Confluence near 82A Avenue and 196 Street	Class A

*These tributaries to Latimer Creek are unnamed by City of Surrey and Township of Langley, and have been assigned a numeric value for the purposes of clarity in this report.

A discrepancy in mapping was noted during the review of existing information and field assessment, as described in Table 4-8.

Table 4-8
Discrepancies in Watercourse Mapping and Classification

Stream and Location	Detail	Recommendation
Unnamed Tributary 1, west of 196 Street to its confluence with Latimer Creek (approximately 75 m)	City of Surrey designates this portion as Class B. East of 196 Street (upstream), this creek is designated as Class A by Township of Langley	Designate as Class A

4.2.2 Fish Species

Most of the streams within the study area are classified as fish-bearing. Several fish species have been documented in streams within the study area either seasonally or year-round in background information and during field observations during stream assessments completed for this study in November 2014. Documented fish species are listed in Table 4-9.

Table 4-9
Fish Species Present in Major Streams of the Study Area

Common Name	Scientific Name
Coho salmon	*Oncorhynchus kisutch*
Chum salmon	*O. keta*
Cutthroat trout	*O. clarki clarki*
Rainbow trout	*O. mykiss*
Threespine stickleback	*Gasterosteus aculeatus*

Sources:
BC MOE, 2014 a (BC MOE, Habitat Wizard, available at http://www.env.gov.bc.ca/habwiz/)
Latimer Creek Master Drainage Plan (ECL 2003)
Port Mann/Highway 1 Environmental Assessment (MOT 2007)

4.2.3 Stream Habitat

4.2.3.1 Assessment Methods

Stream habitat conditions were assessed by conducting a desktop review of background information and reports, available mapping and ortho-imagery. The data was assembled and reviewed in order to characterize fish habitat, including features and potential habitat limitations and to identify potential enhancement opportunities within the study area.

A field assessment was also conducted on November 4 and 5, 2014. A sub-sample of the streams in the study area was selected for the field assessment, with sites located on all major streams. The purpose of the field assessment was to assess current fish habitat conditions, to identify specific issues related to erosion, bank instability, or barriers to fish passage, and to verify and supplement the compiled background information. Areas of potential habitat enhancement and restoration were noted.

At each site, the field assessment was conducted in accordance with the Resource Inventory Standards Committee protocols (RISC, 2001). Each site was georeferenced with GPS and photographed. Detailed information was collected, including:

- Channel width and depth and bankful width and depth
- Channel slope
- Substrate composition
- Habitat quality (spawning, rearing and overwintering potential)
- Barriers to fish movement
- Fish observations
- Riparian vegetation and woody debris
- Habitat values
- Unique or critical features.

4.2.3.2 Channel Habitat Characteristics and Features

Observations of fish habitat characteristics and features measured at each site during the field investigation are summarized in Table B-1, included in Appendix B. The field assessment site locations are shown on Map 4-3; photographs from the aquatic field assessment are included in Appendix B. Summaries for major streams in the study area are provided in the following sections.

4.2.3.3 Latimer Creek

Latimer Creek is a highly variable channel, flowing through both agricultural areas and residential areas. Latimer Creek can be separated into three distinct areas:

- Headwater area, south and east of 200 Street;
- Well established ravine section extending from 196 Street to 200 Street; and
- Lowland section extending from 196 Street to Harvie Road.

The headwaters of Latimer Creek, south and east of 200 Street, are comprised of roadside drainage swales and ephemeral tributaries that drain existing roads, residential properties and agricultural fields. Latimer Creek flows past the Langley Events Centre, (constructed in 2009), and adjacent to sports fields east of 200 Street. The Township of Langley has designated this portion of the creek as Class B (i.e., no fish present, food and nutrient value only). Twin culverts at 200 Street are potential barriers to fish passage (ECL 2003).

Between 196 Street to 200 Street, Latimer Creek flows northwest and is high-value fish habitat, and is comprised of riffles, cascades and pools. Several sections of the channel are located within well-vegetated ravines. Instream vegetation and cover, including small and large woody debris, is abundant and provides good rearing and spawning habitat for salmonids. Evidence of both minor and major channel bank erosion is present in ravine sections of Latimer Creek (ECL 2003). Spawning Coho were observed during the field assessment at several locations in this portion of Latimer Creek.

The lowland area of Latimer Creek is deep, wide, and is low gradient (less than 0.5%). Riparian vegetation in this portion of Latimer Creek is minimal. Substrate consists of mainly organics and instream vegetation is extensive, mainly comprised of reed canary grass (*Phalaris arundinacea*). Use by fish in this lowland area of Latimer Creek is limited to rearing and overwintering, as no suitable spawning habitat is present. Land use in this portion is generally low-density residential development and agriculture.

4.2.3.4 Old Sawmill Creek

Old Sawmill Creek originates as roadside drainage north of, and within, the Highway 1 right-of-way near Harvie Road (MOT 2007). Old Sawmill Creek flows south towards its confluence with Latimer Creek, just east of 188 Street and south of 86 Avenue. The creek is generally located in a well-vegetated ravine with an intact riparian forest. Substrates are mainly comprised of fines, which limits available spawning habitat. There is abundant instream cover, including vegetation and small and large woody debris, which provide rearing and overwintering habitat for salmonids. The channel may not be accessible to salmonids in summer due to its ephemeral nature (ECL 2003).

4.2.3.5 Bartesko Brook

Bartesko Brook originates as roadside drainage along Highway 1 near 194 Street (MOT 2007, ECL 2003). The channel flows southwest through a low-gradient agricultural area, to a large ponding area located east of 192 Street, towards its confluence with Old Sawmill Creek west of 192 Street and south of 90 Avenue. The section downstream of the ponding area is a linear channelized portion, adjacent to a nursery, with numerous ornamental vegetation species along the banks of the channel. Instream vegetation is extensive and comprised mainly of reed canary grass and bulrushes (*Scirpus microcarpes*). Downstream of 192 Street the channel is located in a well-vegetated ravine with abundant instream cover. The channel provides suitable overwintering and rearing habitat for salmonids, but spawning habitat is absent. However, due to the intermittent nature of the channel, fish access may be limited during low flow (ECL 2003).

4.2.3.6 North Latimer Creek

The headwaters of North Latimer Creek originate in a commercial area on the north side of Highway 1 near 202 Street and near the 202 Street Park-and-Ride on the south side of Highway 1. Significant alterations and disturbance to the creek is evident north and south of Highway 1, due to development in these areas. As part of the Port Mann-Highway 1 project, the headwaters of North Latimer Creek were re-aligned, adjacent to the Park and Ride, where a new stormwater outfall and pond were constructed (MOT, 2007). Within the altered section of North Latimer Creek south of Highway 1, there is extensive instream cover including riparian vegetation and woody debris. Substrate consists predominately of fines (silt), with some gravel. The channel provides suitable overwintering and rearing habitat for salmonids, but spawning habitat is absent.

The portion of North Latimer Creek north of Highway 1, between 202 Street and its crossing beneath Highway 1 (near 198 Street), is a low-gradient (less than 0.5%) section with a deep and wide uniform channel. Instream cover is limited and the substrate consists predominately of fines (silt). The channel provides low value habitat with a minor amount of suitable overwintering and rearing habitat for salmonids, and spawning habitat is absent. Beaver activity was noted between 200 and 202 Street.

Downstream of its crossing with Highway 1, North Latimer Creek is more sinuous and meandering, and the substrate composition is cobbles and fines, with some boulders. Instream vegetation and cover, including small and large woody debris, is abundant and provides good rearing and spawning habitat for salmonids. Spawning Coho were observed downstream of 88 Avenue in North Latimer Creek during the site assessment.

4.2.3.7 Unnamed Tributary 1

The headwaters of Unnamed Tributary 1 originate upstream of 86 Avenue, just west of 200 Street. The channel flows southwest towards its confluence with Latimer Creek approximately 75 m east of 196 Avenue, north of 84 Street. The headwaters are located on a private residential property that has removed the majority of riparian vegetation along the banks of the channel, so cover is limited. Twin culverts under the driveway on this property likely preclude fish access upstream. In addition, the channel is not well defined in this portion.

South of 86 Avenue, instream vegetation and cover, including small and large woody debris, is abundant and provides good rearing and spawning habitat for salmonids. Substrate is comprised of both fines and cobbles. There is a wooden fence spanning the channel just downstream of 86 Avenue that is a potential barrier to fish migration at lower flows. However, during the site assessment, spawning Coho were observed upstream (north) of this fence.

4.2.3.8 Unnamed Tributary 1A

Unnamed Tributary 1A is a branch of Unnamed Tributary 1 and originates east of 200 Street near 83 Street. The channel conveys flows northwest to its confluence with Unnamed Tributary 1 west of 196 Street near 85 Street. The channel is located within a deep and well-vegetated ravine where minor and major bank erosion was observed in several locations. The channel has moderate instream cover and substrate is comprised of cobbles and fines. Good rearing and overwintering habitat for salmonids is present with some potential areas for spawning.

4.2.3.9 Unnamed Tributary 2

The headwaters of Unnamed Tributary 2 originate near 76 Avenue and 197 Street, and convey flows north, to its confluence with Latimer Creek near 82A Avenue and 196 Street. The headwaters, upstream of 78 Avenue, drain runoff from surrounding fields and are ephemeral in nature (ECL 2003). Downstream of 78 Avenue, the channel is located in a deep and well-vegetated ravine. This portion of the channel is high-value fish habitat, and is comprised of riffles, cascades and pools. Abundant instream vegetation and cover are present, providing good rearing and spawning habitat for salmonids. Instream cover consists primarily of woody debris. During the site assessment, spawning Coho were observed between 80 and 82 Avenue.

4.2.3.10 Roadside Drainage

Typical roadside drainage in the watershed consists of linear channels, with uniform dimensions of approximately 1-2 m wide and 0.5-1 m deep. These channels typically have a grassy bottom and lack a scoured channel, and were generally dry or not flowing at the time of the site assessment.

4.2.3.11 Riparian Vegetation

Native riparian vegetation is well-established in ravine sections of the Study area. The shrub layer consists primarily of salmonberry (*Rubus spectabilis*), snowberry (*Symphoricarpos albus*), Indian plum (*Oemleria cerasiformis*), beaked hazelnut (*Corylus cornuta*), vine maple (*Acer circinatum*), and red-osier dogwood (*Cornus sericea*). Most areas have a mature tree canopy that includes western red cedar (*Thuja plicata*), big leaf maple (*Acer macrophyllum*), alder (*Alnus rubra)*, black cottonwood (*Populus trichocarpa*), and Douglas fir (*Pseudotsuga menziesii*). Ground cover vegetation species mainly consists of deer fern (*Blechnum spicant*), lady fern (*Athyrium filix-femina*), trailing blackberry (*Rubus ursinus*), and horsetail (*Equisetum* sp.).

Non-native, invasive riparian vegetation was noted in several areas, in particular, where ravines backed onto single-family dwellings. Non-native riparian vegetation identified in the Study area during the assessment and in background information review included Himalayan blackberry (*Rubus armeniacus*), English ivy (*Hedera helix*), Holly (*Ilex aquifolium*), Japanese knotweed (*Fallopia japonica*), Policeman’s helmet (*Impatiens glandulifera*), and Yellow lamium (*Lamiastrum galeobdolon*).

4.2.4 Location-Specific Aquatic Constraints and Enhancement Opportunities

During the review of existing information and field assessments, several barriers or obstructions to fish passage were identified in the study area. Table 4-10 summarizes the recommended improvement for each of these known constraints. The constraints and enhancement opportunities are also identified on Map 4-4.

Table 4-10
Recommended Environmental Improvements

Stream	Location Reference	Type of Barrier	Constraint	Improvement	Cost
Latimer Creek	8 – Langley	Hanging culverts	Barrier to upstream fish migration	Replace hanging culvert with fish passable culvert.	$175,000[1]
Latimer Creek	9 – Langley	Falls	0.4 m falls is an obstacle to fish passage, but passable at higher flows	Modify channel to establish step-pool feature with maximum 0.3 m vertical height.	$25,000
Latimer Creek	10 – Langley	Debris jam	Creates an obstruction at some flows	Remove debris to facilitate access upstream.	$10,000
Latimer Creek	11 – Surrey/Langley	Hanging culvert	Barrier to upstream fish migration	Replace hanging culvert with fish passable culvert.	$100,000
Bartesko Brook	12 – Surrey	Falls	0.4 m falls is an obstacle to fish passage, but passable at higher flows	Modify channel to establish step-pool feature with maximum 0.3 m vertical height.	$25,000
Bartesko Brook	13 – Surrey	Debris jam	Creates an obstruction at some flows	Remove debris to facilitate access upstream.	$10,000
Old Sawmill Creek	14 – Surrey	Debris jam	Creates an obstruction at some flows	Remove debris to facilitate access upstream.	$10,000
Unnamed Tributary 1	15 – Langley	Hanging culvert	Barrier to upstream fish migration	Replace hanging culvert with fish passable culvert.	$60,000[2]
Unnamed Tributary 1	16 – Langley	Debris jam at fencing	Creates an obstruction at some flows	Remove debris to facilitate access upstream.	$15,000
Unnamed Tributary 2	17 – Surrey	Hanging culvert	Barrier to upstream fish migration	Replace hanging culvert with fish passable culvert.	$100,000

Notes:

1. The higher cost at this location is due to the crossing being located under 200th Street. Installation would require trenchless methods and/or significant Traffic Management with an open excavation.
2. The lower cost at this location is due to the crossing being located under a driveway rather than a public road.
3. Culverts within the Township of Langley are to be Concrete or HDPE.

In addition to the site specific opportunities noted above, there are several potential opportunities to enhance and restore fish habitats in the study area (Diamond Head 2014; ECL 2003; ISMP fieldwork). A general overview of enhancement opportunities includes:

- Replace or upgrade culverts that are barriers or obstacles to fish migration.
- Install fencing between trails/private property and creeks to protect environmentally sensitive areas to discourage encroachment and access by humans and animals (including livestock).
- Re-establish riparian vegetation where tree and plant species diversity is low in both the lowland areas and beyond the top-of-ravine.
- Re-establish required setback distances per Streamside Protection and Enhancement Areas (SPEAs), and restore natural habitat as part of re-development.
- Encourage retention of wildlife trees with diameters >30 cm in riparian area.
- Inventory and remove invasive plant species from riparian areas.
- Remove or modify debris jams to facilitate upstream access for fish.
- Clean up garbage within the ravines of Latimer Creek and its tributaries.

4.2.5 Benthic Invertebrate Sampling (Township of Langley)

The City of Surrey has a well-established Benthic Invertebrate sampling program with information dating back to 1999. In order to supplement this available information, we conducted Benthic Invertebrate sampling within the Township of Langley.

We completed benthic invertebrate community sampling within the Township on October 22 and 23, 2014. We conducted the sampling in accordance with GVRD Benthic Macroinvertibrate B-IBI Guide (EVS 2003) and Metro Vancouver (Page 2008). We sampled three streams – Unnamed Tributary 1, Unnamed Tributary 1A, and Latimer Creek, as shown on Map 4-3. While we initially planned to conduct samples on North Latimer Creek, insufficient habitat (fine sediment only; no gravels/cobbles/boulders) precluded this area as a viable sampling location.

In each stream reach we selected four sites, with the exception of Unnamed Tributary 1, where only three sites were available due to habitat constraints; we collected a total of 11 samples at these sites. The sites spanned approximately 500 m within each stream reach. At each site, one three-part composite benthic invertebrate sample was collected with a 500 micron Hess sampler. We also documented habitat characteristics including channel width, wetted depth, bankful width, substrate, and habitat features. The samples were analyzed by Living Streams Environmental Services.

B-IBI scores were calculated for each composite sample using a 10 metric scoring system (EVS 2003). We obtained taxa designations (e.g. long lived taxa, clingers, etc.) from the Northwest Taxa Database (EVS 2003) to calculate scores. Using all of the available data, average scores were calculated for each of the three stream reaches. These scores can then be interpreted according to the GVRD Benthic Macroinvertebrate B-IBI Guide, as outlined in Table 4-11.

Table 4-11
GVRD Benthic Macroinvertebrate B-IBI Guide – Stream B-IBI Scores

10- Metric B-IBI Score	Stream Condition
46-50	Excellent
38-44	Good
28-26	Fair
18-26	Poor
10-16	Very Poor

As noted above, B-IBI sampling is conducted within the City of Surrey as part of their ongoing program. As part of this ongoing program, B-IBI results are available within the City of Surrey from Fall 2013 and Spring 2014. The sampling locations within the study area are noted as L2 and L3, as shown on Map 4-3.

B-IBI Sampling Results

The results from our Fall 2014 sampling are summarized below. Additional details and results from the B-IBI sampling are provided in Appendix C.

- The majority of the specimens were quite small, with most of the taxa being blackworm (Family *Lumbriculidae*), followed by mayflies (Family *Baetidae*).
- Unnamed Tributary 1A contained fewer organisms (average 39) and small number of taxa (average 9) than Unnamed Tributary 1 (average 198 and 11 respectively) and Latimer Creek (average 143 and 15 respectively).

As indicated by Table 4-12, within the study area the B-IBI scores for the samples collected ranged from 14.7 to 28.0. For completeness, we have included the information that is available from the City of Surrey.

Table 4-12
B-IBI Scores

Stream	Municipality	Sampling Time	B-IBI score	Stream Condition**
L2*	Surrey	Fall 2013	18.7	Poor
L3*	Surrey	Fall 2013	23.3	Poor
L2*	Surrey	Spring 2014	16.0	Very Poor
L3*	Surrey	Spring 2014	14.7	Very Poor

Stream	Municipality	Sampling Time	B-IBI score	Stream Condition**
Unnamed Tributary 1	Langley	Fall 2014	18.6	Poor
Unnamed Tributary 1A	Langley	Fall 2014	20.5	Poor
Latimer Creek	Langley	Fall 2014	28.0	Fair

* Streams sampled by Rhithron Associates Inc.
** Source: EVS (2003)

These values are considered to be typical of moderately urbanized streams. The B-IBI score of Latimer Creek within the Township was the highest, and was representative of a “fair” stream condition. Scores were higher in the Fall seasons than the Spring. Scores varied between sampling season and site; however, the majority of scores indicated a “poor” stream condition. During the Fall 2014 sampling period, B-IBI scores were generally higher in stream reaches further south.

We note that this evaluation of stream condition as a function of B-IBI score comes from the GVRD Benthic Macroinvertebrate B-IBI Guide, which is based on higher order streams, and is not directly applicable to the watercourses within the Latimer Creek ISMP study area. This type of evaluation is typical for ISMPs throughout the region, and has been included here for completeness. However, we note that a more meaningful interpretation of B-IBI is to compare data against long-term observations. In addition to monitoring raw numerical B-IBI scores, variations in the species composition also serves as a strong indicator of stream health.

Raw benthic invertebrate analysis data, B-IBI score calculations, habitat assessment, and site photos are provided in Appendix C.

4.2.6 Water Quality Sampling (Township of Langley)

To support the aquatic assessment, the Township of Langley requested that water quality sampling be conducted within the Township’s portion of the study area.

We conducted sampling at three sites within the Township of Langley on October 22 and 23, 2014. The sampling locations are shown on Map 4-3. We collected one sample at each site. The sample ID’s for Unnamed Tributary 1, Unnamed Tributary 1A and Latimer Creek are W1, W2, and W3, respectively. We collected samples in accordance with the BC Ambient Freshwater and Effluent Sampling methodology (MoE, 2003).

Field parameters including temperature, pH, and dissolved oxygen were measured using a YSI probe. Water quality samples were collected for laboratory analysis of turbidity, pH, conductivity, alkalinity, total N, ammonia-N, nitrate-N, nitrite-N, total phosphorous, total metals, dissolved metals, extractable petroleum hydrocarbons (PAH), mineral oils and gas (MOGs), and total suspended solids (TSS). A trip blank and a field duplicate were analyzed for quality assurance. Water quality samples were kept at or below 5°C (refrigerated and/or in coolers on ice) during storage and transportation, and were submitted to the lab within the specified holding times. Laboratory analysis was conducted by ALS Ltd.

We note that no historical water quality data has been provided for the study area.

Water Quality Sampling Results

Table 4-13 provides a summary of the water quality sampling results. The table compares all water quality results to the BC Water Quality Guidelines for Freshwater Aquatic Life (BCWQG 2006) and to the Canadian Environmental Quality Guidelines for the Protection of Aquatic Life (CCME 2007). In general, the results are typical of moderately urbanized streams in the Lower Fraser Valley. Full laboratory results are provided in Appendix D.

Table 4-13
Select Water Quality Sampling Results

Parameter	Unit	CCME[1]	BC WQG[2]	W1	W2	W3
Field Measurements- General Parameters						
Temp	°C	-	See note[3]	12.7	13.9	13.2
pH	pH units	6.5 - 9.0	6.5 - 9.0	6.53	7.30	7.07
Dissolved Oxygen	mg/L	6.5 min[4]	5.0 min[5]	9.34	9.68	10.27
	%	-	-	88.8	95.1	99.4
Laboratory Results- General Parameters						
Hardness ($CaCO_3$)	mg/L	-	-	63.7	41.1	58.9
TSS	mg/L	25[6]	25[7]	4.3	8.4	4.5
Turbidity	NTU	See note[8]	See note[9]	22.8	18.1	6.99
Conductivity	uS/cm	-	-	199	115	150
Laboratory Results- Anions and Nutrients						
Total N	mg/L	-	-	1.77	1.45	1.65
Ammonia-N	mg/L	See note[10]	See note[11]	0.0234	0.0167	<0.0050

Parameter	Unit	CCME[1]	BC WQG[2]	W1	W2	W3
Nitrate-N	mg/L	3.0[12]	See note[13]	1.18	1.03	1.25
Nitrite-N	mg/L	0.06	0.06	0.0052	0.0069	0.0045
Total P	µg/L	-	-	0.0402	0.0461	0.0477
Laboratory Results- Organics and Hydrocarbons						
MOG	mg/L	-	-	<5.0	<5.0	<5.0
EPH10-19	mg/L	-	-	<0.25	<0.25	<0.25
EPH19-32	mg/L	-	-	<0.25	<0.25	<0.25

Bolded values indicate exceedance of guidelines

1) Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME 2007), updated to 2012.
2) BC Water Quality Guidelines (Criteria) Reports for Freshwater Aquatic Life (BCWQG 2006), updated to 2010.
3) Change of +/- 1 °C from optimal temperature for bull trout (incubation: 2.0 - 6.0 °C; rearing: 6.0 - 14.0 °C; spawning: 5.0 - 9.0 °C). See Tables 1 and 2 in Temperature: Overview Report (2001) from BCWQG. Bull trout temperatures used due to their high thermal sensitivity.
4) Dissolved oxygen minimum for cold water biota (salmonids): early life stages = 9.5 mg/L; other life stages = 6.5 mg/L.
5) Dissolved oxygen instantaneous minimum: buried embryo/alevin life stages = 9 mg/L; all other life stages = 5 mg/L. 30-day mean: buried embryo/alevin life stages = 11 mg/L; all other life stages = 8 mg/L.
6) Clear flow: maximum increase of 25 mg/L from background levels for any short-term exposure (e.g., 24-h period). Maximum average increase of 5 mg/L from background levels for longer term exposures (e.g., inputs lasting between 24 hours and 30 days).
7) Maximum total suspended sediments of 25 mg/L in 24 hours when background is less than or equal to 25; mean of 5 mg/L in 30 days when background is less than or equal to 25; 25 mg/L when background is between 25 and 250 mg/L; 10% increase when background is greater or equal to 250 mg/L.
8) Clear flow: maximum increase of 8 NTU from background levels for a short-term exposure (e.g., 24-hour period). Maximum average increase of 2 NTU from background levels for a longer term exposure (e.g., 30-day period).
9) Maximum turbidity: when background is less than or equal to 8 NTU = 8 NTU in 24 hours; when sediment inputs last between 24 hours and 30 days = mean turbidity should not exceed background by more than 2 NTU.
10) Ammonia maximum varies as a function of pH and temperature. See Table 2 in Ammonia (total) Fact Sheet, Update 2010 from CCME.
11) Ammonia maximum varies as a function of pH and temperature. See Table 3 in Nitrogen - nitrate, nitrite, ammonia: Overview Report (2009) from BCWQG.
12) Nitrate as nitrogen long-term exposure for the protection of freshwater aquatic life is 3.0 mg/L. See Table 2 in Nitrate Ion Factsheet (2012) from CCME.

13) Nitrate as nitrogen maximum is 32.8 mg/L. Where nitrate and nitrite are present, the total should not exceed this value.

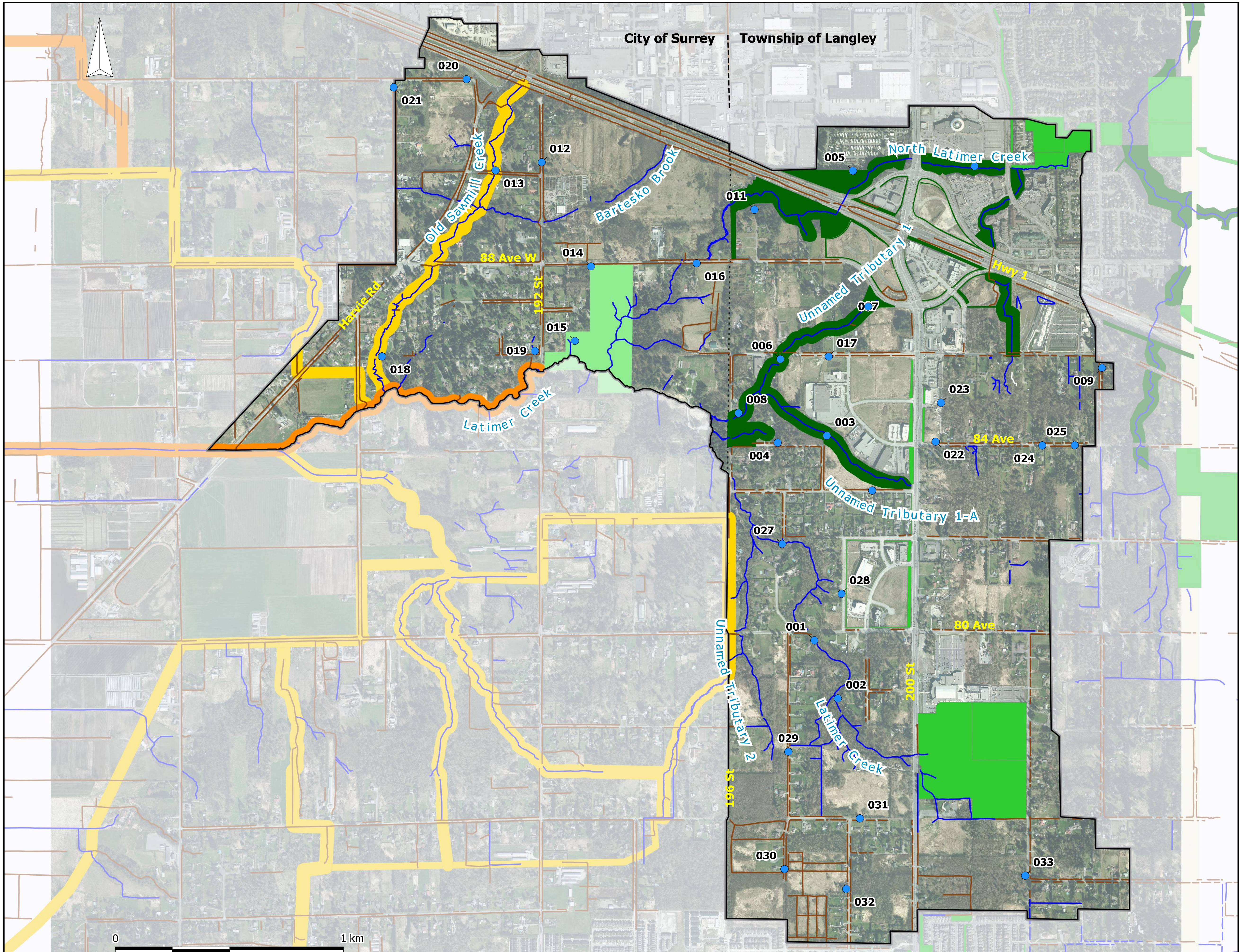
Our general observations regarding the results of the water quality sampling are summarized below:

- General water quality parameters were similar between streams.
- Dissolved oxygen was lowest in W1 followed by W2 and W3.
- Turbidity was highest at W1 followed by W2 and W3 Total suspended solids were highest in W2 while conductivity was lowest.
- Anions and nutrient concentrations were low and were similar between streams.
- No organics or hydrocarbons were detected in the streams.
- Total and dissolved metal concentrations were generally low or below detection limits.

Beyond these general observations, it is challenging to comment on overall water quality based on a single sampling period. Water quality sampling should be conducted on a long-term basis, to monitor potential changes over time, as these changes could reflect improvements and/or degradation to overall watershed health. Recommendations regarding water quality monitoring are presented in Section 13.

Water Quality Sampling QA/QC

For quality assurance to be acceptable, the calculated result must meet a specified Data Quality Objective (DQO). For duplicates, the recommended DQO is <20% relative percent difference (RPD). For trip blank samples, recommended DQO is that blank values should be at or below the detection limit. All trip blanks were below detection limits for the selected parameters, and all duplicate samples were below 20.0% RPD, with the exception of TSS, which was 20.9%. As the RPD difference for TSS was only marginally higher than the recommended limit, and the measured values were overall very low, this result is considered inconsequential.



LEGEND

- ASSESSMENT SITE

SURREY

EXISTING GIN

- HUBS & SITES
- LOCAL CORRIDOR
- REGIONAL CORRIDOR

LANGLEY

- EXISTING PARKS
- EXISTING CONSERVATION AREAS
- WATERCOURSE

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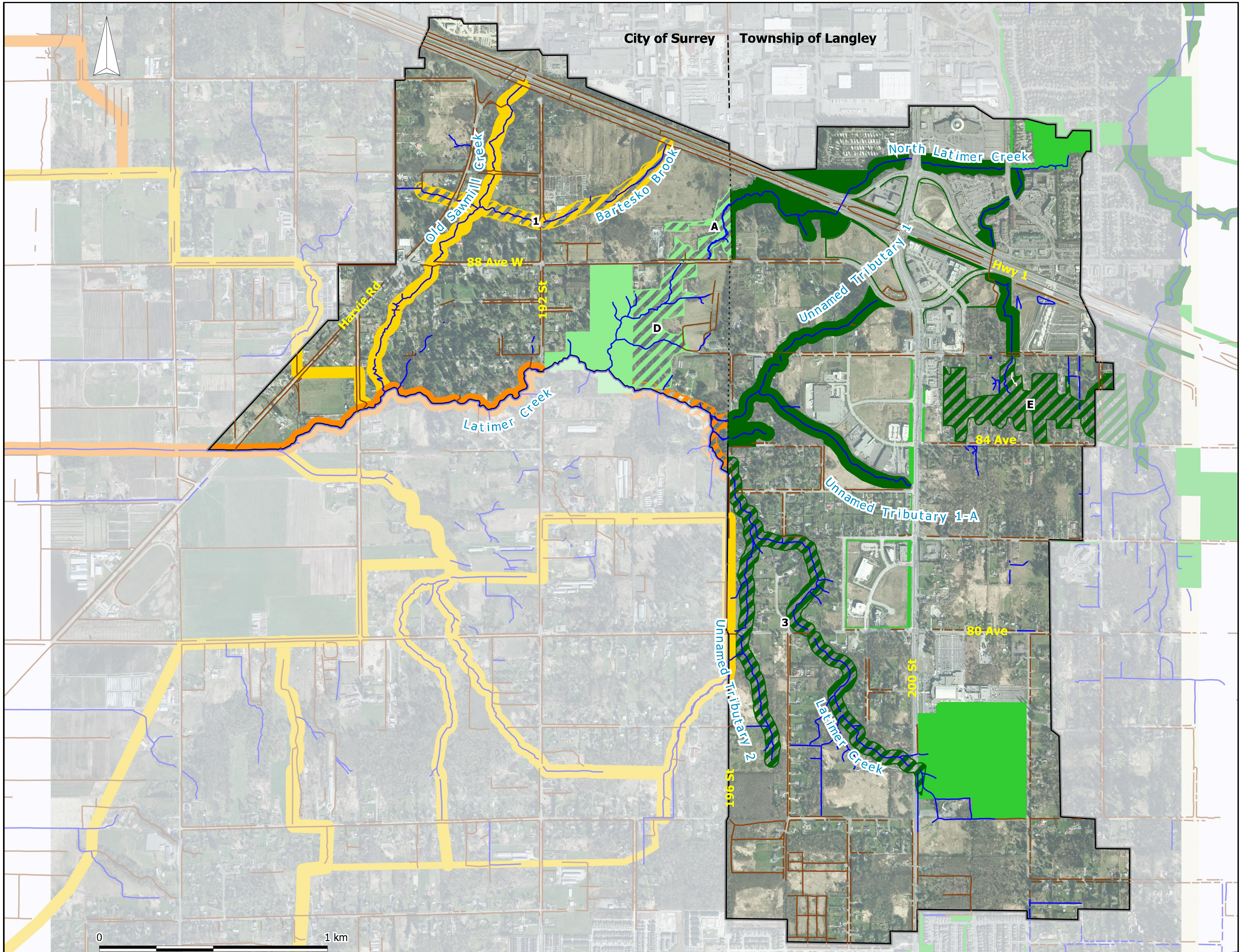
LATIMER CREEK ISMP

TERRESTRIAL ASSESSMENT LOCATIONS

DRAWING NUMBER	REV. NO.	SHEET
MAP 4-1		



Map File: P:\20142768\00_Latimer_Ck_ISMP\Working_Dwgs\010_GIS\map_latimer_ismp_report_figures_20150508_zs.map

LEGEND

SURREY

EXISTING GIN

- HUBS & SITES
- LOCAL CORRIDOR
- REGIONAL CORRIDOR

PROPOSED GIN

- HUBS & SITES
- LOCAL CORRIDOR
- REGIONAL CORRIDOR

LANGLEY

- EXISTING PARKS
- EXISTING CONSERVATION AREAS
- ADDITIONAL HIGH VALUE AREAS
- WATERCOURSE

SITE IDs REFER TO INFORMATION PRESENTED IN TABLE 4-4.

SCALE:	1:16,000		
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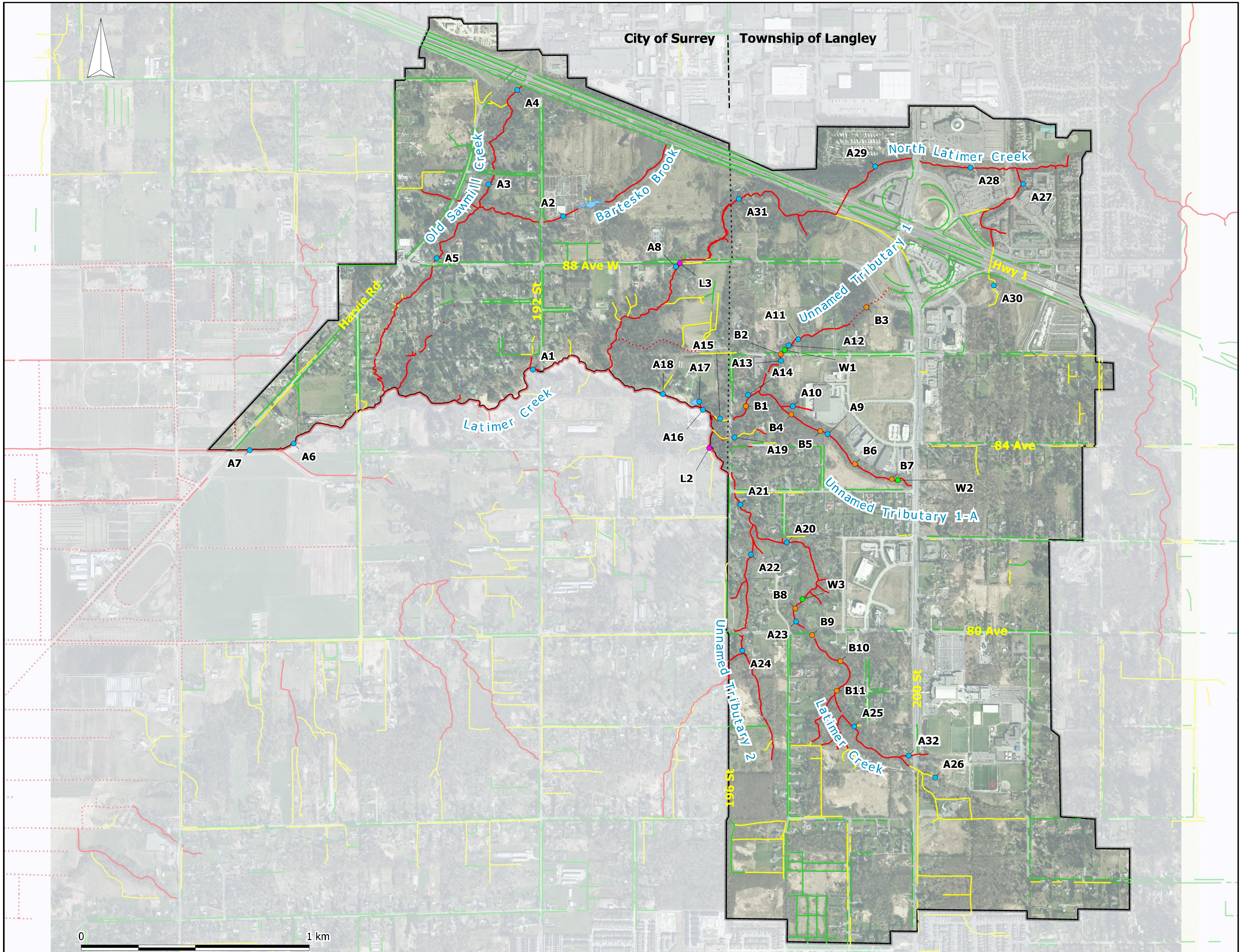
LATIMER CREEK ISMP

TERRESTRIAL NETWORK ENHANCEMENT OPPORTUNITIES

DRAWING NUMBER	REV. NO.	SHEET
MAP 4-2		



LEGEND

- B-IBI SITE - LANGLEY
- **B1** B-IBI SAMPLING SITE ID (ISMP)
- B-IBI SITE - SURREY*
- **L2** SURREY B-IBI SAMPLING SITE ID
- AQUATIC ASESSMENT SITE
- **A1** AQUATIC ASSESSMENT SITE ID
- WATER QUALITY SITE
- **W1** WATER QUALITY SITE ID

WATERCOURSE CLASSIFICATION

- Class A
- Class A(O)
- Class B
- Class C

SITE IDs REFER TO INFORMATION PRESENTED IN APPENDIX B, APPENDIX C, AND TABLE 4-13.

NOTE:
* DATA PROVIDED BY CITY OF SURREY

SCALE:	1:16,000		
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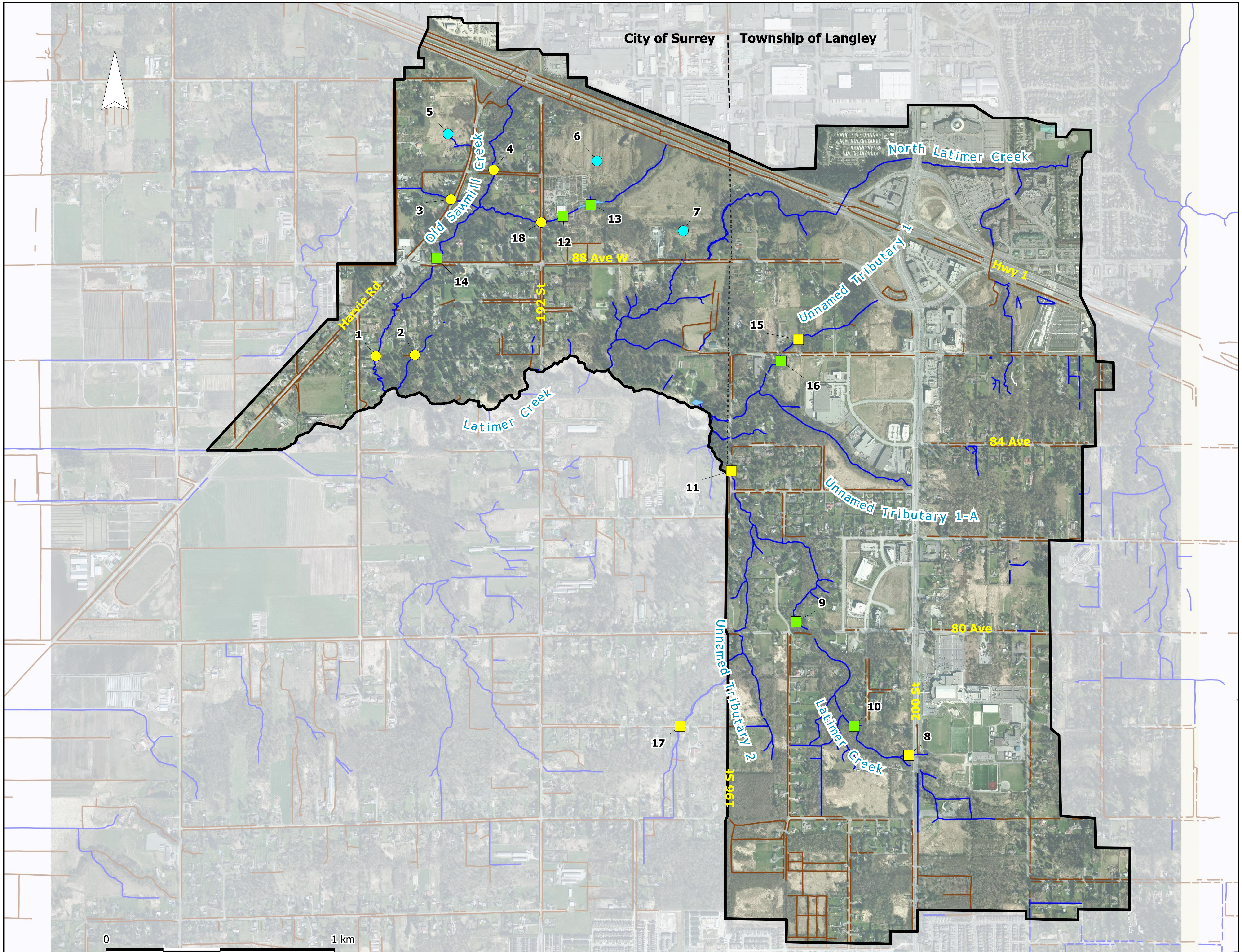
LATIMER CREEK ISMP

WATERCOURSE CLASSIFICATION

DRAWING NUMBER	REV. NO.	SHEET
MAP 4-3		

Map File: P:\20142768\00_Latimer_Ck_ISMP\Working_Dwgs\010_GIS\map_latimer_ismp_report_figures_20141029_ad.map



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LEGEND

RECOMMENDED IMPROVEMENTS

DRAINAGE IMPROVEMENTS
(Refer to Table 10-1)
Culvert
Pond

ENVIRONMENTAL IMPROVEMENTS
(Refer to Table 4-10)
Channel
Culvert

SCALE:	1:16,000		
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LATIMER CREEK ISMP

RECOMMENDED DRAINAGE AND ENVIRONMENTAL IMPROVEMENTS

DRAWING NUMBER	REV. NO.	SHEET
MAP 4-4		

5 Watershed Health Assessment

The Template for Integrated Stormwater Management Planning (Metro Vancouver, 2005) provides guidance on assessing the health of a watershed by using two physical characteristics: total impervious area and percent riparian forest integrity. Also, in principle the Benthic Index of Biotic Integrity (B-IBI), if available, can provide further information on watershed health from a biological perspective.

Total Impervious Area (TIA) provides an estimate of the fraction of paved and hard surface areas within a watershed. The more developed a watershed, the higher a percentage of impervious areas, such as roads, buildings and parking lots. These restrict the amount of land available to support natural infiltration and evapotranspiration of rainfall volumes. The result is a significant change to a watershed's hydrology compared to natural, undeveloped conditions, which often results in changes to stream hydrology (higher high flows, lower base flows) and has been correlated to detrimental stream health and the ability of such streams to provide suitable fish habitat.

TIA calculations assume that impervious surfaces do not provide any infiltration, which is not necessarily the case if source controls are implemented. As such, a common supplement to TIA is the Effective Impervious Area (EIA), which assumes the disconnection of a portion of impervious surfaces from watercourses. Source controls can effectively lower the TIA of a watershed, allowing for improved watershed health. EIA refers to this lowered value of impervious area, and is an important consideration when considering long-term watershed health planning. However, estimation of EIA is a somewhat subjective process, based on interpretation of conditions within developed areas.

Riparian Forest Integrity (RFI) describes the fraction of riparian forest that remains intact within a 60 m buffer zone from watercourses (30 m on either side of the stream). It is well understood that intact natural vegetation within this corridor support stream health by providing shade, supporting nutrient cycling, stabilizing erodible banks, promoting hydrologic processes such as interception and infiltration and supporting terrestrial biodiversity. Currently, property development within these corridors is generally regulated through provincial regulations and/or municipal bylaws, though this is not always the case.

5.1 IMPERVIOUS AREA ASSESSMENT

To establish the existing TIA and EIA of the watersheds within the study area, we assigned TIA and EIA values based on land use characteristics within the study area, supplemented by a review of aerial imagery.

The values used for TIA were adapted in part from the City of Surrey's Engineering Design Criteria Manual (2004), as well as the Township of Langley's Subdivision and Servicing Bylaw No. 4861 (2011). Values for EIA were assumed for each land use classification based on values used in previous studies. The resulting values used in the assessment of watershed TIA and EIA are presented in Table 5-1.

Table 5-1
Assumed Total and Effective Impervious Areas by Land Use

Land-Use Classification	Total Impervious Area (%)	Effective Impervious Area (%)
Agricultural	20%	10%
One Acre Residential (Surrey)	50%	40%
Commercial	90%	80%
Comprehensive Development (Surrey)	90%	80%
Industrial	90%	80%
Institutional	80%	70%
Residential (Langley)	75%	65%
Suburban Residential (Langley)	20%	10%
Comprehensive Development (Langley)	75%	65%

As noted above, the portion of the study area within the City of Surrey is predominately zoned as One Acre Residential and/or Agricultural. We identified two areas where existing development does not reflect the zoning – in the northwest corner of the study area, west of Harvie Road, there is a notable area that has not been developed. Similarly, there is an undeveloped portion of land north of 88 Avenue between 192 Street and 196 Street. In each case we adjusted the impervious areas to reflect current conditions.

We calculated TIA and EIA for the study using the land-use classification mapping in Map 5-1 in concert with the TIA and EIA values for each land use classification. We performed an area-weighted calculation of TIA and EIA for the study area as a whole, as well as for the respective portions of the study area within the City of Surrey and the Township of Langley. The results are presented in
Table 5-2.

Table 5-2
Calculated Total and Effective Impervious Areas

Geographic Extents	Total Impervious Area (%)	Effective Impervious Area (%)
Entire Study Area	39%	29%
City of Surrey Portion	42%	32%
Township of Langley Portion	37%	27%

5.2 RIPARIAN FOREST INTEGRITY ASSESSMENT

We included the major watercourses and their tributaries in the RFI assessment. Map 5-2 compares the desirable 60 m riparian buffer with the identified actual forested buffer along the watercourses within the study area. We calculated the RFI for the study area as a whole, as well as for the respective portions of the study area within the City of Surrey and the Township of Langley. The results are presented in Table 5-3.

Table 5-3
Riparian Forest Integrity

Geographic Extents	Riparian Forested Integrity (%)
Entire Study Area	68%
City of Surrey Portion	67%
Township of Langley Portion	69%

5.3 BENTHIC INVERTEBRATE COMMUNITIES

The ISMP Template (Metro Vancouver, 2005) suggests that monitoring of the benthic invertebrate community within a given watershed can be used to add further detail to watershed health assessments.

The establishment of a Benthic Invertebrate Index of Biotic Integrity (B-IBI) score for a watershed can be used to assess the effectiveness of watershed planning. The B-IBI score determined through monitoring can be compared with a theoretical B-IBI score based on RFI and TIA. The comparison provides an indication of whether the watershed is performing either better or worse than would be expected given the RFI and TIA.

As discussed in Section 4.2.5, B-IBI data is available within the City of Surrey, and was supplemented by sampling conducted within the Township of Langley.

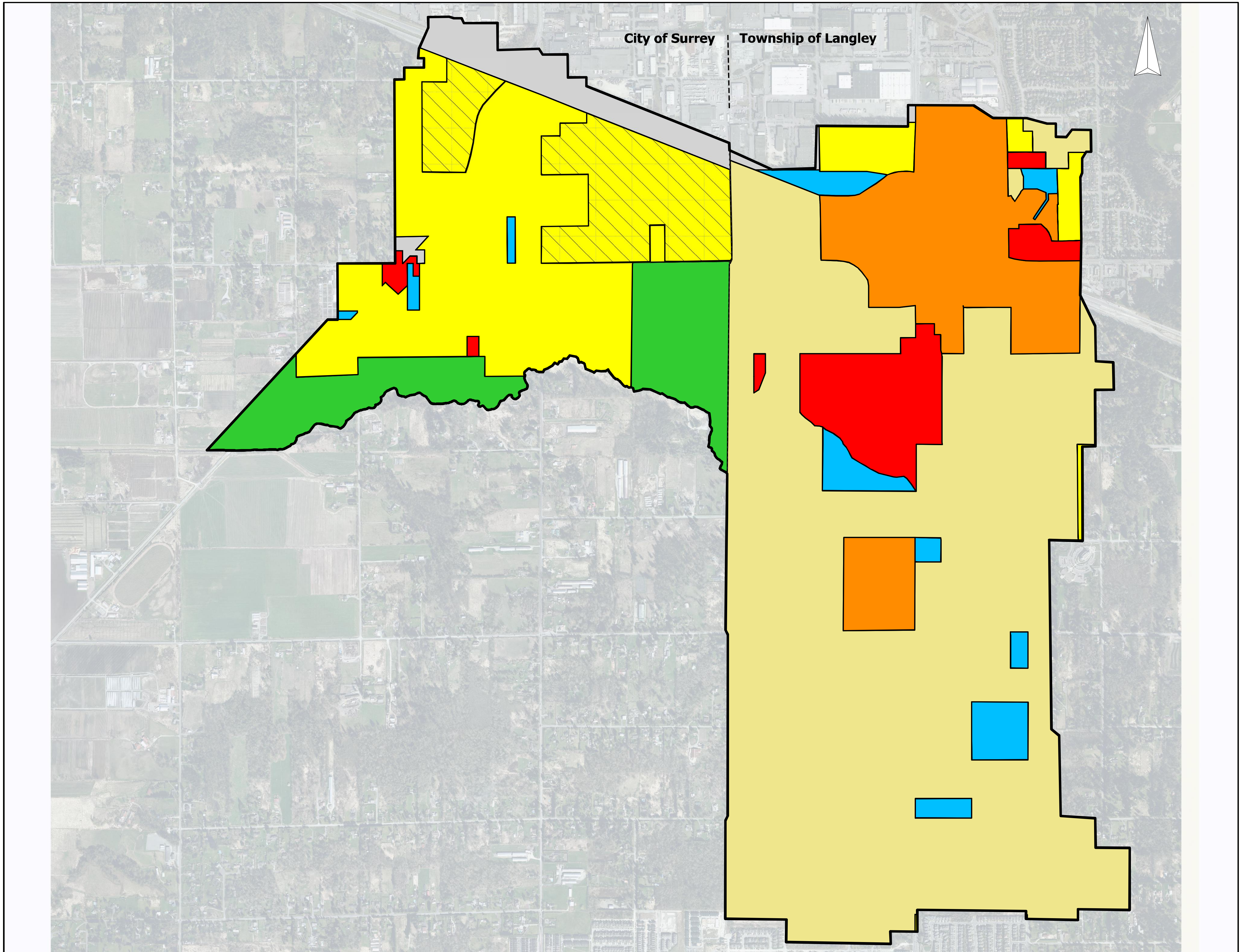
5.4 WATERSHED HEALTH

The health of the study area (as well as the City of Surrey and Township of Langley portions) was plotted using EIA and RFI following the Watershed Health Tracking System methodology outlined in the ISMP Template (Metro Vancouver, 2005).

The EIA and RFI values for existing conditions are presented in Table 5-2 and Table 5-3, respectively, and are overlain on the template chart presented as Figure 5-3.

The Watershed Health Tracking System provides a qualitative indicator of watershed health. A fully healthy watershed would have very high (>90%) RFI, and very low (<5%) EIA, and therefore would plot in the upper left-hand corner of the Health Tracking System figure. As RFI decreases and EIA increases, the watershed health degrades and the plotting position moves toward the bottom right-hand corner of the figure.

Based on the available data from Surrey's B-IBI monitoring program, combined with the data collected through the sampling we completed as part of the current ISMP, the study area appears to be performing slightly better than expected, based on the EIA and RFI values. Based on the EIA and RFI values, the GVRD watershed health tracking system indicates that the B-IBI scores are expected to be in the range of 17 to 18; as discussed in Section 3.2.6, the B-IBI scores vary from 14.7 to 28.0. The average value of the scores presented in Table 4-12 is 20.0.



LEGEND

LAND USE TYPE

- AGRICULTURAL
- COMMERCIAL
- COMPREHENSIVE DEVELOPMENT
- INDUSTRIAL
- INSTITUTIONAL
- RESIDENTIAL
- RESIDENTIAL UNDEVELOPED
- SUBURBAN RESIDENTIAL

TOWNSHIP OF LANGLEY LAND USE MAPPING IS BASED ON THE DATA PROVIDED. FOR ADDITIONAL DETAILS REGARDING LAND USE CONCEPT PLANS PRESENTED IN THE VARIOUS NEIGHBOURHOOD PLANS, REFER TO APPENDIX E.

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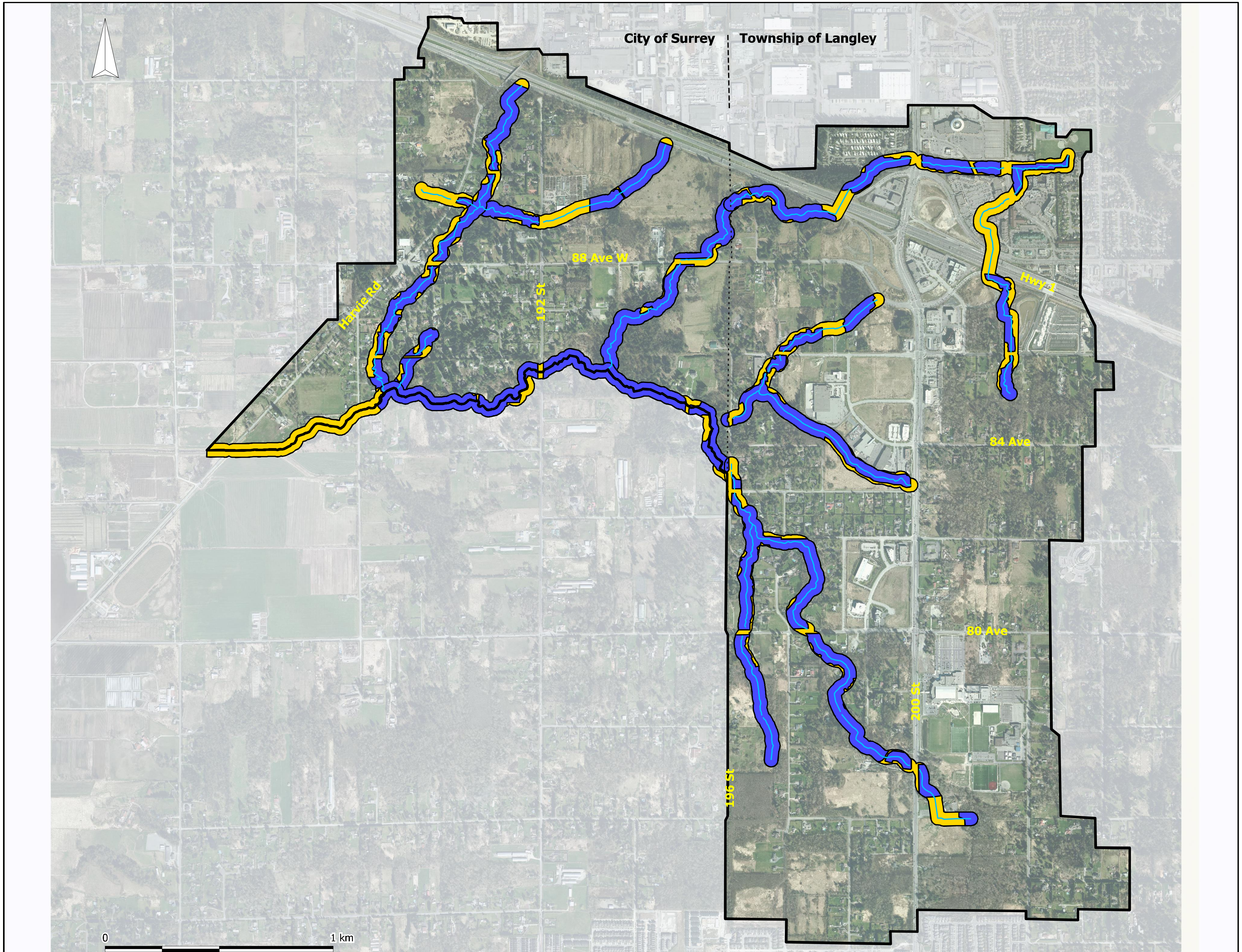
LATIMER CREEK ISMP

LAND USE

DRAWING NUMBER	REV. NO.	SHEET
MAP 5-1		

Map File: P:\20142768\00_Latimer_Crk_ISMP\Working_Dwgs\010_GIS\map_latimer_ismp_report_figures_20141029_ad map



Map File: P:\20142768\00_Latimer_Crk_ISMP\Working_Dwgs\010_GIS\map_latimer_ismp_report_figures_20141029_ad.map

LEGEND

- INTACT FOREST WITHIN RIPARIAN BUFFER ZONE
- 60m RIPARIAN BUFFER ZONE
- WATERCOURSE

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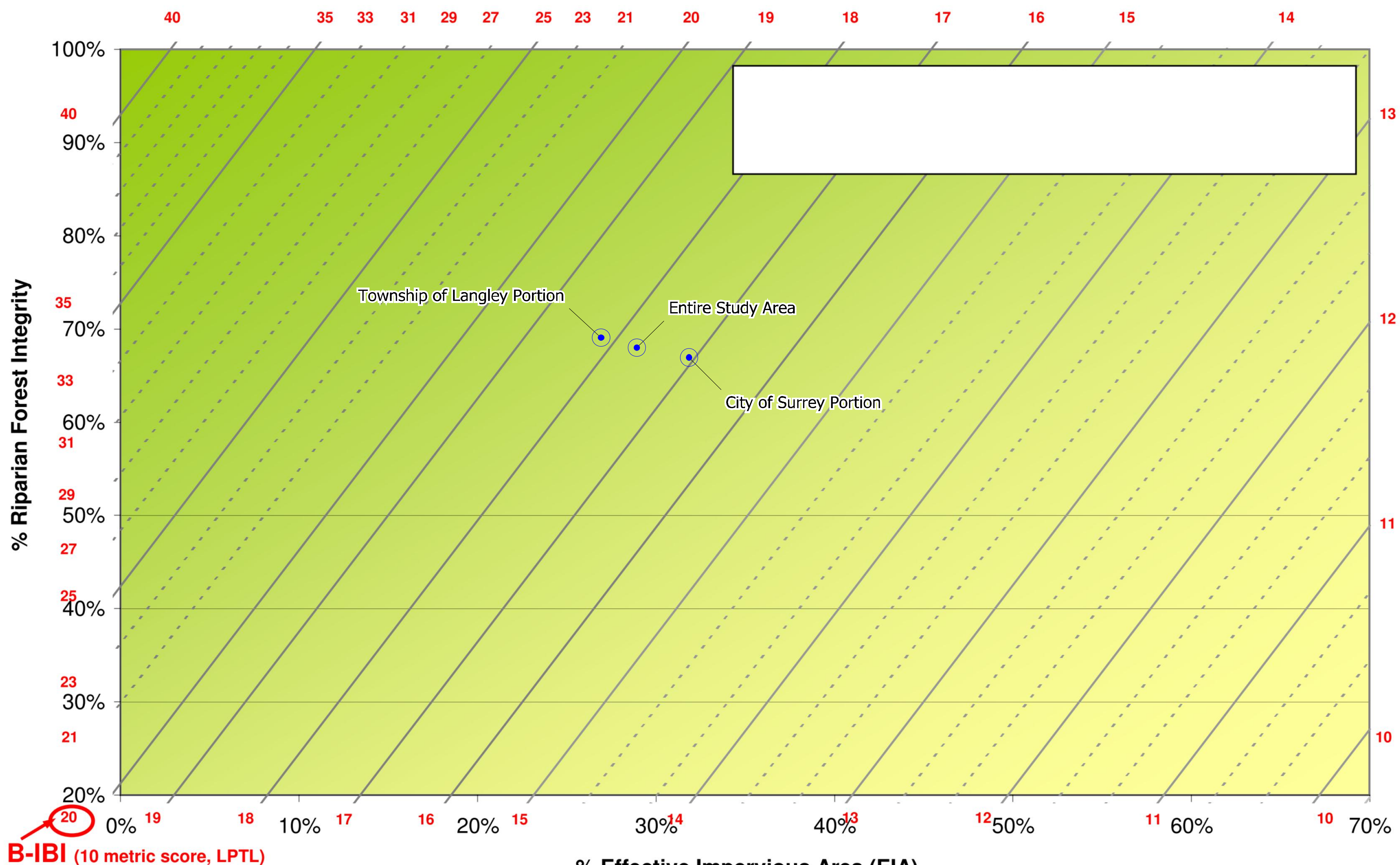
LATIMER CREEK ISMP

RIPARIAN FOREST INTEGRITY

DRAWING NUMBER	REV. NO.	SHEET
MAP 5-2		

GVRD WATERSHED HEALTH TRACKING SYSTEM - Permanent Flow Creeks



Source: Kerr Wood Leidal Associates Ltd. 2005

Note: B-IBI values are based on data from multiple sources, with sampling completed by multiple firms. Variations in the benthic samples include the sampling methods, the year in which samples were collected, and the time of year (season) that sampling was conducted.

LEGEND

SCALE:			
PROJECT NO.	2014-2768	INITIAL	DATE
DRAWN		JT	15-09-04
DESIGNED			
CHECKED			
APPROVED			
PROJECTION:	UTM ZONE 10N NAD 83		

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LATIMER CREEK ISMP

GVRD WATERSHED HEALTH ASSESSMENT

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 5-3		

Map File: \\s-bur-fs-01\projects\20142768\00_Latimer_Crk_ISMP\Working_Dwgs\010_GIS\map_latimer_ismp_report_figures_20141117_ad.mxd

6 Riparian Setbacks

Riparian zones are the areas that surround watercourses or wetlands. Immediately adjacent to the watercourses are the areas that are intermittently wetted by rising water levels. These 'riparian buffer' areas generally provide direct support to aquatic habitat by providing a natural source of woody debris, nutrient input, and resistance to bank erosion. Beyond this region of direct watercourse influence, the 'riparian corridor' provides further ecological benefits, including temperature regulation (shade) for the watercourse, and support of terrestrial biodiversity and wildlife corridors. In locations where the watercourse is located within a ravine, the 'riparian area' that provides ecological benefits can extend beyond the top of the ravine banks.

Intact riparian areas are essential to support the health of watercourses, wetlands, ponds and lakes, and ultimately watershed health. As such, it is essential for the City and the Township to promote the creation and enhancement of riparian areas by enforcing guidelines that require developments to be offset from these features. These offsets must consider the ecological function of the entire riparian zone, and not just the riparian buffer immediately adjacent to the watercourse.

The City of Surrey's Biodiversity Conservation Strategy provides guidelines on the recommended riparian setback distances based on watercourse classification. Table 6-1 presents the recommended riparian setbacks outlined in the BCS.

Table 6-1
City of Surrey BCS – Riparian Setback Recommendations

Watercourse Classification	Riparian Setback
A, A(O), ponds and lakes	30 m
B, wetlands	15 m
C	5 m

As noted in the BCS, these values are consistent with the widths set out in the Land Development Guidelines for the Protection of Aquatic Habitat (DFO, 1993).

In addition to the riparian setback recommendations, the BCS also provides target corridor widths for the regional and local corridors that have been identified within the City's Green Infrastructure Network (GIN). We have reviewed the target corridor widths specified within the BCS for all corridors within the current study area. Table 6-2 summarizes the corridors and recommended target widths as specified in the BCS.

Table 6-2
Target Widths for Corridors as per City of Surrey's GIN (BCS)

BCS ID	Description	Risk of Development	Ecological Value	Corridor Type	Target Width
130	Latimer Creek Downstream of Harvie Rd	Moderate	Moderate	*Local**	60 m
131	Old Sawmill Creek	Moderate	Moderate	Local	60 m
132	Latimer Creek – 88 Ave to Harvie Road	Moderate	High	Regional	60 m

*Note – Latimer Creek d/s of Harvie Road is identified as regional corridor throughout the BCS. It appears as though it may be incorrectly labelled as a "Local" corridor in the BCS 'Table 33 Inventory of Corridors.'

The recommended riparian setbacks from the BCS, and from the Provincial Land Development Guidelines, are measured from the high water mark. As such, the total required leave strip width for fish bearing watercourses under the riparian setback guidelines would be 60 m (30 m each side) plus the main channel width. We note that, for the three GIN Corridors within our study area, the riparian setback areas would also achieve the Target Corridor widths that are recommended as part of the City's BCS.

The City of Surrey is currently in the process of establishing a Riparian Area Bylaw; it is anticipated to be approved by Council in 2015.

While the watercourse centerline data is readily available from both the City of Surrey and the Township of Langley, the high water mark has not been delineated along the length of the watercourses. Accurate high water mark delineation would require a significant amount of field survey throughout the study area, which is beyond the scope of the current assignment.

For the purposes of the current riparian setback mapping, we have assumed an average stream width of 4 m.

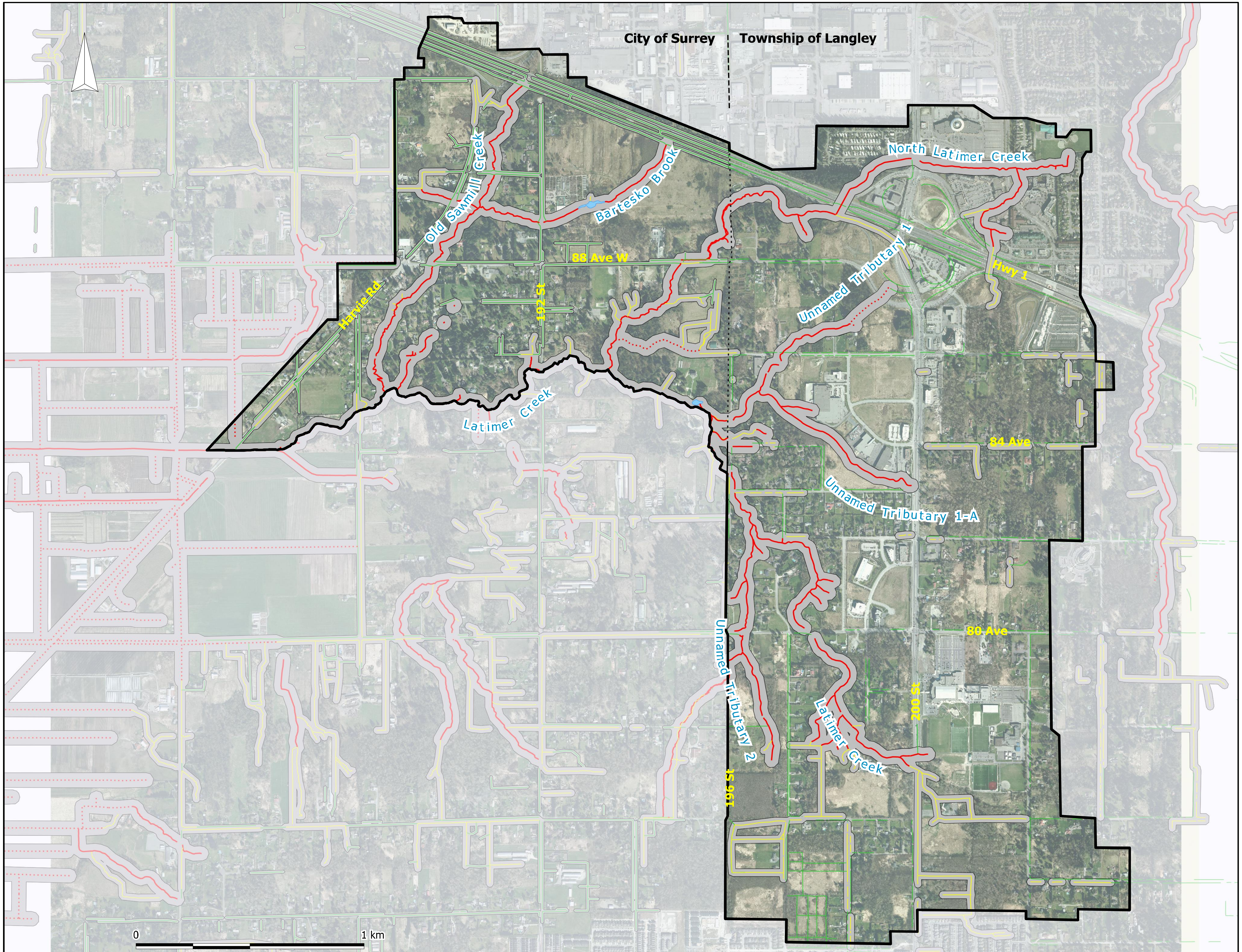
Within the Township of Langley, streamside setback areas are specified within the Amendment (Streamside Protection) Bylaw 2006 No. 4485. The setback requirements vary, based on the watercourse classification. The applicable setbacks within the ISMP study area are summarized in Table 6-3.

Table 6-3
Township of Langley Streamside Protection and Enhancement Development Permit Area Widths

Watercourse Classification	Riparian Setback
A	30 m
B (natural watercourse)	20 m
B (constructed watercourse, base width >= 0.5 m)	15 m
B (constructed watercourse, base width < 0.5 m)	10 m
B (roadside watercourse)	6 m
C	0 m

While the Township's watercourse mapping provides the watercourse classification, it does not specify the watercourse sub-classification (i.e. natural / constructed / roadside). As directed by the Township, for the purposes of this ISMP, we used a riparian setback of 15 m for all class B watercourses. We also note that, as outlined in the Township's streamside protection bylaw, there are no setbacks along Class C watercourses.

Map 6-1 shows the riparian setbacks for watercourses throughout the study area based on the guidelines presented in the BCS.



LEGEND

STREAM CLASS
A
AO
B
C
UN
POND
NOMINAL RIPARIAN SETBACK

SCALE:	1:16,000		
PROJECT NO.	2014-2768	INITIAL	DATE
DRAWN		JT	15-09-04
DESIGNED			
CHECKED			
APPROVED			
PROJECTION:	UTM ZONE 10N NAD 83		

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LATIMER CREEK ISMP

RIPARIAN SETBACKS
FOR EVALUATION PURPOSES

DRAWING NUMBER	REV. NO.	SHEET
MAP 6-1		

Map File: P:\20142768\00_Latimer_Ck_ISMP\Working_Dwgs\010_GIS\map_latimer_ismp_report_figures_20150508_zs.map

7 At-Risk Areas

Within the City of Surrey, expected modifications to land use under future conditions include:

- The area between 192 Street and 196 Street, north of 88 Avenue, was assumed to be One Acre Residential under future development conditions, as per the City's Zoning for this area.

- The area west of Harvie Road was updated to reflect the land uses proposed under the South Port Kells GLUP, which include Cluster Residential, Urban Residential, and Business Center.

- The remainder of the study area is based on the City's Zoning. These areas have already been developed as per the Zoning. There are no changes expected for these areas relative to the land use under Existing Development Conditions.

Within the Township of Langley, future development is expected to occur as outlined in the various neighbourhood plans that have been completed as part of the Willoughby Community Plan, including:

- Carvolth Neighbourhood Plan
- Jericho Sub-Neighbourhood Plan
- Routley Neighbourhood Plan
- Latimer Neighbourhood Plan (Pending – Details not yet available)

7.1 AT-RISK ENVIRONMENTAL HUBS AND CORRIDORS

The City's BCS identifies a number of existing and proposed hubs and corridors within the study area. For each of these sensitive areas, the BCS comments on the risk of development and the ecological value. Table 7-1 summarizes the hubs and corridors within the study area that are identified in the City's BCS.

Table 7-1
Risk of Development to GIN as per City of Surrey BCS

Label / ID	Type	Risk of Development	Ecological Value
130	Regional Corridor	Moderate	Moderate
131	Local Corridor	Moderate	Moderate
132	Regional Corridor	Moderate	High
Port Kells Park	Hub	Low	High
Proposed Site N	Site	Moderate	High

In addition to the areas that are already identified as part of the GIN within the City's BCS, we identified additional opportunities to establish corridors, sites, hubs, and general conservation areas within the study area, as presented in Table 7-2.

Table 7-2
Potential GIN Enhancement Opportunities

Identifier	Type
A	Hub
D*	Site
E	Conservation Area
1	Corridor
3	Conservation Area

*Note – We note that Proposed Hub D is already identified as a Proposed Site within the City's BCS.

The location-specific terrestrial network enhancement opportunities are discussed in detail in Section 4.1.3.

7.2 IMPACTS OF PLANNED DEVELOPMENT

In addition to the Risk of Development Rankings provided by the City's BCS, we compared locations of known development within the study area to the environmentally sensitive areas to identify the potential impacts of planned development (i.e. development locations that coincide with environmentally sensitive areas).

The planned developments and the corresponding impacts to the corridors/hubs/sites/conservation areas are outlined below.

One Acre Residential between 192 Street and 196 Street, north of 88 Avenue (City of Surrey)

This area is zoned as One Acre Residential under the City's current zoning. Although currently undeveloped, it is anticipated that development will occur in accordance with the zoning. We note that this area coincides with the proposed Corridor 1 along the alignment of Bartesko Brook. This potential corridor has been identified as an enhancement opportunity as part of the current ISMP; it is not currently identified within the City's BCS.

West of Harvie Road, South of Highway 1 (City of Surrey)

This area is contained within the South Port Kells General Land Use Plan (included in Appendix E). As outlined by the GLUP, future development within this area will include Cluster Residential, Urban Residential, and Business Center. We note that Cluster Zoning is a strategy to allow development to occur within pockets (or clusters), while preserving environmentally sensitive areas in proximity to the development.

This area coincides with the western extent of the proposed Corridor 1 along the alignment of Harvie Creek to the west of Harvie Road. This potential corridor has been identified as an enhancement opportunity as part of the current ISMP. While it is not explicitly designated as a corridor within the City's BCS, the South Port Kells GLUP does identify a setback area along Harvie Creek west of Harvie Road.

Carvolth Neighbourhood Plan (Township of Langley)

This neighbourhood plan establishes an Integrated Area Concept Plan that extends from 196 Street to 204 Street, and from 88 Avenue to 83 Avenue (included in Appendix E). The development plan comprises a variety of land uses including Office/Mixed Use, Commercial, and various Residential Uses.

The plan also identifies conservation areas along a number of watercourses, including North Latimer Creek, Unnamed Tributary 1, Unnamed Tributary 1-A, as well as the upper reaches of Latimer Creek south of Highway 1 near 202 Street.

As part of the Terrestrial Assessment, we identified an area with high environmental value located between 84 Avenue and 86 Avenue, and extending from just west of 201 Street to just east of 204 Street (Area 'E'). However, as indicated by the Integrated Area Concept Plan, this area is planned to be developed as High Density Residential, Medium Density Residential, and Townhouse Residential. We understand that development is expected to occur in accordance with the Carvolth Neighbourhood Plan, and that there is no opportunity to establish a conservation area at this location E to provide environmental protection.

Latimer Neighbourhood Plan (Township of Langley)

This neighbourhood plan establishes a land use plan that extends from 196 Street to the eastern limit of the study area, and from the southern limit of the study area within the Township to approximately 84 Avenue (included in Appendix E). The land use plan includes single family residential, rowhouse/townhouse, apartment, as well as some business office park and mixed use.

The plan also identifies Streamside Protection and Enhancement Areas along Latimer Creek and along Unnamed Tributary 2, which coincide with Proposed Corridor 3.

Jericho Sub-Neighbourhood Plan (Township of Langley)

The Jericho Sub-Neighbourhood Plan establishes a Land Use Concept Plan between 76 Avenue and 80 Avenue, which extends from approximately 202A Street in the east to Latimer Creek in the west. The Land Use Concept Plan is included in Appendix E for reference.

As indicated by the Land Use Concept Plan, the extents of development adjacent to Latimer Creek have been limited to maintain a setback area.

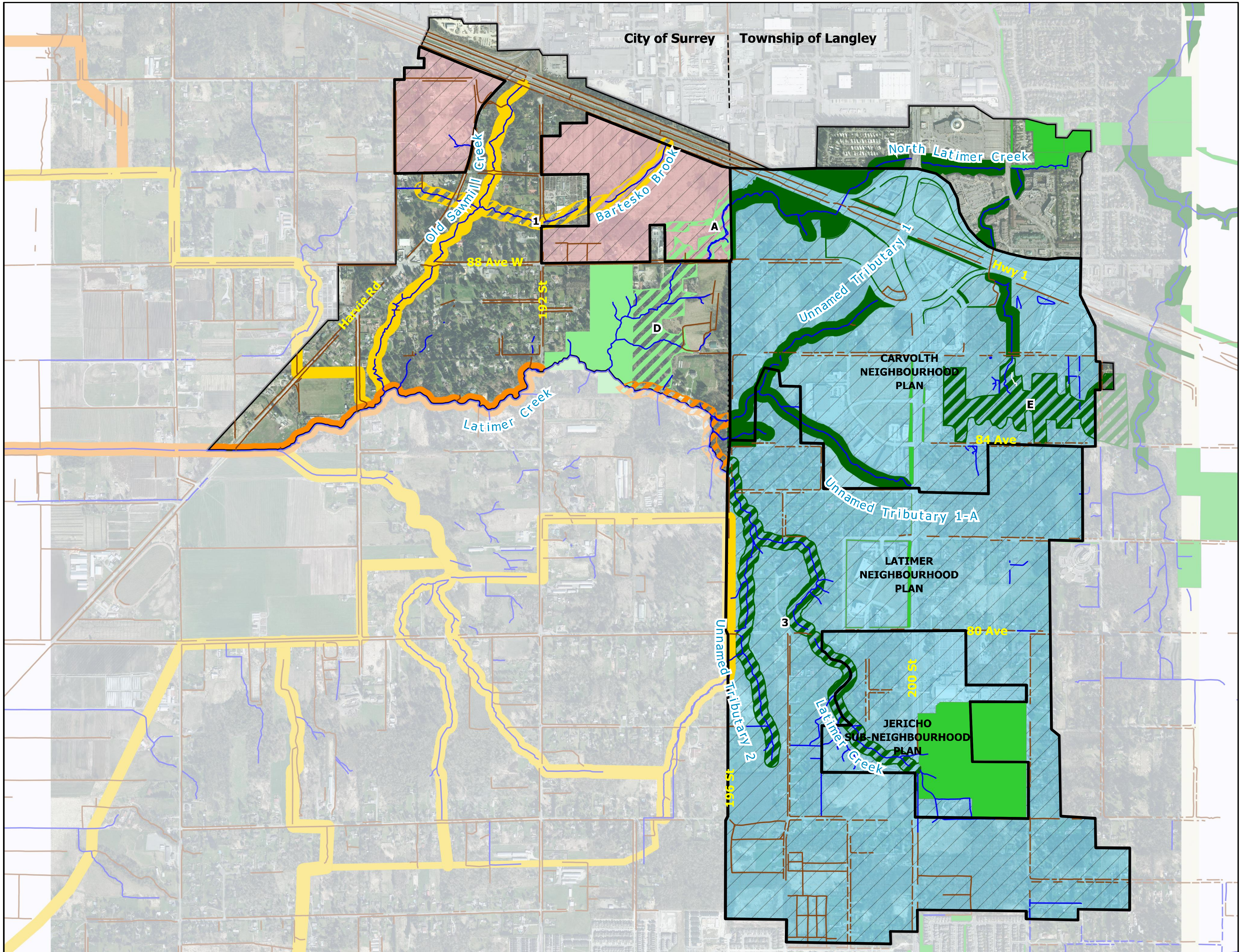
Routley Neighbourhood Plan (Township of Langley)

The Routley Neighbourhood Plan establishes a Land Use Concept between 68 Avenue and approximately 73 Avenue, from 196 Street to 200 Street. The majority of this area is slated for development as residential, with small pockets of institutional and commercial. There are also proposed internal greenways within the Land Use Concept.

We note that this Neighbourhood Plan is located immediately south of the current study area for the Latimer Creek ISMP; it does not impact any existing or proposed conservation areas.

7.3 AT-RISK AREA MAPPING

The extents of the various developments and neighbourhood plans discussed above are presented on Map 7-1, and are overlain on top of the Proposed Green Infrastructure Network. As discussed above, future development under the Carvolth Neighbourhood Plan will preclude the establishment of a conservation area between 84 Avenue and 86 Avenue, located between 201 Street to just east of 204 Street.



LEGEND

SURREY

EXISTING GIN
- HUBS & SITES
- LOCAL CORRIDOR
- REGIONAL CORRIDOR

PROPOSED GIN
- HUBS & SITES
- LOCAL CORRIDOR
- REGIONAL CORRIDOR

LANGLEY
- EXISTING PARKS
- EXISTING CONSERVATION AREAS
- ADDITIONAL HIGH VALUE AREAS

- FUTURE DEVELOPMENT AREA (SURREY)
- NEIGHBOURHOOD PLAN EXTENTS (LANGLEY)
- WATERCOURSE

SCALE:	1:16,000		
PROJECT NO.	2014-2768	INITIAL	DATE
DRAWN		JT	15-09-04
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APPROVED			
PROJECTION:	UTM ZONE 10N NAD 83		

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LATIMER CREEK ISMP

ENVIRONMENTALLY SENSITIVE AREAS AT RISK

DRAWING NUMBER	REV. NO.	SHEET
MAP 7-1		

Map File: P:\20142768\00_Latimer_Ck_ISMP\Working_Dwgs\010_GIS\map_latimer_ismp_report_figures_20150121_ad.map

8 Hydrologic & Hydraulic Event-Based Modelling

Within the Township of Langley's portion of the study area, stormwater management has already been completed under various neighbourhood plans and is not required as part of the current ISMP. As such, the hydrologic and hydraulic modelling completed for the current Latimer Creek ISMP is focused on the City of Surrey's portion of the study area.

8.1 EXISTING CONDITION

8.1.1 Model Approach

To assess the existing drainage system within the study area, we developed a hydrologic and hydraulic model of the existing network using PCSWMM software.

The modelled drainage network is presented in Map 8-1. The network consists primarily of open channels, with culverts at each road crossing. As discussed in Section 2, there is a limited extent of enclosed storm drains within the study area. Each of the storm drains provides local drainage for road rights-of-way, and does not provide conveyance for upstream portions of the system. As such, these localized storm drains were excluded from the model.

For the purpose of this ISMP, we divided the study area into catchments with an average area of approximately 15 ha, which is an appropriate scale for a planning-level assessment.

8.1.2 Base Model Assembly

8.1.2.1 Data Collection

The hydraulic model is based primarily upon the information provided by the City of Surrey. For our network, the key data includes culverts and watercourses, which are both maintained by the City as part of their digital GIS database.

To supplement the background information provided by the City, we undertook a field investigation on October 31, 2014. Our field assessment focused on confirming culvert information (material, dimensions, inlet geometry, outlet geometry) and watercourse information (geometry, Manning's roughness). Details from our site investigation, including photographs, are provided in Appendix F.

8.1.2.2 Modelled Subcatchments

As discussed, we refined the watershed boundaries within the study area into subcatchments with an average area of approximately 15 ha. These catchments were delineated based on areas contributing to each of the major culvert crossings.

One of the key parameters required for hydrologic modelling is the percent of impervious coverage of each subcatchment. We established these parameters for individual subcatchments based on land use mapping provided by the City. For the various land uses, we assigned percent impervious values based on the values recommended in the City of Surrey's Design Criteria Manual, as summarized in Table 8-1.

Table 8-1
Impervious Percent by Land Use

Land Use	Impervious Percent
Agricultural	20%
One Acre Residential (Surrey)	50%
Commercial	90%
Comprehensive Development (Surrey)	90%
Industrial	90%
Institutional	80%

As part of the hydrologic model development, we reviewed the aerial imagery to identify any areas where current development does not reflect the designated land use. We identified two areas where existing development does not reflect the zoning.

In the northwest corner of the study area, west of Harvie Road, there is a notable area that is designated as One Acre Residential, but has not been developed. Similarly, there is a parcel of land north of 88 Avenue between 192 Street and 196 Street which is designated as One Acre Residential, but has not yet been developed as such. In each case we adjusted the impervious percentages to more accurately reflect these current conditions.

8.1.2.3 Hydrologic / Hydraulic Modelling Parameters

The key hydrologic modelling parameters include Horton infiltration rates, average catchment slopes, Manning's roughness coefficients for overland flow, and depression storage depths.

Our initial estimates for these parameters were based on interpretation of air photos, LiDAR data, previous hydrologic models within the study area, available background reports, and information gathered during site visits.

As part of the hydrologic and hydraulic results provided by PCSWMM, the model indicates the effective runoff coefficient for each catchment area, which reflects the total portion of rainfall that is converted into runoff.

We note that, in addition to providing guidance on the percent impervious values for each land use, the City of Surrey's Design Criteria Manual also provides guidelines on the runoff coefficient values for each land use. Using these recommended values, we adjusted the hydrologic modelling parameters until the reported runoff coefficients from the model matched reasonably well with the values recommended by the City's guidelines.

Table 8-2 summarizes the key hydrologic parameters used in the model.

Table 8-2
Hydrologic Model Parameters

Horton Infiltration Parameters	
Maximum Infiltration Rate (mm/hr)	10
Minimum Infiltration Rate (mm/hr)	4
Decay Constant (hr^{-1})	4.14
Drying Time (days)	7
Manning's Roughness Coefficient, n, for Overland Flow	
Impervious Surface (overland flow)	0.020
Pervious Surface (overland flow)	0.400
Depression Storage	
Impervious Surface (mm)	3.0
Pervious Surface (mm)	10.0

Table 8-3 presents the hydraulic parameters assigned to the conduits within the model.

Table 8-3
Conduit Properties

Manning's Roughness Coefficient, n, for Conduit Flow	
PVC	0.010
HDPE	0.012
Steel	0.012
Concrete	0.013
Corrugated Steel Pipe (CSP)	0.024
Structural-Plate Corrugated Steel Pipe (SPCSP)	0.032
Ditches / Watercourses	0.035

Conduit Minor Losses	
Entrance Loss Coefficient	0.2 to 0.9
Exit Loss Coefficient	0.5 to 1.0

The Manning's roughness values are based on pipe material, which was provided as part of the City's GIS storm pipe database, and was confirmed based on field observations.

The entrance and exit losses vary based on the inlet and outlet conditions at each culvert, and were selected based on observations from our field visit.

8.1.2.4 Rainfall Data

For the purposes of modelling the existing drainage system to identify deficiencies and areas of concern, we used design storms based on IDF data from Environment Canada for the Surrey Kwantlen Park rain gauge, dated February 2, 2012. This rain gauge was selected in accordance with the City's Engineering Design Criteria Manual (2004). The IDF data includes 37 years of data (from 1962 to 1999). The IDF curve is presented in Appendix G.

Table 8-4 shows the Coefficient A and Exponent B values from the Surrey Kwantlen Park IDF Curve for the 5-year and 100-year return periods.

Table 8-4
Coefficient A and Exponent B for Surrey Kwantlen Park IDF Curve

	5-Year Return Period	100-Year Return Period
Coefficient A	15.500	25.700
Exponent B	-0.493	-0.534

Based on this data, we created All-Duration Storms (ADS) for the 5-year and 100-year return periods for use in our simulations. The return periods selected represent the City of Surrey's design criteria for the minor and major storm systems, respectively.

The ADS is an effective screening tool that can be used to efficiently identify problem areas within the storm pipe network. The ADS includes all durations on an IDF curve and therefore allows for the inclusion of the total runoff depth experienced with a 24-hour duration storm and also incorporates runoff response as expected with shorter-duration storms.

As discussed, we divided the drainage system to include subcatchments with an average area of approximately 15 ha, and only modelled the open watercourses and culverts. Although this is an appropriate approach for a planning level study, it can potentially skew the results by concentrating flow in the major catchments that would otherwise be moderately attenuated as it is distributed through the minor system, including the roadside ditch network. To buffer the runoff response from this effect, we used a minimum middle time step (representing a short-duration storm) of 50 minutes. This attenuates the peak of the ADS slightly, providing a reasonably reliable hydrologic response. The ADS design storms for the 5-year and 100-year return periods are shown in Figure 8-1. The design rainfall events are also included in tabular form in Appendix J.

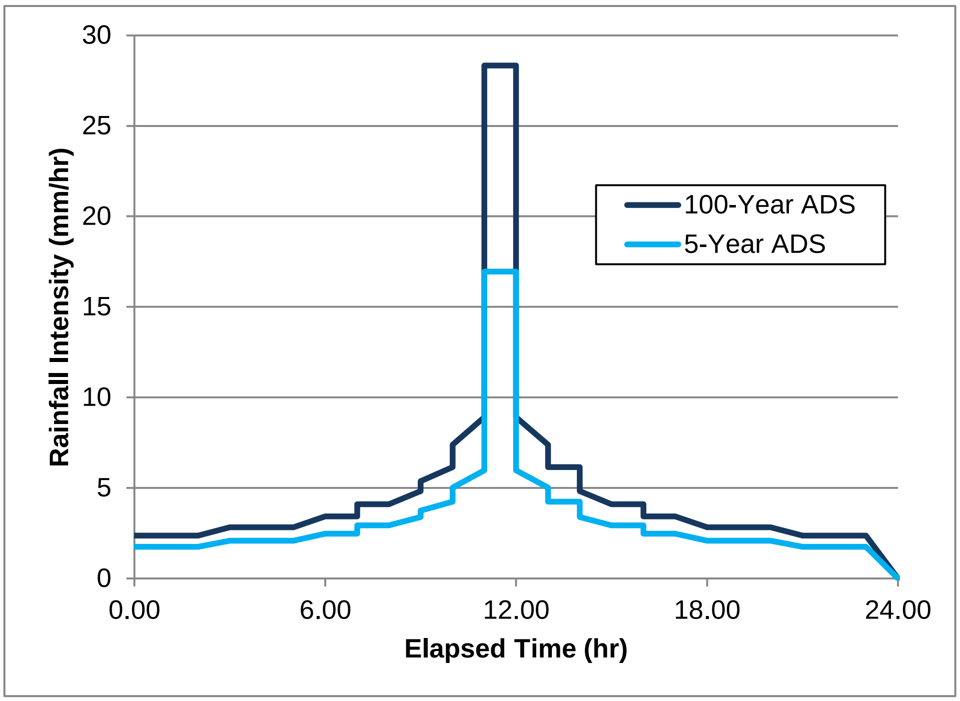

Figure 8-1
ADS Design Storms

8.1.2.5 External Inflows

As discussed, the stormwater management component of the current ISMP is limited to the areas within the City of Surrey on the north side of Latimer Creek. Stormwater management within the Township of Langley has been completed through a number of studies, with development generally occurring in accordance with the recommendations from the 2003 Latimer Creek MDP.

Similarly, stormwater management within the City of Surrey to the south of Latimer Creek was covered by the recently completed Clayton ISMP.

We note that flows from both of these areas drain into the current study area. As such, we included flow rates from these areas as inflows into the current hydraulic model. In each case, we used flow rates for the ‘future development condition with improvements’ scenario. This scenario represents a future development condition, where peak flows are being managed in accordance with the stormwater management recommendations for the respective areas.

At the boundary between the Township of Langley and the City of Surrey, we included constant flow rates as reported by the Latimer Creek MDP. We note that is a conservative approach, since it does not take into account the timing of the hydrographs from runoff that originates within the Township of Langley. In effect, it assumes that the peak flows from within the City's portion of the study area coincide with the peak flows entering the study area from the Township of Langley. Along the main channel of Latimer Creek, we included hydrographs extracted from the XPSWMM model for the Clayton ISMP. Table 8-5 summarizes the peak flow rates for each of the external inflows.

Table 8-5
Peak Flow Rates at External Inflow Locations

Inflow Location	Source	Peak 5-Year Flow Rate	Peak 100-Year Flow Rate
North Latimer Creek at 88 Avenue	2003 Latimer MDP	1.36 m^3/s	2.63 m^3/s
196 Street South of 84 Avenue	2003 Latimer MDP	2.41 m^3/s	4.38 m^3/s
196 Street North of 84 Avenue	2003 Latimer MDP	0.72 m^3/s	1.31 m^3/s
Latimer Creek South	Clayton ISMP Model	3.68 m^3/s	1.54 m^3/s
192 Street Creek	Clayton ISMP Model	1.54 m^3/s	2.64 m^3/s

8.1.3 Model Results

We created scenarios utilizing the 5-year and 100-year return period All-Duration Storms to assess the performance of the storm drainage network, and assessed the peak hydraulic grade lines (HGL) and peak flows at all culvert crossings within the study area.

As discussed above, we have not completed a comprehensive model calibration based on observed flow rates from known rainfall events. Due to the external inflows from the east and the south, detailed model calibration is not possible. Rather, we adjusted the key hydrologic parameters within the model to achieve runoff coefficients that are in line with the values recommended by the City of Surrey's Design Criteria Manual.

Table 8-6 summarizes the peak flows and HGLs for each culvert within the study area for both the 5-year and 100-year return periods. The location of each reporting point is shown on Map 8-1.

Table 8-6
Baseline Peak Flow and HGL for the 5-year and 100-year Return Period ADS

Culvert Reference Location	Location	Existing Pipe	Road Crest Elevation	5-Year Return Period ADS		100-Year Return Period ADS	
				Peak Flow (m^3/s)	Peak HGL (m, GSC)	Peak Flow (m^3/s)	Peak HGL (m, GSC)
11	Latimer Creek at Harvie Rd	Twin 3050 mm x 2400 mm Conc Boxes	4.1	12.7	2.3	22.8	3.0
12	Latimer Creek at 188 St	2870 mm x 4370 mm CSP Arch	4.9	9.1	3.9	16.5	4.5
13	Latimer Creek at 192 St	3050 mm x 3050 mm Conc Box	9.6	3.9	6.1	7.7	6.5
14	Latimer Creek at 192 St	900 mm PVC	9.6	0.9	6.4	1.2	6.6
15	Latimer Creek at 192 St	900 mm PVC	9.6	0.9	6.4	1.1	6.5
21	North Latimer Creek at 88 Ave	800 mm x 1600 mm CSP Arch	11.4	1.9	10.2	2.9	10.7
31	Old Sawmill Creek at 86 Ave	1120 mm x 1630 mm CSP Arch	5.6	2.2	5.3	3.6	5.9
32	Old Sawmill Creek at 88 Ave	1300 mm Conc	9.8	2.0	8.2	3.2	8.8
33	Old Sawmill Creek at 90 Ave	750 mm CSP	13.7	0.6	11.7	0.9	12.3

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Culvert Reference Location	Location	Existing Pipe	Road Crest Elevation	5-Year Return Period ADS		100-Year Return Period ADS	
				Peak Flow (m^3/s)	Peak HGL (m, GSC)	Peak Flow (m^3/s)	Peak HGL (m, GSC)
41	Bartesko Brook at 192 St	600 mm Conc	14.9	0.6	12.8	0.9	13.6
51	Tributary at 86 Ave	450 mm Wood Stave	6.5	0.3	6.5	0.4	7.3
61	Tributary at Harvie Rd	750 mm Conc	14	0.5	11.1	1.0	11.9

During the 5-year event, Culverts 14 and Culvert 15 experience nominal surcharge. Culvert 21 and Culvert 41 have just enough capacity to convey the 5-year flow without surcharging, although the “headwater to diameter ratio” (HW/D) for these culverts is approximately 1.0, indicating that the water level is at the crown of the pipe at the culvert inlet. The remaining culverts convey the peak flow rate with sufficient capacity.

During the 100-year event all of the culverts surcharge, with the exception of culverts 11, 12 and 13. The level of surcharge varies from 0.2 m to 0.8 m. At two locations, (Culvert 31 and Culvert 51) the 100-year surcharge exceeds the adjacent road elevation, indicating that the water level will overtop the road during the peak design event.

Culvert 31 conveys Old Sawmill Creek under 86 Avenue just east of 188 Street. Culvert 51 conveys an unnamed Tributary under 86 Avenue, just east of Culvert 31. These results indicate that Culverts 31 and 51 are deficient, and should be upgraded to safely convey the peak 100-year flow rates without flooding the roads.

Of the remaining culverts that experience surcharge during the 100-year event, Culverts 21, 41 and 61 exhibit the highest levels of surcharge, at 0.6 m, 0.8 m, and 0.6 m respectively. In each case, the upstream HGL is contained within the natural channel, based on the LiDAR data.

For the remaining culverts, the level of surcharge during the 100-year event is less than or equal to 0.4 m.

8.2 FUTURE CONDITION

We updated our Existing Condition Model to reflect future developments that are expected to occur within the study area. The purpose of this model is to identify the hydraulic impacts of future development, including new deficiencies that occur as a result of future development and existing deficiencies that are exacerbated. We have included adjustments to account for changes to the catchment boundaries, land use changes and climate change, each of which are discussed further in the following sections.

8.2.1 Model Adjustments

8.2.1.1 Catchment Boundary Changes

The northwest corner of the Latimer Creek ISMP study area is located within the extents of the Anniedale-Tynehead Neighbourhood Community Plan (NCP). As part of the stormwater management strategy for the NCP, the Anniedale-Tynehead NCP outlines both the existing and proposed drainage catchment areas. Based on the catchment areas shown in the NCP, there will be an increase in the area draining to Old Sawmill creek from the west side of Harvie Road under future conditions. As requested be the City, we updated the future catchment boundaries to reflect the changes presented in the Anniedale-Tynehead NCP. Map 8-2 shows the future catchment boundaries based on the changes presented in the Anniedale-Tynehead NCP.

8.2.1.2 Land Use Changes

As part of the existing development condition modelling, we identified two general areas where the land has not yet been developed as per the City's zoning.

In order to account for future land use conditions, we assume that all areas will be developed as per the zoning. Further, we updated the land use in the northwest corner of the study area based on the City's South Port Kells General Land Use Plan.

Modifications to the land use are summarized as follows:

- The area between 192 Street and 196 Street, north of 88 Avenue, was assumed to be One Acre Residential under future development conditions, as per the City's Zoning for this area.
- The area west of Harvie Road was updated to reflect the land uses proposed under the South Port Kells GLUP, which include Cluster Residential, Urban Residential, and Business Center.
- The remainder of the study area is based on the City's Zoning. These areas have already been developed as per the Zoning. There are no changes for these areas compared to the land use under Existing Development Conditions.

Map 8-3 shows the land use under future development conditions.

8.2.1.3 Climate Change

The City's Climate Adaptation Strategy suggests that by the 2050s, the City will experience an increase in peak rainfall intensity of 21% on 'very wet days (>95th percentile).'

In future development scenarios where climate change is included, we applied an increase of 21% to each discrete point on the ADS hyetograph derived from historical data to account for this effect.

Figure 8-2 presents a comparison of our climate-change-adjusted ADS to the hind-cast ADS. We used the unadjusted ADS for future scenarios where climate change was not applied.

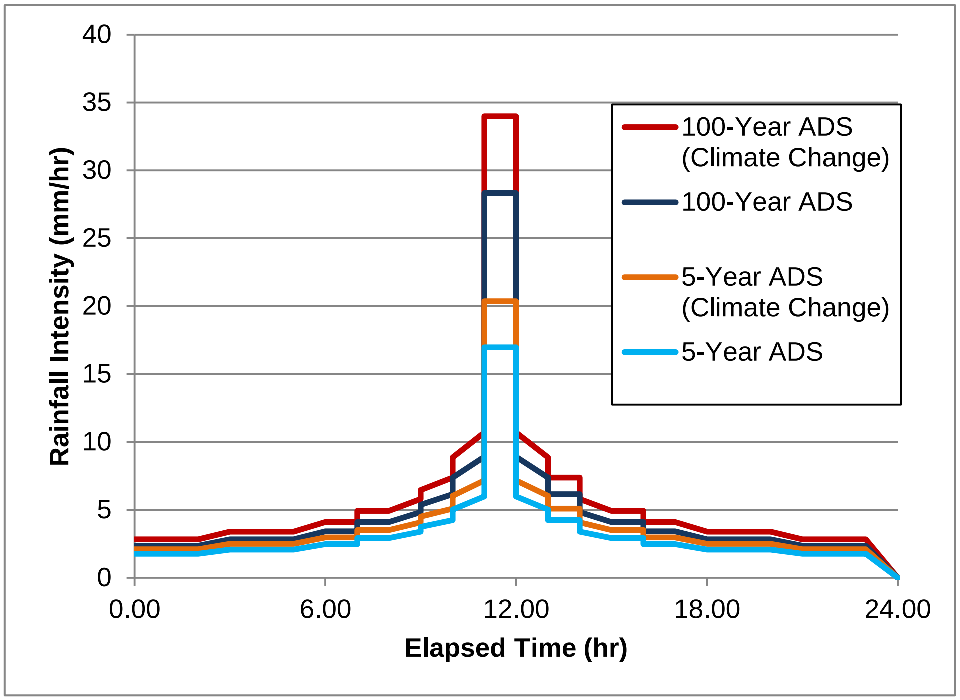


Figure 8-2
ADS With and Without Climate Change Adjustments

8.2.1.4 Hydrologic and Hydraulic Modelling Parameters

We used the same hydrologic and hydraulic modelling parameters that were used for the Existing Condition model.

8.2.1.5 External Inflows

For the Future Development Condition model, we used the same external inflows that were used for the Existing Development Condition model. By keeping the external flows constant for both development conditions, we were able to focus on the impacts of development within the current study area.

While this approach facilitates a clear assessment of the impacts of development within the current study area, it does not take into account the potential impacts of climate change on the external flow rates.

Since the external flow rates have been extracted from separate models that were completed previously by others, a detailed assessment of the potential impacts of climate change on these external flows is not possible as part of the current ISMP. However, to provide an allowance for the potential impacts of climate change on these external flows, we estimated the increase in flows based on the modelling results at Culvert 31.

Culvert 31 represents the location with the largest contributing drainage area that is contained entirely within the current model. As such, model results at this location account for the potential impacts of climate change in accordance with the City's Climate Adaptation Strategy.

Table 8-7 summarizes the flow rates at Culvert 31 for the 5-year and 100-year events. We note that the values presented in Table8-7 below do not reflect the proposed changes to the catchment boundaries outlined in the Anniedale-Tynehead NCP; rather, the flow rates are based on the existing catchment areas. As such, they indicated the potential magnitude of the impacts of climate change based on the current catchment area for Culvert 31.

Table 8-7
Climate Change Impact Approximation

Return Period	Future Development Condition Peak Flow [m3/s]	Future Development Condition with Climate Change Peak Flow [m3/s]	Percent Increase
5-year	2.72	3.20	17.6%
100-year	4.00	4.40	10.0%

The results for Culvert 31 indicate that the 21% increase in rainfall data translates to a 17.6% increase in flow rates for the 5-year event, and a 10.0% increase in flow rates for the 100-year event. The lower percent increase for the 100-year event is likely due to the fact that the system experiences more surcharge during the 100-year event, so the impacts of climate change are somewhat dampened.

It is important to note that the actual increase in flow rates under a future climate change scenario will be different for each portion of the watershed, and will vary based on the unique characteristics of each sub-catchment. Without a detailed understanding and analysis of the entire drainage system, it is not possible to accurately predict these increases. However, for the purposes of a general discussion on the potential impacts of climate change, we applied the same scaling factors observed at Culvert 31 to the external flow rates.

8.2.2 Model Results

Table 8-8 and Table 8-9 present the hydraulic modelling results for the 5-year and 100-year events, respectively. They include the results for the existing development condition, as well as results for the future development condition, both with and without potential climate change. These results are based on the existing drainage infrastructure, and do not reflect any potential upgrades to the system. We note that the peak flow rates and HGLs have been rounded to the nearest 0.1 m^3/s and 0.1 m, respectively. As such, some minor difference in the model results between the existing and future development conditions are not apparent in the reported results.

Table 8-8
5-Year Return Period ADS – Peak Flow and HGL Comparison for Various Scenarios

Culvert Reference Location	Location	Existing Pipe	Road Crest Elevation [m]	Existing Peak Flow [m^3/s]	Existing Peak HGL [m]	Future Peak Flow [m^3/s]	Future Peak HGL [m]	Climate Change Peak Flow [m^3/s]	Climate Change Peak HGL [m]
11	Latimer Creek at Harvie Rd	Twin 3050 mm x 2400 mm Conc Boxes	4.1	12.7	2.3	13.5	2.4	15.3	2.5
12	Latimer Creek at 188 St	2870 mm x 4370 mm CSP Arch	4.9	9.1	3.9	10.0	4.0	11.1	4.1
13	Latimer Creek at 192 St	3050 mm x 3050 mm Conc Box	9.6	3.9	6.1	4.0	6.1	4.2	6.1
14	Latimer Creek at 192 St	900 mm PVC	9.6	0.9	6.4	0.9	6.4	1.0	6.5
15	Latimer Creek at 192 St	900 mm PVC	9.6	0.9	6.4	0.9	6.4	0.9	6.4
21	North Latimer Creek at 88 Ave	800 mm x 1600 mm CSP Arch	11.4	1.9	10.2	1.9	10.2	1.9	10.2
31	Old Sawmill Creek at 86 Ave	1120 mm x 1630 mm CSP Arch	5.6	2.2	5.3	3.1	5.7	3.6	5.9
32	Old Sawmill Creek at 88 Ave	1300 mm Conc	9.8	2.0	8.2	2.9	8.6	3.4	8.9
33	Old Sawmill Creek at 90 Ave	750 mm CSP	13.7	0.6	11.7	0.6	11.7	0.7	11.8
41	Bartesko Brook at 192 St	600 mm Conc	14.9	0.6	12.8	0.7	13.0	0.8	13.3
51	Tributary at 86 Ave	450 mm Wood Stave	6.5	0.3	6.5	0.3	6.6	0.3	6.7
61	Tributary at Harvie Rd	750 mm Conc	14.0	0.5	11.1	1.5	12.8	1.7	13.3

Table 8-9
100-Year Return Period ADS – Peak Flow and HGL Comparison for Various Scenarios

Culvert Reference Location	Location	Existing Pipe	Road Crest Elevation	Existing Peak Flow	Existing Peak HGL	Future Peak Flow	Future Peak HGL	Climate Change Peak Flow	Climate Change Peak HGL
11	Latimer Creek at Harvie Rd	Twin 3050 mm x 2400 mm Conc Boxes	4.1	22.8	3.0	23.4	3.0	25.6	3.1
12	Latimer Creek at 188 St	2870 mm x 4370 mm CSP Arch	4.9	16.5	4.5	17.1	4.6	18.5	4.7
13	Latimer Creek at 192 St	3050 mm x 3050 mm Conc Box	9.6	7.7	6.5	7.8	6.5	8.4	6.6
14	Latimer Creek at 192 St	900 mm PVC	9.6	1.2	6.6	1.2	6.7	1.3	6.8
15	Latimer Creek at 192 St	900 mm PVC	9.6	1.1	6.5	1.2	6.6	1.2	6.7
21	North Latimer Creek at 88 Ave	800 mm x 1600 mm CSP Arch	11.4	2.9	10.7	3.0	10.8	3.1	10.9
31	Old Sawmill Creek at 86 Ave	1120 mm x 1630 mm CSP Arch	5.6	3.6	5.9	4.3	6.2	4.7	6.5
32	Old Sawmill Creek at 88 Ave	1300 mm Conc	9.8	3.2	8.8	4.0	9.3	4.5	9.7
33	Old Sawmill Creek at 90 Ave	750 mm CSP	13.7	0.9	12.3	0.9	12.3	1.0	12.7
41	Bartesko Brook at 192 St	600 mm Conc	14.9	0.9	13.6	1.0	14.0	1.2	14.7
51	Tributary at 86 Ave	450 mm Wood Stave	6.5	0.4	7.3	0.4	7.3	0.5	7.7
61	Tributary at Harvie Rd	750 mm Conc	14.0	1.0	11.9	2.3	14.7	2.7	16.0

While we have presented results for both the 5-year and 100-year return periods, we note that the modelled drainage network consists of open channel and culverts, representing the major drainage system. Accordingly, the discussion below focuses on the hydraulic modelling results for the 100-year return period.

Existing Development Conditions

As noted previously, all of the culverts surcharge during the 100-year event under existing conditions with the exception of Culverts 11, 12, and 13. The level of surcharge varies from 0.2 m to 0.8 m. At two locations (Culvert 31 and Culvert 51) the 100-year surcharge exceeds the adjacent road elevation, indicating that the water level will overtop the road during the peak design event.

Future Development Conditions without Stormwater Mitigation

Under future development conditions, all the culverts will experience an increase in peak flow rates due to the anticipated increase in the amount of impervious cover, with the exception of Culverts 33 and 51; future development is not expected to impact the contributing areas draining to these two culverts.

As discussed above, future development is expected to occur east of 192 Street to the north of 88 Avenue as the area is developed in accordance with the current zoning. Future development is also expected to occur west of Harvie Road in accordance with the South Port Kells General Land Use Plan. The catchment area upstream (west) of Harvie Road will also increase under future conditions, as outlined in the Anniedale-Tynehead NCP. Accordingly, Bartesko Brook and Old Sawmill Creek will experience the most significant increase in peak flow rates under future conditions.

Under future development conditions, the peak 100-year flow rate conveyed through Culvert 41 increases from 0.9 m^3/s to 1.0 m^3/s. The corresponding hydraulic grade line (HGL) at the culvert inlet increases from 13.6 m to 14.0 m under future conditions. The resulting HGL is approximately 0.9 m below the adjacent road grade on 192 Street. Based on the LiDAR data provided by the City, the 100-year HGL will be at approximately the top of bank elevation within the channel upstream of the culvert.

Under future development conditions, the peak 100-year flow rate conveyed through Culvert 61 increases from 1.0 m^3/s to 2.3 m^3/s. This is a significant increase, and reflects the additional catchment area being directed to this location, as well as an increase in the impervious percentage due to development. The corresponding HGL at the culvert inlet increases from 11.9 m to 14.7 m, which exceeds the adjacent top of bank elevations, as well as the road crest elevation on Harvie Road. These results indicate that the existing culvert is not large enough to accommodate future conditions, and should be upgraded.

Downstream of Culvert 41 and Culvert 61, culverts on Old Sawmill Creek will experience a moderate increase in peak flow rates and HGLs under future conditions. At Culvert 32, the peak 100-year flow rate will increase from 3.2 m^3/s to 4.0 m^3/s; the HGL will increase from 8.8 m to 9.3 m. The water level here will remain below the adjacent road elevation, and will be contained within the channel based on the LiDAR data.

Further downstream, at Culvert 31, the 100-year peak flow rate will increase from 3.6 m^3/s to 4.0 m^3/s. As noted above, Culvert 31 is already deficient under existing conditions, and should be upgraded.

In general, the remaining culverts in the City's portion of the study area are located on Latimer Creek and experience higher peak flow rates due to the large upstream catchment area. As such, the impacts of localized developments within the Bartesko Brook and Old Sawmill Creek catchments are less pronounced at these locations. At Culvert 21 and Culverts 13/14/15, the HGL will increase approximately 0.1 m as a result of future development within the City's portion of the study area. Culvert 12 and Culvert 11 are located near the downstream end of the study area. While they are impacted by the planned developments within the study area and the proposed increase to the catchment area under future conditions, the upstream HGL at these two culverts remains below the crown of pipe.

Future Climate Change

As noted, we also simulated the effects of climate change on the rainfall data under future development conditions. As a result of the increased rainfall applied to the study area under future climate change conditions, the peak flow rates and hydraulic grade lines will be increased at all locations within the system.

Based on our analysis, the culverts which appear to be the most sensitive to potential increases in rainfall as a result of climate change are Culvert 32, Culvert 33, Culvert 41, Culvert 51, and Culvert 61.

At Culvert 32, the 100-year HGL would increase by approximately 0.4 m beyond the future development condition scenario as a result of the assumed climate change. While this culvert would experience significant surcharge, the HGL would remain just below the road crest elevation.

At Culvert 33, the 100-year HGL would also increase by approximately 0.4 m beyond the future development condition scenario as a result of the assumed climate change. The HGL at this location would remain approximately 1.0 m below the adjacent road grade, and would be contained within the channel based on the LiDAR data.

At Culvert 41, the HGL would increase by approximately 0.7 m beyond the future development condition scenario as a result of the assumed climate change. While the HGL would remain below the adjacent road elevation, it would overtop the banks of Bartesko Brook and result in localized flooding of adjacent properties.

At Culvert 51, the HGL would increase by approximately 0.4 m beyond the future development condition scenario as a result of the assumed climate change. We note that the existing culvert already surcharges causing the adjacent road to overtop during the 100-year design event, and should be upgraded.

At Culvert 61, the HGL would increase significantly as a result of the assumed climate change. We note that the existing culvert already overtops the adjacent road during the 100-year design event, and should be upgraded.

For the remainder of the culverts, the HGL would increase by 0.3 m or less under climate change conditions, as compared to the future development scenario with current rainfall data.

8.3 RECOMMENDED CULVERT UPGRADES

As noted above, Culvert 31 and Culvert 51 are both undersized; they do not have sufficient hydraulic capacity to safely convey the 100-year peak flow under existing conditions. These deficiencies will be further exacerbated as a result of future development.

Under existing development conditions, Culvert 61 surcharges to an elevation of 11.9 m during the 100-year event. As a result of future increases to the overall catchment area, combined with increases in the amount of impervious area under future development, the flows at this culvert would increase if no attenuation is provided. The resulting HGL would be 14.7 m, which exceeds the elevation of Harvie Road. We also note that the low point on the adjacent property upstream of the culvert is at approximately 12.0 m. Even if storage were provided to maintain the 100-year flow at existing conditions, minimal freeboard would be available. We recommend that this culvert be upgraded.

As noted, Culvert 41 experiences surcharge under existing conditions. While the upstream HGL is contained within the channel, future development will result in an increased water level at this location. Under a future climate change scenario, the surcharge would be further increased to the point of flooding adjacent properties. The City's 10-year Servicing Plan currently indicates a culvert upgrade at this location from 600 mm diameter to 1000 mm diameter.

Table 8-10 outlines the recommended culvert upgrades within the City's portion of the study area.

Table 8-10
Recommended Culvert Upgrades (City of Surrey)

Culvert Reference Location	Location	Existing Pipe	Proposed Pipe	Pipe Rise [m]	100-Year Return Period					
					Future Development		With Ponds No Climate Change		With Climate Change No Ponds	
					Flow Depth at Inlet [m]	HW/D	Flow Depth at Inlet [m]	HW/D	Flow Depth at Inlet [m]	HW/D
31	Old Sawmill Creek at 86 Ave	1120 mm x 1630 mm CSP Arch	1520 mm x 2060 mm CSP Arch	1.52	1.58	1.04	1.46	0.96	1.75	1.15
41	Bartesko Brook at 192 St	600 Conc	1050 mm Conc	1.05	0.82	0.78	0.75	0.71	1.00	0.95

Culvert Reference Location	Location	Existing Pipe	Proposed Pipe	Pipe Rise [m]	100-Year Return Period					
					Future Development		With Ponds No Climate Change		With Climate Change No Ponds	
					Flow Depth at Inlet [m]	HW/D	Flow Depth at Inlet [m]	HW/D	Flow Depth at Inlet [m]	HW/D
51	Tributary at 86 Ave	450 Wood Stave	800 mm CSP	0.80	0.60	0.75	0.60	0.75	0.76	0.95
61	Tributary at Harvie Rd	750 mm Conc	1350 mm Conc	1.35	1.31	0.97	1.13	0.84	1.72	1.27

Notes:

1) Model results are based on the proposed culvert upgrades.
2) CSP Culverts within City of Surrey are to have Aluminize Type 2 Coating.

As indicated by the results, the proposed culverts would all have sufficient capacity to convey the design flow rate under future development conditions, with nominal surcharge at Culvert 31. Taking into account the hydraulic benefits of the proposed storage ponds (discussed in Section 8.4), the flow depth at the inlet of Culvert 31 would be reduced to prevent surcharging. The proposed storage ponds would also reduce the flow depths at the inlets of Culvert 41 and Culvert 61, but would not provide enough of a hydraulic benefit to warrant a smaller culvert size.

We have also presented the model results under a potential climate change scenario, without any stormwater detention ponds; this represents an upper bound on the potential flow rates these culverts would experience. Under these conditions, Culverts 41 and 51 would convey the peak flow rates without any surcharge, while Culverts 31 and 61 would convey the peak flow rate with moderate surcharge.

For Culvert 31, we selected a standard CSP Arch size to replace the existing CSP Arch. We note that the existing pipe has minimal cover; as a result, the crossing would need to be re-graded to accommodate the increased culvert height.

Further, we note that, while CSP Arch culverts have historically been used to maximize stream width, there are potential issues with this style of culvert. In particular, the stress distribution on CSP Arches places a large demand at the culvert haunches. Proper placement and compaction of both the bedding and backfill material is crucial to the successful installation and long term durability of CSP Arches. Given the limited cover at this location, and the issues associated with arch culverts, a concrete box culvert may be required. Another alternative that has become more widely used is to install oversized circular culverts, and embed the lower portion of the pipe with fill material to establish the desired stream width. This option may or may not be possible due to the limited cover. Ultimately, these are items that will need to be considered in further detail as part of any specific culvert replacement project. We simply highlight the issue for future consideration.

We updated the hydraulic model to reflect these proposed culvert upgrades, and reran the simulation to evaluate the system for the 100-year event under future development conditions, both with and without climate change.

The model results for the upgraded system are presented in Table 8-11. As noted, the hydraulic assessment focuses on the major drainage system; accordingly, we present the results for the 100-year event.

Table 8-11
100-Year Return Period ADS – Peak Flow and HGL for Upgraded System

Culvert Reference Location	Location	Pipe	Road Crest Elevation [m]	Future Peak Flow [m^3/s]	Future Peak HGL [m]	Climate Change Peak Flow [m^3/s]	Climate Change Peak HGL [m]
11	Latimer Creek at Harvie Rd	Twin 3050 mm x 2400 mm Conc Boxes	4.1	24.3	3.0	26.9	3.2
12	Latimer Creek at 188 St	2870 mm x 4370 mm CSP Arch	4.9	18.0	4.7	19.8	4.8
13	Latimer Creek at 192 St	3050 mm x 3050 mm Conc Box	9.6	7.8	6.5	8.4	6.6
14	Latimer Creek at 192 St	900 mm PVC	9.6	1.2	6.6	1.2	6.6
15	Latimer Creek at 192 St	900 mm PVC	9.6	1.0	6.5	1.2	6.6
21	North Latimer Creek at 88 Ave	800 mm x 1600 mm CSP Arch	11.4	3.0	10.8	3.1	10.9
31	Old Sawmill Creek at 86 Ave	1520 mm x 2060 mm CSP Arch*	5.6	5.0	5.9**	5.7	6.1**
32	Old Sawmill Creek at 88 Ave	1300 mm Conc	9.8	4.6	9.8	5.2	10.3
33	Old Sawmill Creek at 90 Ave	750 mm CSP	13.7	0.9	12.3	1.0	12.7
41	Bartesko Brook at 192 St	1050 mm Conc*	14.9	2.1	13.0	2.6	13.2
51	Tributary at 86 Ave	800 mm CSP*	6.5	0.6	6.4**	0.8	6.6**
61	Tributary at Harvie Rd	1350 mm Conc*	14.0	3.1	11.9	3.9	12.3

*Culverts 31, 41, 51, and 61 are based on recommended upgrades.

**HGLs are based on estimated culvert inverts derived from LiDAR. Proposed culverts have sufficient capacity, as indicated by Table 8-10. Culverts 31 and 51 will need to be re-graded when upgrades are implemented, due to limited cover.

If the proposed upgrades are implemented, Culverts 31, 41, 51, and 61 will have sufficient capacity to safely convey the 100-year flow rate under future development conditions. By increasing the hydraulic capacity at Culverts 31, 41, 51, and 61, the throttling effect of the culvert surcharge has been reduced. In turn, the downstream flows are increased. We have taken this into account in the culvert upgrades that have been proposed.

We note that the road crest elevations and culvert inverts at Culvert 31 and Culvert 51 were estimated from the LiDAR data. While the HGL values presented above suggest that the 100-year flows would overtop the road at these locations under a future climate change scenario, the culverts have sufficient capacity as indicated by the HW/D ratios presented in Table 8-10. The actual HGL values at these two culverts would be reduced to acceptable levels when the crossings are re-graded at the time of culvert upgrades.

The proposed upgrades at Culvert 41 and Culvert 61 result in a significant increase in flow rates at Culvert 32. Under future development conditions with the proposed upgrades, the peak 100-year flow rate at Culvert 32 would be 4.6 m^3/s; the HGL would be 9.8 m, which is at the approximate elevation of the road at this location. The HGL would be increased further under a future climate change scenario, and would potentially overtop the road. We note that the City of Surrey's Ten-Year Servicing Plan identifies a culvert upgrade at this location to 1500 mm. This incremental increase in culvert size would reduce the HGL under the future development condition to 9.4 m. The potential culvert upgrade at this location is discussed further in Section 10.2.

Culvert 12 and Culvert 11, which are both located on the main stem of Latimer Creek near the downstream limit of the study area, would also experience an increase in flow rates by removing the throttling effect of upstream culverts. However, these culverts both have sufficient capacity to accommodate the increased flows with minimal changes in upstream water levels.

Of the remaining crossings, Culverts 21 and 33 experience the highest levels of surcharge. At both of these locations, despite the surcharge levels, the upstream HGL remains below the adjacent road crest elevation, and is contained within the natural channel upstream of the culvert, based on the City's LiDAR data.

8.4 STORAGE REQUIREMENTS

As noted, we identified two general areas where future development is expected to occur within the City's portion of the study area:

- The area between 192 Street and 196 Street, to the north of 88 Avenue is zoned as One Acre Residential, but is currently undeveloped. Future development is expected to occur in accordance with the City's zoning.
- The area west of Harvie Road is expected to be developed in accordance with the South Port Kells GLUP and the Anniedale-Tynehead NCP, which will include Cluster Residential, Urban Residential, and Business Center.

As indicated by the modelling results, the increase in impervious surfaces associated with these development activities will result in an increase in the peak flow rates generated during rain events. Recognizing the potential impact that increased flow rates can have on both the natural system and the existing drainage infrastructure, the City's Design Criteria Manual specifies that peak flow rates must be controlled, using the more stringent of the two following criteria:

- Control the 5-year post-development flow to 50% of the 2-year post-development rate, or
- Control the 5-year post-development flow to the 5-year pre-development flow rate.

Using the pond-sizing functionality of PCSWMM, we estimated the required storage volumes for the four catchment areas where future development is expected to occur, using both criteria noted above. For sub-catchments 'Sub_41', 'Sub_21', and 'Sub_21a', the '50% of the 2-year post-development rate' governs, and requires larger storage volumes. Due to increases in the catchment area proposed under the Anniedale-Tynehead NCP, the governing condition for 'Sub_61' was the '5-year pre-development rate'. Table 8-12 summarizes the required storage volumes for the four catchments where future development is expected to occur.

Table 8-12
Storage Volume Requirements

Catchment Area	Maximum Allowable Release Rate [m^3/s]	Required Storage Volume* [m^3]
Sub_61	0.47	10,600
Sub_41	0.27	3,800
Sub_21	0.08	1,100
Sub_21a	0.07	1,100

*Storage volumes are rounded to the nearest 100 m^3.

As outlined in the City's Design Criteria Manual, the minimum catchment area of any pond should be 20 ha. The purpose of this guideline is to limit the overall number of stormwater management ponds throughout the City, so that peak flow attenuation can be achieved in an efficient manner, while limiting the maintenance that would be required with an excessive number of small ponds.

Catchments Sub_61 and Sub_41 have areas of approximately 44 ha (future) and 30 ha, respectively. In accordance with the City's guidelines, we recommend that a stormwater management pond be provided for each of these catchments to attenuate peak flows under future development conditions.

Conversely, we note that catchments Sub_21 and Sub_21a are approximately 9 ha and 8 ha, respectively. In line with the City's desire to limit the number of storage ponds, we recommend that a single pond be established to meet the combined storage requirements for these two catchments.

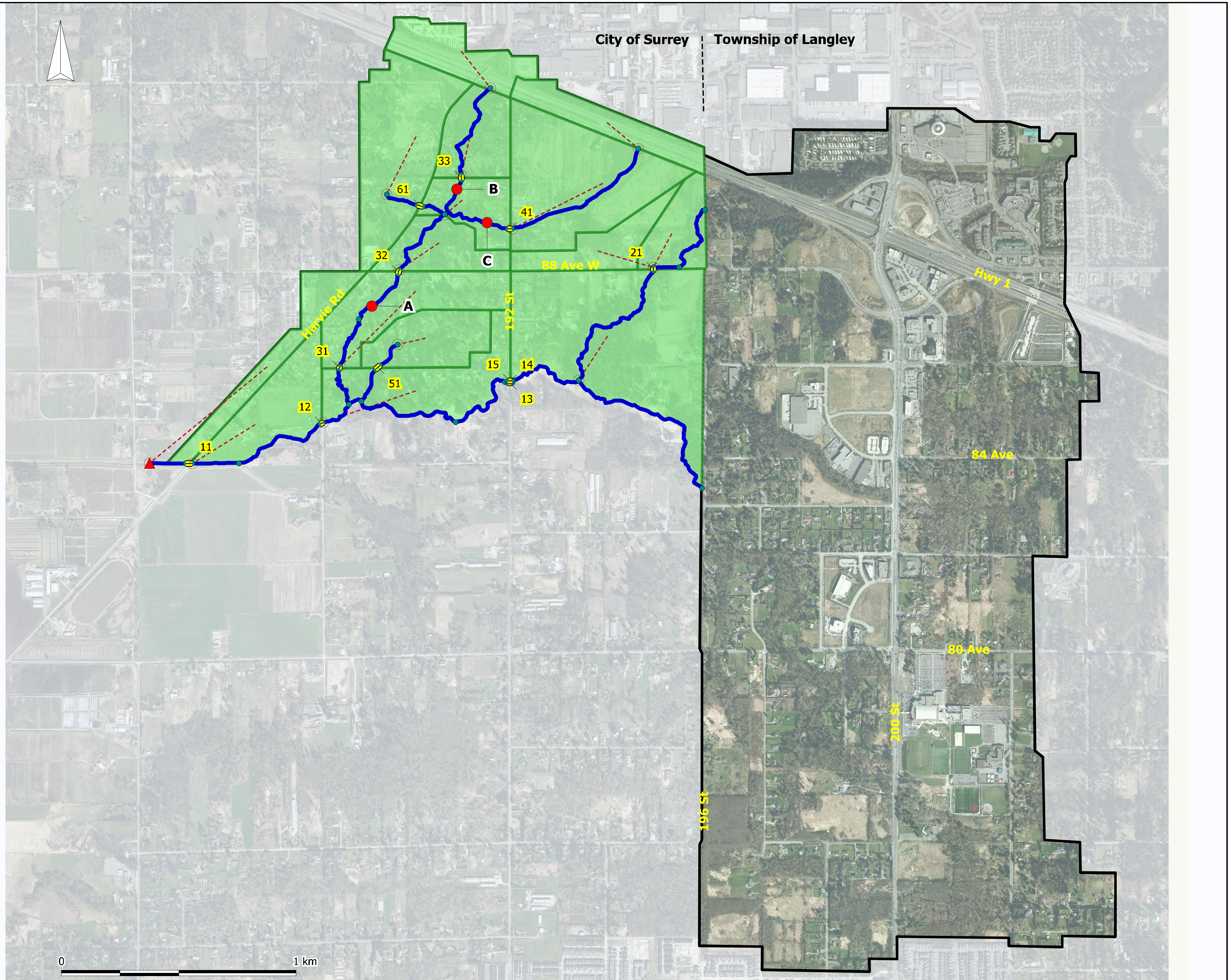
In addition to evaluating the storage requirements for the 5-year event based on the City's guidelines, we also estimated the storage volume that would be required to limit the 100-year post-development flow rates to the 100-year pre-development levels. For catchments 'Sub_41', 'Sub_21', and 'Sub_21a,' the required storage volume for the 5-year event is also sufficient to limit the 100-year post-development flow rate to pre-development levels. This suggests that the ponds could be used to provide attenuation for both the 5-year design event and the 100-year design event. In order to meet the target release rates for a variety of events, a staged flow-control structure would be required with multiple orifices and/or weirs.

For catchment 'Sub_61,' an additional 2500 m^3 of storage would be required in order to provide sufficient attenuation for the 100-year event. As noted above, this is due to the increase in contributing area under future conditions.

We note that the Stage 1 Stormwater Servicing Report for the Anniedale-Tynehead NCP provides a number of recommendations for the Anniedale-Tynehead area, which coincides with the portion of the current study area to the west of Harvie Road. As part of these recommendations, the report includes recommended storage volumes for six stormwater management ponds. The report indicates that a storage volume of 4,200 m^3 is required for 'Pond 3' which is located immediately west of Harvie Road to the north of 90 Avenue. This pond coincides with our recommended pond for Catchment Sub_61, with an estimated storage volume of 10,600 m^3.

In addition to considering changes in land cover under a future development condition, our modelling also reflects the proposed changes to the catchment areas as indicated by the Anniedale-Tynehead NCP. Based on these proposed changes, the contributing area upstream of Harvie Road would increase from 26 ha to 44 ha under future development conditions. This represents a significant increase in the amount of water that will be directed to this location under future conditions. As a result, a significantly larger storage volume will be required to attenuate peak flows to pre-development levels.

As discussed in Section 8.3, stormwater detention ponds would reduce the peak flow rates experienced by downstream culverts, and would improve the hydraulic performance of these culverts. However, the hydraulic benefits are not significant enough to warrant a reduction in proposed culvert sizes.



LEGEND

- REPORTING LOCATION
- A — REPORTING ID
- JUNCTION
- OUTFALL
- CULVERT
- 32 — CULVERT ID
- OPEN CHANNEL
- SUBCATCHMENT
- CATCHMENT CONNECTION

SCALE:	1:16,000		
PROJECT NO.	2014-2768	INITIAL	DATE
DRAWN		JT	15-09-04
DESIGNED			
CHECKED			
APPROVED			
PROJECTION:	UTM ZONE 10N NAD 83		

Associated Engineering — GLOBAL PERSPECTIVE. LOCAL FOCUS.

CITY OF SURREY — the future lives here.

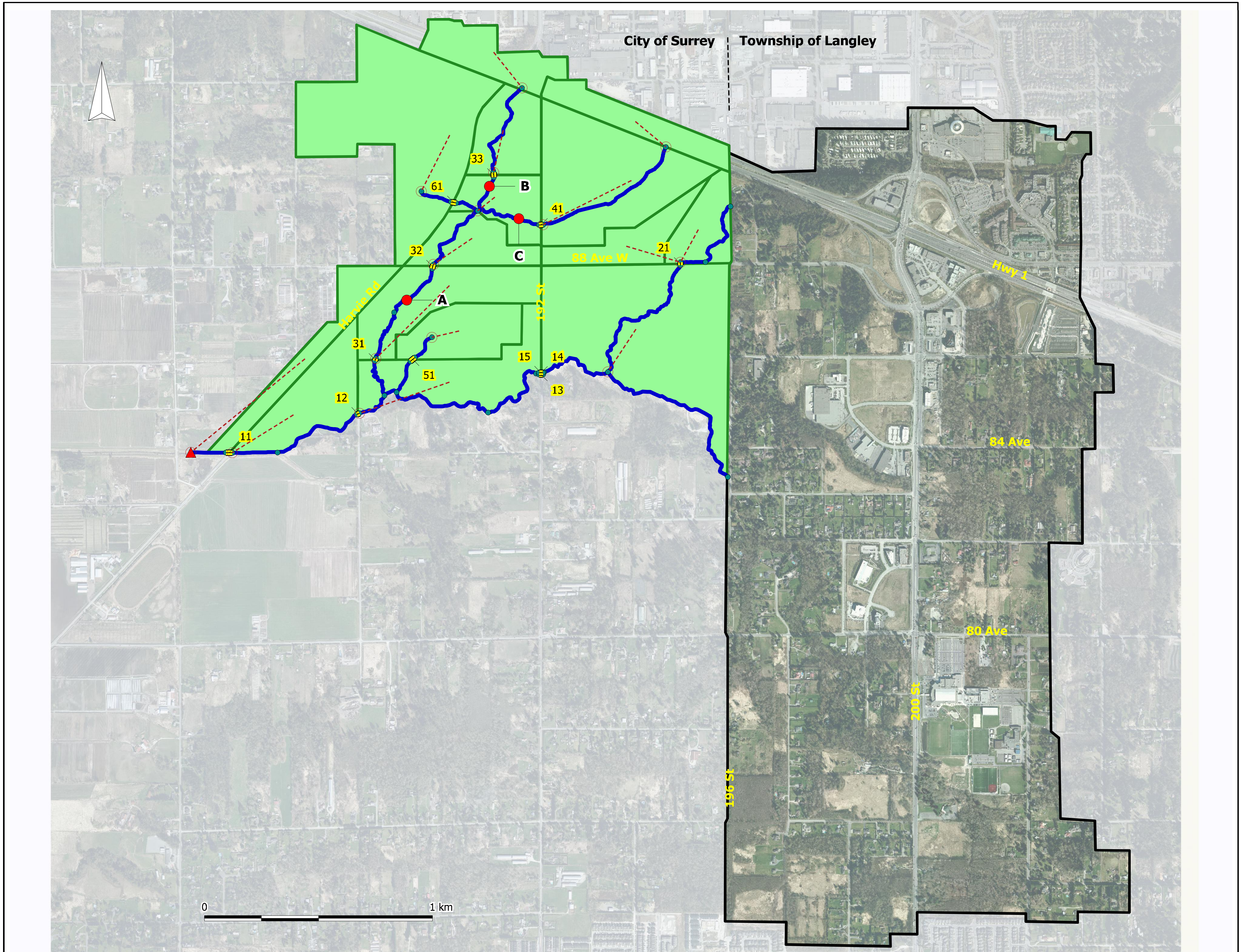
Township of Langley — Est. 1873

LATIMER CREEK ISMP

MODEL OVERVIEW

DRAWING NUMBER	REV. NO.	SHEET
MAP 8-1		

Map File: P:\20142768\00_Latimer_Ck_ISMP\Working_Dwgs\010_GIS\map_latimer_ismp_report_figures_20150326_jl.map



LEGEND

- REPORTING LOCATION
- A — REPORTING ID
- JUNCTION
- OUTFALL
- CULVERT
- 32 — CULVERT ID
- OPEN CHANNEL
- SUBCATCHMENT
- CATCHMENT CONNECTIONS

SCALE:	1:16,000		
PROJECT NO.	2014-2768	INITIAL	DATE
DRAWN		JT	15-09-04
DESIGNED			
CHECKED			
APPROVED			
PROJECTION:	UTM ZONE 10N NAD 83		

Associated Engineering — GLOBAL PERSPECTIVE. LOCAL FOCUS.

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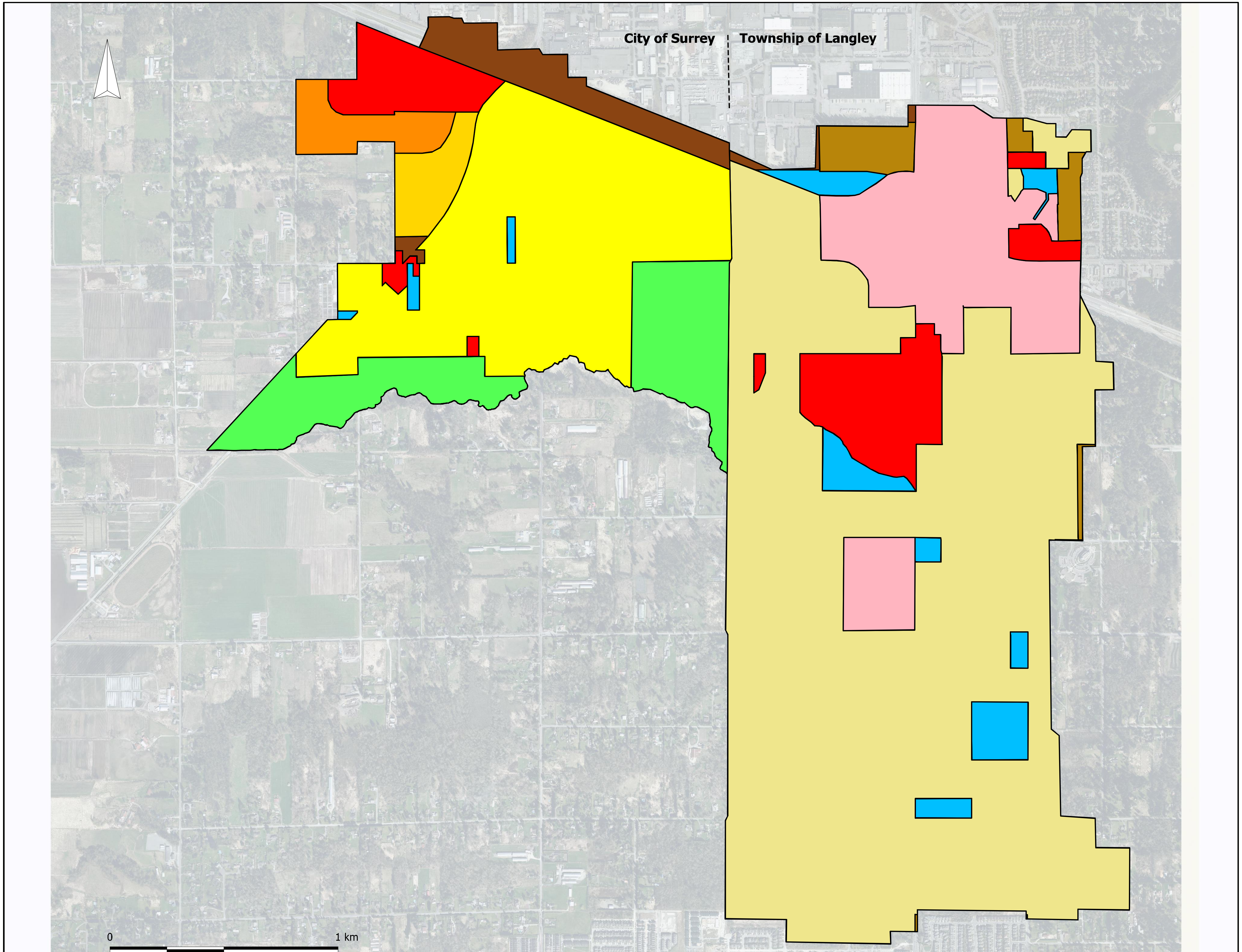
Township of Langley — Est. 1873

LATIMER CREEK ISMP

MODEL OVERVIEW
FUTURE CONDITIONS

DRAWING NUMBER	REV. NO.	SHEET
MAP 8-2		

Map File: P:\20142768\00_Latimer_Crk_ISMP\Working_Dwgs\010_GIS\map_latimer_ismp_report_figures_20150326_jl.map



LEGEND

- AGRICULTURAL
- COMMERCIAL
- COMPREHENSIVE DEVELOPMENT
- INDUSTRIAL
- INSTITUTIONAL
- RESIDENTIAL (LANGLEY)
- CLUSTER RESIDENTIAL
- URBAN RESIDENTIAL
- SUBURBAN RESIDENTIAL

TOWNSHIP OF LANGLEY LAND USE MAPPING IS BASED ON THE DATA PROVIDED. FOR ADDITIONAL DETAILS REGARDING LAND USE CONCEPT PLANS PRESENTED IN THE VARIOUS NEIGHBOURHOOD PLANS, REFER TO APPENDIX E.

SCALE:	1:16,000		
PROJECT NO.	2014-2768	INITIAL	DATE
DRAWN		JT	15-09-04
DESIGNED			
CHECKED			
APPROVED			
PROJECTION:	UTM ZONE 10N NAD 83		

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LATIMER CREEK ISMP

LAND USE - FUTURE DEVELOPMENT

DRAWING NUMBER	REV. NO.	SHEET
MAP 8-3		

Map File: P:\20142768\00_Latimer_Crk_ISMP\Working_Dwgs\010_GIS\map_latimer_ismp_report_figures_20150121_ad.map

9 Assessment of Potential Impacts

In addition to evaluating the system hydraulics for the 5-year and 100-year design events, we also ran a three-year continuous simulation of the drainage network to compare the existing and future conditions in the watershed. This allowed us to analyze the potential impacts of development in the Latimer Creek study area, absent of mitigative measures such as Low-Impact Developments (LIDs) and Best-Management Practices (BMPs). As noted, the stormwater management component of this ISMP is focused on the portion of the study area contained within the City of Surrey. External inflows have been modelled at the interface between the Township of Langley and the City of Surrey, based on the stormwater management plans that have been completed previously within the Township.

As such, the continuous simulation modelling focuses on the impacts of development within the City's portion of the study area. Specifically, the purpose of the simulation is to assess the impact of development on the hydrologic regime in natural watercourses. This provides an indication of changes in flow-duration characteristics following development, which can indicate locations where accelerated stream erosion may arise. Accelerated erosion poses a risk for developments situated near the edges of ravines, can detrimentally affect aquatic habitat, and can cause sediment accumulation that leads to reduced channel capacity and possible flooding in lowland reaches.

9.1 EXTENDED PERIOD SIMULATION

Initially, we completed Extended Period Simulation (EPS) modelling for two scenarios. The first scenario was based on existing land use, while the second scenario was based on future land use. The modifications to the land use under future development conditions are the same as those used for the event-based models, as discussed in Section 8.

For both scenarios, the same hydraulic network and rainfall data were applied to the model.

9.1.1 Rainfall Data

We used rainfall data spanning from January 1, 2009 to January 1, 2012 from the Surrey Kwantlen Park rain gauge, as shown in Figure 9-1.

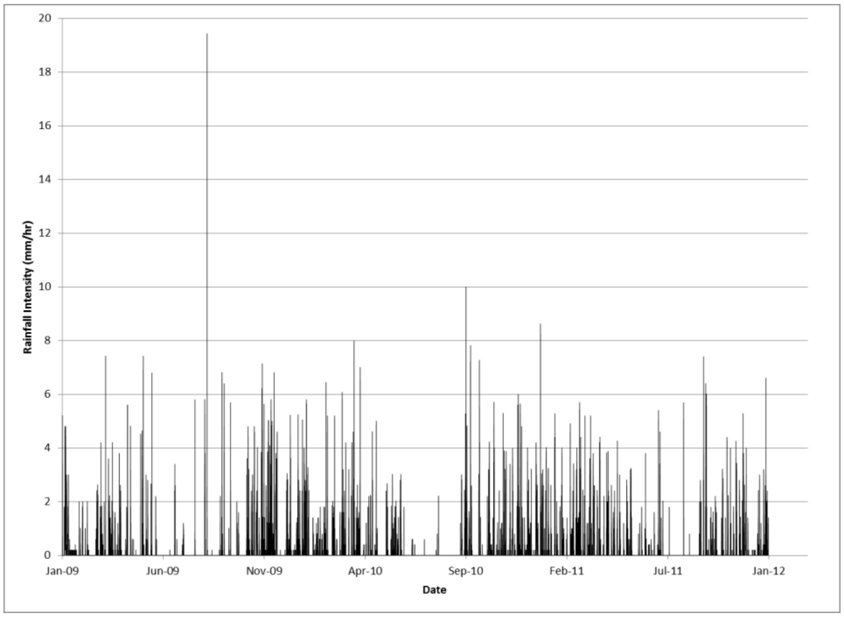


Figure 9-1
Rainfall Data used in EPS Scenarios

The Canadian Climate Normals entry for Surrey Kwantlen Park indicates an average annual rainfall of 1528 mm. The period selected for the EPS has an average annual rainfall of 1586 mm, and therefore is representative of typical conditions.

9.2 POTENTIAL IMPACTS OF DEVELOPMENT

The hydrologic modifications to the model under future development conditions are the same as those for the event based modelling, as described in Section 8. In addition to changes in the percent impervious values, there is also a significant increase in the catchment area upstream of Harvie Road under future conditions.

9.2.1 Hydrologic Impacts

The EPS modelling is based on actual observed rainfall data over an extended period, not on synthetic design events. As such, it is representative of the typical rainfall events that occur within the study area, and therefore provides quantitative insight into the study area's response to development, absent any mitigation measures such as source controls or BMPs.

The key hydrologic results from the EPS model are summarized in Table 9-1.

Table 9-1
Hydrologic Results from Extended Period Simulation Model

	Existing Development	Future Development	Change
Impervious Percent (%)	40.9%	52.6%	28.6%
Runoff Volume (10^9 m^3)	45.37	61.83	36.3%
Average Infiltration (mm)	2,765	2,248	-18.7%

The increased impervious area associated with the future development condition results in an increase in the total runoff volume. This is also consistent with the results from the event-based modelling described in Section 8, which demonstrated increases in the peak flow rates under future development conditions.

In the absence of mitigation measures, the increase in impervious area within the study area also reduces the infiltration, as there is an increase in hard surfaces which cannot accommodate infiltration. The potential benefits of various Low Impact Development (LID) and Best Management Practice (BMP) measures are considered subsequently, as discussed in Section 9.3 and Section 9.4.

We created flow-duration-exceedance curves at three locations: one on Bartesko Brook, one on Old Sawmill Creek upstream of the confluence with Bartesko Brook, and one on Old Sawmill Creek downstream of the confluence with Bartesko Brook. The curves are presented in Figure 9-2, and the reporting location for each curve is indicated on Map 8-1. These curves represent the fraction of the total simulation time that a particular flow rate is exceeded in each watercourse.

As noted, a significant portion of the Latimer Creek watershed is located within the Township of Langley, where stormwater management has been completed separately under the various Neighbourhood Plans. As discussed, we are using the peak flow rates reported by the Latimer Creek Master Drainage Plan (2003) at the boundary between the Township and the City.

As a result of this limitation, the hydraulic results from the EPS simulation would be obscured for all channels within the model that convey flows generated from the external inputs. This includes the main channel of Latimer Creek, as well as North Latimer Creek.

In order to provide meaningful results, the EPS simulation focuses on watercourses whose entire catchment area is contained within the City of Surrey's portion of the current study.

We also note that, due to the limitation discussed above, the model has not been calibrated. As such, the results of the EPS model provide a qualitative comparison between existing and future development conditions.

Under future development conditions, Bartesko Brook is subject to a significant increase in the occurrence of high flows. This makes sense, given that a significant portion of the area draining into Bartesko Brook is assumed to be developed as One Acre Residential under future conditions, whereas it is currently undeveloped.

Figure 9-2
Flow Duration Exceedance Curves for Study Area Watercourses

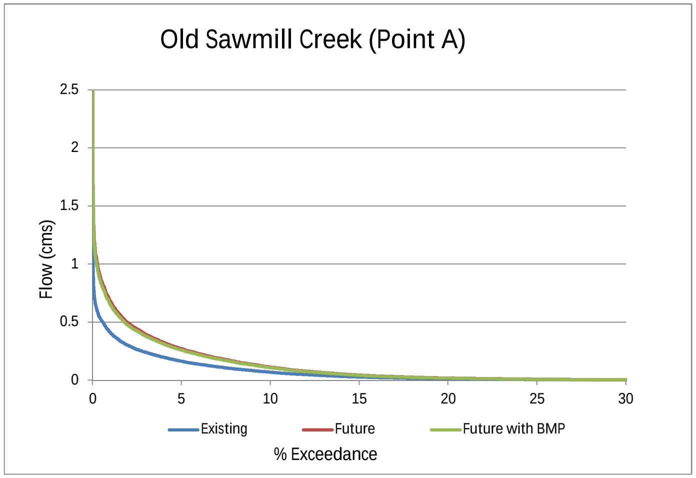


Figure 9-2a
Old Sawmill Creek Downstream of Confluence with Bartesko Brook
(Point A on Map 8-1)

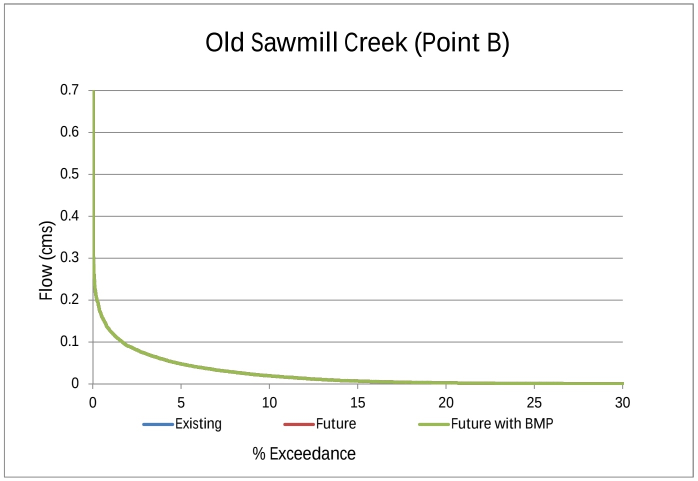


Figure 9-2b
Old Sawmill Creek Upstream of Confluence with Bartesko Brook
(Point B on Map 8-1)

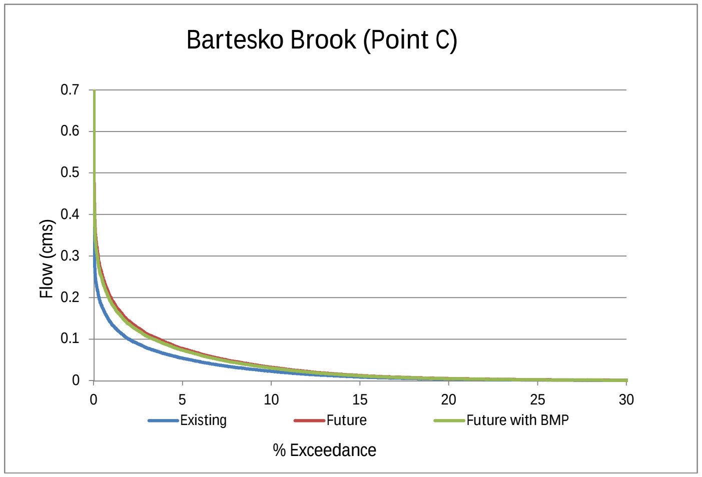


Figure 9-2c
Bartesko Brook
(Point C on Map 8-1)

Upstream of its confluence with Bartesko Brook, Old Sawmill Creek exhibits no change in the occurrence of high flows, since there is no assumed change in the land use that contributes to this reach of the stream. However, downstream of the confluence, Old Sawmill Creek is subject to a significant increase in the occurrence of high flows. This increase is due to the combined effects of development along Bartesko Brook, as well as development under the Anniedale-Tynehead NCP which will increase the contributing area, as well as the percent of impervious area.

9.2.2 Erosion Potential

Greater runoff volumes and increased frequency of high flows originating from subcatchments can translate into accelerated erosion rates in natural watercourses. Erosion occurs when the force of the water concentrated in the watercourse exceeds the critical tractive force for the threshold of movement of the bed material.

The indicators of increased erosion potential in a natural watercourse are the tractive force and stream impulse. Tractive force is the shear force acting on the stream bed, caused by flowing water concentrated in the watercourse. When the tractive force exceeds the threshold of movement of the bed material, erosion occurs. Stream impulse is a parameter that describes the energy of a given watercourse, and is a function of the tractive force and the wetted perimeter over time.

Using the results from our EPS, we calculated the increase in both maximum tractive force and stream impulse. The reporting locations are the same as those used for the flow exceedance curves, as shown on Map 8-1. The results of the maximum tractive force and total stream impulse evaluation are presented in Table 9-2.

Table 9-2
Maximum Tractive Force and Total Stream Impulse for Existing Development and Future Development without Mitigation

Point ID (Map 8-1)	Watercourse	Maximum Tractive Force (N/m^2)			Total Stream Impulse (kNh/m)		
		Existing	Future	Increase	Existing	Future	Increase
A	Old Sawmill Creek d/s of Bartesko	19.5	22.3	14.4%	144.0	192.9	34.0%
B	Old Sawmill Creek u/s of Bartesko	17.7	17.7	0.0%	16.9	16.9	0.0%
C	Bartesko Brook	18.8	20.6	9.6%	96.8	118.6	22.5%

The maximum tractive force and total stream impulse experience notable increases under future development conditions on Bartesko Brook, and on Old Sawmill Creek downstream of the confluence with

Bartesko Brook. As discussed above with respect to the flow-duration-exceedance curves, these increases make sense based on the significant change in land use upstream of these locations.
The majority of the tributary area draining to Bartesko Brook (upstream of 192 Street) is currently undeveloped. Under future conditions, this area is anticipated to be fully developed as One Acre Residential.

Likewise, the area draining into Harvie Creek from the west side of Harvie Road is anticipated to be developed under future conditions in accordance with the South Port Kells GLUP, and as described in the Anniedale-Tynehead NCP. This will change the land use from partially-developed One Acre Residential to Urban Residential, Cluster Residential, and Business Center. It will also significantly increase the contributing area that drains to Old Sawmill Creek.

The EPS results indicate there will be no increases in erosion activity on Old Sawmill Creek upstream of the confluence with Bartesko Brook under future development conditions. This is reflective of the fact that no future development is expected to occur within the tributary areas that drain to Old Sawmill Creek upstream of this confluence.

As noted above, erosion occurs when the tractive force exceeds the watercourse’s critical tractive force (the threshold of the bed material to resist movement). Without detailed information about the streambed composition and particle size distribution within the watercourses, it is difficult to comment on the actual erosion potential. We would generally only calculate stream impulse for periods where the tractive force exceeds the critical tractive force. However, given the uncertainty regarding the streambed composition, we have instead calculated stream impulse for each time step in the EPS.

We also note that the model is uncalibrated. As such, the tractive force and stream impulse values provide a qualitative comparison of existing and future development conditions.

If the watercourses are already near the threshold where average tractive forces would exceed the natural resistance to movement under existing conditions, then the increases noted above could result in the onset of erosion problems. However, if the watercourses are well below that threshold under existing conditions, then the increases noted above may not result in significant erosion problems.

As noted, the City’s ongoing ravine assessment program has not identified any significant instability sites within the current Latimer Creek ISMP study area. While this does not provide any guarantee on the potential for erosion problems under future conditions, it does suggest that the watercourses are relatively stable under current conditions.

Regardless, the EPS modelling indicates that future development will have a significant impact on the erosion potential for both Bartesko Brook and Old Sawmill Creek, absent mitigative measures.

9.3 LOW-IMPACT DEVELOPMENT AND BEST MANAGEMENT PRACTICES

In order to mitigate the negative impacts that future development will have on peak flow rates, total runoff volumes, and stormwater quality, we identified potential Low-Impact Development (LID) measures and Best Management Practices (BMPs). The focus of these measures is on stormwater management; as such, the analysis is geared towards the City's portion of the study area.

As noted, stormwater management within the Township of Langley has been completed through the various Neighbourhood Plans. As part of these plans, a number of Stormwater Source Controls have been recommended, including:

- Absorbent Landscaping
- Rain Gardens
- Underground Storage and Release
- Green Roofs
- Bioswales and Infiltration Galleries
- Pervious Paving

For details regarding the recommended stormwater management within the Township of Langley, including recommended Stormwater Source Controls, refer to the various Neighbourhood Plans that have been completed within the Township:

- Bylaw 4013 – Routley Neighbourhood Plan
- Bylaw 4825 – Jericho Sub-Neighbourhood Plan
- Bylaw 4995 – Carvolth Neighbourhood Plan
- Latimer Neighbourhood Plan (Pending)

We identified a number of LIDs and BMPs that can potentially be applied within the City's portion of the study area, including:

- Absorbent Landscaping and Growing Media
- Disconnect Impervious Areas
- Pervious Pavement
- Limit On-Lot Effective Impervious Coverage
- Underground Storage
- Bioswales
- Green Roof
- Rain Garden
- Water Quality Devices

These various LIDs and BMPs are discussed in the following sections, arranged by land use within the City's portion of the study area.

9.3.1 One Acre Residential Land Use

9.3.1.1 One Acre Residential Lots

One Acre Residential is the most predominant land use within the City's portion of the study area. The lot sizes within this zoning for the study area vary from approximately 700 m^2 up to approximately 20,000 m^2 (2 ha). The average lot size is approximately 5,580 m^2.

Based on the City of Surrey's Zoning Bylaw, lot coverage for One Acre Residential is to be limited to a maximum of 20% of the area. Lot coverage is a measurement of the combined areas of all building, outdoor covered areas, and structures on a lot, but does not include additional hard surfaces such as driveways, patios or pathways.

Recognizing that, in practice, the percentage of hard surfaces typically exceeds the limits that are specified in the Zoning Bylaw, the City's Design Criteria Manual provides a recommended value of 50% impervious for One Acre Residential for hydrologic modelling purposes.

Based on our review of the ortho-imagery for the study area, the actual percent impervious values appear to vary. The larger lots tend to have a lower percent of impervious area, while the smaller lots tend to have a higher percent of impervious area. The recommended value of 50% impervious presented in the City's Design Criteria Manual appears to be on the upper end of values observed within the study area. However, it appears to be a reasonable estimate for the purposes of hydrologic modelling. Figure 9-3 shows an example of a One Acre Residential lot within the study with approximately 50% impervious area.

Figure 9-3
Example of One Acre Residential Lot with Approximately 50% Impervious Area

9.3.1.2 Urban Residential and Cluster Residential Lots

None of the lots within the City's portion of the study area are currently developed as Urban Residential or Cluster Residential; these land uses are proposed as part of the future development that is expected to occur under the South Port Kells General Land Use Plan.

The City's Zoning Bylaw specifies a maximum lot coverage of 40% for Cluster Residential.

Recognizing that, in practice, the percentage of hard surfaces typically exceeds the limits that are specified in the Zoning Bylaw, the City's Design Criteria Manual provides a recommended value of 65% impervious for Cluster Residential for hydrologic modelling purposes.

The Land Use 'Urban Residential' is not explicitly identified by the City's Zoning Bylaw nor the Design Criteria Manual. However, we have interpreted Urban Residential to be similar to Multiple Residential Commercial and Semi-Detached Residential, both of which have a recommend impervious value of 80% in the City's Design Criteria Manual.

9.3.1.3 Potential Best Management Strategies – Residential Lots

Absorbent Landscaping and Growing Media

Absorbent landscaping acts like a sponge that retains rainfall, stores it temporarily, and then slowly releases it. Its primary purpose is to mimic the hydrologic function of undeveloped land on a developed site. It tends to have only a limited capacity, and will saturate and lose functionality during large rainfall events. Regardless, it is an appropriate measure to manage stormwater at the source, and is particularly effective for small, frequent rainfall events. Additionally, the filtration mechanism of the soil layer provides water quality benefits.

Absorbent landscapes typically consist of a layer of absorbent soil with vegetation such as shrubs and trees. The vegetation provides an additional function of supporting interception and evapotranspiration. Absorbent landscapes receive direct rainfall and runoff from small impervious surfaces (such as driveways, paths and patios).

Absorbent landscapes are easily applied (relative to other source controls) to existing residential lots, and provide aesthetic benefits for the community and individual homeowners. Vegetation can be selected such that it also supports backyard biodiversity and the increased presence of native plants. Required maintenance includes typical gardening activities such as weeding and replacing dead plants, as well as watering during extended dry periods. As well, an overflow should be considered, and should be inspected monthly and debris removed.

For the purpose of effective stormwater management, the depth of absorbent soils should be a minimum of 450 mm, and be comprised of soils with high organic content, such as sandy loam.

Disconnect Impervious Areas

In conventional drainage systems, impervious surfaces such as roads, driveways, parking lots, and roofs are connected directly into a conveyance system or receiving watercourse. Runoff from these impervious surfaces moves very rapidly and mobilizes and transports sediment and other pollutants. The result is very flashy flows with low times of concentration, high peak flow rates, large runoff volumes, and high pollutant mobility. These negative hydrologic impacts can be mitigated by disconnecting impervious areas from each other and the downstream pipe networks.

We understand that, in general, residential roof leaders constructed prior to 1984 were connected directly to the storm drainage system, while those constructed after 1984 are generally not connected. Based on the plan year information available on the City’s Online Mapping System (COSMOS), the majority of lots within the study area appear to predate 1984; actual construction dates for residential dwellings are not available.

Disconnection can also include parking lots, roads, and other impervious surfaces; runoff can be directed to vegetated/pervious surfaces prior to arriving at a conventional drainage system. This approach will promote infiltration (subject to local soil conditions), evapotranspiration, and overland filtering. Even where runoff volumes are not significantly reduced, slowing of runoff provides downstream benefits in receiving streams, and is closer to a natural hydrologic regime.

The location, capacity, and soil conditions of each receiving vegetated area should be given careful consideration to ensure that directing impervious area runoff to pervious surfaces does not result in potential flooding or erosion.

Disconnecting impervious areas has good potential in medium and low density residential developments since there are generally green spaces available to receive runoff.

Pervious Pavement

Pervious pavement provides an alternate configuration for otherwise impermeable surfaces, such as driveways, walkways and patios. It consists of a paving system that allows rainfall to percolate into an underlying subgrade reservoir. If sufficient infiltration capacity exists in the subgrade or underlying soils, the water will be infiltrated. Otherwise, it can be discharged to the storm network through an underdrain.

Metro Vancouver’s Stormwater Source Control Guidelines (2012) suggests that pervious pavement can receive runoff from other impermeable areas, provided sediment loads are not excessively high. Pervious pavement can provide a reduction in peak flows and runoff volume, as well as some contaminant removal, and in certain areas assists in rehabilitating base flows to natural watercourses via groundwater recharge.

Pervious pavement typically consists of five layers including the surface (porous asphalt / concrete, concrete / plastic grid pavers, concrete pavers installed with gapped joints), an aggregate bedding, open graded base, open graded sub base, and subsoil. Additionally, the use of a geotextile to prevent migration of fines into the base drainage courses is recommended. For areas that have been identified as having low infiltration potential, a partial-infiltration configuration that includes an underdrain may be required.

On residential lots, pervious pavement provides excellent mitigation to the effects of driveway expansions, new walkways, porches and patios. Due to the relatively complicated nature of construction, however, home owners may be hesitant to install pervious pavement for these types of projects. Supplemental support and encouragement from the City may be necessary to maximize the implementation of pervious pavements within the study area.

Limit On-Lot Effective Impervious Coverage

Impervious areas are any surface that water cannot penetrate and include areas such as parking lots, pathways, driveways, roads, and rooftops. In hydrologic terms, impervious surfaces prevent infiltration, generate increased runoff volumes and peak flow rates, facilitate mobilization of accumulated sediment, transport nonpoint source pollutants, and increase the potential for erosion and water quality problems in receiving watercourses.

The majority of the other stormwater management BMPs discussed in this report aim to reduce the negative hydrologic effects of runoff from impervious surfaces. Their function can be heightened by reducing the percent impervious values of contributing developments. We recommend that impervious surface reduction be considered at the planning stage of site development and re-development.

We note that lots which are currently undeveloped present the best opportunity to implement limits on impervious areas during future development.

Underground Storage

Future development under the South Port Kells GLUP is expected to have high proportions of impervious cover and land consumption. While large scale surface detention and treatment systems are proposed within this area, they would take up a significant amount of space. As an alternative, storage can potentially be provided by underground systems. In commercial, industrial, and high density residential areas, detention storage can be provided as tanks located under parking or working areas and in urban residential areas within lawns or under driveways, preferably at the low point of each site.

These systems could be designed to provide both peak flow attenuation and volume reduction functions. To provide attenuation, storage units should be sized and configured with sufficient volume to retain a significant portion of the runoff for an extended period of time. They would require a flow control feature at the outlet to limit release rates. Water would be temporarily stored, and release at a slower rate, which would better mimic the slow percolation and concentration rates of the organic surficial soils and vegetation present under natural conditions. These units would require a bypass system, either external to the unit or an internal overflow, to ensure large design storms exceeding the unit capacity can be conveyed to the downstream system.

To provide a volume reduction function, these units can be hydraulically connected to the underlying soils to promote infiltration. We note that the area where these units are most likely to be employed is in the northwest corner of the study area within the South Port Kells GLUP. This area has also been identified as having moderate infiltration potential.

9.3.2 Business Centre (New Commercial Development)

9.3.2.1 Business Center Lots

There are no lots currently developed as Business Centre within the study area. Future development under the South Port Kells GLUP is expected to include Business Centre Lots.

Under the City's Zoning Bylaw, the maximum lot coverage specified for Business Park Zone is 60%. Recognizing the additional hard surfaces associated with Business Centres, the percent impervious value for this land use should be higher. While the City's Design Criteria Manual does not provide a recommended value for percent impervious specifically for Business Centre, we estimate that it will be similar to the recommended value of 80% for commercial land use.

9.3.2.2 Potential Best Management Practices – New Business Center Lots

Bioswales

Bioswales are shallow open channels that capture and convey stormwater runoff. They are typically comprised of a vegetated topsoil layer, a drain rock layer and a subgrade drain. In locations where stormwater treatment is a concern, as with commercial developments, bioswales provide stormwater treatment by assisting in the removal of Total Suspended Solids (TSS), heavy metals and some hydrocarbons.

Compared to a traditional piped drainage network, bioswales can significantly attenuate runoff received from impervious surfaces due to the relatively high roughness of the surface layer, and the effect of temporary subsurface storage in the drain rock layer and promotion of shallow infiltration.

Bioswales can be implemented along the edges of parking lots and provide benefits to stormwater quality while lessening the strain on the City's piped drainage network.

Green Roof

A green roof is an amended conventional roof that incorporates features such as planter boxes that support living vegetation. For the purposes of stormwater management, soil depth is typically 300 mm or less. Green roofs operate similar to absorbent landscaping as discussed above by soaking up and temporarily retaining direct rainfall.

Buildings located on commercial lots tend to occupy a significant fraction of the total lot area and often have flat roofs. This makes the implementation of green roofs a possibility for these developments.

Various studies have highlighted that green roofs provide extra insulation reducing heat transfer as well as improving the longevity of the roof structure by helping to protect the membrane from extreme temperature fluctuations (Metro Vancouver, 2012). With proper communication of these benefits, property managers may be more inclined to support the inclusion of green roofs on their lots.

Rain Gardens

Rain gardens are aesthetically pleasing landscape features designed to capture, detain, treat and infiltrate stormwater runoff. Rain gardens typically consist of 450 mm of absorbent topsoil supporting trees, shrubs and groundcover, overlying a drain rock reservoir. The soil and vegetative layers provide attenuation and treatment of water as it percolates and collects in the drain rock reservoir. If infiltration capacity in the drain rock reservoir is sufficient, the water will infiltrate. Otherwise, the water is directed into the storm drainage network either through an overflow catch basin at the surface or through a subdrain located in the drain rock layer.

Within commercial areas, rain gardens can provide a pleasant aesthetic feature while collecting and treating the majority of direct runoff developed from impervious surfaces such as parking lots or rooftops.

Water Quality Devices

Propriety water quality devices are becoming common, and are available from a variety of vendors. The most common devices separate sediment and oils from the water stream through settling chambers, inverted weirs, swirl chambers, and submerged outlets. There are also more advanced units which incorporate absorbent materials and filters; some devices are also available with chemical agents to promote coagulation and settling of fine particles.

In general, these devices are most effective when applied to areas where pollutants are mobilized and concentrated at a single point, such as parking lots, soil or sediment stockpiles, and vehicle maintenance locations.

They can also be provided as spill traps to reduce the spread of accidental pollutant releases and facilitate emergency cleanup and response. As with all BMPs, water quality devices can be used in conjunction with other features. In particular, they can help protect other BMPs, such as infiltration systems and vegetated features, from excessive loadings that could degrade their performance.

Underground Storage

Underground storage units could be implemented within the Business Center Lots proposed under the South Port Kells GLUP. Underground storage may be appropriate in this area, given the limited space that will be available for surface storage, provided they can drain by gravity.

Underground storage can potentially provide peak flow attenuation as well as volume reduction. For details regarding underground storage, refer to Section 9.3.1.

9.3.3 Roadways

Private land redevelopment faces practical limitations on the source controls that can feasibly be implemented. While source controls provide excellent community benefits, lot owners may not be willing to commit the effort into proper design that would translate to real benefits for the City. Considering this, City road rights-of-way (ROW) have significant opportunities for the implementation of BMPs because they are linear, and within the City's control. Enhancing roadways through 'green-street' type developments not only provides stormwater management benefits, but also supports the City's goals of providing aesthetically pleasing communities.

Below we outline a list of potential BMPs that can be implemented on road rights-of-way that support stormwater management while enhancing community aesthetics. The BMPs discussed in this section are best-suited to local/collector and arterial roads.

Bioswales

The hydrologic benefits and typical structure of bioswales was discussed in Section 9.3.2. Runoff from travelled lanes and parking areas can be directed to bioswales, rather than being immediately discharged into the storm drainage network. This provides for treatment of TSS, heavy metals and hydrocarbons, reducing the direct loading on the storm drainage network.

Pervious Pavement

The hydrologic benefits and typical structure of pervious pavements were discussed in Section 9.3.1.

While pervious pavement should not be implemented in high-traffic areas due to potential structural concerns and ponding, sidewalks and parking lanes can utilize pervious pavement to attenuate runoff and promote shallow infiltration to the underlying soil.

Rain Gardens

The hydrologic benefits and typical structure of rain gardens were discussed in Section 9.3.2.

Runoff from travelled lanes and parking lanes can be directed to rain gardens to provide treatment and runoff attenuation. Rain gardens can be placed at the downstream ends of bioswales to provide maximum treatment efficiency and runoff reduction. Rain gardens may be linear features or incorporated into curb bulges.

Absorbent Landscaping and Street Trees

The hydrologic benefits and structure of absorbent landscaping were discussed in Section 9.3.1.

Absorbent landscaping can be employed in combination with street trees to support the City's ultimate tree canopy goals as well as the City's goal to provide aesthetically pleasing communities. Absorbent landscaping in a roadway context is best suited to the inclusion of street trees to maximize the hydrologic benefits. Trees can consist of coniferous or deciduous trees, and are most beneficial if they possess high leaf densities. Coniferous trees are preferred over deciduous trees, as leaf litter can restrict the absorption of the underlying soil, and their retention of foliage through the winter rainy season promotes maximum interception.

For maximum effectiveness, the growing medium should have a minimum depth of 450 mm. Analysis of the feasibility of street trees must consider implications to the surrounding pavement structures, as tree roots can damage concrete sidewalks and paved roads, although this effect can be mitigated by the use of structural soils.

Structural Soils

Structural soils are soil media that can be compacted to meet pavement design and installation requirements while permitting adequate root growth. It is generally composed of gap-graded crushed stone, clay loam and a hydrogel stabilizing agent to bind the mixture together. It provides a root-penetrable, high strength pavement system that shifts design away from individual tree pits.

Structural soil can be located under the sidewalks adjacent to most arterial and local roads. By allowing roots to cover a greater area without damaging pavement structure, structural soil can reduce some of the drawbacks of street trees.

9.3.4 Green Space

There is a significant amount of existing green space within the study area. This includes park areas as well as green spaces surrounding schools:

- Park areas:
  - Port Kells Park (Surrey)
  - McClughan Park (Langley)
  - Willoughby Community Park (Langley)
  - Dorothy Peacock Park
- Green areas surrounding schools:
  - Port Kells Elementary (Surrey)
  - R.E. Mountain Secondary School (Langley)
  - Dorothy Peacock Elementary (Langley)

All of these existing green spaces should be preserved.

There is also a significant amount of green space within the riparian corridors along the various watercourses throughout the study area. This is reflected by the riparian forest integrity assessment, which identified that 68% of the riparian buffer zones have intact forest.

We note that, as part of the City of Surrey's Biodiversity Conservation Strategy, local corridors, regional corridors, sites and hubs have been identified for environmental protection to maintain and enhance the aquatic and terrestrial value of the existing Green Infrastructure Network.

In addition to the corridors, sites and hubs contained within the City's BCS, we identified additional enhancement opportunities within both the City of Surrey and the Township of Langley.

We also note that there are a number of Neighbourhood and Land Use Plans within the study area, which have identified conservation areas along existing watercourse to protect the integrity of these vital corridors. Refer to the various Neighbourhood Plans and Land Use Plans for details:

- South Port Kells General Land Use Plan (Surrey)
- Bylaw 4013 – Routley Neighbourhood Plan (Langley)
- Bylaw 4825 – Jericho Sub-Neighbourhood Plan (Langley)
- Bylaw 4995 – Carvolth Neighbourhood Plan (Langley)
- Latimer Neighbourhood Plan (Langley – Pending)

9.3.5 Alternate Land Uses (Existing)

The remaining land uses within the City under current conditions (institutional, commercial, industrial, comprehensive development) occupy a small fraction of the study area.

These areas have a high percentage of impervious cover; the City's Design Criteria Manual recommends values of 80% to 90% for hydrologic modelling purposes. Based on our review of the ortho-imagery for the study area, these values appear reasonable. Figure 9-4 shows an example of two adjacent lots currently zoned as Highway Commercial Industrial.

Figure 9-4
Example of Highway Commercial Industrial Lots with Approximately 90% Impervious Area

The various lots that fall under these alternate land uses are located within areas that have low or no infiltration potential, based on the hydrogeological assessment discussed in Section 2.

9.3.6 Agricultural Land Reserve

There are portions of the study area which are contained within the Agricultural Land Reserve. We note that the operation and management of land within the ALR is protected under the Farm Practices Protection (Right to Farm) Act. As such, there is little to no opportunity for municipalities to enforce stormwater management LIDs and BMPs on agricultural lands.

In general, stormwater management within the City's agricultural areas is covered under the lowland drainage studies, which are distinct from the various ISMPs within the upland areas.

9.4 EFFECTIVENESS OF POTENTIAL BMPS

9.4.1 Water Balance Model

We used the Water Balance Model (WBM) to evaluate the effectiveness of the potential Best Management Strategies for the study area. The Water Balance Model is a web-based tool that allows the user to determine hydrologic benefits of applied source controls. The user enters soil information, details on land use type, surface conditions and source control details, and the model outputs volume, flow, infiltration, losses and discharge under an extended period simulation. We used rainfall data based on records from the Surrey Kwantlen Park station from 1965 to 1990.

Using the WBM, we compared the hydrologic response of existing (undeveloped) and future (developed) scenarios with and without BMPs for One Acre Residential and Urban Residential land uses. The WBM results are intended as a qualitative indication of the potential benefits of BMPs.

For the One Acre Residential land use, we modelled existing undeveloped conditions and future development conditions. We adjusted the percent impervious under future conditions based on the recommended values presented in the City's Design Criteria Manual. The results indicate an increase in the runoff volume under future conditions. As discussed above, we identified various potential BMPs to address the impacts of future development. We simulated an additional scenario using the WBM to assess the potential benefits. For the One Acre Residential lot, we applied absorbent landscaping over half of the pervious area (25% of the total lot size). We also modelled pervious pavement over 10% of the impervious area (5% of the total lot size).

For the Urban Residential Areas, we applied Absorbent Landscaping for the entire pervious area (20% of the total lot), as well as pervious pavement over 10% of the impervious area (8% of the total lot).

The Water Balance Model results are presented in Figure 9-5.

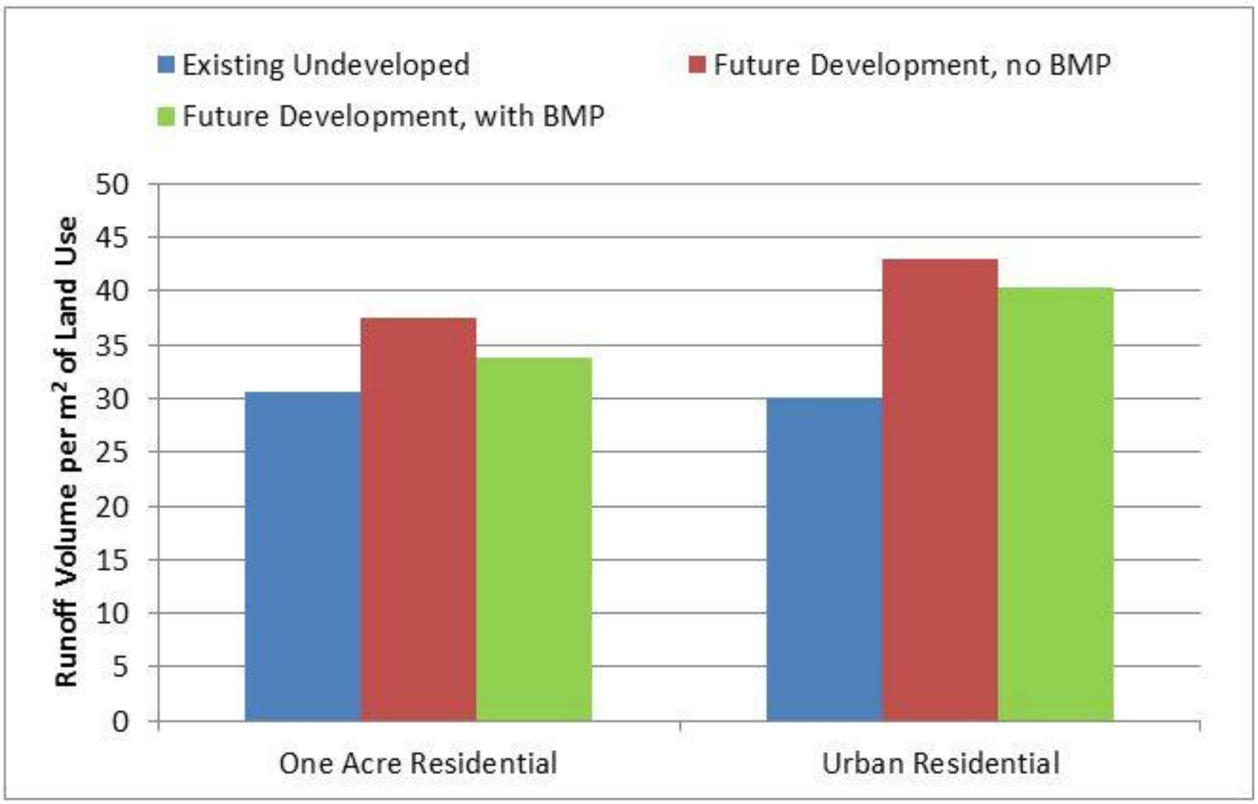


Figure 9-5
WBM Results: Effectiveness of BMPs for One Acre and Urban Residential Land Uses

The results indicate that implementing BMPs can provide a benefit in terms of reducing runoff volumes under future development conditions. The increase in runoff volume from existing conditions to future development conditions for the One Acre Residential reflects the increase in impervious coverage from 20% to 50%. If BMPs are applied, the increase in runoff volumes can potentially be reduced.

The increase in runoff volume for the Urban Residential land use is more significant, which reflects the change in impervious coverage from 20% to 80%. While the results indicate that absorbent landscaping and pervious pavement can limit the increase in runoff volume, they cannot reduce runoff volumes to existing conditions.

Detailed summary reports from the Water Balance Model evaluation are provided in Appendix H.

9.4.2 Extended Period Simulation

The WBM results indicate that, through the application of the proposed BMPs, the runoff coefficients for One Acre Residential and Urban Residential / Commercial lots can be reduced by approximately 10% and 6%, respectively, under future conditions.

Using these values as targets, we reduced the percent impervious values within the PCSWMM model, reran the EPS simulation, and reviewed the runoff coefficients reported by the model. We continued this iterative process of adjusting the percent impervious values and reviewing the reported runoff coefficients until the results matched the reductions indicated by the WBM.

Using the updated EPS results, we created flow-duration-exceedance curves for the future development condition with the application of BMPs. The results are presented on Figure 9-2, which also includes the flow-duration-exceedance curves for both the existing development condition and the future development condition without BMPs. The reporting location for each curve is indicated on Map 8-1. The flow-duration-exceedance curves illustrate the increase in erosion potential on the natural watercourses within the study area based on the anticipated development activities, as well as the benefits of the proposed BMPs.

On Bartesko Brook (Point C), and on Old Sawmill Creek downstream of the confluence with Bartesko Brook (Point A), the curves indicate that, while the BMPs will provide some benefit in terms of reducing the erosion potential on the natural watercourses, they will not be able to reduce the post-development flow regime to match existing conditions. This highlights the need to also provide detention ponds to control peak flow rates to allowable levels during larger events.

Upstream of the confluence with Bartesko Brook, Old Sawmill Creek (Point B) exhibits no change in the occurrence of high flows under future development conditions, since there is no assumed change in the landuse that contributes to this reach of the stream. Likewise, the application of BMPs within the study area does not reduce the occurrence of high flows at this location, since there are no assumed BMPs applied upstream of this point.

For the purposes of this assessment, we assumed that BMPs will only be applied in areas of future development. This reflects that fact that future development activities will provide the City with an opportunity to enforce Low Impact Development (LID) and BMP measures as development occurs. Conversely, it is more challenging to implement and enforce LIDs/BMPs in areas that are already developed. We note that any additional BMPs which are retroactively applied through re-development and/or densification would provide further benefits in terms of reducing flow rates within the natural watercourses in the study area.

10 Recommended Drainage Improvements and BMPs

10.1 LOCATION-SPECIFIC DRAINAGE IMPROVEMENTS

As discussed in Section 8, we completed modelling of future mitigation measures to determine the required drainage upgrades within the City of Surrey's portion of the study area. These drainage improvements include culvert upgrades and detention ponds.

Table 10-1 outlines the proposed drainage upgrades within the City's portion of the study area, and Map 4-4 shows the location of each specific upgrade recommendation. The LID and BMP measures, which will be applied in general areas rather than specific locations, are discussed in subsequent sections.

Table 10-1
Recommended Drainage Improvements

ID / Municipality	Location	Item	Surrey 10-Year Servicing Plan ID	Reason for Upgrade	Description	Cost
1 – Surrey	Old Sawmill Creek at 86 Ave	Culvert (31)	8124	Undersized for 100-year flow. Overtops road.	Replace 1120 mm x 1630 mm CSP Arch with 1520 mm x 2060 mm CSP Arch	$100,000
2 – Surrey	86 Ave east of188 St	Culvert (51)	8125	Undersized for 100-year flow. Overtops road.	Replace 450 mm Wood Stave with 800 mm CSP.	$100,000
3 – Surrey	Harvie Rd south of 90 Ave	Culvert (61)	n/a	Undersized for 100-year flow. Floods adjacent property.	Replace 750 mm Conc with 1350 mm Conc	$100,000
4 – Surrey	Old Sawmill Creek at 90 Ave	Culvert (33)	n/a	Existing culvert in poor condition; invert corroded through.	Replace 750 mm CSP with new 800 mm CSP	$100,000
5 – Surrey	West of Harvie Rd, north of 90 Ave	Pond	13244	Control peak flows.	10,600 m^3 storage pond	$8,276,000[1]
6 – Surrey	East of 192 St, north of 90 Ave	Pond	n/a	Control peak flows.	3,800 m^3 storage pond.	$2,964,000[1]

ID / Municipality	Location	Item	Surrey 10-Year Servicing Plan ID	Reason for Upgrade	Description	Cost
7 – Surrey	West of 196 St, north of 88 Ave	Pond	n/a	Control peak flows.	2,200 m^3 storage pond.	$1,716,000[1]
18 – Surrey	Bartesko Brook at 192 St.	Culvert (41)	8122	Undersized for 100-year flow with climate change.	Replace 600 mm Conc with 1050 mm Conc	$80,000[2]

Notes:

1. Pond cost estimated at $780/$m^3$, based on reported cost of pond within Anniedale-Tynehead NCP, and the previously reported volume requirement ($3,279,000 / 4200 m^3). Unit rate for ponds includes land costs.
2. The lower cost at this location is due to the crossing being located under a driveway rather than a public road.
3. CSP culverts within the City of Surrey are to have an Aluminized Type 2 coating.

10.2 ADDITIONAL DRAINAGE UPGRADES

Four of the proposed drainage upgrades noted in Table 10-1 are currently included in the City of Surrey's Ten-Year Servicing Plan. The plan also identifies an additional three improvement projects within the study area. These additional drainage upgrades are summarized in Table 10-2.

Table 10-2
Additional Drainage Upgrades

Municipality	Location	Item	Surrey 10-Year Servicing Plan ID	Cost
Surrey	Harvie Rd, north of 90 Ave	100 m of ditch improvements	13239	$14,000
Surrey	Old Sawmill Creek at 88 Ave	Culvert	8123	$25,000
Surrey	North of 88 Ave at 196 St	Storm Trunk	8127	$125,000

These additional drainage upgrades are discussed below. Appendix I includes a snapshot from the City's Ten-Year Servicing Plan, and indicates the drainage projects within the current study area.

10.2.1 Ditch Improvements along Harvie Road

The City's Ten-Year Servicing Plan identifies 100 m of ditch improvement along Harvie Road just north of 90 Avenue. These upgrades (Project ID 13239) are identified under the umbrella of the Anniedale NCP. The estimated cost for the proposed improvements is $14,000.

10.2.2 Culvert Upgrade on Old Sawmill Creek at 88 Avenue

The City' Ten-Year Servicing Plan identifies an upgrade of the existing culvert on Old Sawmill Creek under 88 Avenue. The upgrade (Project ID 8123) identifies the existing pipe as a 700 mm diameter, with a proposed upgrade to a 1500 mm diameter pipe. The reported cost estimate for the culvert replacement is $25,000. The City's online mapping system, COSMOS, identifies the existing pipe as an 800 mm.

We note that the existing culvert was identified as a 1300 mm diameter concrete pipe as part of the 2003 Latimer Creek Master Drainage Plan. Based on site constraints, our field staff were not able to directly access the culvert during our field investigation for the current ISMP. However, based on our observations from the top of the headwall at the culvert inlet and outlet, the reported diameter of 1300 mm appears accurate; we modelled the culvert accordingly.

As a result of development upstream of this culvert, flows will increase under future conditions. Culvert upgrades upstream of this location will also increase the flow rates at this crossing. Our modelling results indicate that the existing 1300 mm concrete culvert will surcharge to approximately 9.8 m under future development conditions, which is roughly equal to the adjacent road elevation. Under a future climate change scenario, the surcharge would increase further to the point of flooding the road. If this culvert were upgraded to a 1500 mm diameter concrete pipe in accordance with the City's Ten-Year Servicing Plan, the upstream 100-year HGL would be limited to 9.4 m under future development conditions.

10.2.3 New Storm Trunk Pipe North of 88 Avenue at 196 Street

There is a new storm trunk identified just north of 88 Avenue, immediately west of the municipal boundary with the Township. The City's Ten-Year Servicing Plan does not provide additional information on this proposed upgrade (Project ID 8127); it is unclear what this future storm trunk is expected to service. The reported cost estimate is $125,000 for 150 m of trunk storm pipe.

10.3 RECOMMENDED BMPS

In addition to the specific drainage upgrades outlined above, stormwater Best Management Practices (BMPs) should be implemented to mitigate the potential hydrologic impacts of development within the study area. The proposed BMPs are discussed below for various land uses. As a performance target for volume reduction and water quality control, BMPs and LIDs should be sized to accommodate site runoff from 72% of the 2-year, 24-hour rainfall event, in accordance with the draft Land Development Guidelines (DFO/MoE).

Porous Pavement

10.3.1 One Acre Residential Lots

Based on the City of Surrey's Zoning Bylaw, lot coverage for One Acre Residential is to be limited to a maximum of 20% of the area. This value represents the combined areas of all buildings, outdoor covered areas, and structures on a lot. Beyond these specific structures, additional hard surfaces such as driveways, walkways and patios generally account for approximately 30% of the lot, resulting in a total percent impervious value of 50%, as noted in the City's Design Criteria Manual.

Porous Pavement

All impervious areas should be hydraulically disconnected from the downstream conveyance system or receiving watercourse. This includes roofs, parking lots, and other impervious surfaces.

For One Acre Residential lots, we recommend absorbent landscaping and pervious pavement be applied to the extent possible. Absorbent soils should have a minimum depth of 450 mm, and should be applied over at least 50% of the pervious area (25% of the total lot area). Pervious pavement should be applied to the extent possible; we recommend that at least 10% of the total impervious area be pervious pavement.

While underground storage and infiltration has also been identified as a potential BMP for residential areas, we note that the lots which are expected to be developed as One Acre Residential are located in areas with low infiltration potential. As such, we do not recommend widespread application of underground storage and infiltration within the One Acre Residential lots that are anticipated to be developed. Community scale detention storage ponds are proposed to provide peak flow attenuation for the design events, while the absorbent landscaping, pervious pavement, and disconnection of impervious areas are aimed at reducing runoff volumes within the One Acre Residential lots.

10.3.2 Urban Residential

Based on the City's Zoning Bylaw, lot coverage for Urban Residential is limited to 40% (buildings, covered areas, structures, etc.). Additional hard surfaces, including driveways, walkways and patios, generally account for approximately 40% of the lot, resulting in a total percent impervious value of 80%, as noted in the City's Design Criteria Manual.

Pervious Paving

As with One Acre Residential, all impervious areas should be hydraulically disconnected from the downstream conveyance system or receiving watercourses for Urban

Residential lots.

Recognizing the limited amount of available pervious area, we recommend that absorbent landscaping should be applied to the entire pervious area on Urban Residential lots (20% of the total lot area). Pervious pavement should also be applied to the extent possible; we recommend that at least 10% of the total impervious area be pervious pavement.

As indicated, there is moderate infiltration potential in the northwest corner of the study area, where urban residential development is expected to occur. As such, these lots present a potential opportunity to apply underground storage and infiltration facilities. While a detention storage pond is proposed in this area to provide peak flow attenuation for the design events, underground storage facilities would be aimed at capturing and infiltrating runoff from the more frequent, low-intensity rainfall events.

10.3.3 Business Centre (Commercial Development)

Based on the City's Zoning Bylaw, lot coverage specified for Business Park Zone is 60%. While the City's Design Criteria Manual does not provide a recommended total impervious area for Business Centre, we estimate that it would be similar to the 80% value recommended for commercial land use.

There are a number of potential BMPs that can be applied on Business Center lots, including bioswales, green roofs, rain gardens, water quality devices, and underground storage facilities.

Rain garden adjacent to parking lot.

We recommend implementing bioswales along the edges of parking lots, while rain gardens can be located to receive runoff from parking lots and/or rooftops. Based on the GVS&DD Stormwater Source Control Design Guidelines (2012), bioswales and rain gardens should both be sized to at least 5% of the impervious area they service. This represents a 20:1 ratio of impervious area to bioswale/rain garden footprint. The guidelines provide additional recommendations regarding the detailed design and application of these BMPs.

Where buildings have flat roofs, and occupy a large fraction of the total lot area, we recommend that green roofs be implemented. The potential size of green roof is limited by the roof area that is available. The standard range for green roof soil depths is 150 mm to 600 mm, as noted in the Stormwater Source Control Design Guidelines.

Rain garden adjacent to buildings.

As an alternative to these more natural BMPs, structural treatment devices can be implemented to remove total suspended solids (TSS) prior to discharging flows from the site. There are a number of proprietary treatment devices available from a variety of vendors. These units are typically sized based on a treatment flow rate, and a representative particle size distribution for the site (or average particle size). We recommend that structural treatment devices be sized to accommodate site runoff from 72% of the 2-year, 24-hour rainfall event.

As noted, there is moderate infiltration potential in the northwest corner of the study area, where business centre development is expected to occur. As such, these lots present a potential opportunity to apply underground storage and infiltration facilities. While a detention storage pond is proposed in this area to provide peak flow attenuation for the design events, underground storage facilities would be aimed at capturing and infiltrating runoff from the more frequent, low-intensity rainfall events.

Structural Treatment Device

10.3.4 Road Rights-of-Way

There are a variety of road classifications within the study area, including local, collector, and arterial. Highway 1, which runs through the north end of the study area, falls under the jurisdiction of the Ministry of Transportation and Infrastructure.

Within the City's portion of the study area, local and collector road rights-of-way account for approximately 35% of the total road length (excluding Highway 1). We examined cadastral road data provided by the City of Surrey, satellite imagery from the City, and City of Surrey Supplementary Standard Drawings to determine the representative local and collector right-of-way configuration. Local and collector road rights-of-way typically consist of 20 m total right-of-way widths comprised of two 3.0 m wide travelled lanes, two 2.25 m wide on-street parking spaces, two 3.25 m wide grassed boulevards, and two 1.5 m wide sidewalks.

Within the City's portion of the study area, arterial road rights-of-way account for approximately 65% of the total road length (excluding Highway 1). We examined cadastral and road data provided by the City of Surrey, satellite imagery from the City, and City of Surrey Supplementary Standard Drawings to determine a representative arterial right-of-way configuration. Arterial road rights-of-way generally consist of 27 m total right-of-way widths, comprised of four 3.65 m wide travelled lanes, one 4.4 m wide centre median, two 2.5 m wide grassed boulevards, and two 1.5 m wide sidewalks.

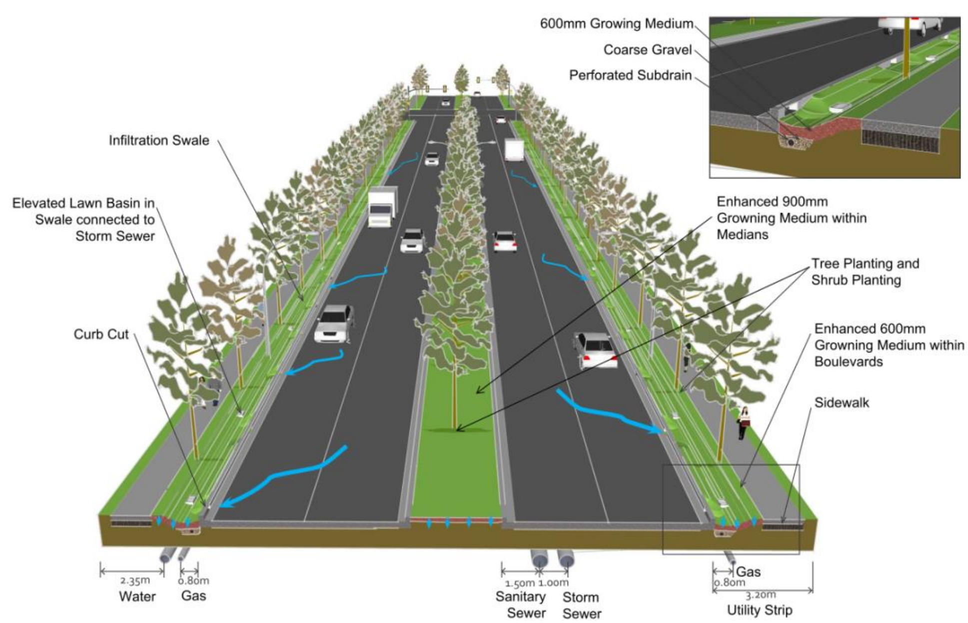
As noted, road rights-of-way present significant opportunities to implement BMPs because they are linear and are within the City's control. These projects also present an opportunity to incorporate BMP measures in a cost-effective manner; rather than planning and funding Stormwater Low Impact Development projects in isolation, existing road projects can be modified to achieve LID goals. Road rights-of-way can incorporate a variety of BMPs, including:

- Bioswales,
- Pervious pavement,
- Rain gardens,
- Absorbent landscaping and street trees, and
- Structural soils

Figure 10-1 illustrates the potential configuration of BMPs to provide hydrologic benefits across the study area.

Given the challenges in estimating the potential extent of various BMP applications within road rights-of-way, we did not explicitly calculate the impact of road right-of-way source controls. As noted, our analysis focused on applying various BMPs for different land uses. Nevertheless, road right-of-way BMPs will provide a hydrologic benefit, and we recommend these measures be implemented wherever possible.

a)



b)

Figure 10-1
Road Right-of-Way Source Control / BMP Configurations
a) Local and Collector Roads

b) Arterial roads

11 Funding Strategy

Township of Langley

As noted, the Township of Langley has completed a significant amount of planning within the current study area through a number of Neighbourhood Plans. These plans provide direction for future growth, and address a number of issues ranging from establishing neighbourhood vision, to environmental protection, to community facilities as well as infrastructure and services. As part of this overview, the Neighbourhood Plans outline stormwater management strategies (both for conventional stormwater system as well as enhanced infiltration systems), financial strategies, and implementation plans. As such, the funding strategy for the Latimer Creek ISMP largely focuses on the portion of the study area located within the City of Surrey, and refers to existing information within the Township of Langley to the extent possible.

Financing strategies are included in each of the Neighbourhood Plans within the Township, including:

- Bylaw 4825 – Jericho Sub-Neighbourhood Plan
- Bylaw 4995 – Carvolth Neighbourhood Plan
- Latimer Neighbourhood Plan

City of Surrey

A variety of funding sources are available to support the implementation, operation and maintenance of the stormwater management components recommended within the Latimer Creek ISMP.

Individual land owners are responsible for funding and implementing source controls and BMPs specific to their own properties. Where development activities result in a need for upgrades to the City's minor storm system, these offsite upgrades are also funded by the subject property owner/developer who is responsible for the impact.

The City is generally responsible for City-owned property and for upgrades to the major storm system required to accommodate development. Where upgrades to the major storm system are required as a result of development, these upgrades are implemented with funding support from Development Cost Charges (DCCs). The City is also responsible for upgrades to address existing deficiencies within both the minor and major storm systems.

Major system works identified in the City's 10-Year Servicing Plan are prioritized with other City projects. Developers can pay for these works if they are required sooner than the plan specifies, and recover the DCC-eligible portion of the total cost.

11.1 MUNICIPAL FUNDING

The City of Surrey's 10-Year Servicing Plan compiles and prescribes engineering infrastructure projects across the City required to support existing and required future infrastructure. The plan is developed based on projects proposed in the City's OCP, NCPs, ISMPs, and other specific studies. The required projects identified in the Plan are queued by priority, and annual funds are allocated accordingly. The funding sources most relevant to the Latimer Creek ISMP study area are Development Cost Charges (DCCs) and utility service charges. We discuss these funding options below. We note that development-driven upgrades servicing catchments greater than 20 hectares are eligible for funding from DCCs, while upgrades related to developments in service areas smaller than 20 hectares must be directly funded by development proponents.

We encourage the City to include the implementation of source controls along local, collector, and arterial projects, and in road renewal projects where applicable. This will provide a substantial benefit to watershed health, and be much more cost-effective than stand-alone stormwater management projects in locations where roads are not otherwise being improved.

11.1.1 Development Cost Charges

Development Cost Charges (DCCs) are governed by the Surrey Development Cost Charge By-law No. 18148 (2014). They provide approximately one third of the total funding to the Capital Construction Program, which supports development activities identified in the City's Official Community Plan (OCP) and Neighbourhood Concept Plans (NCPs).

DCCs are paid to the City by proponents who obtain approval for lot subdivision or a building permit to develop or alter buildings. For properties zoned as Single Family Residential, DCCs are determined on a per-lot basis; for all remaining land uses within the City, DCCs are determined on a per-area basis. The City's DCCs are comprised of six different DCC components:

- Water
- Sanitary
- Arterial Roads
- Collector Roads
- Drainage, and
- Parkland Acquisition

As outlined in the City's Development Cost Charge Bylaw, the rates are constant throughout the City, with two exceptions; the Anniedale-Tynehead area has unique rates based on land use, while Campbell Heights has one DCC rate for all land uses. Table 11-1 identifies the DCC Drainage Component for each land use within the City's portion of the study area.

Table 11-1
DCC Drainage Components (City of Surrey, 2014)

<table>
<tr><th colspan="2">Land Use</th><th>DCC Drainage Component</th><th>Units</th></tr>
<tr><td colspan="4">City-Wide Rates</td></tr>
<tr><td colspan="2">RA, One Acre Residential</td><td>$6,105</td><td>/lot</td></tr>
<tr><td colspan="2">A-1, General Agricultural</td><td>$0</td><td>/lot</td></tr>
<tr><td colspan="2">PA-1, Assembly Hall 1 Zone</td><td>$1.36</td><td>/sq.ft. of BA*</td></tr>
<tr><td rowspan="2">C-4, CG-2, Commercial</td><td>Ground Floor</td><td>$2.27</td><td>/sq.ft. of BA*</td></tr>
<tr><td>All Other Floors</td><td>$0.45</td><td>/sq.ft. of BA*</td></tr>
<tr><td colspan="4">Anniedale-Tynehead Rates</td></tr>
<tr><td colspan="2">Urban Residential</td><td>$1.19 - $1.84
(varies based on density)</td><td>/sq.ft of DU**</td></tr>
<tr><td colspan="2">RM-10, Cluster Residential</td><td>$1.84</td><td>/sq.ft of BA*</td></tr>
<tr><td rowspan="2">Business Center (Industrial)</td><td>Developed Area</td><td>$40,489</td><td>/acre</td></tr>
<tr><td>All other Floors</td><td>$0.19</td><td>/sq.ft. of BA*</td></tr>
</table>

*BA = Building Area

**DU = Dwelling Unit

11.1.2 Drainage Parcel Tax

The drainage element of utility funding comes from the Drainage Parcel Tax, which is based on a flat rate and is collected by the City along with property taxes.

As of 2014, the rate charge varies on a per-lot basis depending on property class (as determined by the BC Assessment Agency). Residential, non-profit recreational, and farm properties pay $201/parcel, and non-residential properties pay $224/parcel. While variation in fees based on Property Class is a positive improvement over the tax structure of previous years, the flat per-lot fee structure (rather than per-area) does not reflect the magnitude of discharge to the drainage system. Since these funds are specifically allocated to drainage system expenditures, it would be in the City's interest to revise the fee structure to more representatively reflect the impact of the property on the drainage system by accounting for parcel area and other factors, such as impervious coverage. The overall drainage parcel tax collected on a City-wide basis would not change with this re-structuring; rather, the rates for each parcel would be weighted based on hydrologic considerations.

11.1.3 Land Owners and Private Developers

Land owners and private developers do not receive City-controlled funding to implement stormwater Best-Management Practices on private property. The cost of constructing, operating and maintaining source controls, riparian area buffers, Green-Infrastructure Network (GIN), stormwater detention or retention facilities, and system upgrades necessitated as part of the development is the responsibility of land owners and developers.

While there are two specific areas where future development is expected to occur within the City's component of the study area, a significant portion is already developed as One Acre Residential land use. In order to promote widespread application of source controls throughout the study area, the City can offer incentives to encourage the application of BMPs.

11.1.4 Incentives

DCC 'Front-Ender'

One of the financing mechanisms currently used by the City is a DCC 'Front-Ender.' Under this approach, developers pay the up-front capital costs to construct infrastructure. These initial costs are recovered through a late-comers fee, which is paid to the City by individuals at the time they develop. In turn, the City provides these monies to the developer who paid for the initial capital costs. It is important to note that the infrastructure being funded under this mechanism needs to be located on City-owned land, or within City rights-of-way; it cannot be applied to infrastructure constructed on private lots.

This 'Front-Ender' approach could be applied to stormwater LIDs and BMPs, provided they are constructed on City-owned property, or within a City right-of-way.

Drainage Parcel Tax Reduction

The existing Drainage Parcel Tax provides a significant source of revenue to the City to be used for capital drainage projects. To encourage private property owners to reduce the impact of their property on the drainage system, incentives could be provided in the form of a reduced drainage parcel tax.

The initial tax rate could be assessed based on Total Impervious Area (TIA), which is relatively simple to estimate based on aerial imagery. Land owners could implement source controls to reduce the Effective Impervious Area (EIA) by hydraulically disconnecting runoff from the receiving storm drainage infrastructure. Land owners could then apply for a re-evaluation of their rates with supporting evidence, such as photographs or contractors' invoices.

These changes would be applied for future development and re-development projects and enable watershed health improvements in the City's portion of the Latimer Creek study area. The proposed utility rate structure and rebate program would require a relatively accurate measurement of the EIA ratios of each lot, which may prove difficult. We recommend that the City of Surrey determine the proposed fee structure so that they can develop a system tailored to their needs and abilities.

We note that, in order for a potential tax reduction to be economically feasible, the hydrologic benefits of source controls would have to be accompanied by savings in infrastructure spending in order to compensate for the reduced tax revenue. If the implementation of source controls does not result in a direct savings in terms of infrastructure spending, it would not make sense for the City to offer Drainage Parcel Tax Reductions.

One-Time Rebates

While incentive programs are relatively low-cost to the City, they do result in lost revenue that would be otherwise used on capital projects. As such, we recommend that rebate-centered incentive programs be offered on a one-time basis to promote the initial establishment of source controls and awareness of their benefits.

The City of Surrey currently has two programs in place that offer residents and business owners financial incentives for participating in voluntary programs. The first is the Tree Voucher Program, which enables participants to purchase a tree voucher for $25 and receive a tree worth $75. Tree vouchers are purchased at City Hall and are redeemed at a participating nursery. This program encourages residents to plant trees on their property, effectively increasing the tree canopy. The second program is the Surrey Water Meter Program, which allows participants to pay for their water use according to how much water they use instead of being charged a flat rate. The program encourages water conservation through reduced costs to participants.

Similar to these two existing programs, we recommend that the City create a Stormwater Management Rebate Program to encourage land owners and developments to construct stormwater source control measures and detention and retention systems on their properties. The program could potentially be administered through the City of Surrey Planning and Development Department.

We recommend that in the initial stages of the project that the approval process for rebates be relatively easy to meet and administer. For example, a fixed rebate of a monetary value set by the City of Surrey can be offered to participating land owners who show proof of on-site stormwater management control measures. Proof can take the form of a photo or receipt for constructed works. For the program to be effective, it will be important for the City to promote the inter-related benefits of stormwater management features, such as reduced municipal water requirements for landscaping (thus reducing their potable water use in association with the Surrey Water Meter Program), and the insulation benefits of a green roof for industrial and commercial property owners.

Once the program is established, we recommend that the approval process for rebates be more thorough to ensure proper design and installation of works. The procedure will require more effort from both the City and the participant. Rebates should no longer be fixed, but be based on compliance with the approval process and projected reduction in total annual runoff volume. For example, participants could have to satisfy a sequence of steps as follows:

1. Submit to the City the conceptual design, including design drawings, engineering calculations and/or computer modelling of the proposed works.
2. Submit to the City detailed design drawings of the proposed works.
3. Submit to the City operation and maintenance plans of the proposed works.

4. Provide the City with a construction plan and schedule.
5. Facilitate inspection and monitoring by City of Surrey inspectors.

Administering a Stormwater Management Rebate Program for works completed on private property will prove to be more challenging than Tree Voucher or Water Metering programs. Successful completion of the program will require proper introduction to developers and a thorough understanding of the approval process by those City of Surrey staff administering or involved in the program.

Salmon Marshall Certification Program

The City's Salmon Habitat Restoration Program (SHaRP) presently runs a Salmon Marshall (SaM) certification program. The program provides certification to businesses who consciously undertake action items that lead to salmon protection and habitat enhancement. The program offers bronze, silver, gold and platinum certification based on the level of effort put forth by a particular business. For certification to be granted, businesses must commit to action items and meet certain long-term requirements. The more action items taken on by businesses, the more prestigious certification received. The benefit to businesses is that they become more involved in their communities and can be seen as watershed stewards with a commitment to environmental protection. To date, this program has seen great success.

One 'action item' listed in the existing program is for the business to collect water samples for a nearby stream. The initial testing requires three separate samplings, with ongoing sampling required on an annual basis. Given the cost of City-sponsored water quality programs, businesses undertaking this action item should work with the City to compliment the City's existing water sampling program.

Additionally, the City could produce further action items specifically related to the objectives of this ISMP, including: source control implementation, monitoring and pilot studies; daylighting of storm pipes; and specific environmental enhancement projects.

11.2 FEDERAL FUNDING

The federal government provides funding for infrastructure and environmental projects primarily through Infrastructure Canada and Environment Canada.

Although typically not as readily available as municipal funding sources, we highlight below some of the programs most applicable to the type of works recommended in this ISMP.

11.2.1 New Building Canada Plan

The New Building Canada Plan (NBCP) is a federal government program intended to support infrastructure projects across Canada. Much of the funding is intended for projects of national, regional, or local significance, and therefore may not be accessible for the projects associated with this ISMP; however, part of the NBCP is the Federal Gas Tax Fund, intended to provide municipalities with stable and predictable funding over the next ten years to support infrastructure projects. It is allocated on a per-capita basis to all municipalities across Canada, and could be used for infrastructure upgrade projects in the Latimer Creek study area.

We anticipate that within municipal governments such as the City of Surrey and the Township of Langley, competition for these funds may not allow a significant investment in independent drainage projects. We strongly recommend the City and Township push to have stormwater BMPs included in all infrastructure projects, where practical.

11.2.2 EcoAction Community Funding Program

The EcoAction Community Funding Program provides funds to non-profit community-based groups.

While the City of Surrey and the Township of Langley are not eligible to apply for funding, community-based groups are. Community or environmental groups may apply for funding for various environmental enhancement projects. Minor terrestrial or riparian enhancement projects, such as the removal of debris jams and management of invasive species are the most likely types of projects to have success under this arrangement, and should be promoted by the City and the Township, and encouraged where possible to improve watershed health.

11.2.3 Green Municipal Fund

The Green Municipal Fund (GMF) is distributed through the Federation of Canadian Municipalities (FCM), but funded by the Government of Canada. The GMF funds municipal environmental initiatives, including plans, studies, and projects. Projects in the energy, transportation, waste and water sectors undergo a competitive process and are ultimately reviewed for approval or denial by the GMF Council. In 2014-2015, the fund aims to provide $40M in loans and $5M in grants for capital projects in energy, transportation, waste and water sectors.

The stormwater management projects supported by the fund must manage the majority of rainfall events for a community, which is the shared objective of source controls and stormwater BMPs. The funding is therefore directly relevant to the goals of this ISMP, and should be applied for as applicable.

We note that there are a number of updates to the current GMF which take effect as of April 1, 2015. These updates include an updated competitive selection process, updated eligibility criteria and funding limits, as well as an updated application process.

11.3 PROVINCIAL FUNDING

The British Columbia provincial government provides funding for community and stormwater management projects through the Ministry of Community, Sport and Cultural Development. Currently, the only applicable funding source is the Infrastructure Planning Grant Program, as the funds from all other relevant programs are fully allocated.

11.3.1 Infrastructure Planning Grant Program

The Infrastructure Planning Grant Program provides grants up to $10,000 to assist in the development or improvement of long-term comprehensive plans. Existing projects (such as this ISMP) are ineligible for the funding. However, this planning-level ISMP recommends further studies in particular locations of concern within the study area, and this funding may be available for those studies.

12 Enforcement Strategy

The City of Surrey's and Township of Langley's ability to enforce the recommendations of this ISMP is critical to the successful implementation of the plan.

The Latimer Creek ISMP requires both an enforceable regulatory framework, and community motivation to actively work towards improved watershed health.

12.1 UPDATES AND ADDITIONS TO POLICIES, BYLAWS AND MANUALS

Several of the recommendations critical for supporting watershed health and responsible stormwater management within the study area are not currently supported by enforcement mechanisms under current bylaws, policies and design guidelines. In the following sections we outline key recommended changes to relevant policies to assist in enforcing the recommendations in this ISMP.

We note that these documents are typically City-wide or Township-wide, and our recommendations must be considered in the context of recommendations arising from other studies.

12.1.1 City of Surrey Engineering Design Criteria Manual – Section 5 Storm Drainage System

The City of Surrey provides an Engineering Design Criteria Manual to present the minimum requirements for engineering design of projects located in the City of Surrey. The most recent edition of the manual is from May 2004. The Storm Drainage System section of the manual provides guidelines to assist in planning and designing stormwater drainage facilities and systems.

The Design Criteria Manual establishes consistency in design across the entire City of Surrey, and provides critical information on minimum design standards.

We recommend the following updates to the manual:

- Provide clear guidance to designers as to how to incorporate climate change impacts into sizing of drainage infrastructure. While the City's Climate Adaptation Strategy provides guidance on estimating the impacts of climate change on design rainfall data, the Design Criteria Manual does not specify the standard to which infrastructure should be sized. The details of how climate change impacts should be accounted for in infrastructure sizing is beyond the scope of this ISMP, yet is critical, and should be addressed immediately.
- Maximum acceptable runoff rates by land use (performance targets) should be included.
- Source control design criteria, including:
    - Maximum outflow rates per hectare of tributary area,
    - Rainfall capture targets (72% of 2-year return period, 24-hour duration rainfall, as per the draft Land Development Guidelines [DFO/MoE])

- Water quality objectives and a list of acceptable mechanisms to achieve these targets (bioswales, manufactured treatment units, constructed ponds/wetlands).
- Minimum subsoil infiltration rate for infiltration-based BMPs to be permitted.

12.1.2 Township of Langley Subdivision and Development Servicing Bylaw – Schedule B Design Criteria – Section D Drainage

As part of the Township of Langley's Subdivision and Development Servicing Bylaw, Schedule B 'Design Criteria' provides the minimum requirements for engineering design of projects located in the Township of Langley. The current edition of the Township's Subdivision and Development Servicing Bylaw is from 2011. Section D of the Design Criteria (Schedule B) provides guidelines to assist in planning and designing stormwater drainage facilities and systems.

The Design Criteria establishes consistency in design across the entire Township of Langley, and provides critical information on minimum design standards.

We recommend the following updates to the manual:

- Provide clear guidance to designers on how to account for the impacts of climate change on design rainfall data.
- Provide clear guidance to designers as to how to incorporate climate change impacts into sizing of drainage infrastructure. The details of how climate change impacts should be accounted for in infrastructure sizing is beyond the scope of this ISMP, yet is critical, and should be addressed immediately.
- Maximum acceptable runoff rates by land use (performance targets) should be included.
- Source control design criteria:
  - The Township's design criteria provides good information for on-site infiltration targets and measures. Similarly, the Township's Supplementary Detail Drawings specify topsoil requirements and infiltration facility requirements.
    - We recommend that the minimum topsoil depth be increased from 300 mm to 450 mm.
  - While the Township's design criteria provides some guidance on stormwater quality control, we recommend that explicit objectives be specified.
    - Design rainfall event
    - Target particle size(s) for TSS removal
    - Target removal efficiencies for other pollutants
  - Maximum outflow rates per hectare of tributary area,

12.1.3 City of Surrey Zoning Bylaw, 1993, No. 12000

The purpose of the Zoning Bylaw is to regulate lot use permissions and restrictions, the location and height of buildings, required setbacks from various features, floodproofing requirements, minimum and maximum floor areas, and other land-use-specific parameters.

Within the City's portion of the study area, the three most significant zoning classifications are One Acre Residential, General Agriculture, and Light Impact Industrial. These three land uses represent approximately 98% of the City's portion of the study area.

We note that the operation and management of land within the Agricultural Land Reserve (ALR) is protected under the Farm Practices Protection (Right to Farm) Act. As such, there is little to no opportunity for municipalities to enforce stormwater management LIDs and BMPs on agricultural lands; we have focused on One Acre Residential Zoning and Light Impact Industrial Zoning. Recommended amendments to the City's Zoning Bylaw are outlined in Table 5-1.

Table 12-1
Recommended Zoning Bylaw Amendments (City of Surrey)

Bylaw Part	Recommendations
Part 5: Parking and Loading / Unloading	Part 5, Section 5(a) states "All parking areas, excluding those listed under Sub-section A.5(b) shall be surfaced with an asphalt, concrete or similar pavement, so as to provide a surface that is dust free and shall be so graded and drained as to properly dispose of all surface water." We recommend modification to this section to specifically mention permeable pavement. Additional notation on structural requirements will be needed. Further, the term "properly dispose of all surface water" should be defined to include meeting runoff control targets, and 'dispose' should be reworded to 'manage.'
Part 7: Special Building Setbacks	Part 7 describes specific atypical building setbacks depending on proximity to major road allowances within the City of Surrey. Once the Riparian Areas Bylaw (discussed in the following section) is implemented, this section should be amended to reference specific requirements for lots located adjacent to watercourses, GIN hubs and corridors, wetlands, ponds, and areas of environmental significance.
Part 12: RA: One-Acre Residential Zone	Section F describes Yards and Setback requirements. On private residential lots, it is more practical for the City to monitor and enforce source controls (absorbent soils, rain gardens) when they are located in front yards. To facilitate this, we recommend the minimum front yard setback to the principal building be increased. Section I describes landscaping requirements. We recommend this Section be reworded to require the provision of a minimum 450 mm thick layer of absorbent topsoil on all landscaped areas.
Part 48: Light-Impact Industrial Zone	Section I describes landscaping requirements, including a special provision of a minimum 1.5 m landscaping strip for all developed sites of the lot which abut a highway. We recommend that these sections be reworded to require a minimum 450 mm thick layer of absorbent topsoil on all landscaped areas, including the landscape strips described.

12.1.4 Township of Langley Zoning Bylaw 1987 No. 2500

The purpose of the Zoning Bylaw is to regulate lot use permissions and restrictions, the location and height of buildings, required setbacks from various features, floodproofing requirements, minimum and maximum floor areas, and other land-use-specific parameters.

Within the Township of Langley the study area is dominated by five land uses: Suburban Residential, Comprehensive Development, Commercial, Institutional, and Residential. These land uses represent over 99% of the Township's portion of the study area.

Section 107 – Parking and Loading Requirements, outlines the parameters governing the design of parking facilities. Section 107.5 (4) states "*for all Multiple Family Residential (RM) and Commercial (C) developments each required parking space and maneuvering aisle shall be surfaced with asphalt or concrete*", and Section 107.5 (5) states "*for all Industrial (M) developments, each required parking space and maneuvering aisle shall be surfaced with asphalt, concrete or other dust free material*." We recommend modifying this section to specifically mention permeable pavement. Additional notation on structural requirements will be needed.

We recommend Section 111 – Landscaping, Screening, and Fencing be reworded to require the provision of a minimum 450 mm thick layer of absorbent topsoil on all landscaped areas.

As documented in Section 300 – Suburban Residential, the minimum front lot line setback for principal buildings is 9.75 m, while the minimum rear lot line setback is 7.5 m. By requiring larger front yards, this will encourage the application of stormwater source controls (absorbent landscaping, rain gardens, etc.) on portions of private property that area easier for the Township to monitor and enforce.

As noted in Section 400 – Residential, the minimum front lot line setback for principal buildings is equal to the rear lot line setback at 6.0 m. We recommend that the minimum front lot line setback be increased to facilitate enforcement of source controls.

12.1.5 City of Surrey Drainage Parcel Tax Bylaw, 2001, No. 14593

The Drainage Parcel Tax Bylaw is in place to allow the City to construct and operate storm drainage systems for the convenience and safety of the residents and businesses within the City of Surrey. The bylaw describes the imposition of a flat rate parcel tax on all properties within the City that is used to fund the construction and operation of drainage and stormwater management services.

As noted, we recommend the bylaw and fee assessment be revised to collect fees on a per-area and TIA coverage basis, rather than a flat rate.

12.1.6 City of Surrey Stormwater Drainage Regulation and Charges Bylaw, 2008, No. 16610

The Stormwater Drainage Regulation and Charges Bylaw is in place to allow the City to operate and maintain a stormwater drainage system as a municipal service for the benefits of residents and property owners in the City of Surrey. The bylaw states that the cost of servicing a property within the City with drainage works should be paid for in whole or in part by the owners of the property requiring connection to the stormwater drainage system.

Part 5 of the bylaw pertains to on-site stormwater management requirements. Reference is given to compliance with ISMPs, specifically that "Newly created parcels shall be constructed with on-site stormwater management facilities when these are prescribed through Council approved neighbourhood plans, master drainage plans, integrated stormwater management plans or as required in a Servicing Agreement or specific service connection." We recommend this definition be expanded to encompass re-developed parcels.

Part 8 of the bylaw lists a number of pollutants that no person shall discharge or allow or cause to be discharged into the stormwater drainage system, ditches, watercourses or other water bodies including, but not limited to, prohibited or hazardous wastes, sediment-laden water, industrial cooling water, and untreated wash water. While Part 10 outlines offences and penalties for non-compliance with any provisions within the bylaw, we recommend that specific consequences for non-compliance with the elements described in Part 8 be developed and enacted.

Further, we recommend that Part 8 be revised to reference stormwater quality and quantity performance targets described within the City's Integrated Stormwater Management Plans. We note that to be effective, this provision may require a comprehensive review of the recommendations from ISMPs for all watersheds within the City.

12.1.7 City of Surrey Erosion and Sediment Control Bylaw, 2006, No. 16138

The Erosion and Sediment Control Bylaw is in place to allow the City to protect the best interests and environmental well-being of the streams, creeks, waterways, watercourses, ditches, storm sewers and drains that make up community drainage systems. This includes protection from pollution, obstructions, sediment, and sediment-laden water during construction activity. The bylaw consists of several sections including Prohibition of Discharge, Erosion and Sediment Control (ESC) Permit, ESC Plan, Monitoring and Reporting, and Offences and Enforcement.

Erosion and sediment control BMPs are defined in Schedule "B". We recommend that special provisions for construction of source control stormwater best management facilities be added to Schedule "B". Requirements regarding the following practices should be added:

- Stockpiling and placement of growing media, and
- Protection of trees, shrubs and their planting locations.

12.1.8 City of Surrey Supplementary Master Municipal Construction Documents, 2004

We recommend that the City of Surrey develop specifications and standard drawings for several of the recommended source control best management strategies. The standards can be integrated into the City's Supplementary Master Municipal Construction Documents and detail the physical design, construction, and operation and maintenance procedures for pervious pavement, green roofs, bioswales, infiltration trenches and rain gardens. Technical design guidelines should be incorporated into the City's Engineering Design Criteria Manual, as described in Section 12.1.1 of this report. Formal specifications and standards will encourage their use while promoting standard and effective design, construction, implementation, operation and maintenance of the facilities.

12.1.9 City of Surrey Riparian Areas Regulation Bylaw (Pending)

We understand that the City presently follows the Land Development Guidelines for the Protection of Aquatic Habitat (DFO, 1993), and intends to pass a formal bylaw outlining setback requirements in accordance with the Ministry of Environment's (MoE) Riparian Areas Regulation (RAR). This bylaw should take into account aquatic habitat, overall watershed health, terrestrial habitat, and wildlife movement corridors.

12.1.10 City of Surrey Invasive Species Management Plan

We understand that presently the City's Parks department has weed-management protocols in place. To support environmental enhancement in the study area, we recommend the City develops and implements a City-wide Invasive Species Management Plan. This should be done with reference to the City's Biodiversity Conservation Strategy, as well as recommendations made in this and other ISMPs throughout the City.

12.1.11 Development Applications

Individuals wanting to develop or alter the use of land within the City of Surrey must obtain proper approval from the City. As stated on the City's website, land development applications must meet the requirements set out in the OCP, Zoning Bylaw, and other public documents. Individuals wanting to re-develop an existing property within the same land use type must obtain proper approval from the City of Surrey with a building permit. Building permits within the City of Surrey are divided into two categories, Residential Section and Commercial Section. The Residential Section applies only to single family residential buildings. The Commercial Section applies to all commercial, industrial, institutional, and multi-family buildings.

It is important that the recommendations of this ISMP be reflected in the appropriate land development and building permit application forms and checklists to ensure they are successfully incorporated into the planning and permitting phases of development.

12.1.11.1 Single Family Residential Criteria

The following should be incorporated into development and building permit applications for residential land development projects, and new single family dwellings:

- Landscaping plans showing tree and/or shrub plantings, and enhanced growing media, and
- Site plans showing the locations and extents of pervious pavement.

12.1.11.2 Commercial, Industrial, and Multi-Family Residential Criteria

The following should be incorporated into development and building permit applications for commercial, industrial, or multiple-family residential land development projects or building re-construction:

- Landscaping plans showing tree and/or shrub plantings, enhanced growing medium, green roof vegetation, bioswales, and rain gardens,
- Site plans showing the locations and extents of pervious pavement, green roofs / detention roofs, bioswales / infiltration trenches, and rain gardens,
- Summary of calculations and methodology used to design and locate any detention/retention storage facilities, which may consist of calculations and specifications from suppliers in the case of proprietary design products.
- Summary of calculations and methodology used to design and locate any stormwater LIDs.
- Hydrologic analysis to demonstrate that the selected source controls are meeting the desired targets.

12.1.12 Township of Langley Bylaw 4825 – Jericho Sub-Neighbourhood Plan

Section 4.5 of the Jericho Sub-Neighbourhood Plan outlines environmental considerations and requirements for the sub-neighbourhood. As part of this section, there is a discussion on water quality and runoff. Section 4.5.3 'Water Quality and Runoff' indicates that stormwater best management practices and Low Impact Development features shall be implemented as part of any stormwater management plan within the Jericho Sub-Neighbourhood. It states that these features should be designed in accordance with Section 6.4 Stormwater Drainage of the same bylaw.

However, Section 6.4 does not include any specific criteria in terms of performance targets, design rainfall events to be considered, or design parameters.

We recommend that the Jericho Sub-Neighbourhood Plan specifically reference the Township's Drainage Design Criteria, which are included in Schedule B of the Township's Subdivision and Development Servicing Bylaw. Further, we note that the Drainage Design Criteria should be updated as discussed above in Section 12.1.2

We also recommend that a minimum topsoil depth of 450 mm be specified in Section 4.6 Landscape Components.

12.1.13 Township of Langley Bylaw 4995 – Carvolth Neighbourhood Plan

The Carvolth Neighbourhood Plan identifies the various aspects of integrated stormwater management, and specifically addresses the three main components:

- Infiltrate the small events
- Detain the medium events
- Convey the large events

The neighbourhood plan notes that development within the Township must proceed in accordance with any Master Drainage Plans for the area. Since the entire Carvolth Neighbourhood is contained within the Latimer Creek study area, stormwater management must comply with the recommendations from the 2003 Latimer Creek MDP. The Carvolth Neighbourhood Plan explicitly refers to the 2003 MDP for stormwater pond requirements, as well as culvert and storm drain requirements.

The Carvolth Neighbourhood Plan also addresses stormwater source controls / LIDs / BMPs throughout the bylaw. This topic is addressed in Section 2.6.5 Integrated Open Space, Section 2.6.7 Stormwater Strategy, Section 2.7.3 Stormwater Drainage, Section 3.4.6 Green Development, and Section 3.4.14 Stormwater Source Control. While these various sections provide a description of the recommended source controls, as well as some general design guidelines, the bylaw does not specify specific design criteria to facilitate the design of these features.

We recommend that the bylaw be updated to facilitate the design and implementation of stormwater source controls by including specific targets for the following:

- Design rainfall event for infiltration-based source controls
- Design rainfall event for water quality treatment features
- Target particle size(s) for TSS removal
- Target removal efficiencies for water quality

Alternatively, if these requirements are explicitly specified in the Township's Drainage Design Criteria, then the neighbourhood plan could simply be updated to reference the design criteria.

13 Monitoring Strategy

In order to manage development within with study area, the City and Township should monitor key metrics that indicate the condition of the watershed. These metrics will track the condition of the watershed and identify areas of improvement as well as areas of degradation. This will indicate where enhancement projects and upgrades have been successful, and will also highlight areas where additional mitigation is required.

The drainage network within the City's portion of the study area consists of open channels and culverts. The City currently has a number of monitoring locations established throughout their portion of the study area. These include a streamflow monitoring station on Latimer Creek at 88 Avenue, a water level monitoring station on Latimer Creek at Harvie Road, and a Benthic Invertebrate Sampling Site on Latimer Creek at 88 Avenue. We are not aware of any water quality or flow monitoring programs within the Township's portion of the study area.

We note that the hydrometric, water quality, and benthic invertebrate metrics should be pursued in accordance with Metro Vancouver's Adaptive Management Framework (AMF). The additional metrics presented should be integrated into City of Surrey and Township of Langley programs and development activities where appropriate, to improve the efficiency of problem-identification as it pertains to the objectives of this ISMP.

13.1 RECOMMENDED KEY PERFORMANCE INDICATORS

We assessed the recommended monitoring parameters from Metro Vancouver's Adaptive Management Framework (2014) and the ISMP Template (2005) to create a suite of indicators capable of tracking the success of the ISMP and the short-term and long-term health of the watersheds.

Below we briefly describe each of the recommended metrics, divided into three categories:

Land Use Metrics

- Intended to identify subtle changes resulting primarily from small-lot redevelopment and minor enhancement projects that may otherwise be overlooked, and to address the terrestrial component of the ISMP.

Flow Regime Metrics

- Intended to monitor the condition of the major natural watercourses and ravine areas to identify major changes in flow patterns (positively or negatively).

Environmental Metrics

- Intended to track the success of environmental enhancement projects and source controls on supporting habitat.

13.1.1 Land Use Metrics

Metric 1 – Percent Tree Cover

Extensive vegetative cover supports terrestrial habitat and can reduce or attenuate runoff through interception and evapotranspiration.

We note that the City of Surrey currently tracks vegetative cover as part of the City's 'sustainability dashboard'. Since this information is already being monitored City-wide, the assessment could be expanded to assess tree cover specifically within the Latimer Creek ISMP study area. We recommend the City establishes a watershed-specific baseline vegetative cover value using the same process as is used for the City-wide tracking. This same approach could also be applied to other ISMP study areas throughout the City.

We recommend that the Township also begin to track percent tree cover within the study area for the Latimer Creek ISMP.

Measurement: Percent tree cover.

Timing / Triggers: Given the low cost, this assessment should be conducted once every two years by the Township, and each time vegetative cover is assessed for the City's Sustainability Dashboard. Decreased vegetative cover should trigger restorative work; within the City, this should focus specifically on enhancing terrestrial hubs and corridors identified in the City's Biodiversity Conservation Strategy for maximum value.

Cost: $1500 per assessment.

Metric 2 – Percent Total Impervious Area (TIA)

Percent Total Impervious Area (TIA) is a measure of the proportion of the total area covered by impervious surfaces (e.g. asphalt, concrete, buildings) to the total watershed area. It is an indicator of the general intensity of development, and whether development is occurring in accordance with applicable zoning bylaws.

The TIA values used in our assessment are based on the values recommended in the City of Surrey's 2004 Engineering Design Criteria Manual (2004) and the Township of Langley's Subdivision and Servicing Bylaw No. 4861 (2011). For each municipality, the TIA values are based on land use. Table 13-1 describes the baseline (2014) TIA for the study area to be compared against in the future.

Table 13-1
Baseline Total Impervious Area

Geographic Extents	Baseline Total Impervious Area
Entire Study Area	39%
City of Surrey Portion	42%
Township of Langley Portion	37%

We note that a more detailed analysis of TIA values can be completed using LiDAR, or by tracing impervious areas based on orthophotos; however, both of these approaches are data-intensive, and require significant quality control to ensure accurate results.

We recommend that TIA be reassessed during the next ISMP cycle. While additional assessments could be completed in the short term, they would likely not provide significant benefit given the nature of the assessment, and the rate at which land use designations change. Further, larger planning servicing studies are initiated when significant areas are planned for re-zoning.

Measurement: Percentage of total impervious area (based on zoning classifications) to total watershed area.

Timing / Triggers: Reassessed during the next ISMP cycle.

Cost: $2,000 per investigation

Metric 3 – Percent Effective Impervious Area (EIA)

TIA calculations assume that impervious surfaces do not provide any infiltration, which is not necessarily the case if source controls are implemented. As such, a common supplement to TIA is the Effective Impervious Area (EIA), which accounts for the hydraulic disconnection of a portion of impervious surfaces from the storm system (e.g. roof downspouts discharging to lawns rather than storm pipes).

An objective measurement of EIA would require an extremely detailed evaluation of the watershed, essentially on a lot-by-lot scale, and would require a thorough analysis of ground water conditions and infiltration characteristics. A detailed evaluation to this degree was not included in the scope of this ISMP, and would be challenging for the City to undertake, even once.

A common approach for estimating EIA values is to use flow monitoring data to back-calculate EIA. This is often completed as a calibration step in detailed hydrologic and hydraulic modelling assignments, and requires flow monitoring data for a known rainfall event(s). Under this approach, the hydraulic model results are compared to the observed flow data for a known rainfall event. The EIA values within the hydrologic component of the model are then adjusted, and the model results are again compared to the observed flow data. This iterative process is continued until the modelled results exhibit a strong correlation with the observed flow data.

However, we note that EIA is not the only parameter that can be adjusted within the hydrologic component of the model. Other parameters include infiltration values, initial abstractions, as well as physical parameters for each catchment such as overland slope, flow length, and flow width. As such, this approach only provides limited detail in terms of assessing EIA.

Depending on the number of flow monitoring locations used in this process, this approach may only provide an indication of the overall EIA for the contributing portion of the study area. Multiple flow monitoring locations with several years of accurate flow monitoring data are required to establish a more detailed breakdown of EIA values by land use or by neighbourhood.

Once the initial assessment has been completed to establish the baseline EIA value for a portion(s) of the study area, additional hydrometric monitoring data can be used to identify changes in EIA. Increases in EIA will become evident if the observed flow rates for known rainfall events continually exceed the hydraulic response predicted by the calibrated model. Conversely, reductions in EIA will become evident if the observed flow rates are less than the values estimated by the calibrated model.

The initial assessment of EIA should be established using a variety of rainfall events to capture the full spectrum of the hydraulic response of the system. Efforts should then be made in subsequent years to select rainfall / runoff events with similar characteristics to those used in establishing the baseline value. EIA will only be calculable for areas where hydrometric monitoring data is available.

Measurement: Percentage of effective impervious area for watersheds with hydrometric data.

Timing / Triggers: Assessed during the next ISMP cycle to establish baseline values for areas where hydrometric data is available; reassessed during subsequent ISMP cycles to identify changes.

Cost: $5,000 - $7,500. Varies, based on size and detail of hydrologic/hydraulic model. Flow monitoring data is required to facilitate this evaluation; flow monitoring costs are discussed separately under Metric 6.

Metric 4 – Percent Riparian Forest Integrity (RFI)

Percent Riparian Forest Integrity (RFI) is a key factor used in establishing overall watershed health. In the context of watershed health, natural watercourses should maintain an appropriate buffer on either side of the watercourse such that the riparian forest remains intact. This supports riparian functions that contribute to terrestrial and aquatic health, provide erosion mitigation, and help maintain natural flow regimes in the watercourses.

The buffer zone used for the Riparian Forest Integrity assessment for the watercourses in the Latimer Creek study area is based on a total width of 60 m. We note that this evaluation is a high-level assessment of the riparian forest within the study area, and is different from riparian setbacks for development, which impose limits on development footprints.

Table 13-2 presents the baseline RFI values determined as part of the watershed health assessment presented in Section 5. The assessment is based on the March 2014 orthophoto and includes the natural watercourses in the study area and their tributaries, as illustrated on Map 5-2.

Table 13-2
Baseline (2014) Riparian Forest Integrity

Geographic Extents	Intact Riparian Forest Area (ha)	60m Corridor Width Riparian Area (ha)	% RFI
Entire Study Area	64.7	95.1	68%
City of Surrey Portion	30.4	45.1	67%
Township of Langley Portion	34.3	50.0	69%

Given the importance of an intact riparian area in all of the fundamental functions of natural watercourses, maintenance or improvement of RFI is a critical contributor to watershed health. The reestablishment of riparian vegetation takes time, and therefore a noted reduction in RFI is difficult to reverse. It is therefore critical that the riparian setbacks in place for development and redevelopment be clearly established, communicated to developers, and enforced. RFI as a key performance indicator will quickly identify where development and/or redevelopment are/is impacting watershed health.

Measurement: Percentage of intact riparian forest to the 60 m riparian buffer zone.

Timing / Triggers: Reassessed during the next ISMP cycle, or if development / redevelopment within the watersheds equal or exceed 5% of the total study area.

Cost: $4,000 per investigation.

13.1.2 Flow Regime Metrics

Metric 5 – Number and Condition of Erosion Sites

On semi-regular intervals, the City of Surrey engages consultants to assess ravines in order to identify high-risk erosion sites, debris blockages and other problem areas. The regular ravine stability assessments are beneficial, not only for identifying high and medium risk erosion sites, but also for monitoring the progression of erosion. The progression of even low-risk erosion areas over time can be indicative of broader watershed problems, including insufficient RFI, lack of upstream source controls, or redevelopment. Conversely, decelerated erosion may indicate that upstream source controls and/or mitigation measures are functioning as intended.

As part of the background data provided by the City, we received the 2002, 2005, and 2009 City of Surrey Ravine Assessments. Based on our review of this data, no instability sites were identified within the City's portion of the current study area. As part of the City's existing ravine assessment program, North Latimer Creek is the only watercourse currently being assessed. We recommend that Old Sawmill Creek also be added to the City's existing program, given the development activities that are anticipated to occur in this portion of the City.

Within the Township of Langley, there is no established ravine assessment program. We recommend that a Township-Wide program be initiated to assess ravines throughout the entire Township of Langley on a semi-regular basis. The assessment within the Latimer Creek ISMP study area would fall under this program.

Measurement: Locations and level of severity of erosion sites, as well as supplemental information, including:

- Date / weather / general site conditions
- Photographs of erosion sites / channel and bank substrate / upstream and downstream channel conditions.
- Bank location,
- Channel dimensions,
- Risk probability and consequence,
- Description of stability issue(s),
- Notation on progression since previous assessment, including for low-risk sites,
- Approximate dimensions / scale of erosion, and
- Cost to mitigate.

Timing / Triggers: Nominally every two years. A desktop assessment of potential contributing factors and mitigation projects should be undertaken for areas where a widespread increase in erosion risk is identified during the Ravine Stability Assessment program.

Cost: Included as part of the City's overall Ravine Stability Assessment budget. We recommend that the Township establish a Township-Wide ravine stability assessment program to monitor watercourses throughout Langley, which would include watercourses within the current study area.

Metric 6 – Hydrometric Monitoring

The City of Surrey currently monitors hydrometric data at two locations within the study area. There is a stream flow monitoring station located on Latimer Creek at 88 Avenue, and a water level monitoring station located on Latimer Creek at Harvie Road.

Hydrometric data provides insight into the actual response of the watersheds to rainfall events. Sufficient monitoring periods are required to establish a reliable record for making representative assessments. The data is also necessary to estimate effective impervious area, as discussed in Metric 3.

Metro Vancouver's AMF recommends a minimum of one-year of continuous hydrometric monitoring, and provides guidance on collection methodology and analysis of hydrologic indicators. The AMF recommends that where resources allow, longer duration flow monitoring be done to provide additional benefits. Some of these benefits include:

- Improved dataset representativeness;
- Increased value because the majority of costs are felt in the first year or two of data collection;
- More reliable identification of temporal trends;
- More reliable data for statistical analysis to determine the magnitude of extreme events;
- Potential application of the data to similar catchments with limited / no hydrometric data.

The City should continue to monitor water levels and flow rates at these locations. Based on the development activities that are expected to occur, the next highest priority location for hydrometric monitoring would be on Old Sawmill Creek, downstream of the confluence with Bartesko Brook.

We are not aware of any surface flow monitoring stations within the Township. The City of Surrey monitoring station on Latimer Creek at 88 Avenue provides useful data for North Latimer Creek, most of which is located within the Township. We recommend that the Township prioritize continuous, ongoing monitoring on Latimer Creek immediately east of 196 Street. A second priority location would be on Unnamed Tributary 1 immediately east of 196 Street.
The recommended hydrometric monitoring sites are shown on Map 13-1 at the end of this section.

Measurement: Continuous water level and flow data.

Timing / Triggers: Data to be collected continuously on a permanent basis. Once every five years, data should be analyzed for the parameters recommended in the AMF (i.e. T_{Qmean}, low pulse count and duration, summer base flow, winter base flow, high pulse count and duration).

Cost: $30,000 for initial setup and $5,000 annually for data collection, per monitoring location.

13.1.3 Environmental Metrics

Metric 7 – Water Quality Monitoring
Monitoring the water quality at key locations within the watersheds can provide insight into the success of the ISMP and identify areas of concern where mitigative measures may be required.

Metro Vancouver's AMF suggests water quality monitoring be done in low gradient, high gradient, and piped systems, with samples taken two periods per year – once in the dry season (July to August) and once in the wet season (November to December). The recommended sampling procedure is to collect 5 samples over a 30 day period on a weekly basis. The AMF recommends testing dissolved oxygen, temperature, turbidity, pH, conductivity, nitrate, E. coli, fecal coliforms, total iron, total copper, total lead, total zinc, and total cadmium.

In addition to the primary constituents outlined above, Total Suspended Solids (TSS) should be monitored. Most water quality source controls are designed based on TSS removal efficiency. Therefore, information on TSS loading and removal efficiencies can assist in selecting source controls on future projects. We note that TSS is less indicative of issues in natural watercourses than in piped systems, and this should be considered in the analysis of results.

Testing for polycyclic aromatic hydrocarbons (PAH) is beneficial to monitor the performance of water quality devices, such as oil-water separators, but is relatively costly to implement. Without mandating stormwater source controls as a way of addressing historic contamination, the presence of PAH may not be actionable by the City and the Township. We recommend that PAH testing be completed at locations where distinct concerns are noted in the field (e.g. oily sheen on the surface of natural streams, evidence of spills).

Water quality sampling was conducted within the Township's portion of the study at three locations as part of the aquatic assessment. These locations are shown on Map 13-1. We recommend that future monitoring be continued at these locations.

Within the City of Surrey, we recommend monitoring water quality on Latimer Creek at 88 Avenue. This location coincides with the City's active Benthic Sampling Site L3. Further, based on the development activities that are expected to occur, we also recommend the City monitors water quality on Old Sawmill Creek downstream of the confluence with Bartesko Brook.

Measurement: Water quality monitoring of the following parameters:

- Dissolved oxygen;
- Temperature;
- Turbidity;
- Total Suspended Solids;
- pH;
- Conductivity;
- Nitrate;
- E. coli;
- Fecal coliforms;
- Total iron, total copper, total lead, total zinc and total cadmium.

Timing / Triggers: Two sampling periods per year (wet season and dry season) as per the AMF on a maximum repeated cycle of five years.

Cost: $8,000 per site per sampling period (including analysis and reporting).

Metric 8 – Benthic Invertebrates (B-IBI)

Measuring the presence of benthic invertebrates via the Benthic Index of Biotic Integrity (B-IBI) provides an estimate of the population and species of streambed insects present within a watercourse. Benthic invertebrates are considered 'indicator species', meaning they can provide an indication of general watershed health. Over time, as subtle changes in the watershed occur, a change in the B-IBI score provides a biologically-based indication of watershed health. If watershed health is improving, we expect to see an improved B-IBI score. In contrast, if watershed health is degrading, the B-IBI score will drop. The condition and presence of benthic invertebrates is influenced by subtle changes in a watershed, including alterations in flow regime, changes to in-stream habitat, and the presence of excess sediment or harmful substances.

The City of Surrey has a well-established benthic invertebrate sampling program with information dating back to 1999. The program includes two sampling sites within the current study area: ‘L3’ located on Latimer Creek (North) at 88 Avenue, and ‘L2’, located on Latimer Creek at 196 Street. In order to supplement this available information, we conducted benthic invertebrate sampling at three locations within the Township of Langley as part of the aquatic assessment.

We recommend that the City of Surrey continue benthic invertebrate sampling at the two locations within the current study area as part of the ongoing City-wide B-IBI sampling program. We also recommend that the Township of Langley continue ongoing B-IBI sampling at the three locations where sampling was conducted as part of the aquatic assessment for this ISMP.

Given the development that is expected to occur within the City’s portion of the study area, we recommend the City add a sampling site on Old Sawmill Creek, downstream of the confluence with Bartesko Brook. This will allow the City to monitor the B-IBI scores and species composition over time to assess the potential impacts of the planned developments as they occur. In order to assess the impacts of these planned developments, it is important to establish baseline testing at this location before the development occurs.

In addition to monitoring the raw numerical B-IBI scores, the sampling program should monitor species composition, as a change in composition would provide a stronger indication of improvement or degradation in stream health than the numerical scores. We also note that the overall B-IBI scores can vary widely from year to year; individual results do not provide a direct correlation with the health of a particular watershed. Rather, the results should be compared against long-term observations. To adequately monitoring watershed health, the timing of the sampling should be consistent from year to year. The City uses environmental indicators (appearance of buds on trees) to guide the timing for spring sampling; we recommend that the Township adopt a similar protocol.

Measurement: Mean B-IBI score.

Timing / Triggers: Once per year (spring) in concert with the City’s Benthic Sampling Program. Additional watercourses should be sampled if development and/or redevelopment in their upstream subcatchments exceeds 5% of the total tributary area. It is important that the timing of the sampling be consistent from year to year, and that the methodology be consistent from year to year, to facilitate valid comparisons of long-term observations.

Cost: $3,500 per site (within Surrey, sampling is conducted as part of the City's Benthic Invertebrate Sampling Program).

Metric 9 – Fisheries Habitat Assessment

The stream classification mapping presented in this ISMP is based on information provided by both the City of Surrey and the Township of Langley. This includes the City of Surrey's Mapping Online System (COSMOS), the City of Surrey's Fish Classification Map, the Township of Langley's online mapping system (Geosource), and the Township of Langley's Watercourse Classification Map. Based on our review of the existing information and field assessment, we identified a discrepancy in the stream classification mapping as follows:

- Unnamed Tributary 1, west of 196 Street to the confluence with Latimer Creek is designated as Class B in the City's mapping, but is designated as Class A by the Township's mapping. As noted previously, we recommend that this ~75m of creek be designated as Class A.

To better monitor the effect of enhancement projects, we recommend regular habitat assessments to assess watercourse classification. Stream reaches should be surveyed in accordance with the Resource Inventory Standards Committee procedures outlined in the Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Standards and Procedures (April 2001).

Stream reaches should be assessed on foot by a Qualified Environmental Professional (QEP) to collect information including:

- Channel morphology,
- Wetted width and depth,
- Bankful width and depth,
- Substrate composition,
- Habitat values,
- Fish presence,
- Barriers to fish passage, and
- Riparian characteristics.

Habitat characteristics should be evaluated and the habitat should be classified and compared to baseline conditions. Where habitat degradation is found to be occurring, sufficient information should be collected to identify the source of the degradation (e.g. development in the upstream subcatchment, local loss of bank vegetation, insufficient intact riparian forest), and improvement projects suggested.

Measurement: Condition of fisheries habitat.

Timing / Triggers: Prior to in-stream restoration works and when proposed development may impact watercourses / aquatic habitat / riparian habitat, either directly or through stormwater discharge. Following completion of the Anniedale-Tynehead development, watercourses downstream of the development should be assessed annually for four years; subsequent assessments should be triggered by development activity and enhancement initiatives.

Cost: $8,000 per watercourse.

Metric 10 – Spill Reporting

We understand that the City of Surrey and Township of Langley already have systems in place to track spills. These programs help to prevent, prepare for, mitigate, and respond to spills that may affect the health of the watersheds. These programs rely on reporting by residents and business owners in the area. With well-documented spill reporting, the City and Township can identify regions that are particularly high-risk for spills. Even if the magnitude of most spills is minor, the reporting can identify problem areas that may one day lead to a greater magnitude spill if pre-emptive mitigative measures are not undertaken. Well-documented spill reporting also helps to identify the types of development that are most prone to harmful spills.

Individuals can report spills using any of the following numbers:

- City of Surrey Engineering Department (business hours) 604.590.7226
- City of Surrey Engineering Department (24-hour) 604.591.4431
- Township of Langley Engineering Department (business hours) 604.532.7300
- Township of Langley Engineering Department (24-hour) 604.532.6700
- Provincial Emergency Program, Emergency Management BC 1.800.663.3456
- Environment Canada, Environmental Emergencies 604.666.6100
- Department of Fisheries and Oceans 24-hr Hotline 604.666.3500

We recommend that the City and Township continue to use their respective spill tracking programs to further enhance the existing database. The information that should be gathered for each reported spill includes:

- Contact information for reporting individual (voluntary)
- Location and time of the spill
- Type and quantity of substance spilled
- Natural watercourse(s) potentially impacted by the spill
- Cause of the spill
- Contact information for polluting individual (if available)
- Names of agencies on the scene
- Names of other persons or agencies advised concerning the spill
- Details of actions proposed to stop / contain / minimize the effects of the spill
- Details of actions taken to stop / contain / minimize the effects of the spill
- Details of further action required / taken.

As a minimum standard, three or more occurrences of minor spills should trigger a comprehensive review of the cause, and should trigger mitigation work. For example, three releases of hydrocarbons due to accidents at a high-collision intersection should trigger the City to immediately correct the issue to reduce the likelihood of a crash, or apply mitigating technology (e.g. oil-water separators) immediately upstream of the receiving waters. We understand that, based on the current programs in place, action can be taken after the first occurrence of a minor spill. Action should also be taken for every occurrence of medium / major spills.

Measurement: Number and details of reported spills.

Timing / Triggers: When a spill has been reported. Detailed analysis and mitigative measures to be undertaken when three or more minor spills reported at one location, and for every medium / major spill reported.

Cost: $500 per incident. Additional costs to analyse problem areas as they are identified.

13.2 SUMMARY OF RECOMMENDED KEY PERFORMANCE INDICATORS

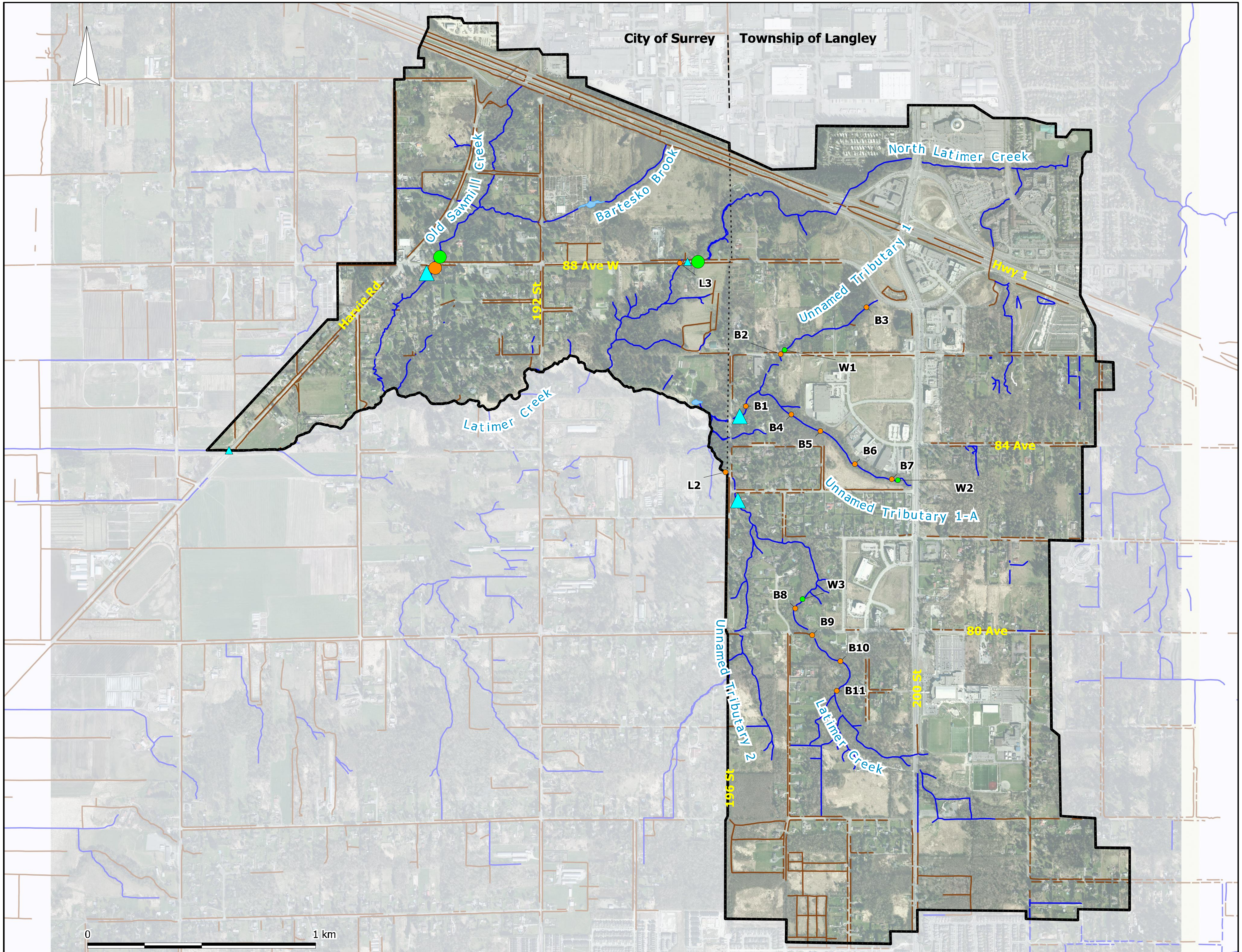
Table 13-3 provides a summary of the recommended key performance indicators.

Table 13-3
Recommended Key Performance Indicators

	Performance Indicator	Estimated Cost	Monitoring Program
Land Use Metrics			
Metric 1	**Percent Tree Cover**	$1,500 per investigation	Supplemental
Metric 2	**Percent Total Impervious Area**	$2,000 per investigation	Supplemental
Metric 3	**Percent Effective Impervious Area**	$5,000 - $7,500 per investigation (where flow monitoring data is available)	Supplemental
Metric 4	**Percent Riparian Forest Integrity**	$4,000 per investigation	Supplemental
Flow Regime Metrics			
Metric 5	**Number and Condition of Erosion Sites**	Part of overall Ravine Stability Assessment budget (Surrey – existing / Langley – recommended).	Ravine Stability Assessments
Metric 6	**Hydrometric Monitoring (Water Level and Flow)**	$30,000 for setup (per site) $5,000 annually for data collection (per site)	AMF

	Performance Indicator	Estimated Cost	Monitoring Program
Environmental Metrics			
Metric 7	**Water Quality Monitoring**	$8,000 per site per sampling period	AMF
Metric 8	**Benthic Invertebrates (B-IBI)**	$3,500 per site	AMF
Metric 9	**Fisheries Habitat Assessment**	$8,000 per watercourse	Supplemental
Metric 10	**Spill Reporting**	$500 per incident Additional costs to analyze and remediate problem areas	Supplemental

The timing and triggers of each performance indicator vary, and for maximized value should be integrated into existing City of Surrey and Township of Langley programs where feasible. While all of these metrics are recommended as Key Performance Indicators, we recognize that funding can be a constraint, and certain metrics may need to be prioritized. In general, the metrics that are most directly related to hydraulic conditions within the creeks provide high value for cost. This includes monitoring the number and condition of erosion sites (Metric 5), as well as hydrometric monitoring (Metric 6). Water quality monitoring (Metric 7) also provides a good value for cost, and should also be prioritized where funding is constrained.



LEGEND

EXISTING MONITORING LOCATIONS

- B-IBI SITE
- HYDROMETRIC STATION
- **L2** SURREY B-IBI SAMPLING SITE ID (ISMP STAGE 1)

ISMP SAMPLING LOCATIONS

- B-IBI SITE
- WATER QUALITY SITE
- **B1** B-IBI SAMPLING SITE ID (ISMP STAGE 1)
- **W1** WQ SAMPLING SITE ID (ISMP STAGE 1)

PROPOSED MONITORING LOCATIONS

- B-IBI SITE
- WATER QUALITY SITE
- HYDROMETRIC STATION

SITE IDs REFER TO INFORMATION PRESENTED IN APPENDIX B AND TABLE 4-13.

SCALE:	1:16,000		
PROJECT NO.	2014-2768	INITIAL	DATE
DRAWN		JT	15-09-04
DESIGNED			
CHECKED			
APPROVED			
PROJECTION:	UTM ZONE 10N NAD 83		

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Township of Langley

LATIMER CREEK ISMP

MONITORING LOCATIONS

DRAWING NUMBER	REV. NO.	SHEET
MAP 13-1		

Map File: P:\20142768\00_Latimer_Ck_ISMP\Working_Dwgs\010_GIS\map_latimer_ismp_report_figures_20150326_jl.map

Closure

The fundamental purpose of this Integrated Stormwater Management Plan for the Latimer Creek study area is to provide a framework for the City of Surrey and Township of Langley to protect the overall health of the watershed while allowing for future development.

The services provided by Associated Engineering (B.C.) Ltd. in the preparation of this report were conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions. No other warranty expressed or implied is made.

Yours truly,

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SEPT. 9, 2015

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JT/JF/lp

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Appendix A - Terrestrial Assessment

Appendix A

Table A-1. Plant species of Conservation Concern within the bioegeoclimatic zone Coastal Western Hemlock and Regional District of Metro Vancouver that have the potential to occur in the Latimer watershed.

English Name	Scientific Name	[1]B.C. Status	[2]COSEWIC	[3]SARA	Habitat Subtype
Carolina meadow-foxtail	*Alopecurus carolinianus*	Red			Vernal Pools/Seasonal Seeps; Meadow; Garry Oak Vernal Pool; Garry Oak Maritime Meadow
chaffweed	*Anagallis minima*	Blue			Estuary; Stream/River; Rock/Sparsely Vegetated Rock; Meadow; Beach; Pond/Open Water; Gravel Bar; Garry Oak Vernal Pool; Garry Oak Maritime Meadow
Vancouver Island beggarticks	*Bidens amplissima*	Blue	SC (Nov 2001)	1-SC (Jun 2003)	Estuary; Marsh; Beach; Mudflats - Intertidal
two-edged water-starwort	*Callitriche heterophylla* var. *heterophylla*	Blue			Pond/Open Water
yellow marsh-marigold	*Caltha palustris* var. *radicans*	Blue			
green-fruited sedge	*Carex interrupta*	Red			Stream/River; Riparian Herbaceous; Gravel Bar
fox sedge	*Carex vulpinoidea*	Blue			Bog; Fen; Swamp; Marsh; Beach
Washington springbeauty	*Claytonia washingtoniana*	Red			Cliff; Talus; Conifer Forest - Dry; Mixed Forest (deciduous/coniferous mix)
field dodder	*Cuscuta campestris*	Blue			Bog; Fen; Swamp; Marsh; Pasture/Old Field; Cultivated Field; Rock/Sparsely Vegetated Rock; Sagebrush Steppe; Antelope-brush Steppe

English Name	Scientific Name	[1]B.C. Status	[2]COSEWIC	[3]SARA	Habitat Subtype
three-flowered waterwort	*Elatine rubella*	Blue			Estuary; Bog; Fen; Swamp; Marsh; Pond/Open Water; Mudflats - Intertidal
small spike-rush	*Eleocharis parvula*	Blue			Swamp; Intertidal Marine; Pond/Open Water; Mudflats - Intertidal
beaked spike-rush	*Eleocharis rostellata*	Blue			Marsh; Meadow; Hot Spring
Nuttall's waterweed	*Elodea nuttallii*	Blue			Stream/River; Lake; Pond/Open Water
salt marsh Philadelphia fleabane	*Erigeron philadelphicus* var. *glaber*	Red			
slender-spiked mannagrass	*Glyceria leptostachya*	Blue			Bog; Fen; Swamp; Marsh; Lake; Pond/Open Water; Mudflats - Intertidal
mountain sneezeweed	*Helenium autumnale* var. *grandiflorum*	Blue			Meadow; Garry Oak Maritime Meadow
western St. John's-wort	*Hypericum scouleri* ssp. *nortoniae*	Blue			Rock/Sparsely Vegetated Rock; Meadow; Alpine/Subalpine Meadow
short-tailed rush	*Juncus brevicaudatus*	Red			
pointed rush	*Juncus oxymeris*	Blue			Estuary; Marsh; Intertidal Marine; Meadow
flowering quillwort	*Lilaea scilloides*	Blue			Marsh; Pond/Open Water; Mudflats - Intertidal
false-pimpernel	*Lindernia dubia* var. *anagallidea*	Blue			Bog; Fen; Swamp; Marsh; Vernal Pools/Seasonal Seeps; Riparian Shrub
yellowseed false pimpernel	*Lindernia dubia* var. *dubia*	Red			Bog; Fen; Swamp; Marsh; Vernal Pools/Seasonal Seeps
streambank lupine	*Lupinus rivularis*	Red	E (Nov 2002)	1-E (Jan 2005)	Stream/River; Meadow; Urban/Suburban/Rural; Mudflats - Intertidal; Garry Oak Woodland

English Name	Scientific Name	[1]B.C. Status	[2]COSEWIC	[3]SARA	Habitat Subtype
western water-milfoil	*Myriophyllum hippuroides*	Blue			Stream/River; Lake; Pond/Open Water
green parrot's-feather	*Myriophyllum pinnatum*	Red			Lake; Pond/Open Water
Ussurian water-milfoil	*Myriophyllum ussuriense*	Blue			Lake; Riparian Herbaceous
needle-leaved navarretia	*Navarretia intertexta*	Red			Vernal Pools/Seasonal Seeps; Meadow
nodding semaphoregrass	*Pleuropogon refractus*	Blue			Riparian Forest; Conifer Forest - Moist/wet; Mixed Forest (deciduous/coniferous mix)
snow bramble	*Rubus nivalis*	Blue			Conifer Forest - Mesic (average); Conifer Forest - Moist/wet
California-tea	*Rupertia physodes*	Blue			Deciduous/Broadleaf Forest; Garry Oak Woodland
Henderson's checker-mallow	*Sidalcea hendersonii*	Blue			Estuary; Marsh
blue vervain	*Verbena hastata* var. *scabra*	Blue			Marsh; Meadow
northern water-meal	*Wolffia borealis*	Red			Pond/Open Water

* Search Type: Plants & Animals; Regional Districts: Metro Vancouver (MVRD) (Restricted to Red, Blue, and Legally designated species; and BGC Zone:CWH

[1]The red-listed includes any ecological community, and indigenous species and subspecies that is extirpated, endangered, or threatened in British Columbia. The blue-list includes any ecological community, and indigenous species and subspecies considered to be of special concern (formerly vulnerable) in British Columbia.

[2]The Committee on the Status of Endangered Wildlife in Canada is a committee of experts that assesses and designates which wildlife species are in some danger of disappearing from Canada. E = Endangered, T = Threatened, SC = Special Concern, DD = Data Deficient.

[3]The *Species at Risk Act* establishes Schedule 1, as the official list of wildlife species at risk. It classifies those species as being either extirpated, endangered, threatened, or a special concern. Once listed, the measures to protect and recover a listed wildlife species are implemented

Table A-2. Wildlife species of Conservation Concern within the bioegeoclimatic zone Coastal Western Hemlock and Regional District of Metro Vancouver that have the potential to occur in the Latimer watershed.

	English Name	Scientific Name	[1]B.C. Status	[2]COSEWIC	[3]SARA	Habitat
Amphibians, Reptiles, and Turtles	Western Toad	*Anaxyrus boreas*	Blue	SC (Nov 2012)	1-SC (Jan 2005)	Bog; Fen; Swamp; Marsh; Riparian Forest; Riparian Shrub; Stream/River; Lake; Meadow; Grassland; Deciduous/Broadleaf Forest; Conifer Forest - Mesic (average); Conifer Forest - Dry; Conifer Forest - Moist/wet; Mixed Forest (deciduous/coniferous mix); Pond/Open Water; Riparian Herbaceous; Warm Spring; Gravel Bar
	Coastal Tailed Frog	*Ascaphus truei*	Blue	SC (Nov 2011)	1-SC (Jun 2003)	Riparian Forest; Stream/River; Meadow; Alpine/Subalpine Meadow
	Northern Red-legged Frog	*Rana aurora*	Blue	SC (Nov 2004)	1-SC (Jan 2005)	Bog; Fen; Swamp; Marsh; Riparian Forest; Riparian Shrub; Stream/River; Lake; Meadow; Deciduous/Broadleaf Forest; Pond/Open Water; Riparian Herbaceous; Gravel Bar
	Oregon Spotted Frog	*Rana pretiosa*	Red	E (May 2011)	1-E (Jun 2003)	Bog; Fen; Swamp; Marsh; Riparian Forest; Riparian Shrub; Stream/River; Lake; Pond/Open Water; Riparian Herbaceous; Gravel Bar
	Northern Rubber Boa	*Charina bottae*	Yellow	SC (May 2003)	1-SC (Jan 2005)	Riparian Forest; Stream/River; Sub-soil; Rock/Sparsely Vegetated Rock; Talus; Meadow; Grassland; Sagebrush Steppe; Conifer Forest - Mesic (average); Conifer Forest - Dry; Mixed Forest (deciduous/coniferous mix); Antelope-brush Steppe
	Painted Turtle - Pacific Coast Population	*Chrysemys picta pop. 1*	Red	E (Apr 2006)	1-E (Dec 2007)	Bog; Fen; Swamp; Marsh; Riparian Forest; Riparian Shrub; Lake; Urban/Suburban/Rural; Pond/Open Water; Riparian Herbaceous; Gravel Bar; Industrial
	Northern	*Accipiter gentilis*	Red	T (Apr	1-T	Estuary; Riparian Forest; Pasture/Old Field;

	English Name	Scientific Name	[1]B.C. Status	[2]COSEWIC	[3]SARA	Habitat
Birds	Goshawk, *laingi* subspecies	*laingi*		2013)	(Jun 2003)	Cultivated Field; Hedgerow; Meadow; Conifer Forest - Mesic (average); Conifer Forest - Dry; Conifer Forest - Moist/wet; Mixed Forest (deciduous/coniferous mix)
	Western Grebe	*Aechmophorus occidentalis*	Red	SC (2014)		Lakes; Pond/Open Water; Ocean -Sheltered Waters - Marine; Wetland / Marsh
	Great Blue Heron, *fannini* subspecies	*Ardea herodias fannini*	Blue	SC (Mar 2008)	1-SC (Feb 2010)	Estuary; Swamp; Marsh; Vernal Pools/Seasonal Seeps; Riparian Forest; Lake; Pasture/Old Field; Cultivated Field; Hedgerow; Intertidal Marine; Meadow; Deciduous/Broadleaf Forest; Conifer Forest - Mesic (average); Conifer Forest - Moist/wet; Mixed Forest (deciduous/coniferous mix); Marine Island; Beach; Urban/Suburban/Rural; Pond/Open Water; Reefs; Eelgrass Beds; Riparian Herbaceous; Mudflats - Intertidal; Sheltered Waters - Marine
	Short-eared Owl	*Asio flammeus*	Blue	SC (Mar 2008)	1-SC (Jul 2012)	Estuary; Marsh; Pasture/Old Field; Cultivated Field; Hedgerow; Meadow; Grassland; Urban/Suburban/Rural; Pond/Open Water; Riparian Herbaceous; Alpine/Subalpine Meadow; Alpine Grassland
	American Bittern	*Botaurus lentiginosus*	Blue			Estuary; Marsh; Lake; Pasture/Old Field; Cultivated Field; Hedgerow; Grassland; Pond/Open Water; Riparian Herbaceous
	Marbled Murrelet	*Brachyramphus marmoratus*	Blue	T (May 2012)	1-T (Jun 2003)	Kelp Bed; Riparian Forest; Stream/River; Lake; Rock/Sparsely Vegetated Rock; Conifer Forest - Mesic (average); Conifer Forest - Moist/wet; Subtidal Marine; Sheltered Waters - Marine
	Rough-legged Hawk	*Buteo lagopus*	Blue	NAR (May 1995)		Bog; Fen; Swamp; Marsh; Pasture/Old Field; Cultivated Field; Hedgerow; Meadow; Grassland; Sagebrush Steppe; Urban/Suburban/Rural;

	English Name	Scientific Name	[1]B.C. Status	[2]COSEWIC	[3]SARA	Habitat
						Riparian Herbaceous; Alpine/Subalpine Meadow; Alpine Grassland
	Green Heron	*Butorides virescens*	Blue			Estuary; Swamp; Marsh; Riparian Forest; Riparian Shrub; Stream/River; Lake; Urban/Suburban/Rural; Pond/Open Water; Riparian Herbaceous
	Common Nighthawk	*Chordeiles minor*	Yellow	T (Apr 2007)	1-T (Feb 2010)	Bog; Fen; Swamp; Marsh; Stream/River; Lake; Pasture/Old Field; Cultivated Field; Hedgerow; Cliff; Rock/Sparsely Vegetated Rock; Talus; Meadow; Grassland; Sagebrush Steppe; Deciduous/Broadleaf Forest; Conifer Forest - Mesic (average); Conifer Forest - Dry; Conifer Forest - Moist/wet; Mixed Forest (deciduous/coniferous mix); Urban/Suburban/Rural; Pond/Open Water; Antelope-brush Steppe; Gravel Bar
	Olive-sided Flycatcher	*Contopus cooperi*	Blue	T (Nov 2007)	1-T (Feb 2010)	Bog; Fen; Swamp; Riparian Forest; Conifer Forest - Mesic (average); Conifer Forest - Moist/wet; Mixed Forest (deciduous/coniferous mix); Pond/Open Water
	Sooty Grouse	*Dendragapus fuliginosus*	Blue			Riparian Forest; Pasture/Old Field; Cultivated Field; Hedgerow; Meadow; Shrub - Natural; Conifer Forest - Mesic (average); Conifer Forest - Dry; Conifer Forest - Moist/wet; Krummholtz; Shrub - Logged
	Peregrine Falcon	*Falco peregrinus*	No Status	SC (Apr 2007)		
	Peregrine Falcon, *anatum* subspecies	*Falco peregrinus anatum*	Red	SC (Apr 2007)	1-SC (Jun 2012)	Bog; Fen; Swamp; Marsh; Alkali Ponds/Salt Flats; Stream/River; Lake; Pasture/Old Field; Cultivated Field; Hedgerow; Cliff; Rock/Sparsely Vegetated Rock; Talus; Meadow; Grassland; Shrub - Natural; Sagebrush Steppe; Beach; Urban/Suburban/Rural; Pond/Open Water; Riparian Herbaceous; Antelope-

	English Name	Scientific Name	[1]B.C. Status	[2]COSEWIC	[3]SARA	Habitat
						brush Steppe; Gravel Bar
	Sandhill Crane	*Grus canadensis*	Yellow	NAR (May 1979)		Estuary; Bog; Fen; Swamp; Marsh; Stream/River; Lake; Pasture/Old Field; Cultivated Field; Hedgerow; Intertidal Marine; Sagebrush Steppe; Pond/Open Water; Riparian Herbaceous
	Barn Swallow	*Hirundo rustica*	Blue	T (May 2011)		Estuary; Bog; Fen; Swamp; Marsh; Riparian Forest; Riparian Shrub; Stream/River; Lake; Pasture/Old Field; Cultivated Field; Hedgerow; Meadow; Grassland; Shrub - Natural; Sagebrush Steppe; Deciduous/Broadleaf Forest; Conifer Forest - Mesic (average); Conifer Forest - Dry; Conifer Forest - Moist/wet; Mixed Forest (deciduous/coniferous mix); Urban/Suburban/Rural; Pond/Open Water; Riparian Herbaceous; Antelope-brush Steppe; Gravel Bar; Shrub - Logged; Industrial
	Caspian Tern	*Hydroprogne caspia*	Blue	NAR (May 1999)		Estuary; Marsh; Stream/River; Lake; Intertidal Marine; Subtidal Marine; Beach; Urban/Suburban/Rural; Gravel Bar; Sheltered Waters - Marine
	Western Screech-Owl, *kennicottii* subspecies	*Megascops kennicottii kennicottii*	Blue	T (May 2012)	1-SC (Jan 2005)	Riparian Forest; Pasture/Old Field; Hedgerow; Conifer Forest - Mesic (average); Conifer Forest - Dry; Conifer Forest - Moist/wet; Mixed Forest (deciduous/coniferous mix); Urban/Suburban/Rural
	Black-crowned Night-heron	*Nycticorax nycticorax*	Red			Swamp; Marsh; Riparian Shrub; Stream/River; Pasture/Old Field; Cultivated Field; Hedgerow; Shrub - Natural; Urban/Suburban/Rural; Pond/Open Water
	Band-tailed Pigeon	*Patagioenas fasciata*	Blue	SC (Nov 2008)	1-SC (Feb 2011)	Riparian Forest; Pasture/Old Field; Cultivated Field; Deciduous/Broadleaf Forest; Conifer Forest - Mesic (average); Conifer Forest - Moist/wet; Mixed Forest

	English Name	Scientific Name	[1]B.C. Status	[2]COSEWIC	[3]SARA	Habitat
						(deciduous/coniferous mix); Hot Spring; Urban/Suburban/Rural; Warm Spring; Cold Spring
	Double-crested Cormorant	*Phalacrocorax auritus*	Blue	NAR (May 1978)		Estuary; Stream/River; Lake; Cliff; Rock/Sparsely Vegetated Rock; Intertidal Marine; Conifer Forest - Mesic (average); Subtidal Marine; Marine Island; Urban/Suburban/Rural; Sheltered Waters - Marine
	Purple Martin	*Progne subis*	Blue			Estuary; Bog; Fen; Swamp; Marsh; Riparian Forest; Stream/River; Pasture/Old Field; Cultivated Field; Hedgerow; Deciduous/Broadleaf Forest; Conifer Forest - Mesic (average); Conifer Forest - Dry; Conifer Forest - Moist/wet; Urban/Suburban/Rural; Sheltered Waters - Marine
	Spotted Owl	*Strix occidentalis*	Red	E (Mar 2008)	1-E (Jun 2003)	Riparian Forest; Conifer Forest - Mesic (average); Conifer Forest - Dry; Conifer Forest - Moist/wet
	Barn Owl	*Tyto alba*	Blue	T (Nov 2010)	1-SC (Jun 2003)	Marsh; Riparian Forest; Riparian Shrub; Pasture/Old Field; Cultivated Field; Hedgerow; Meadow; Grassland; Sagebrush Steppe; Mixed Forest (deciduous/coniferous mix); Urban/Suburban/Rural; Riparian Herbaceous; Antelope-brush Steppe; Gravel Bar
Mammals	Mountain Beaver	*Aplodontia rufa*	Yellow	SC (May 2012)	1-SC (Jun 2003)	
	Townsend's Big-eared Bat	*Corynorhinus townsendii*	Blue			Riparian Forest; Caves; Grassland; Shrub - Natural; Deciduous/Broadleaf Forest; Conifer Forest - Mesic (average); Conifer Forest - Dry; Conifer Forest - Moist/wet; Mixed Forest (deciduous/coniferous mix); Urban/Suburban/Rural; Shrub - Logged; Industrial

	English Name	Scientific Name	[1]B.C. Status	[2]COSEWIC	[3]SARA	Habitat
	Wolverine, *luscus* subspecies	*Gulo gulo luscus*	Blue	SC (May 2014)		Bog; Fen; Swamp; Marsh; Riparian Forest; Stream/River; Cliff; Rock/Sparsely Vegetated Rock; Talus; Avalanche Track; Meadow; Grassland; Shrub - Natural; Deciduous/Broadleaf Forest; Conifer Forest - Mesic (average); Conifer Forest - Dry; Conifer Forest - Moist/wet; Mixed Forest (deciduous/coniferous mix); Krummholtz; Alpine/Subalpine Meadow; Alpine Grassland
	Snowshoe Hare, *washingtonii* subspecies	*Lepus americanus washingtonii*	Red			Riparian Forest; Riparian Shrub; Meadow; Shrub - Natural; Deciduous/Broadleaf Forest; Conifer Forest - Mesic (average); Conifer Forest - Dry; Conifer Forest - Moist/wet; Mixed Forest (deciduous/coniferous mix); Riparian Herbaceous
	Long-tailed weasel, *altifrontalis* subspecies	*Mustela frenata altifrontalis*	Red			Bog; Fen; Swamp; Marsh; Riparian Forest; Riparian Shrub; Sub-soil; Pasture/Old Field; Cultivated Field; Hedgerow; Cliff; Rock/Sparsely Vegetated Rock; Talus; Tundra; Avalanche Track; Meadow; Grassland; Shrub - Natural; Deciduous/Broadleaf Forest; Conifer Forest - Mesic (average); Conifer Forest - Dry; Conifer Forest - Moist/wet; Mixed Forest (deciduous/coniferous mix); Urban/Suburban/Rural; Riparian Herbaceous; Gravel Bar; Alpine/Subalpine Meadow; Alpine Grassland
	Southern Red-backed Vole, *occidentalis* subspecies	*Myodes gapperi occidentalis*	Red			Bog; Riparian Forest; Conifer Forest - Moist/wet
	Keen's Myotis	*Myotis keenii*	Blue	DD (Nov 2003)	3 (Mar 2005)	Riparian Forest; Caves; Cliff; Rock/Sparsely Vegetated Rock; Talus; Conifer Forest - Mesic (average); Conifer Forest - Moist/wet; Hot Spring; Urban/Suburban/Rural; Industrial

	English Name	Scientific Name	[1]B.C. Status	[2]COSEWIC	[3]SARA	Habitat
	Little Brown Myotis	*Myotis lucifugus*	Yellow	E (Nov 2013)		
	Pacific Water Shrew	*Sorex bendirii*	Red	E (Apr 2006)	1-E (Jun 2003)	Estuary; Bog; Fen; Swamp; Marsh; Riparian Forest; Riparian Shrub; Stream/River; Conifer Forest - Moist/wet; Riparian Herbaceous; Gravel Bar
	Olympic Shrew	*Sorex rohweri*	Red			Riparian Forest; Riparian Shrub; Mixed Forest (deciduous/coniferous mix); Riparian Herbaceous; Gravel Bar
	Trowbridge's Shrew	*Sorex trowbridgii*	Blue			Riparian Forest; Conifer Forest - Mesic (average); Conifer Forest - Moist/wet; Mixed Forest (deciduous/coniferous mix)
Invertebrate Animals	Oregon Forestsnail	*Allogona townsendiana*	Red	E (Apr 2013)	1-E (Jan 2005)	Mixed Forest (deciduous/coniferous mix)
	Emma's Dancer	*Argia emma*	Blue			Riparian Shrub; Stream/River; Lake; Pond/Open Water; Riparian Herbaceous
	Western Pine Elfin, *sheltonensis* subspecies	*Callophrys eryphon sheltonensis*	Blue			Bog; Shrub - Natural; Krummholtz
	Johnson's Hairstreak	*Callophrys johnsoni*	Red			Conifer Forest - Mesic (average); Conifer Forest - Moist/wet
	Western Thorn	*Carychium occidentale*	Blue			Mixed Forest (deciduous/coniferous mix)
	Puget Oregonian	*Cryptomastix devia*	Red	XT (Apr 2013)	1-X (Jan 2005)	Riparian Forest; Mixed Forest (deciduous/coniferous mix)

	English Name	Scientific Name	[1]B.C. Status	[2]COSEWIC	[3]SARA	Habitat
	Monarch	*Danaus plexippus*	Blue	SC (Apr 2010)	1-SC (Jun 2003)	Pasture/Old Field; Cultivated Field; Hedgerow; Meadow; Grassland; Sagebrush Steppe; Urban/Suburban/Rural
	Silver-spotted Skipper, *californicus* subspecies	*Epargyreus clarus californicus*	Red			Pasture/Old Field; Cultivated Field; Hedgerow; Meadow; Grassland; Shrub - Natural; Deciduous/Broadleaf Forest; Conifer Forest - Mesic (average); Conifer Forest - Dry; Conifer Forest - Moist/wet; Mixed Forest (deciduous/coniferous mix); Urban/Suburban/Rural
	Beaverpond Baskettail	*Epitheca canis*	Blue			Bog; Fen; Stream/River; Lake; Pond/Open Water; Riparian Herbaceous
	Dun Skipper	*Euphyes vestris*	Red	T (Apr 2013)	1-T (Jun 2003)	Vernal Pools/Seasonal Seeps; Meadow
	Northern Abalone	*Haliotis kamtschatkana*	Red	T (May 2000)	1-T (Jun 2003)	Intertidal Marine; Pelagic
	Pacific Sideband	*Monadenia fidelis*	Blue			Deciduous/Broadleaf Forest; Conifer Forest - Moist/wet; Mixed Forest (deciduous/coniferous mix)
	Grappletail	*Octogomphus specularis*	Red			Riparian Forest; Riparian Shrub; Stream/River
	Audouin's Night-stalking Tiger Beetle	*Omus audouini*	Red	T (Nov 2013)		
	Blue Dasher	*Pachydiplax longipennis*	Blue			Marsh; Riparian Forest; Stream/River; Lake; Cliff; Pond/Open Water
	Clodius Parnassian,	*Parnassius clodius*	Blue			

	English Name	Scientific Name	[1]B.C. Status	[2]COSEWIC	[3]SARA	Habitat
	claudianus subspecies	*claudianus*				
	Greenish Blue, *insulanus* subspecies	*Plebejus saepiolus insulanus*	Red	E (May 2012)	1-E (Jun 2003)	Riparian Forest; Riparian Shrub; Pasture/Old Field; Meadow; Grassland; Deciduous/Broadleaf Forest; Riparian Herbaceous; Gravel Bar
	Scarletback Taildropper	*Prophysaon vanattae*	Blue			Mixed Forest (deciduous/coniferous mix)
	Zerene Fritillary, *bremnerii* subspecies	*Speyeria zerene bremnerii*	Red			Meadow; Grassland; Deciduous/Broadleaf Forest; Urban/Suburban/Rural; Industrial
	Rocky Mountain Fingernailclam	*Sphaerium patella*	Red			Stream/River; Lake; Pond/Open Water
	Autumn Meadowhawk	*Sympetrum vicinum*	Blue			Riparian Shrub; Stream/River; Lake; Mixed Forest (deciduous/coniferous mix); Pond/Open Water; Riparian Herbaceous
	Black Petaltail	*Tanypteryx hageni*	Blue			Bog; Fen; Swamp; Marsh; Vernal Pools/Seasonal Seeps; Stream/River
	Black Gloss	*Zonitoides nitidus*	Blue			Bog; Fen; Swamp; Marsh; Riparian Forest; Riparian Shrub; Riparian Herbaceous; Gravel Bar

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[1]The red-listed includes any ecological community, and indigenous species and subspecies that is extirpated, endangered, or threatened in British Columbia. The blue-list includes any ecological community, and indigenous species and subspecies considered to be of special concern (formerly vulnerable) in British Columbia.

[2]The Committee on the Status of Endangered Wildlife in Canada is a committee of experts that assesses and designates which wildlife species are in some danger of disappearing from Canada. E = Endangered, T = Threatened, SC = Special Concern, DD = Data Deficient.

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Appendix B - Aquatic Assessment

Table B-1
Fish Habitat Characteristics (see Map 4-3)

Site #	Stream Name	Location	BW (m)	BD (m)	WW (m)	WD (m)	Subst. (D/Sd)	Grad. (%)	Morph.	Habitat Features	Fish Use	Photo #
1	Latimer Creek	West of 192 St.	7	1	2	1.1	F	1	LC	Slow moving deep water glides. Some overhanging vegetation and woody debris cover. Poor water quality (turbid).	Good rearing and overwinter-ing habitat. Poor spawning habitat.	1
2	Bartesko Brook	East of 192 St.	2.3	0.4	0.7	0.24	F	2	CP	Straight, slow moving, low gradient channel with a series of cascades and pool. Channel has extensive instream vegetation.	Good rearing and overwinter-ing habitat. Poor spawning habitat.	2, 3
3	Old Sawmill Creek	South of 90 Ave.	1.3	0.4	1.1	0.19	F	1	CP	Sinuous riffle-pool channel. Lots of overhanging vegetation and woody debris cover.	Good rearing and overwinter-ing habitat. Poor spawning habitat.	4
4	Old Sawmill Creek	South of Highway 1	1.8	0.8	1.2	0.09	F	1	CP	Sinuous riffle-pool channel. Lots of overhanging vegetation and woody debris cover. Intact riparian forest.	Good rearing and overwinter-ing habitat. Poor spawning habitat.	5
5	Old Sawmill Creek	North of 88 Ave.	1.6	0.8	1.4	0.48	F	1	CP	Slow moving deep water glides. Overhanging vegetation and woody debris cover.	Good rearing and overwinter-ing habitat. Poor spawning habitat.	6

Site #	Stream Name	Location	BW (m)	BD (m)	WW (m)	WD (m)	Subst. (D/Sd)	Grad. (%)	Morph.	Habitat Features	Fish Use	Photo #
6	Latimer Creek	East of Harvie Road, Upstream of South Latimer Creek confluence	7	1	2	1.1	F	0.5	LC	Slow moving deep water glides. Channel has extensive instream vegetation.	Good rearing and overwinter-ing habitat. Poor spawning habitat.	7
7	Latimer Creek	East of Harvie Road, Downstream of South Latimer Creek confluence	10	1.5	8	1.5	F	0.5	LC	Slow moving deep water glides. Channel has extensive instream vegetation.	Good rearing and overwinter-ing habitat. Poor spawning habitat.	8
8	North Latimer Creek	Downstream of 88 Ave.	2.5	0.6	2.1	0.15	C/F	2	RP	Sinuous riffle-pool channel. Overhanging vegetation and woody debris cover.	Good spawning and rearing areas for salmonids. Spawning Coho observed.	9
9	Unnamed Tributary 1A	Near 84 Ave and 198 St.	2.4	0.8	1.3	0.14	C/F	3	RP	Sinuous riffle-pool channel located near steep eroding south bank. Some overhanging vegetation and woody debris cover. Intact forest riparian area.	Good spawning and rearing areas for salmonids.	10
10	Drainage swale to Unnamed Tributary 1	Near 85 Avenue and 198 St.	n/a	n/a	n/a	n/a	F	1	n/a	Linear drainage channel in field with extensive instream vegetation.	Moderate rearing and overwinter-ing habitat.	-

Site #	Stream Name	Location	BW (m)	BD (m)	WW (m)	WD (m)	Subst. (D/Sd)	Grad. (%)	Morph.	Habitat Features	Fish Use	Photo #
11	Unnamed Tributary 1	North of 86 Ave.	3	0.1	0.5	0.2	F	1	RP	Slow moving deep water glides. Headwaters of channel. Lots of instream vegetation.	Good rearing and overwinter-ing habitat. Poor spawning habitat.	11
12	Unnamed Tributary 1	North of 86 Ave.	1.1	0.3	0.6	0.13	F	2	RP	Straight to sinuous riffle-pool channel. Lacking cover due to cleared riparian vegetation.	Potential rearing habitat. Poor spawning habitat.	12
13	Unnamed Tributary 1	South of 86 Ave.	1.5	0.4	1.3	0.17	F/G	3	RP	Sinuous riffle-pool channel. Overhanging vegetation and woody debris cover.	Good rearing and overwinter-ing habitat. Moderate spawning habitat. Spawning Coho observed.	13
14	Unnamed Tributary 1	East of 192 St.	2.4	0.6	2.1	0.26	F	2	RP	Straight to sinuous riffle-pool channel. Overhanging vegetation and woody debris cover.	Good rearing and overwinter-ing habitat. Poor spawning habitat.	14
15	Unnamed Tributary 1	West of 192 St.	1.9	0.8	1.6	0.31	F	2	RP	Slow moving deep water glides. Some overhanging vegetation and woody debris cover.	Good rearing and overwinter-ing habitat. Poor spawning habitat.	15
16	Latimer Creek	West of 192 St.	6	NC	4	0.4	F	1	LC	Slow moving deep water	Good rearing	16

Site #	Stream Name	Location	BW (m)	BD (m)	WW (m)	WD (m)	Subst. (D/Sd)	Grad. (%)	Morph.	Habitat Features	Fish Use	Photo #
										glides. Lots of instream vegetation	and overwintering habitat. Poor spawning habitat.	
17	Pond near Latimer Creek	Downstream of 192 St.	n/a	n/a	n/a	n/a	F	n/a	n/a	Large ponding area adjacent to Latimer Creek	Good rearing and overwintering habitat. Poor spawning habitat.	17
18	Latimer Creek	West of 192 St.	6	NC	4	0.4	F	1	LC	Slow moving deep water glides. Lots of instream vegetation.	Good rearing and overwintering habitat. Poor spawning habitat.	18
19	Unnamed Tributary to Latimer Creek (yellow coded)	East of 192 St.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Wetland section with a poorly defined channel contributing flows/nutrients downstream.	No fish potential.	19
20	Latimer Creek	Near 82 Avenue and 197 St.	4.2	0.4	3.9	0.16	C/F	4	RP	Straight to sinuous riffle-pool channel. Lots of overhanging vegetation and deep pools and instream cover. Intact riparian forest area.	Good salmonid rearing and spawning habitat. Dead spawner observed.	20, 21
21	Latimer Creek	Near 82 Avenue and 192 St.	5.2	0.6	3.5	0.18	C/F	5	RP	Straight to sinuous riffle-pool channel. Lots of overhanging vegetation and deep pools and	Good salmonid rearing and spawning habitat.	22

Site #	Stream Name	Location	BW (m)	BD (m)	WW (m)	WD (m)	Subst. (D/Sd)	Grad. (%)	Morph.	Habitat Features	Fish Use	Photo #
										instream cover. Intact riparian forest area.	Spawning Coho observed.	
22	Unnamed Tributary 2	Parallel to 192 Ave., south of 82A Ave.	2.5	0.4	2.3	0.14	C/F	4	RP	Straight to sinuous riffle-pool channel. Lots of overhanging vegetation and deep pools and instream cover. Intact riparian forest area.	Good salmonid rearing and spawning habitat. Spawning Coho observed.	23, 24
23	Latimer Creek	North of 80 Ave near 197 St.	4.6	0.6	3.3	4.6	F/C	4	RP	Sinuous riffle-pool channel. Overhanging vegetation and woody debris cover.	Good rearing and overwinter-ing habitat. Moderate spawning habitat. Spawning Coho observed.	25
24	Unnamed Tributary 2	South of 80 Avenue near 197 St.	3.2	0.3	2.1	0.1	C/F	4	RP	Straight to sinuous riffle-pool channel. Lots of overhanging vegetation and deep pools and instream cover. Intact riparian forest area.	Good spawning and rearing areas for salmonids.	26
25	Latimer Creek	Near the south end of 99 St., south of 80 Ave.	2.5	0.6	2.2	0.13	C/F	5	RP	Straight to sinuous riffle-pool channel. Lots of overhanging vegetation and deep pools and instream cover. Intact riparian forest area.	Good spawning and rearing areas for salmonids.	27

Site #	Stream Name	Location	BW (m)	BD (m)	WW (m)	WD (m)	Subst. (D/Sd)	Grad. (%)	Morph.	Habitat Features	Fish Use	Photo #
26	Latimer Creek HW	East of 200 St.	1	0.2	0.3	0.02	F/G	2	RP	Straight uniform drainage channel. Some overhanging vegetation. Compact sands and gravel substrate.	Poor rearing, overwinter-ing and spawning habitat.	28
27	North Latimer Creek	East of 202 St.	0.5	0.2	0.5	0.6	F	1	LC	Slow moving deep water glides. Channel has extensive instream vegetation.	Good rearing and overwinter-ing habitat. Poor spawning habitat.	29
28	North Latimer Creek	Near 91A Ave.	12	1	8	NC	F	2	LC	Slow moving deep water glides. Some overhanging vegetation and woody debris cover. Poor water quality (turbid).	Good rearing and overwinter-ing habitat. Poor spawning habitat.	30
29	North Latimer Creek	Near Birch Avenue, west of 200 St.	2.3	0.4	1.9	0.31	F	2	RP	Sinuous riffle-pool channel. Some overhanging vegetation and woody debris cover. Intact mature riparian canopy.	Good rearing and overwinter-ing habitat. Poor spawning habitat.	31
30	North Latimer Creek	South of Highway 1, between 201 and 202 St.	1.1	0.4	0.8	0.18	F/G	2	RP	Mostly straight channel. Overhanging vegetation and woody debris cover. Poor water quality (turbid).	Good rearing and overwinter-ing habitat. Poor spawning habitat.	32
31	North Latimer Creek	East of 196 St.	2.6	0.6	1.9	0.15	C/F	2	RP	Sinuous riffle-pool channel. Overhanging vegetation and woody	Good spawning and rearing areas for	-

Site #	Stream Name	Location	BW (m)	BD (m)	WW (m)	WD (m)	Subst. (D/Sd)	Grad. (%)	Morph.	Habitat Features	Fish Use	Photo #
										debris cover.	salmonids. Poor spawning habitat.	
32	Latimer Creek	West of 200 St.	2.4	0.5	2.1	0.15	C/F	4	RP	Straight to sinuous riffle-pool channel. Lots of overhanging vegetation and deep pools and instream cover. Intact riparian forest area.	Good spawning and rearing areas for salmonids.	33

NOTES:

BW = bankful width

BD = bankful depth

WW = wetted width

WD = wetted depth

Subst (D/Sd): Substrate (Dominant/Subdominant), C - cobbles, B - boulders, G - gravel, F - fines

Morph.: Channel morphology, RP - riffle-pool, CP - cascade-pool, LC, large channel

N/A - Not available, not applicable

Photo 1: Site 1, Latimer Creek, west of 192 Street, looking downstream

Photo 2: Site 2, Bartesko Brook, east of 192 Street, looking upstream

Photo 3: Bartesko Brook ponding area, near Site 2, looking upstream

Photo 4: Site 3, Old Sawmill Creek, south of 90 Avenue, looking downstream

Photo 5: Site 4, Old Sawmill Creek, south of Highway 1, looking upstream

Photo 6: Site 5, Old Sawmill Creek, north of 88 Avenue, looking upstream

Project Number:

Date: November 2014

Latimer ISMP – Aquatic Assessment

Prepare

City of Surrey — the future lives here.

Township of Langley BC — Est. 1873

Drawn By: LJ

Data Sources: Field Photos November 2014

SUMMIT Environmental Consultants Inc.
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Photo 7: Site 6, Latimer Creek, east of Harvie Road, looking upstream

Photo 8: Site 7, Latimer Creek, east of Harvie Road, looking upstream

Photo 9: Site 8, North Latimer Creek, south of 88 Avenue, looking upstream

Photo 10: Site 9, Unnamed Tributary 1, near 84 Ave and 198 St, looking downstream

Photo 11: Site 11, Unnamed Tributary 1, north of 86 Avenue, looking downstream

Photo 12: Site 12, Unnamed Tributary 1, north of 86 Avenue, looking upstream

Project Number: 2014-2768.010.008	Date: November 2014	Latimer ISMP – Aquatic Assessment
Prepared For: City of Surrey the future lives here. / Township of Langley BC Est. 1873	Drawn By: LJ Data Sources: Field Photos November 2014	SUMMIT Environmental Consultants Inc. A Member of the Associated Engineering Group of Companies

Photo 13: Site 13, Unnamed Tributary 1, south of 86 Avenue, looking downstream

Photo 14: Site 14, Unnamed Tributary 1, east of 192 Street, looking downstream

Photo 15: Site 15, Unnamed Tributary 1, west of 192 Street, looking downstream

Photo 16: Site 16, Latimer Creek, west of 192 Street, looking upstream

Photo 17: Site 17, Ponding area near Latimer Creek Site 16, west of 192 Street, looking upstream

Photo 18: Site 18, Latimer Creek, west of 192 Street, looking downstream

Project Number: 2014-2768.010.008	Date: November 2014	Latimer ISMP – Aquatic Assessment	
Prepared For: City of Surrey the future lives here. Township of Langley BC Est. 1873	Drawn By: LJ Data Sources: Field Photos November 2014	SUMMIT Environmental Consultants Inc. A Member of the Associated Engineering Group of Companies	

Photo 19: Site 19, Yellow-coded drainage east of 192 Street, looking upstream

Photo 20: Site 20, Latimer Creek, south of 197 Street, looking upstream

Photo 21: Dead spawner near Site 20 on Latimer Creek

Photo 22: Site 21, Latimer Creek south of 83 Avenue, looking downstream

Photo 23: Site 22, Unnamed Tributary 2 south of 82A Ave, looking upstream

Photo 24: Coho observed near Site 22

Project Number:	Date: November 2014	Latimer ISMP – Aquatic Assessment	
Prepared For: City of Surrey, the future lives here. Township of Langley BC, Est. 1873	Drawn By: LJ Data Sources: Field Photos November 2014	SUMMIT Environmental Consultants Inc. A Member of the Associated Engineering Group of Companies	

Photo 25: Site 23, Latimer Creek north of 80 Avenue, looking upstream

Photo 26: Site 24, Unnamed Tributary 2, south of 80 Avenue, looking downstream

Photo 27: Site 25, Latimer Creek, south of 199 Street, looking upstream

Photo 28: Site 26, Latimer Creek headwaters, east of 200 Street, looking upstream

Photo 29: Site 27, North Latimer Creek headwaters, east of 202 Street, looking downstream

Photo 30: Site 28, North Latimer Creek, east of 200 Street, looking downstream

Project Number: 2014-2768	Date: November 2014	Latimer ISMP – Aquatic Assessment
Prepared For: City of Surrey, the future lives here. Township of Langley BC Est. 1873	Drawn By: LJ Data Sources: Field Photos November 2014	SUMMIT Environmental Consultants Inc. A Member of the Associated Engineering Group of Companies

Photo 31: Site 29, North Latimer Creek, south of Birch Avenue, looking upstream

Photo 32: Site 30, South Latimer Creek, south of Highway 1, west of 202 Street, looking downstream

Photo 33: Site 32, Twin culverts on Latimer Creek east of 200 Street

Photo 34: Typical roadside drainage along 88 Avenue, looking west

Photo 35: Typical roadside drainage along Harvie Road, looking north

Photo 36: Typical roadside drainage along 192 Street, looking south

Project Number: 2014-2768	Date: November 2014	Latimer ISMP – Aquatic Assessment	
Prepared For: City of Surrey, the future lives here. / Township of Langley BC, Est. 1873	Drawn By: LJ Data Sources: Field Photos November 2014	SUMMIT Environmental Consultants Inc. A Member of the Associated Engineering Group of Companies	

Appendix C - B-IBI

Thibault Doix, certified taxonomist
Living Streams Environmental Services
401 - 1150 West 8th Avenue
Vancouver, BC V6H 3Z5
livingstreams@live.ca

Project Refs: **#2014-2768.010.060.009** **See Map 4-3**
Stream Name: **Latimer Creek**
Reporting Date: **03-Nov-14**

TAXON			B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11
			Unnamed Tributary 1			Unnamed Tributary 1A				Latimer Creek			
Non Arthropod Taxa													
	F. Enchytraeidae	*Enchytraeidae*		9		3	50	2	1				
	F. Lumbricidae	*Lumbricidae*		8								3	
	F. Lumbriculidae	*Lumbriculidae*	172	193	13	6	17	10	10	62	12	54	24
	F. Piscicolidae	*Piscicola sp.*				3	3	1				4	
	F. Ancylidae	*Ancylidae*	4										
	F. Lymnaeidae	*Lymnaeidae*					2		4				
	F. Physidae	*Physa sp.*		2			1		1				
	F. Planorbidae	*Promenetus sp.*			1						1	2	1
	F. Valvatidae	*Valvatidae*											1
	F. Pisidiidae	*Pisidium sp.*	8	3	53			1					
		Nematoda		1									
	F. Planariidae	*Polycelis coronata*		18			3				1		
O. Coleoptera	F. Elmidae	*Lara sp.*										1	
O. Diptera	F. Chironomidae	(Juvenile)			1					17	4		14
O. Diptera	F. Chironomidae	*Chironomini*	5	15	3								
O. Diptera	F. Chironomidae	*Tanypodinae*		6			1			9	3	3	4
O. Diptera	F. Chironomidae	*Tanytarsini*	1	7									
O. Diptera	F. Chironomidae	*Orthocladiinae*	2	4								3	
O. Diptera	F. Ceratopogonidae	*Mallochohelea sp.*		1	1	1	3					1	1
O. Diptera	F. Sciomyzidae	*Sciomyzidae*					2	1			1		
O. Diptera	F. Simuliidae	*Prosimulium sp.*											3
O. Diptera	F. Simuliidae	*Simulium sp.*								4	7	6	
O. Diptera	F. Tipulidae	*Tipula sp.*			2								
O. Ephemeroptera	F. Baetidae	*Baetis* sp.						1		74	36	48	31
O. Ephemeroptera	F. Heptageneiidae	*Nixe sp.*								2	1	1	4
O. Ephemeroptera	F. Leptophlebiidae	*Paraleptophlebia sp.*								2			2
O. Isopoda	F. Asellidae	*Caeciotea sp.*	2										
O. Lepidoptera		*Lepidoptera*					1					1	
O. Megaloptera	F. Sialidae	*Sialis sp.*									1		5
O. Plecoptera	F. Capniidae	*Capniidae (juvenile)*	1			1	5	1				5	
O. Plecoptera	F. Capniidae	*Capnia sp.*								5	4		
O. Plecoptera	F. Nemouridae	*Zapada cinctipes*		1	1					5		3	4
O. Plecoptera	F. Perlodidae	*Perlodidae* (juvenile)	1							1		3	1
O. Trichoptera	F. Glossosomatidae	*Glossosoma* sp.				1				34	14	2	1
O. Trichoptera	F. Rhyacophilidae	*Rhyacophila sp.*			2	1	1	2		1	1	1	
O. Amphipoda	F. Crangonyctidae	*Crangonyx sp.*		33	19	5	9	1	2	5	1	19	7
		Total Number of Organisms	196	301	96	21	98	20	18	221	87	160	103
		Total Number of Taxa	9	14	10	8	13	9	5	13	14	18	15

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11
	Unnamed Tributary 1			Unnamed Tributary 1A				Latimer Creek			
METRIC VALUES											
Taxa richness	14	9	10	8	13	9	5	13	14	18	15
Ephemeroptera richness	0	0	0	0	0	1	0	3	2	2	3
Plecoptera richness	1	2	1	1	1	1	0	3	1	3	2
Trichoptera richness	0	0	1	2	1	1	0	2	2	2	1
Intolerant taxa richness	1	3	3	3	2	3	0	9	6	8	7
Clinger richness	1	2	1	1	5	2	0	7	4	7	5
Long Lived taxa richness	0	0	0	1	0	0	0	1	1	2	1
% tolerant	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% predator	0.5	0.3	3.1	9.5	4.1	10.0	0.0	0.9	1.1	3.1	1.9
% dominance (top 3 taxa)	124.5	61.5	88.5	66.7	77.6	70.0	88.9	56.6	62.1	75.6	67.0
METRIC SCORES											
Taxa richness	3	1	3	1	3	1	1	3	3	3	3
Ephemeroptera richness	1	1	1	1	1	1	1	3	1	1	3
Plecoptera richness	1	1	1	1	1	1	1	3	1	3	1
Trichoptera richness	1	1	1	3	1	1	1	3	3	3	1
Intolerant taxa richness	3	5	5	5	5	5	1	5	5	5	5
Clinger richness	1	1	1	1	1	1	1	1	1	1	1
Long Lived taxa richness	1	1	1	3	1	1	1	3	3	5	3
% tolerant	5	5	5	5	5	5	5	5	5	5	5
% predator	1	1	1	1	1	5	1	1	1	1	1
% dominance (top 3 taxa)	1	1	1	3	1	3	1	3	3	3	3
SAMPLE SCORE	18.0	18.0	20.0	24.0	20.0	24.0	14.0	30.0	26.0	30.0	26.0
SITE AVERAGE		18.7			20.5				28.0		

See Map 4-3

Site #	Location	CD (cm)	WW (m)	Wb (m)	Subst. (D/Sd)	Habitat Features	Photo #
B1	Unnamed Tributary 1 (see map)	12	1.4	2.5	F	Limited water and channel depth, narrow riparian corridor, very silty	1
B2	Unnamed Tributary 1 (see map)	12	1.5	1.8	F/G	Shallow, less cover, slightly eroded	2, 3
B3	Unnamed Tributary 1 (see map)	8	0.68	1.2	F	vegetation and woody debris, slightly eroded with undercuts, artesian wells	4, 5
B4	Unnamed Tributary 1A (see map)	13	1.9	6.5	G/C	Slow moving, shallow, overhanging vegetation and woody debris	6
B5	Unnamed Tributary 1A (see map)	14	2.6	4.3	G	Slow moving, overhanging vegetation, woody debris	7
B6	Unnamed Tributary 1A (see map)	17	2.3	5.2	C	Slow moving, overhanging vegetation, woody debris	8, 9
B7	Unnamed Tributary 1A (see map)	14	1.5	2.7	G	Slow moving, overhanging vegetation	10
B8	Latimer Creek (see map)	9	2.7	4.8	F/G	Overhanging vegetation, outlets from road	11, 12
B9	Latimer Creek (see map)	15	3	3.4	C	Overhanging vegetation, eroded with undercuts	13
B10	Latimer Creek (see map)	17	2.7	3.9	C/G	Overhanging vegetation, slightly eroded with undercuts	14
B11	Latimer Creek (see map)	13	2.3	4.2	C	Overhanging vegetation, slow moving	15, 16

NOTES

CD	Channel Depth
WW	Wetted Width
Wb	Bankfull Width
Subst. (D/Sd)	Substrate (Dominant/ Subdominant), C-cobble, B-boulder, G-gravel, F-fines
N/A	not available/ not applicable

See Map 4-3

Photo 1: **B1**, Unnamed Tributary 1 looking downstream

Photo 3: **B2**, Unnamed Tributary 1 looking downstream

Photo 5: **B3**, Unnamed Tributary 1 looking upstream

Photo 2: **B2**, Unnamed Tributary 1 looking upstream

Photo 4: **B3**, Unnamed Tributary 1 looking upstream

Photo 6: **B4**, Unnamed Tributary 1A looking upstream

See Map 4-3	Project Number: 2014-2768.060.009	Date: November 2014	Latimer ISMP – Aquatic Assessment
	Prepare	Drawn By: SB Data Sources: Field Photos October 2014	SUMMIT Environmental Consultants Inc. A Member of the Associated Engineering Group of Companies

Photo 7: **B5**, Unnamed Tributary 1A looking upstream

Photo 9: **B6**, Unnamed Tributary 1A looking downstream

Photo 11: **B8**, Latimer Creek looking upstream

Photo 8: **B6**, Unnamed Tributary 1 A looking upstream

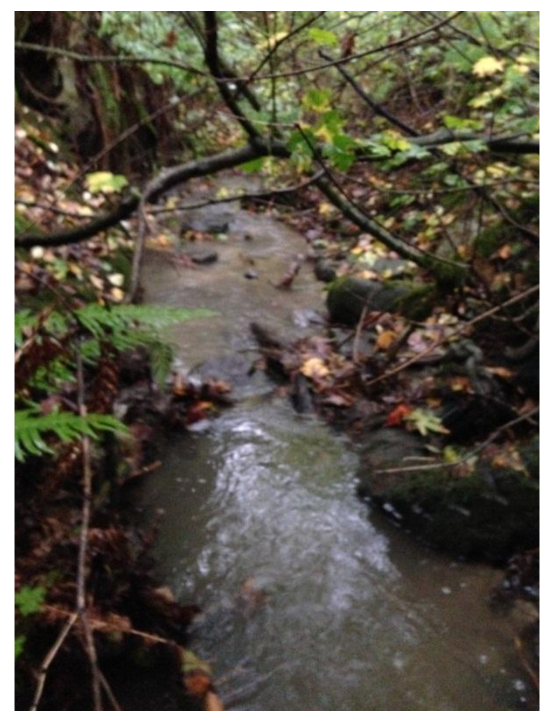


Photo 10: **B7**, Unnamed Tributary 1A looking upstream

Photo 12: **B8**, Latimer Creek looking downstream

See Map 4-3	Project Number: 2014-2768.060.009	Date: November 2014	Latimer ISMP – Aquatic Assessment
	Prepare	Drawn By: SB Data Sources: Field Photos October 2014	

Photo 13: **B9**, Latimer Creek looking downstream

Photo 15: **B11**, Latimer Creek looking upstream

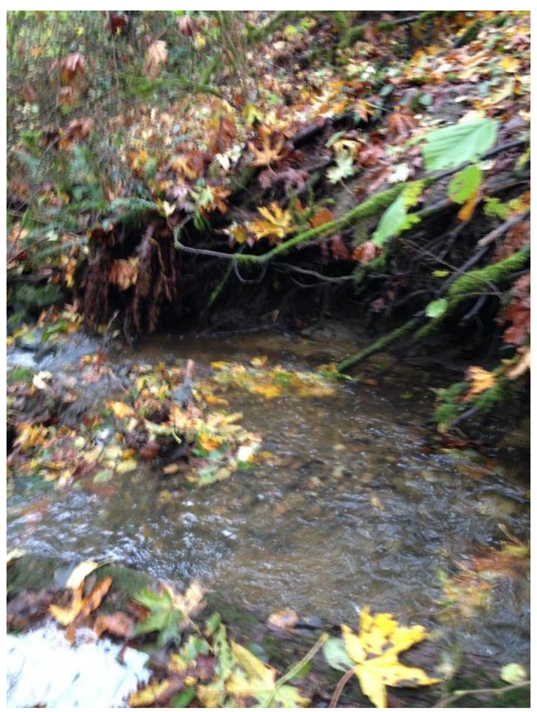


Photo 14: **B10**, Latimer Creek looking downstream

Photo16: **B12**, Latimer Creek looking downstream

See Map 4-3	Project Number: 2014-2768.060.009	Date: November 2014	Latimer ISMP – Aquatic Assessment
	Prepared For: City of SURREY the future lives here. Township of Langley BC Est. 1873	Drawn By: SB Data Sources: Field Photos October 2014	SUMMIT ENVIRONMENTAL CONSULTANTS INC. A Member of the Associated Engineering Group of Companies

Appendix D - Water Quality

Project 2014-2768-060-010

ALS Global

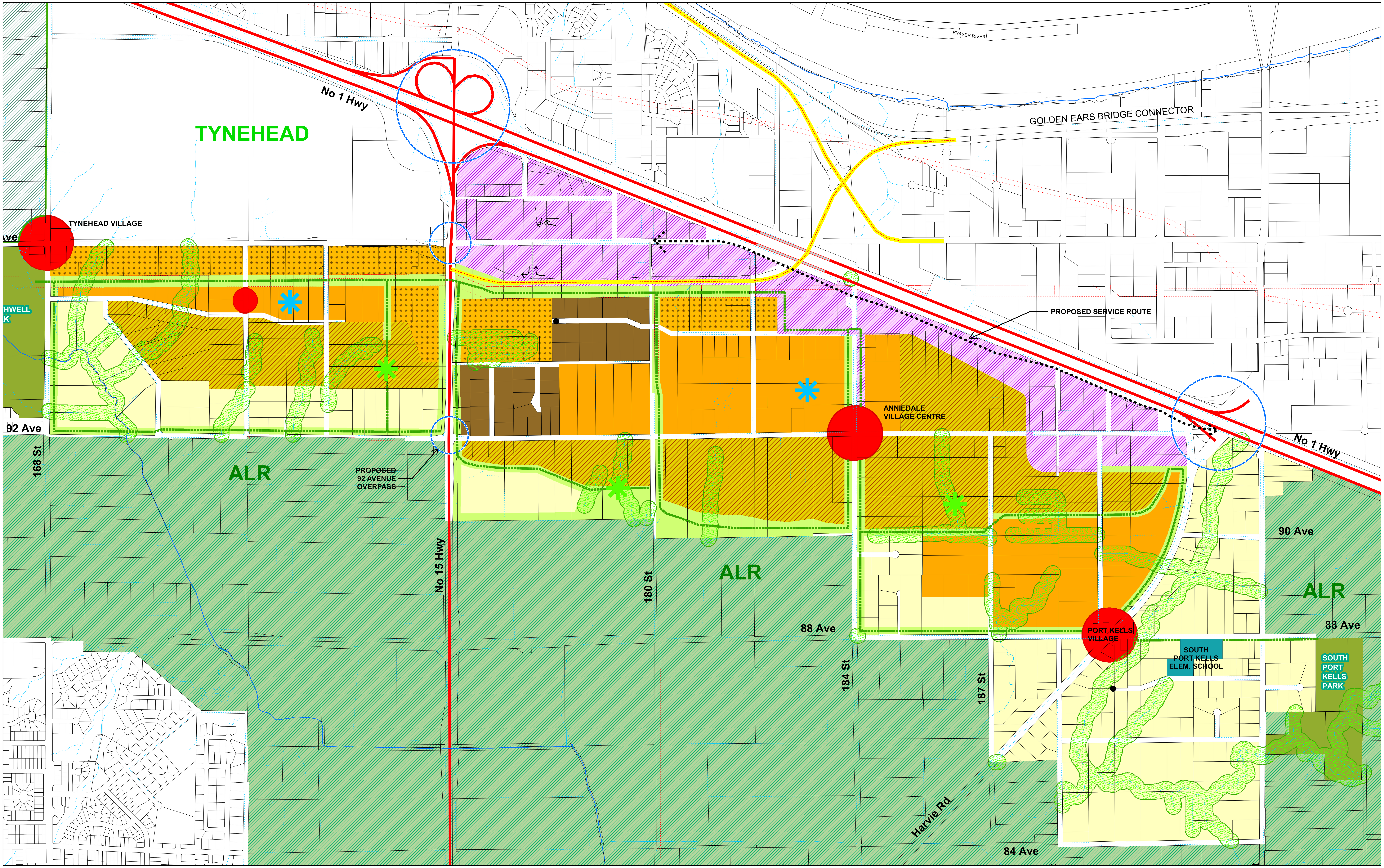
ALS File No. L1537447
Date Received 23-Oct-14 16:20
Date 04-Nov-14
WQ results Full

Sample ID	Unit	W1	W2	W3	Replicate (W1)	RPD	Trip Blank
Physical Tests							
Conductivity	uS/cm	199	115	150	199	0.0	<2.0
Hardness (as CaCO3)	mg/L	63.7	41.1	58.9	63.5	0.3	<0.50
Total Suspended Solids	mg/L	4.3	8.4	4.5	5.2	20.9	-
Turbidity	NTU	22.8	18.1	6.99	22.3	2.2	<0.10
Anions and Nutrients							
Ammonia, Total (as N)	mg/L	0.0234	0.0167	<0.0050	0.0234	0.0	<0.0050
Nitrate (as N)	mg/L	1.18	1.03	1.25	1.18	0.0	<0.0050
Nitrite (as N)	mg/L	0.0052	0.0069	0.0045	0.0053	1.9	<0.0010
Total Nitrogen	mg/L	1.77	1.45	1.65	1.71	3.4	-
Phosphorus (P)-Total	mg/L	0.0402	0.0461	0.0477	0.0456	13.4	-
Total Metals							
Aluminum (Al)-Total	mg/L	1.73	1.04	0.503	1.48	14.5	<0.0050
Antimony (Sb)-Total	mg/L	<0.00050	0.00052	<0.00050	<0.00050	N/A	<0.00050
Arsenic (As)-Total	mg/L	0.00124	0.00099	0.00096	0.00113	8.9	<0.00050
Barium (Ba)-Total	mg/L	0.031	0.027	<0.020	0.028	9.7	<0.020
Beryllium (Be)-Total	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	N/A	<0.0010
Boron (B)-Total	mg/L	<0.10	<0.10	<0.10	<0.10	N/A	<0.10
Cadmium (Cd)-Total	mg/L	0.000024	0.000028	0.000013	0.00002	16.7	<0.000010
Calcium (Ca)-Total	mg/L	17.9	12.1	17.5	17.4	2.8	<0.10
Chromium (Cr)-Total	mg/L	0.0023	0.0052	0.0013	0.0021	8.7	<0.0010
Cobalt (Co)-Total	mg/L	0.00054	0.00052	<0.00030	0.00053	1.9	<0.00030
Copper (Cu)-Total	mg/L	0.0061	0.0065	0.0058	0.006	1.6	<0.0010
Iron (Fe)-Total	mg/L	1.37	1.09	0.494	1.3	5.1	<0.030
Lead (Pb)-Total	mg/L	0.00062	0.00109	<0.00050	0.00063	1.6	<0.00050
Lithium (Li)-Total	mg/L	<0.0050	<0.0050	<0.0050	<0.0050	N/A	<0.0050
Magnesium (Mg)-Total	mg/L	4.97	3.21	3.56	4.84	2.6	<0.10
Manganese (Mn)-Total	mg/L	0.0412	0.0275	0.0147	0.0406	1.5	<0.00030
Mercury (Hg)-Total	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	N/A	<0.000010
Molybdenum (Mo)-Total	mg/L	0.0014	<0.0010	<0.0010	0.0013	7.1	<0.0010
Nickel (Ni)-Total	mg/L	0.0026	0.0019	0.0016	0.0025	3.8	<0.0010
Potassium (K)-Total	mg/L	2.7	<2.0	2.7	2.6	3.7	<2.0
Selenium (Se)-Total	mg/L	0.00012	<0.00010	<0.00010	0.00011	8.3	<0.00010
Silver (Ag)-Total	mg/L	0.000026	<0.000020	<0.000020	0.000033	26.9	<0.000020
Sodium (Na)-Total	mg/L	14.9	6.3	6.4	14.7	1.3	<2.0
Thallium (Tl)-Total	mg/L	<0.00020	<0.00020	<0.00020	<0.00020	N/A	<0.00020
Tin (Sn)-Total	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	N/A	<0.00050
Titanium (Ti)-Total	mg/L	0.077	0.044	0.024	0.063	18.2	<0.010
Uranium (U)-Total	mg/L	<0.00020	<0.00020	<0.00020	<0.00020	N/A	<0.00020
Vanadium (V)-Total	mg/L	0.0038	0.0027	0.0018	0.0035	7.9	<0.0010
Zinc (Zn)-Total	mg/L	0.0184	0.0204	0.0075	0.0195	6.0	<0.0050
Dissolved Metals							
Dissolved Mercury Filtration Location	-	FIELD	FIELD	FIELD	-	-	-
Dissolved Metals Filtration Location	-	LAB	LAB	FIELD	-	-	-
Aluminum (Al)-Dissolved	mg/L	0.326	0.0854	0.344	-	-	-
Antimony (Sb)-Dissolved	mg/L	<0.00050	<0.00050	<0.00050	-	-	-
Arsenic (As)-Dissolved	mg/L	0.00089	0.00068	0.00095	-	-	-
Barium (Ba)-Dissolved	mg/L	<0.020	<0.020	<0.020	-	-	-
Beryllium (Be)-Dissolved	mg/L	<0.0010	<0.0010	<0.0010	-	-	-
Boron (B)-Dissolved	mg/L	<0.10	<0.10	<0.10	-	-	-
Cadmium (Cd)-Dissolved	mg/L	<0.000010	0.000011	0.00001	-	-	-
Calcium (Ca)-Dissolved	mg/L	17.8	11.7	17.7	-	-	-
Chromium (Cr)-Dissolved	mg/L	<0.0010	0.0032	<0.0010	-	-	-
Cobalt (Co)-Dissolved	mg/L	<0.00030	<0.00030	<0.00030	-	-	-
Copper (Cu)-Dissolved	mg/L	0.0039	0.0039	0.0054	-	-	-
Iron (Fe)-Dissolved	mg/L	0.285	0.084	0.312	-	-	-
Lead (Pb)-Dissolved	mg/L	<0.00050	<0.00050	<0.00050	-	-	-
Lithium (Li)-Dissolved	mg/L	<0.0050	<0.0050	<0.0050	-	-	-
Magnesium (Mg)-Dissolved	mg/L	4.66	2.87	3.59	-	-	-
Manganese (Mn)-Dissolved	mg/L	0.00263	0.0012	0.0132	-	-	-
Mercury (Hg)-Dissolved	mg/L	<0.000010	<0.000010	<0.000010	-	-	-
Molybdenum (Mo)-Dissolved	mg/L	0.0013	<0.0010	<0.0010	-	-	-
Nickel (Ni)-Dissolved	mg/L	0.0012	<0.0010	0.0014	-	-	-
Potassium (K)-Dissolved	mg/L	2.6	<2.0	2.7	-	-	-
Selenium (Se)-Dissolved	mg/L	<0.00010	<0.00010	<0.00010	-	-	-
Silver (Ag)-Dissolved	mg/L	<0.000020	<0.000020	<0.000020	-	-	-
Sodium (Na)-Dissolved	mg/L	14.7	6.3	6.5	-	-	-
Thallium (Tl)-Dissolved	mg/L	<0.00020	<0.00020	<0.00020	-	-	-
Tin (Sn)-Dissolved	mg/L	<0.00050	<0.00050	<0.00050	-	-	-
Titanium (Ti)-Dissolved	mg/L	0.025	<0.010	0.016	-	-	-
Uranium (U)-Dissolved	mg/L	<0.00020	<0.00020	<0.00020	-	-	-
Vanadium (V)-Dissolved	mg/L	0.0013	<0.0010	0.0015	-	-	-
Zinc (Zn)-Dissolved	mg/L	0.008	0.0075	0.0063	-	-	-
Aggregate Organics							
Mineral Oil & Grease	mg/L	<5.0	<5.0	<5.0	<5.0	-	-
Hydrocarbons							
EPH10-19	mg/L	<0.25	<0.25	<0.25	<0.25	-	-
EPH19-32	mg/L	<0.25	<0.25	<0.25	<0.25	-	-

Note: N/A indicate sRelative Percent Difference Not Available due to result(s) being less than detection limit.

See Map 4-3

Appendix E - Land Use Plans

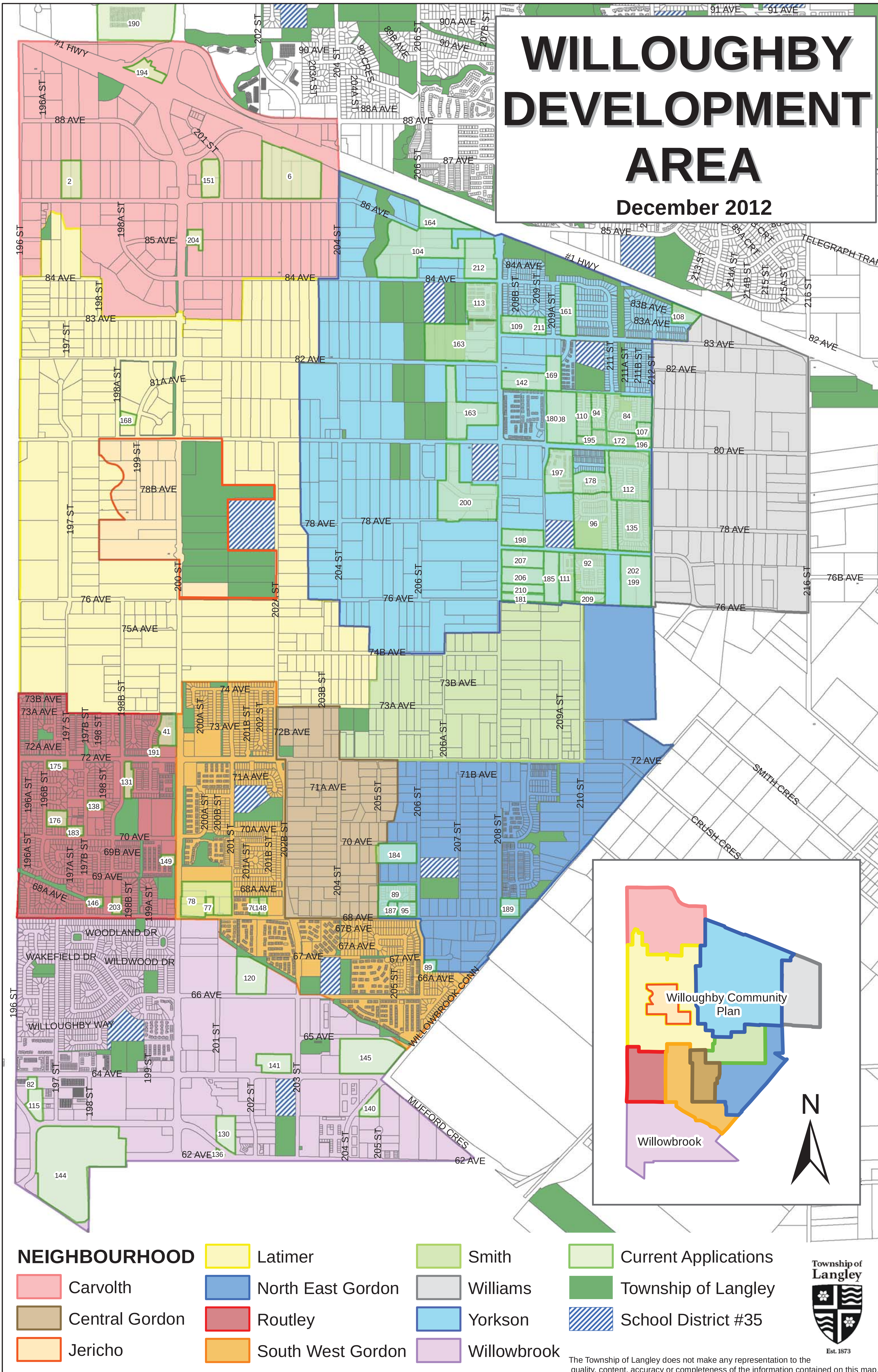


SOUTH PORT KELLS GENERAL LAND USE PLAN

City of Surrey Planning & Development Department

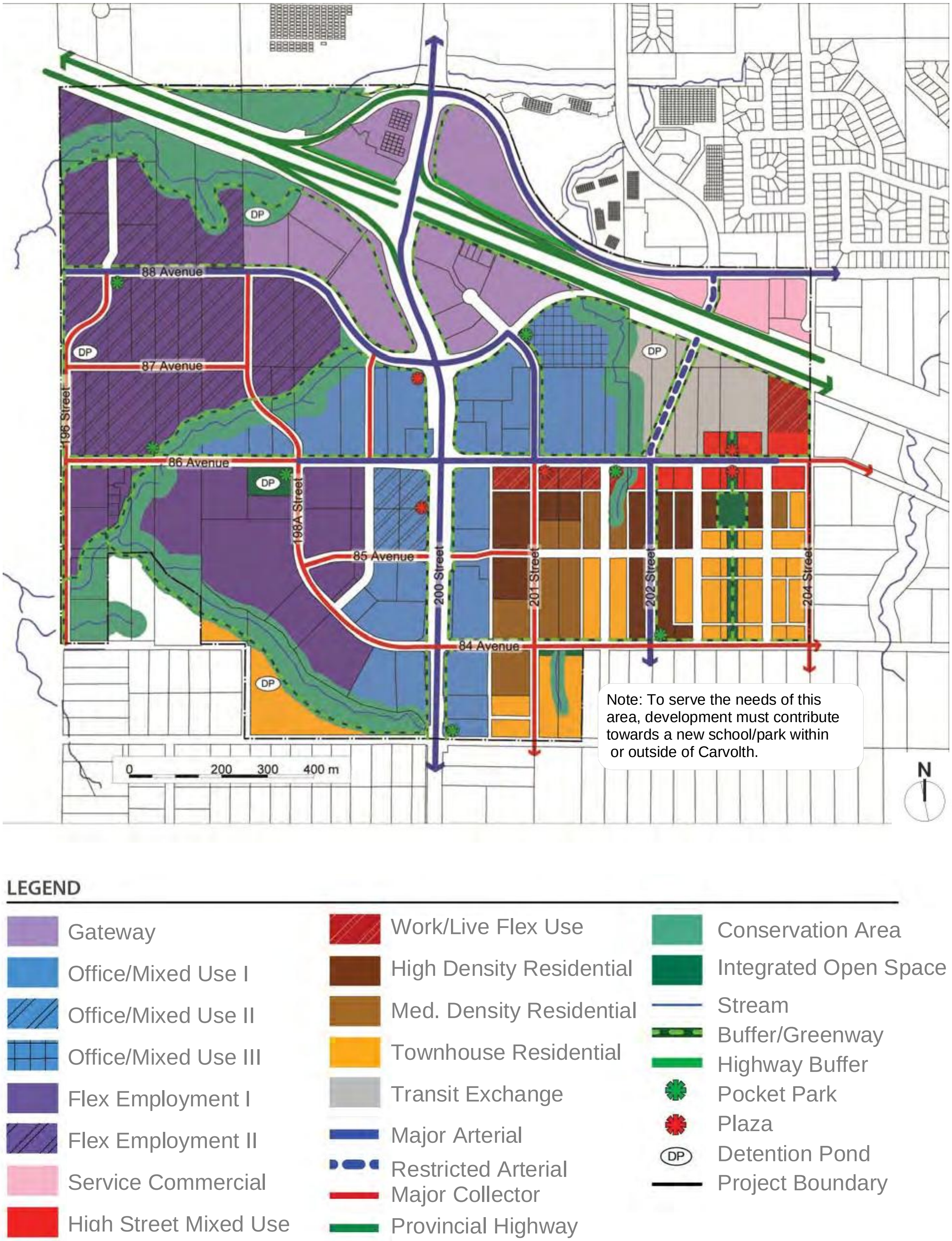
- BUSINESS CENTRE
- COMMERCIAL
- MULTIPLE RESIDENTIAL
- URBAN RESIDENTIAL
- CLUSTER RESIDENTIAL
- SUBURBAN RESIDENTIAL
- FUTURE MULTIPLE RESIDENTIAL
- PARK
- BUFFER
- TYNEHEAD PARK
- MULTI-USE TRAILS
- PROPOSED SCHOOL AND PARK (GENERAL)
- PROPOSED PARK (GENERAL)
- REGIONAL OR PROVINCIAL HIGHWAY
- PROPOSED REGIONAL OR PROVINCIAL HIGHWAY
- PROPOSED SERVICE ROUTE
- INTERCHANGE/ INTERSECTION/ OVERPASS T.B.D.
- HYDRO R.O.W.
- CONTOURS 5m
- CONTOURS 1m
- CREEKS & SETBACK AREA
- ALR BOUNDARY
- SCHOOL

May 27, 2005



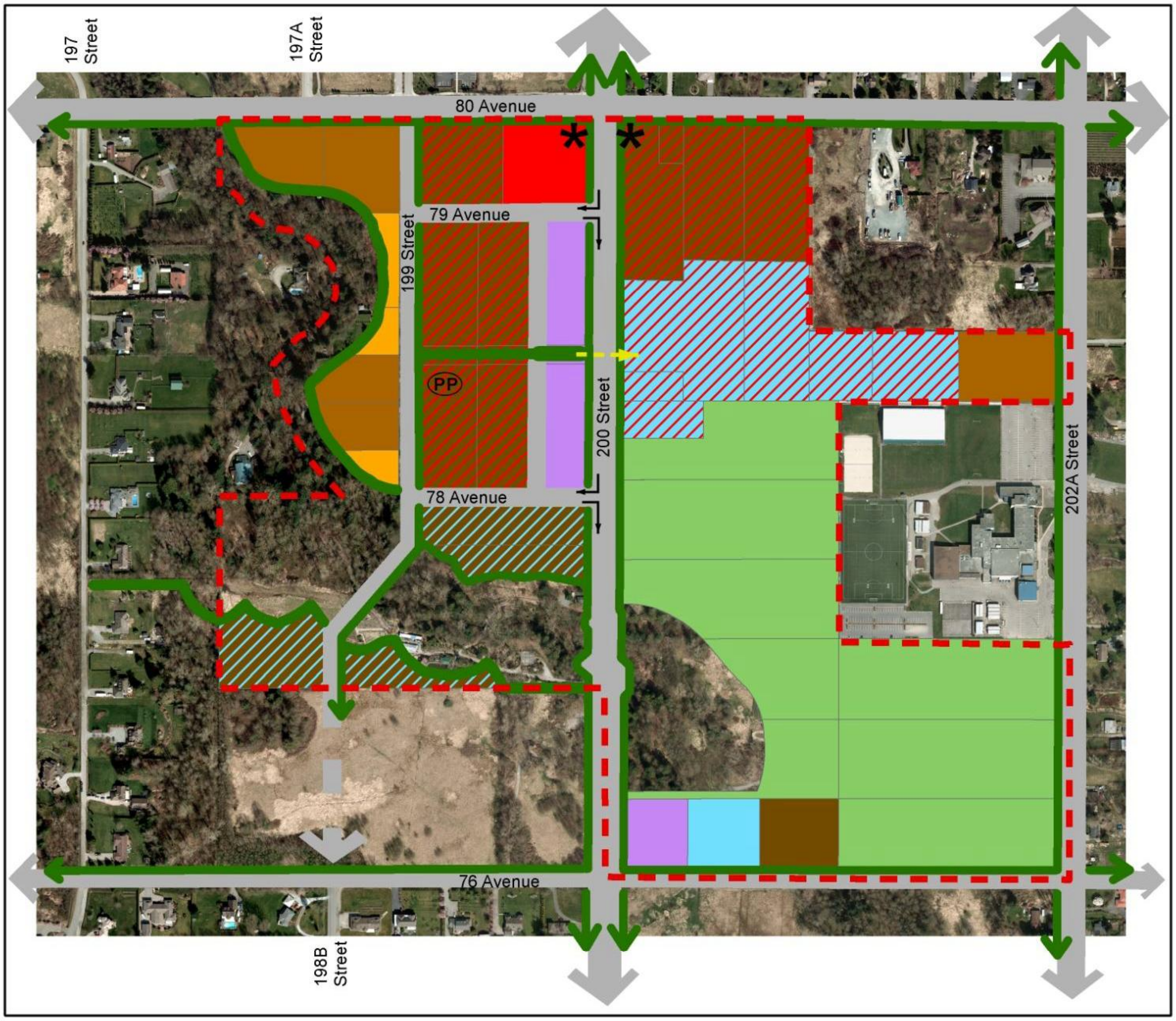
F:\data\LRDP Mapping\Willoughby Developement Plan\ESRI\2012\December 2012.mxd

Figure 7. Integrated Area Concept Plan



Jericho Sub-Neighbourhood Plan

Map 4 – Land Use Concept Plan



LEGEND

Commercial	High Density Multi-Family and Seniors Residential / Institutional
Townhoiuse	Business Office Park
Apartment	Mixed Institutional
High Density Residential	Institutional
High Density Mixed Use	Park

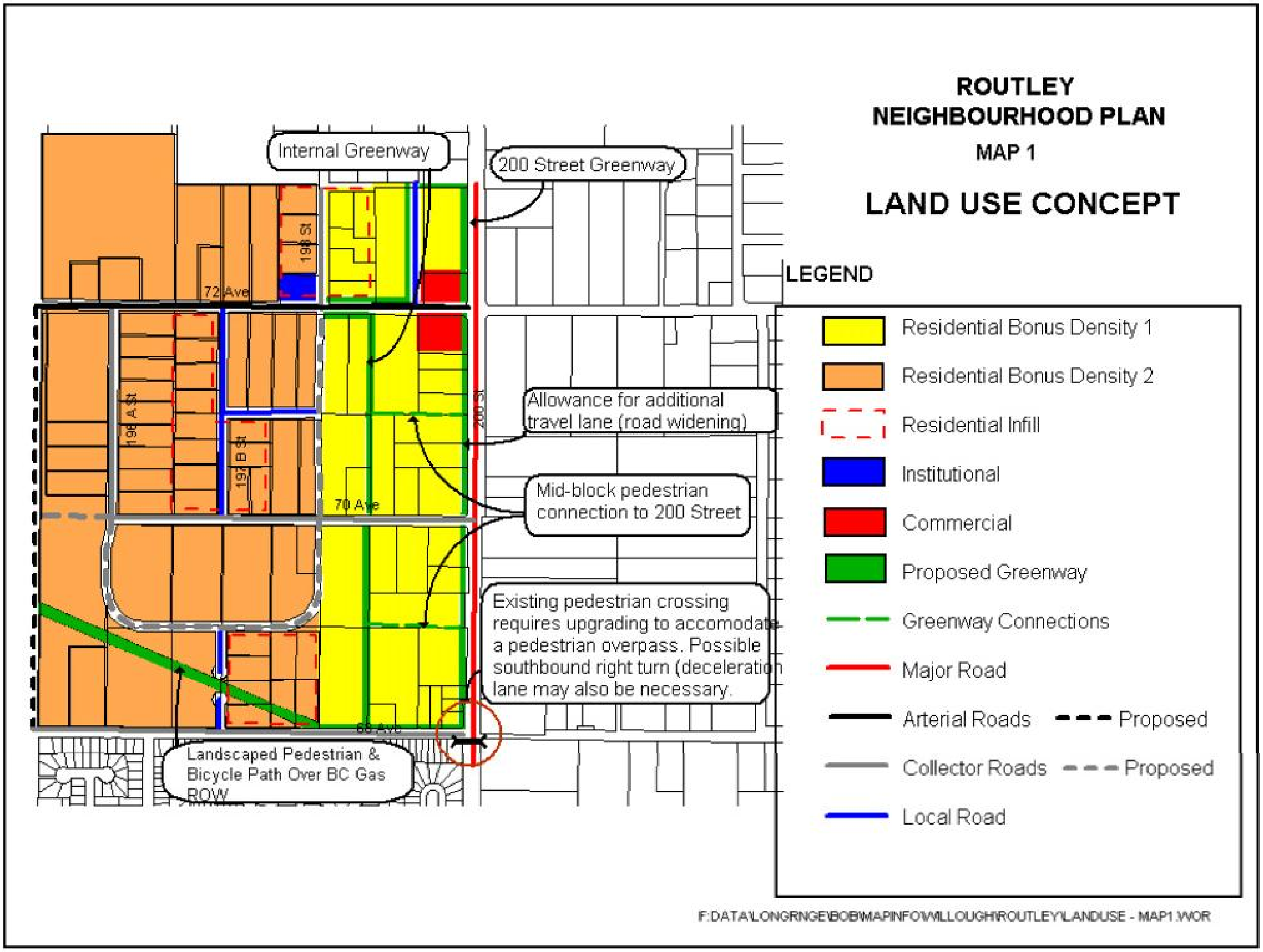
* Landmark Features

(PP) Pocket Park

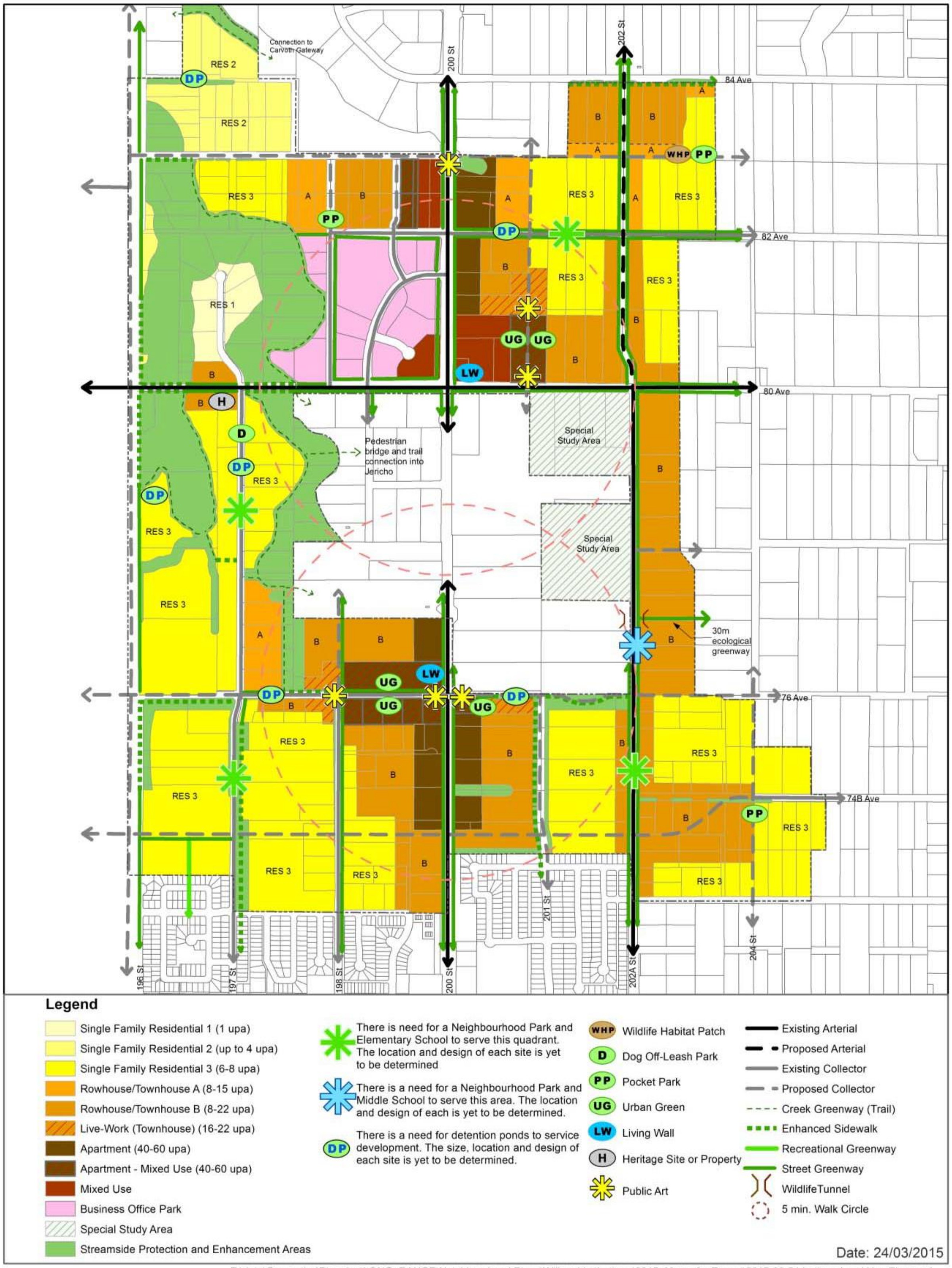
SNP Boundary

Includes Amendment Bylaw 4957

2012-Jericho Map 4 Land Use Concept


ROUTLEY
NEIGHBOURHOOD PLAN
MAP 1
LAND USE CONCEPT
Internal Greenway
200 Street Greenway
72 Ave
198 A St
70 Ave
200 St
Allowance for additional travel lane (road widening)
Mid-block pedestrian connection to 200 Street
Existing pedestrian crossing requires upgrading to accomodat a pedestrian overpass. Possible southbound right turn (deceleratio lane may also be necessary.
Landscaped Pedestrian & Bicycle Path Over BC Gas ROW
LEGEND
Residential Bonus Density 1
Residential Bonus Density 2
Residential Infill
Institutional
Commercial
Proposed Greenway
Greenway Connections
Major Road
Arterial Roads
Proposed
Collector Roads
Proposed
Local Road
F:DATA\LONGRNGE\BOB\MAPINFO\WILLOUGH\ROUTLEY\LANDUSE - MAP1.WOR

Map 1 – Latimer Land Use Plan



F:\data\Geomatics\Planning\LONG_RANGE\Neighbourhood Plans\Willoughby\Latimer\2015_Maps_for Report\2015-03-24 Latimer Land Use Plan.mxd

Appendix F - Hydraulic Field Inventory

ID	Culvert_11 (see Map 8-1)
Location:	Latimer Creek, Harvie Road (near 184 Street and 84 Avenue)
Field Notes:	• 3050 mm high x 2400 mm wide twin concrete box culverts • Channel upstream: 3 m channel depth, 5 m base width, 4:1 side slopes • Channel downstream: 4 m channel depth, 5 m base width, 4:1 side slopes
Photos:	 **Photo 1 – Inlet**  **Photo 2 – Channel Looking Upstream**  **Photo 3 – Oulet**  **Photo 4 – Channel Looking Downstream**

ID	Culvert_12 (see Map 8-1)
Location:	Latimer Creek, 188 Street (between 84 Avenue and 86 Avenue)
Field Notes:	• 2870 m high x 4370 m wide arch CSP culvert • Channel upstream: 3 m channel depth, 5 m base width, 4:1 side slopes • Channel downstream: 3 m channel depth, 5 m base width, 4:1 side slopes
Photos:	 **Photo 5 - Inlet**  **Photo 6 – Channel Looking Upstream**  **Photo 7 – Outlet**  **Photo 8 – Channel Looking Downstream**

ID	Culvert_31 (see Map 8-1)
Location:	Old Sawmill Creek, 86 Avenue (between 188 Street and 192 Street)
Field Notes:	• 1120 mm high x 1630 mm wide arch CSP culvert • Channel upstream: 2 m channel depth, 3 m base width, 4:1 side slopes • Channel downstream: 2 m channel depth, 3 m base width, 4:1 side slopes
Photos:	 **Photo 9 – Inlet**  **Photo 10 – Channel Looking Upstream**  **Photo 11 – Outlet**  **Photo 12 – Channel Looking Downstream**

ID	Culvert_51 (see Map 8-1)
Location:	Fruno Creek, 86 Avenue (between 188 Street and 192 Street)
Field Notes:	• 450 mm diameter wood stave culvert • Channel upstream: 0.5 m channel depth, 1 m base width, 10:1 side slopes • Channel downstream, 0.5 m channel depth, 1 m base width, 10:1 side slopes
Photos:	 **Photo 13 – Inlet**  **Photo 14 – Channel Looking Upstream**  **Photo 15 – Outlet**  **Photo 16 – Channel Looking Downstream**

ID	Culvert_13, Culvert_14, and Culvert 15 (see Map 8-1)
Location:	Latimer Creek, 192 Street (between 84 Avenue and 86 Avenue)
Field Notes:	• 3050 mm high x 3050 mm wide concrete box culvert • 900 mm twin PVC culverts • Channel upstream: 4 m channel depth, 10 m base width, 4:1 side slopes • Channel downstream: 4 m channel depth, 10 m base width, 4:1 side slopes
Photos:	 **Photo 17 – Inlet**  **Photo 18 – Channel Looking Upstream**  **Photo 19 – Outlet**  **Photo 20 – Channel Looknig Downstream**

ID	Culvert_21 (see Map 8-1)
Location:	Upper Latimer Creek , 88 Avenue (between 192 Street and 196 Street)
Field Notes:	• 800 mm high x 1600 mm wide arch CSP • Channel immediately upstream (ditch along 88 Ave): 1 m channel depth, 4 m base width, 4:1 left slope (north), 1.5: 1 right slope (south) • Channel upstream of 88 Ave ditch: 1 m channel depth, 4 m base width 4:1 side slopes • Channel downstream: 1 m channel depth, 4 m base width, 4:1 side slopes
Photos:	 **Photo 21 – Inlet**  **Photo 22 – Channel Looking Upstream**  **Photo 23 – Outlet**  **Photo 24 – Channel Looking Downstream**

ID	Culvert_41 (see Map 8-1)
Location:	Bartesko Creek, 192 Street (between 88 Avenue and 90 Avenue)
Field Notes:	• 600 mm diameter concrete culvert • Channel upstream: 1 m channel depth, 4 m base width, 4:1 side slopes • Channel downstream: 1 m channel depth, 4 m base width, 4:1 side slopes
Photos:	 **Photo 25 – Inlet**  **Photo 26 – Channel Looking Upstream**  **Photo 27 – Inlet**  **Photo 28 – Channel Looking Downstream**

ID	Culvert_33 (see Map 8-1)
Location:	Old Sawmill Creek, 90 Avenue (between 192 Street and Harvie Road)
Field Notes:	• 750 mm diameter CSP culvert (bad conditions) • Channel upstream: 1 m channel depth, 2.5 m base width, 5:1 side slopes, hard to access • Channel downstream: 1m channel depth, 2.5 m base width, 5:1 side slopes

Photos:

Photo 29 Outlet

Photo 30 – Outlet

Photo 31 – Outlet

Photo 32 – Channel Looking Downsream

ID	Culvert_61 (see Map 8-1)
Location:	Harvie Creek, Harvie Road (between 88 Avenue and 90 Avenue)
Field Notes:	• 750 mm concrete culvert • Channel upstream: 1 m channel depth, 1 m base width, 4:1 side slopes • Channel downstream, 1 m channel depth, 1 m base width, 4:1 side slopes, hard to access
Photos:	

Photo 33 – Inlet

Photo 34 – Channel Looking Upstream

Photo 35 – Outlet

Photo 36 – Channel Looking Downstream

ID	Culvert_32 (see Map 8-1)
Location:	Old Sawmill Creek, 88 Avenue (between Harvie Road and 192 Street)
Field Notes:	• 1300 mm concrete culvert • Channel upstream: 2 m channel depth, 5 m base width, 4:1 side slopes • Channel downstream: 2 m channel depth, 5 m base width, 4:1 side slopes
Photos:	

Photo 37 – Inlet

Photo 38 – Channel Looking Upstream

Photo 39 – Outlet

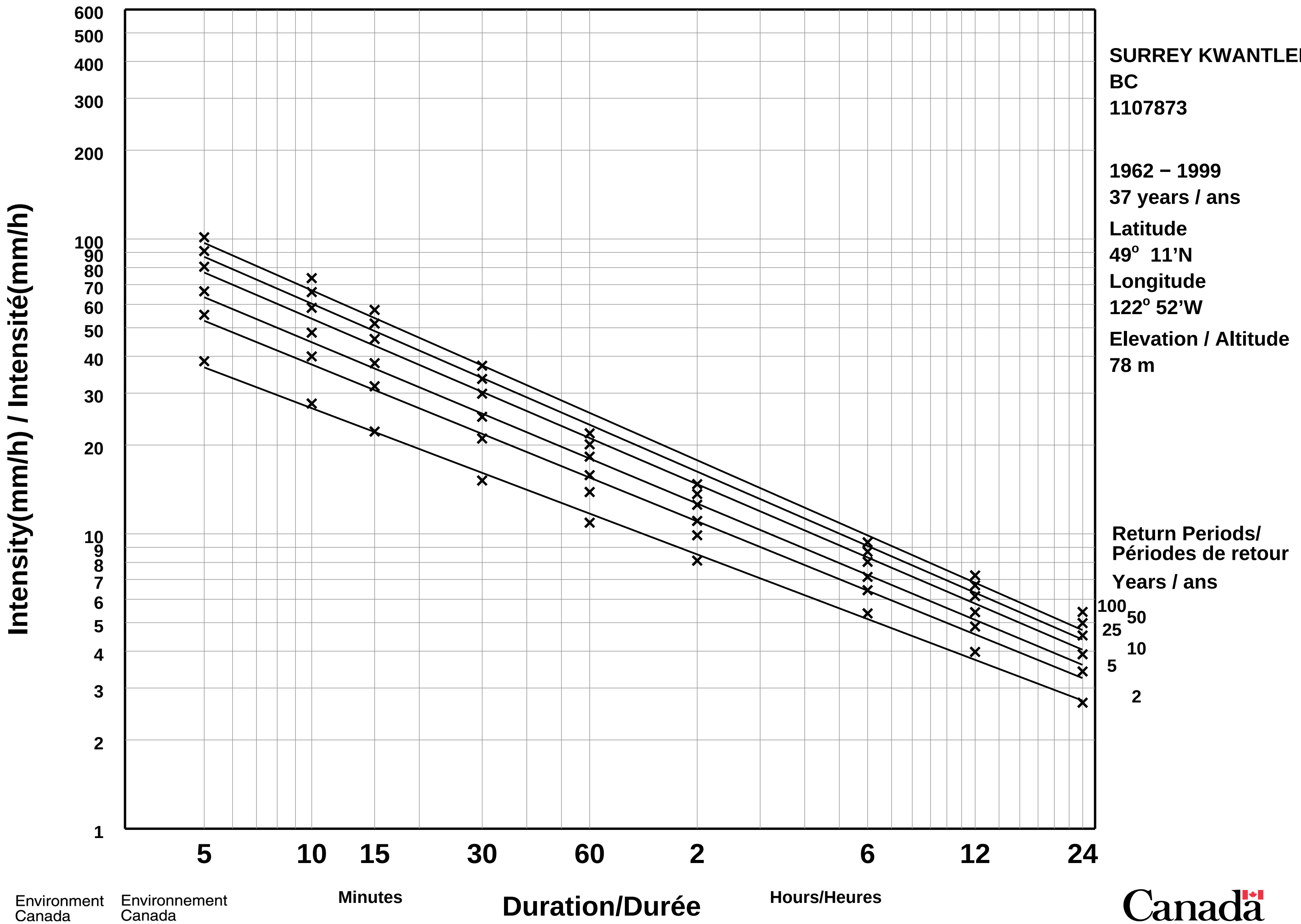
Photo 40 – Channel Looking Downstream

Appendix G - IDF Curve: Surrey Kwantlen Park

Short Duration Rainfall Intensity−Duration−Frequency Data

2012/02/09

Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée



SURREY KWANTLEN PARK
BC
1107873

1962 − 1999
37 years / ans
Latitude
49° 11'N
Longitude
122° 52'W
Elevation / Altitude
78 m

Environment Canada Environnement Canada

Canada

REPORT

Appendix H - Water Balance Model Reports

Report for

Undeveloped 4050

Latimer

Report Details

Project

Site Name	Latimer
Site Description	Latimer ISMP
Site Location	Surrey, City of
Site Type	Site
Site Size	4050 sq. m
Stream Present	No
Climate Data File	Surrey Kwantlen Park
Climate Start & End Dates	01/01/1965 to 12/31/1990

Scenario

Scenario Name	Undeveloped 4050
Scenario Description	Undeveloped

This is the base case or pre-development scenario for: Latimer

Timestamps

Report Generated	Mon, 26 Jan 2015 10:55:33 -0600
Processed by QUALHYMO	Mon, 26 Jan 2015 10:55:30 -0600

Drainage Area Configuration

Drainage Areas

Drainage Areas	Native Soil Types	Land Uses	Surface Conditions	Source Controls
Modelled Area Area 4050 sq. m Length 70.4 m Slope 0.005 m/m	Silty Loam Area 4050 sq. m Depth 100 mm Field Capacity 33.7% Wilting Point 18.5%	Park Area 4050 sq. m Description Park, Recreation, and Open Space Zones: PC, CPR, CPG Floor Area Ratio: 0.10 to 0.40 Maximum building coverage = 10% to 40% Note: Surface Conditions are based on maximum values where ranges are shown. For zone specific values refer to the District of Surrey zoning bylaws.	Pervious Cover Area 3240 sq. m Depth 100 mm	
			Rooftop - Building Area 810 sq. m	

Surface Conditions

Name	Area	Type	Depression Storage	Rational Coefficient	Retardance Roughness	Field Capacity	Wilting Point
Pervious Cover	3240 sq. m	Pervious	6 mm	.3	.03	19%	10%
Rooftop - Building	810 sq. m	Impervious	0 mm	-	.013	-	-

Stored Results of Last Scenario Run

Volume Summary (m³)

Rainfall Total	201558.84
Total Discharge	1.243325e+5
Total Losses	1.954229e+4
Catchment Infiltration	5.768405e+4
Source Control Infiltration	0.000000e+0

Exceedance Summary

Duration (hours)	Rate (m³/sec)
1	0.017
3	0.015
6	0.013
16	0.011
38	0.009
85	0.008
292	0.006
1271	0.004
5085	0.002
227904	0

WATER Balance MODEL Powered By QUALHYMO

Report for

Developed 4050 - 50%IMP

Latimer

Report Details

Project

Site Name	Latimer
Site Description	Latimer ISMP
Site Location	Surrey, City of
Site Type	Site
Site Size	4050 sq. m
Stream Present	No
Climate Data File	Surrey Kwantlen Park
Climate Start & End Dates	01/01/1965 to 12/31/1990

Scenario

Scenario Name	Developed 4050 - 50%IMP
Scenario Description	One Acre Residential

Timestamps

Report Generated	Mon, 26 Jan 2015 10:56:20 -0600
Processed by QUALHYMO	Mon, 26 Jan 2015 10:56:15 -0600

Drainage Area Configuration

Drainage Areas

Drainage Areas	Native Soil Types	Land Uses	Surface Conditions	Source Controls
Modelled Area Area 4050 sq. m Length 70.4 m Slope 0.005 m/m	Silty Loam Area 4050 sq. m Depth 100 mm Field Capacity 33.7% Wilting Point 18.5%	Residential Level 1 Area 4050 sq. m Description Single Family Residential Zones: RA, RA-G, RH, RH-G, RC, RF-O, RF, RF-SS, RF-G, RF-12, RF-12C, RF-9, RF-9C, RF-9S Minimum lot size: RA-G, RH-G, RF-G 1 ha Floor Area Ratio: 0.25 to 0.70 Maximum building coverage = 20% to 60% Maximum total impervious coverage = 60% Note: Surface Conditions are based on maximum values where ranges are shown. For zone specific values refer to the District of Surrey zoning bylaws.	Pervious Cover Area 2025 sq. m Depth 100 mm	
			Rooftop - Building Area 1012.5 sq. m	
			Impervious Paving Area 1012.5 sq. m	

Surface Conditions

Name	Area	Type	Depression Storage	Rational Coefficient	Retardance Roughness	Field Capacity	Wilting Point
Pervious Cover	2025 sq. m	Pervious	6 mm	.3	.03	19%	10%
Rooftop - Building	1012.5 sq. m	Impervious	0 mm	-	.013	-	-
Impervious Paving	1012.5 sq. m	Impervious	2 mm	-	.013	-	-

Stored Results of Last Scenario Run

Volume Summary (m^3)

Rainfall Total	201558.84
Total Discharge	1.519459e+5
Total Losses	1.251156e+4
Catchment Infiltration	3.710138e+4
Source Control Infiltration	0.000000e+0

Exceedance Summary

Duration (hours)	Rate (m^3/sec)
1	0.017
4	0.015
6	0.013
18	0.011
42	0.009
106	0.008
358	0.006
1541	0.004
6230	0.002
227904	0

WATER Balance MODEL Powered By QUALHYMO

Report for

Developed 4050 w BMP 25%Imp

Latimer

Report Details

Project

Site Name	Latimer
Site Description	Latimer ISMP
Site Location	Surrey, City of
Site Type	Site
Site Size	4050 sq. m
Stream Present	No
Climate Data File	Surrey Kwantlen Park
Climate Start & End Dates	01/01/1965 to 12/31/1990

Scenario

Scenario Name	Developed 4050 w BMP 25%Imp
Scenario Description	

Timestamps

Report Generated	Mon, 26 Jan 2015 10:57:06 -0600
Processed by QUALHYMO	Mon, 26 Jan 2015 10:57:04 -0600

Drainage Area Configuration

Drainage Areas

Drainage Areas	Native Soil Types	Land Uses	Surface Conditions	Source Controls
Modelled Area Area 4050 sq. m Length 70.4 m Slope 0.005 m/m	Silty Loam Area 4050 sq. m Depth 100 mm Field Capacity 33.7% Wilting Point 18.5%	Residential Level 1 Area 4050 sq. m Description Single Family Residential Zones: RA, RA-G, RH, RH-G, RC, RF-O, RF, RF-SS, RF-G, RF-12, RF-12C, RF-9, RF-9C, RF-9S Minimum lot size: RA-G, RH-G, RF-G 1 ha Floor Area Ratio: 0.25 to 0.70 Maximum building coverage = 20% to 60% Maximum total impervious coverage = 60% Note: Surface Conditions are based on maximum values where ranges are shown. For zone specific values refer to the District of Surrey zoning bylaws.	Pervious Cover Area 3037.5 sq. m Depth 100 mm	
			Rooftop - Building Area 1012.5 sq. m	

Surface Conditions

Name	Area	Type	Depression Storage	Rational Coefficient	Retardance Roughness	Field Capacity	Wilting Point
Pervious Cover	3037.5 sq. m	Pervious	6 mm	.3	.03	19%	10%
Rooftop - Building	1012.5 sq. m	Impervious	0 mm	-	.013	-	-

Stored Results of Last Scenario Run

Volume Summary (m³)

Rainfall Total	201558.84
Total Discharge	1.291433e+5
Total Losses	1.810364e+4
Catchment Infiltration	5.431190e+4
Source Control Infiltration	0.000000e+0

Exceedance Summary

Duration (hours)	Rate (m³/sec)
1	0.017
3	0.015
6	0.013
17	0.011
40	0.009
90	0.008
301	0.006
1322	0.004
5247	0.002
227904	0

WATER Balance MODEL Powered By QUALHYMO

Report for

Developed 4050 w BMP

Latimer

Report Details

Project

Site Name	Latimer
Site Description	Latimer ISMP
Site Location	Surrey, City of
Site Type	Site
Site Size	4050 sq. m
Stream Present	No
Climate Data File	Surrey Kwantlen Park
Climate Start & End Dates	01/01/1965 to 12/31/1990

Scenario

Scenario Name	Developed 4050 w BMP
Scenario Description	

Timestamps

Report Generated	Mon, 26 Jan 2015 10:57:43 -0600
Processed by QUALHYMO	Mon, 26 Jan 2015 10:57:40 -0600

Drainage Area Configuration

Drainage Areas

Drainage Areas	Native Soil Types	Land Uses	Surface Conditions	Source Controls
Modelled Area Area 4050 sq. m Length 70.4 m Slope 0.005 m/m	Silty Loam Area 4050 sq. m Depth 100 mm Field Capacity 33.7% Wilting Point 18.5%	Residential Level 1 Area 4050 sq. m Description Single Family Residential Zones: RA, RA-G, RH, RH-G, RC, RF-O, RF, RF-SS, RF-G, RF-12, RF-12C, RF-9, RF-9C, RF-9S Minimum lot size: RA-G, RH-G, RF-G 1 ha Floor Area Ratio: 0.25 to 0.70 Maximum building coverage = 20% to 60% Maximum total impervious coverage = 60% Note: Surface Conditions are based on maximum values where ranges are shown. For zone specific values refer to the District of Surrey zoning bylaws.	Pervious Cover Area 2025 sq. m Depth 100 mm	Abs Soil Size 1012.5 sq. m
			Rooftop - Building Area 1012.5 sq. m	
			Impervious Paving Area 1012.5 sq. m	PervPav Size 202.5 sq. m

Surface Conditions

Name	Area	Type	Depression Storage	Rational Coefficient	Retardance Roughness	Field Capacity	Wilting Point
Pervious Cover	2025 sq. m	Pervious	6 mm	.3	.03	19%	10%
Rooftop - Building	1012.5 sq. m	Impervious	0 mm	-	.013	-	-
Impervious Paving	1012.5 sq. m	Impervious	2 mm	-	.013	-	-

Source Controls - Surface Enhancements

Abs Soil

[Absorbent Landscaping]

Size	Crop Coefficient	Design Soil Rooting Depth
1012.5 sq. m	1	450 mm

Soil Definition

Name	Type	Depression Storage	Rational Coefficient	Retardance Roughness	Field Capacity	Wilting Point
Sandy Loam	Pervious	7 mm	0.2	0.03	20.3%	13.7%

PervPav

[Pervious Paving]

Size	Design Soil Rooting Depth
202.5 sq. m	600 mm

Soil Definition

Name	Type	Depression Storage	Rational Coefficient	Retardance Roughness	Field Capacity	Wilting Point
Silty Loam	Pervious	7 mm	0.2	0.03	33.7%	18.5%

Stored Results of Last Scenario Run

Volume Summary (m^3)

Rainfall Total	201558.84
Total Discharge	1.370971e+5
Total Losses	1.369529e+4
Catchment Infiltration	5.076645e+4
Source Control Infiltration	0.000000e+0

Exceedance Summary

Duration (hours)	Rate (m^3/sec)
0	0.017
3	0.015
6	0.013
16	0.011
36	0.009
80	0.008
275	0.006
1245	0.004
5344	0.002
227904	0

WATER Balance MODEL Powered By QUALHYMO

Report for

Undeveloped 2000

Latimer - 2

Report Details

Project

Site Name	Latimer - 2
Site Description	Latimer ISMP
Site Location	Surrey, City of
Site Type	Site
Site Size	2000 sq. m
Stream Present	No
Climate Data File	Surrey Kwantlen Park
Climate Start & End Dates	01/01/1965 to 12/31/1990

Scenario

Scenario Name	Undeveloped 2000
Scenario Description	Undeveloped

This is the base case or pre-development scenario for:
Latimer - 2

Timestamps

Report Generated	Mon, 26 Jan 2015 10:50:47 -0600
Processed by QUALHYMO	Mon, 26 Jan 2015 10:50:44 -0600

Drainage Area Configuration

Drainage Areas

Drainage Areas	Native Soil Types	Land Uses	Surface Conditions	Source Controls
Modelled Area Area 2000 sq. m Length 50 m Slope 0.005 m/m	Silty Loam Area 2000 sq. m Depth 100 mm Field Capacity 33.7% Wilting Point 18.5%	Park Area 2000 sq. m Description Park, Recreation, and Open Space Zones: PC, CPR, CPG Floor Area Ratio: 0.10 to 0.40 Maximum building coverage = 10% to 40% Note: Surface Conditions are based on maximum values where ranges are shown. For zone specific values refer to the District of Surrey zoning bylaws.	Pervious Cover Area 1600 sq. m Depth 100 mm	
			Rooftop - Building Area 400 sq. m	

Surface Conditions

Name	Area	Type	Depression Storage	Rational Coefficient	Retardance Roughness	Field Capacity	Wilting Point
Pervious Cover	1600 sq. m	Pervious	6 mm	.3	.03	19%	10%
Rooftop - Building	400 sq. m	Impervious	0 mm	-	.013	-	-

Stored Results of Last Scenario Run

Volume Summary (m³)

Rainfall Total	99535.23
Total Discharge	6.028760e+4
Total Losses	1.076168e+4
Catchment Infiltration	2.848595e+4
Source Control Infiltration	0.000000e+0

Exceedance Summary

Duration (hours)	Rate (m³/sec)
1	0.008
3	0.007
6	0.007
16	0.006
38	0.005
85	0.004
293	0.003
1272	0.002
5095	0.001
227904	0

WATER Balance MODEL Powered By QUALHYMO

Report for

Urban Residential Future

Latimer - 2

Report Details

Project

Site Name	Latimer - 2
Site Description	Latimer ISMP
Site Location	Surrey, City of
Site Type	Site
Site Size	2000 sq. m
Stream Present	No
Climate Data File	Surrey Kwantlen Park
Climate Start & End Dates	01/01/1965 to 12/31/1990

Scenario

Scenario Name	Urban Residential Future
Scenario Description	Future - No BMPs

Timestamps

Report Generated	Mon, 26 Jan 2015 10:52:22 -0600
Processed by QUALHYMO	Mon, 26 Jan 2015 10:52:19 -0600

Drainage Area Configuration

Drainage Areas

Drainage Areas	Native Soil Types	Land Uses	Surface Conditions	Source Controls
Modelled Area Area 2000 sq. m Length 50 m Slope 0.005 m/m	Silty Loam Area 2000 sq. m Depth 100 mm Field Capacity 33.7% Wilting Point 18.5%	Residential Level 3 Area 2000 sq. m Description Multi-Family Residential, Ground-Oriented, Low Density Zones: RM-10, RM-15, RMS-1, RMS-1A, RMS-2 Floor Area Ratio: 0.50 to 0.60 Maximum building coverage = 25% to 45% Maximum total impervious coverage = 82% Note: Surface Conditions are based on maximum values where ranges are shown. For zone specific values refer to the District of Surrey zoning bylaws.	Impervious Cover Area 800 sq. m	
			Pervious Cover Area 400 sq. m Depth 100 mm	
			Rooftop - Building Area 800 sq. m	

Surface Conditions

Name	Area	Type	Depression Storage	Rational Coefficient	Retardance Roughness	Field Capacity	Wilting Point
Impervious Cover	800 sq. m	Impervious	2 mm	-	.013	-	-
Pervious Cover	400 sq. m	Pervious	6 mm	.3	.03	19%	10%
Rooftop - Building	800 sq. m	Impervious	0 mm	-	.013	-	-

Stored Results of Last Scenario Run

Volume Summary (m^3)

Rainfall Total	99535.23
Total Discharge	8.587750e+4
Total Losses	6.010220e+3
Catchment Infiltration	7.647510e+3
Source Control Infiltration	0.000000e+0

Exceedance Summary

Duration (hours)	Rate (m^3/sec)
2	0.008
4	0.007
6	0.007
23	0.006
45	0.005
134	0.004
467	0.003
1978	0.002
7551	0.001
227904	0

WATER Balance MODEL Powered By QUALHYMO

Report for

Urban Residential - Future Imp Limited

Latimer - 2

Report Details

Project

Site Name	Latimer - 2
Site Description	Latimer ISMP
Site Location	Surrey, City of
Site Type	Site
Site Size	2000 sq. m
Stream Present	No
Climate Data File	Surrey Kwantlen Park
Climate Start & End Dates	01/01/1965 to 12/31/1990

Scenario

Scenario Name	Urban Residential - Future Imp Limited
Scenario Description	Future Condition, Limited Impervious Area

Timestamps

Report Generated	Mon, 26 Jan 2015 10:53:09 -0600
Processed by QUALHYMO	Mon, 26 Jan 2015 10:53:07 -0600

Drainage Area Configuration

Drainage Areas

Drainage Areas	Native Soil Types	Land Uses	Surface Conditions	Source Controls
Modelled Area Area 2000 sq. m Length 50 m Slope 0.005 m/m	Silty Loam Area 2000 sq. m Depth 100 mm Field Capacity 33.7% Wilting Point 18.5%	Residential Level 3 Area 2000 sq. m Description Multi-Family Residential, Ground-Oriented, Low Density Zones: RM-10, RM-15, RMS-1, RMS-1A, RMS-2 Floor Area Ratio: 0.50 to 0.60 Maximum building coverage = 25% to 45% Maximum total impervious coverage = 82% Note: Surface Conditions are based on maximum values where ranges are shown. For zone specific values refer to the District of Surrey zoning bylaws.	Impervious Cover Area 600 sq. m	
			Pervious Cover Area 600 sq. m Depth 100 mm	
			Rooftop - Building Area 800 sq. m	

Surface Conditions

Name	Area	Type	Depression Storage	Rational Coefficient	Retardance Roughness	Field Capacity	Wilting Point
Impervious Cover	600 sq. m	Impervious	2 mm	-	.013	-	-
Pervious Cover	600 sq. m	Pervious	6 mm	.3	.03	19%	10%
Rooftop - Building	800 sq. m	Impervious	0 mm	-	.013	-	-

Stored Results of Last Scenario Run

Volume Summary (m³)

Rainfall Total	99535.23
Total Discharge	8.223490e+4
Total Losses	6.021890e+3
Catchment Infiltration	1.127844e+4
Source Control Infiltration	0.000000e+0

Exceedance Summary

Duration (hours)	Rate (m³/sec)
2	0.008
4	0.007
6	0.007
23	0.006
42	0.005
126	0.004
421	0.003
1803	0.002
7154	0.001
227904	0

WATER Balance MODEL Powered By QUALHYMO

Report for

Urban Residential Future w/ BMPs

Latimer - 2

Report Details

Project

Site Name	Latimer - 2
Site Description	Latimer ISMP
Site Location	Surrey, City of
Site Type	Site
Site Size	2000 sq. m
Stream Present	No
Climate Data File	Surrey Kwantlen Park
Climate Start & End Dates	01/01/1965 to 12/31/1990

Scenario

Scenario Name	Urban Residential Future w/ BMPs
Scenario Description	Future Development with BMPs

Timestamps

Report Generated	Mon, 26 Jan 2015 10:53:51 -0600
Processed by QUALHYMO	Mon, 26 Jan 2015 10:53:49 -0600

Drainage Area Configuration

Drainage Areas

Drainage Areas	Native Soil Types	Land Uses	Surface Conditions	Source Controls
Modelled Area Area 2000 sq. m Length 50 m Slope 0.005 m/m	Silty Loam Area 2000 sq. m Depth 100 mm Field Capacity 33.7% Wilting Point 18.5%	Residential Level 3 Area 2000 sq. m Description Multi-Family Residential, Ground-Oriented, Low Density Zones: RM-10, RM-15, RMS-1, RMS-1A, RMS-2 Floor Area Ratio: 0.50 to 0.60 Maximum building coverage = 25% to 45% Maximum total impervious coverage = 82% Note: Surface Conditions are based on maximum values where ranges are shown. For zone specific values refer to the District of Surrey zoning bylaws.	Impervious Cover Area 800 sq. m	Perv Paving Size 160 sq. m
			Pervious Cover Area 400 sq. m Depth 100 mm	Abs Landscaping Size 400 sq. m
			Rooftop - Building Area 800 sq. m	

Surface Conditions

Name	Area	Type	Depression Storage	Rational Coefficient	Retardance Roughness	Field Capacity	Wilting Point
Impervious Cover	800 sq. m	Impervious	2 mm	-	.013	-	-
Pervious Cover	400 sq. m	Pervious	6 mm	.3	.03	19%	10%
Rooftop - Building	800 sq. m	Impervious	0 mm	-	.013	-	-

Source Controls - Surface Enhancements

Abs Landscaping

[Absorbent Landscaping]

Size	Crop Coefficient	Design Soil Rooting Depth
400 sq. m	1	450 mm

Soil Definition

Name	Type	Depression Storage	Rational Coefficient	Retardance Roughness	Field Capacity	Wilting Point
Sandy Loam	Pervious	7 mm	0.2	0.03	20.3%	13.7%

Perv Paving

[Pervious Paving]

Size	Design Soil Rooting Depth
160 sq. m	600 mm

Soil Definition

Name	Type	Depression Storage	Rational Coefficient	Retardance Roughness	Field Capacity	Wilting Point
Silty Loam	Pervious	7 mm	0.2	0.03	33.7%	18.5%

Stored Results of Last Scenario Run

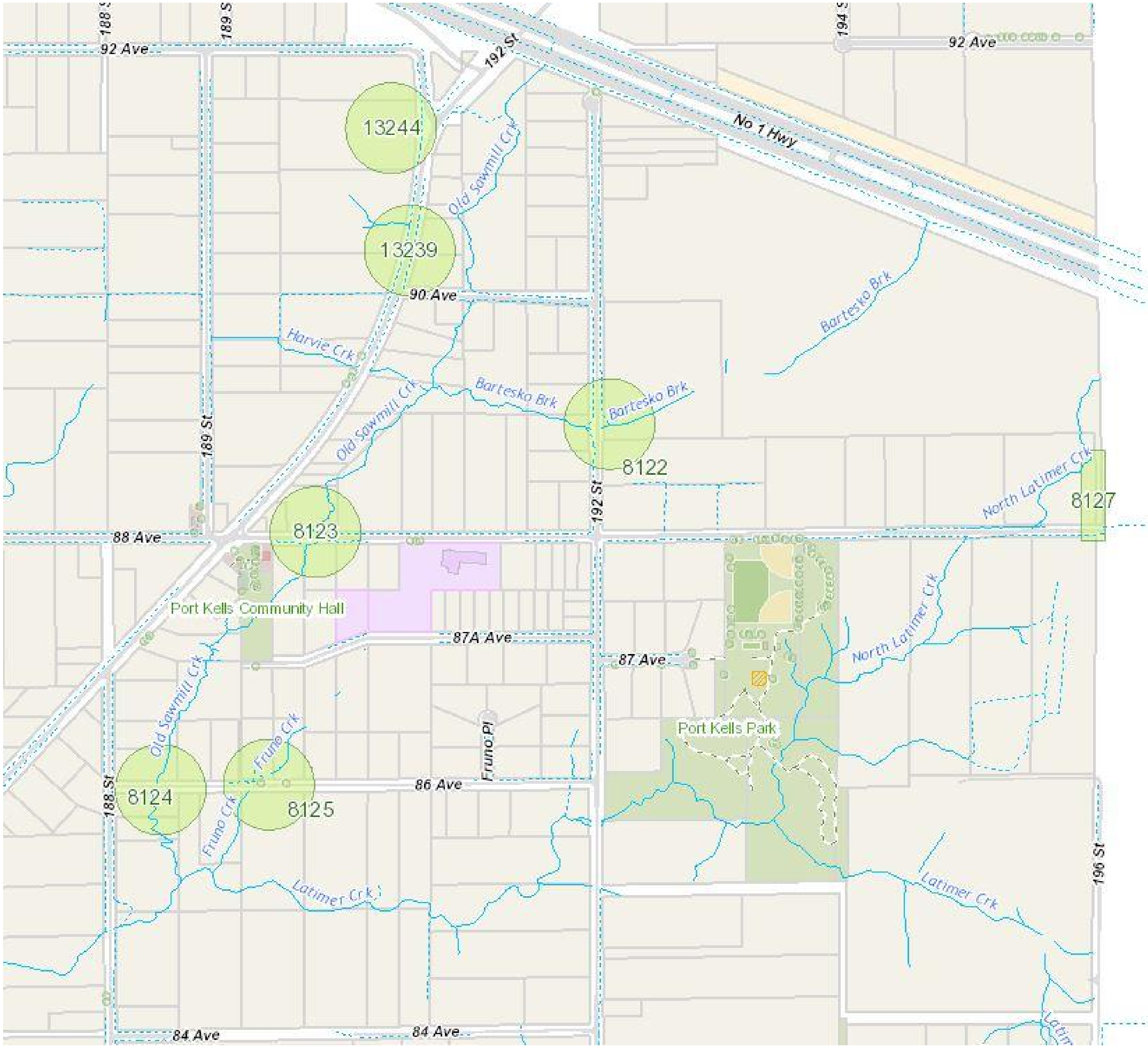
Volume Summary (m³)

Rainfall Total	99535.23
Total Discharge	8.065650e+4
Total Losses	6.169560e+3
Catchment Infiltration	1.270917e+4
Source Control Infiltration	0.000000e+0

Exceedance Summary

Duration (hours)	Rate (m³/sec)
2	0.008
4	0.007
6	0.007
21	0.006
42	0.005
112	0.004
386	0.003
1693	0.002
6900	0.001
227904	0

Appendix I - CoS Ten-Year Servicing Plan Excerpt



92 Ave
189 St
192 St
194 St
No 1 Hwy
13244
13239
Old Sawmill Crk
90 Ave
Harvie Crk
Bartesko Brk
8122
189 St
192 St
North Latimer Crk
8127
88 Ave
8123
Port Kells Community Hall
87A Ave
87 Ave
Port Kells Park
Fruno Pl
Fruno Crk
8124
8125
86 Ave
188 St
Latimer Crk
196 St
84 Ave

Appendix J - Design Rainfall Events

Latimer Creek ISMP
City of Surrey / Township of Langley
Design Rainfall Events
AE Project #2014-2768

	Design Rainfall Intensity [mm/hr]					Design Rainfall Intensity [mm/hr]			
	ADS Storm		ADS w/ Climate Change			ADS Storm		ADS w/ Climate Change	
Time Step [hh:mm]	5-Year	100-Year	5-Year	100-Year	Time Step [hh:mm]	5-Year	100-Year	5-Year	100-Year
0:00	1.76	2.36	2.11	2.84	12:00	16.96	28.33	20.35	33.99
0:15	1.76	2.36	2.11	2.84	12:15	14.04	23.07	16.85	27.69
0:30	1.76	2.36	2.11	2.84	12:30	7.08	10.69	8.49	12.83
0:45	1.76	2.36	2.11	2.84	12:45	5.98	8.91	7.17	10.69
1:00	1.76	2.36	2.11	2.84	13:00	5.03	7.38	6.03	8.86
1:15	1.76	2.36	2.11	2.84	13:15	5.03	7.38	6.03	8.86
1:30	1.76	2.36	2.11	2.84	13:30	4.25	6.15	5.10	7.38
1:45	1.76	2.36	2.11	2.84	13:45	4.25	6.15	5.10	7.38
2:00	1.76	2.36	2.11	2.84	14:00	3.75	5.37	4.50	6.45
2:15	1.76	2.36	2.11	2.84	14:15	3.75	5.37	4.50	6.45
2:30	1.76	2.36	2.11	2.84	14:30	3.39	4.82	4.07	5.79
2:45	1.76	2.36	2.11	2.84	14:45	3.39	4.82	4.07	5.79
3:00	2.08	2.84	2.49	3.40	15:00	2.92	4.11	3.51	4.93
3:15	2.08	2.84	2.49	3.40	15:15	2.92	4.11	3.51	4.93
3:30	2.08	2.84	2.49	3.40	15:30	2.92	4.11	3.51	4.93
3:45	2.08	2.84	2.49	3.40	15:45	2.92	4.11	3.51	4.93
4:00	2.08	2.84	2.49	3.40	16:00	2.92	4.11	3.51	4.93
4:15	2.08	2.84	2.49	3.40	16:15	2.92	4.11	3.51	4.93
4:30	2.08	2.84	2.49	3.40	16:30	2.47	3.42	2.97	4.11
4:45	2.08	2.84	2.49	3.40	16:45	2.47	3.42	2.97	4.11
5:00	2.08	2.84	2.49	3.40	17:00	2.47	3.42	2.97	4.11
5:15	2.08	2.84	2.49	3.40	17:15	2.47	3.42	2.97	4.11
5:30	2.08	2.84	2.49	3.40	17:30	2.47	3.42	2.97	4.11
5:45	2.08	2.84	2.49	3.40	17:45	2.47	3.42	2.97	4.11
6:00	2.47	3.42	2.97	4.11	18:00	2.08	2.84	2.49	3.40
6:15	2.47	3.42	2.97	4.11	18:15	2.08	2.84	2.49	3.40
6:30	2.47	3.42	2.97	4.11	18:30	2.08	2.84	2.49	3.40
6:45	2.47	3.42	2.97	4.11	18:45	2.08	2.84	2.49	3.40
7:00	2.47	3.42	2.97	4.11	19:00	2.08	2.84	2.49	3.40
7:15	2.47	3.42	2.97	4.11	19:15	2.08	2.84	2.49	3.40
7:30	2.92	4.11	3.51	4.93	19:30	2.08	2.84	2.49	3.40
7:45	2.92	4.11	3.51	4.93	19:45	2.08	2.84	2.49	3.40
8:00	2.92	4.11	3.51	4.93	20:00	2.08	2.84	2.49	3.40
8:15	2.92	4.11	3.51	4.93	20:15	2.08	2.84	2.49	3.40
8:30	2.92	4.11	3.51	4.93	20:30	2.08	2.84	2.49	3.40
8:45	2.92	4.11	3.51	4.93	20:45	2.08	2.84	2.49	3.40
9:00	3.39	4.82	4.07	5.79	21:00	1.76	2.36	2.11	2.84
9:15	3.39	4.82	4.07	5.79	21:15	1.76	2.36	2.11	2.84
9:30	3.75	5.37	4.50	6.45	21:30	1.76	2.36	2.11	2.84
9:45	3.75	5.37	4.50	6.45	21:45	1.76	2.36	2.11	2.84
10:00	4.25	6.15	5.10	7.38	22:00	1.76	2.36	2.11	2.84
10:15	4.25	6.15	5.10	7.38	22:15	1.76	2.36	2.11	2.84
10:30	5.03	7.38	6.03	8.86	22:30	1.76	2.36	2.11	2.84
10:45	5.03	7.38	6.03	8.86	22:45	1.76	2.36	2.11	2.84
11:00	5.98	8.91	7.17	10.69	23:00	1.76	2.36	2.11	2.84
11:15	7.08	10.69	8.49	12.83	23:15	1.76	2.36	2.11	2.84
11:30	14.04	23.07	16.85	27.69	23:30	1.76	2.36	2.11	2.84
11:45	16.96	28.33	20.35	33.99	23:45	1.76	2.36	2.11	2.84

Appendix K - Public Consultation

Client: City of Surrey
Project: Latimer Creek Integrated Stormwater Management Plan
Results of Public Consultation Survey
Date: July 31, 2015
File: 20142768.00.E.03.00

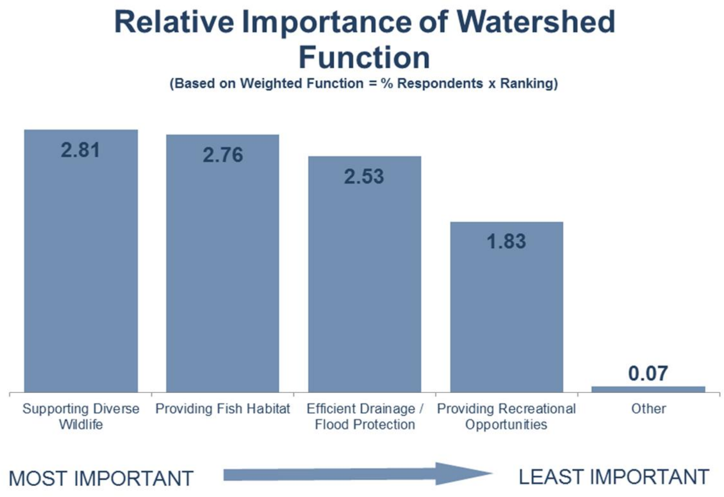
Question	Result

Question 1 (72 Responses)

Although one function of a watershed is to provide efficient drainage of storm events, it also serves a variety of other purposes.

Please rank the following functions of a watershed, based on their importance to you, from most important to least important.

- Providing recreational opportunities, such as biking or walking trails
- Supporting a diversity of wildlife
- Providing habitat for fish
- Allowing for efficient drainage of rainfall and flood protection
- Other (please specify below)

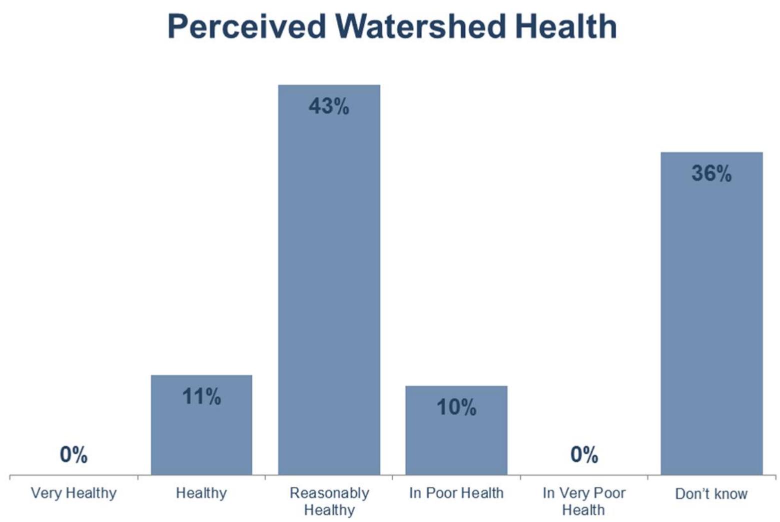


Question 2 (81 Responses)

The health of a watershed is often indicated by ecological factors, such as the quality of water flowing through natural watercourses, the presence of trash in forested areas, the ability to support fish species and whether natural vegetated areas surrounding creeks and wetlands are intact.

How do you perceive the health of your watershed? Would you say the watershed appears to be:

- Very Healthy
- Healthy
- Reasonably healthy, but could use improvement
- In poor health
- In very poor health
- Don't know

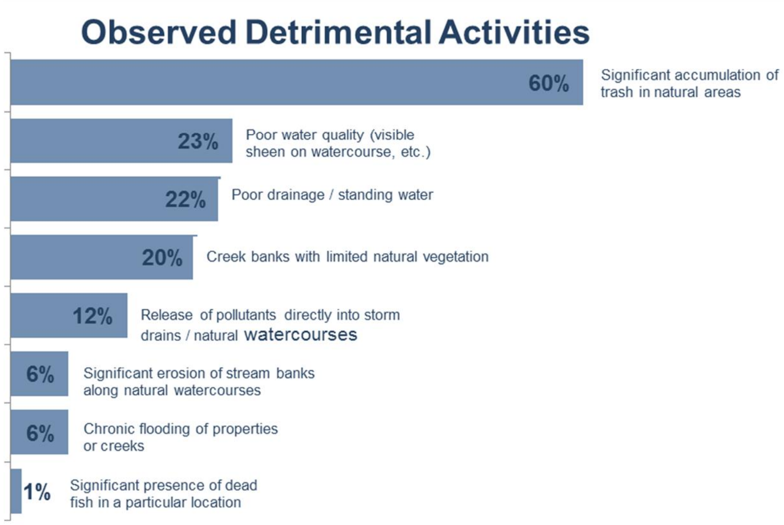


Question 3 (81 Responses)

A watershed's health can be diminished by several factors related to human activity.

Have you witnessed, or witness on an on-going basis any of the following:

- Release of pollutants directly into natural watercourses in high concentrations (industrial / commercial chemicals, high concentrations of fertilizers)
- Significant erosion of stream banks along natural watercourses
- Poor water quality, (oil on water as it flows through gutters or natural watercourses; suds in water)
- Chronic flooding of properties or creeks
- Poor drainage leading to standing water for extended periods of time following rain.
- Creek banks with limited natural vegetation (vegetation extending less than 10 m on either side)
- Significant accumulation of trash in natural / park areas
- Fish kills (a significant presence of deceased fish in a particular location)



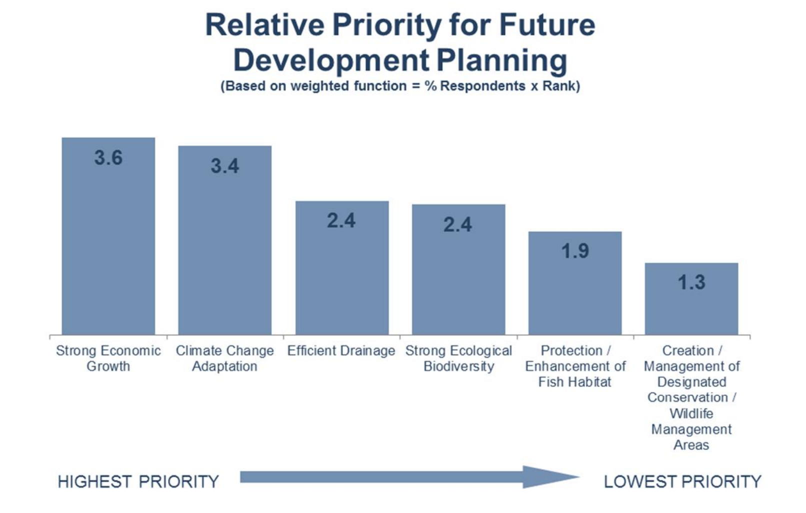
Associated Engineering GLOBAL PERSPECTIVE. LOCAL FOCUS.

Question 4 (81 Responses)

Future growth priorities

Between now and 2050, if you could establish the priorities when moving towards future development and implementation of the Official Community Plan, what ranking would you give the following (1 – Highest priority, 6 – Lowest priority

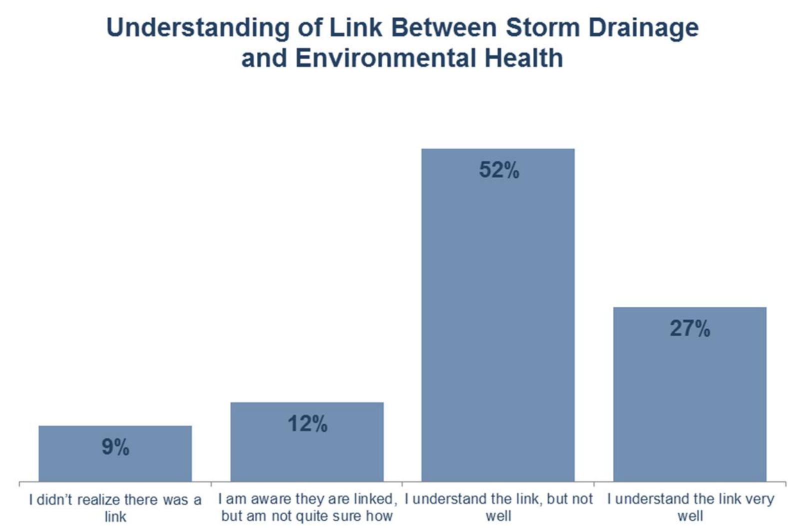
- Creation and management of designated conservation / wildlife management areas
- Strong economic growth
- Strong ecological biodiversity
- Protection and enhancement of fish habitat
- Efficient drainage of storms
- Adaptation to climate change



Question 5 (81 Responses)

How would you rank your understanding of the link between storm drainage and environmental health?

- I didn't realize there was a link
- I am aware they are linked, but am not quite sure how
- I understand the link, but not well
- I understand the link very well



Question 6 (81 Responses)

As rain falls and runs off of hard surfaces, such as concrete and asphalt in developed areas, it can pick up and transport pollutants such as oils and heavy metals that over time have a negative impact on stream health and fish habitat. To combat this, many municipalities, including the City of Surrey and the Township of Langley, use rainwater management features that improve water quality while managing rainfall, and serve to lessen the impacts of development.

The following is a list of some common approaches to managing rainfall and maintaining the quality of water reaching streams. These are often termed Low-Impact Development (LID) and Best-Management Practices (BMPs). Please indicate your level of familiarity with each:

- Bioswales
- Detention Pond / Infiltration Basin
- Rain Gardens
- Permeable / Porous Pavement
- Rain barrels