City of Surrey

Clayton ISMP – Final Report

Prepared by:

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Project Number:

60158414

Date:

July 27, 2012

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July 27, 2012

David Hislop, P. Eng.
Engineering Department
City of Surrey
14245 – 56 Avenue
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Dear Mr Hislop:

Regarding: Clayton ISMP – Final Report

Please find attached our final report for the Clayton ISMP, which includes the updated sensitive habitat inventory mapping (SHIM) for the watershed.

It was a pleasure working with you on this project. If you have any questions please don't hesitate to contact me at 604.444.6463.

Sincerely,
AECOM Canada Ltd.

Nancy Hill

Nancy Hill, P.Eng., PMP
Nancy.hill@aecom.com

Encl.

Distribution List

# of Hard Copies	PDF Required	Name
5	yes	David Hislop, City of Surrey

Version Log

Version #	Written By	Date	Version Description
1	MP/NH	February 21, 2012	Draft Report
2	NH	July 27, 2012	Final report with updated SHIM

AECOM Signatures

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Executive Summary

An Integrated Stormwater Management Plan (ISMP) is a policy document that provides direction to local government and land owners to preserve and improve the overall health of the watershed while balancing and integrating the requirements of land use planning, stormwater engineering, flood and erosion protection, and environmental protection. The Clayton ISMP study area lies to the south of Latimer Creek and to the east of Harvie Road. The study area, which is shown in **Figure ES.2,** is ultimately tributary to the Serpentine River. The Clayton ISMP is part of a planning process that will provide input into the future Neighbourhood Concept Plans within the Clayton ISMP Study Area.

This ISMP was developed in four stages, as described below.

- **Stage 1** - Summarize existing conditions - *What do we have?*
- **Stage 2** - Establish a vision for future development – *What do we want?*
- **Stage 3** - Develop an implementation plan with funding and enforcement strategies – *How do we put this into action?*
- **Stage 4** - Develop a monitoring and assessment plan – *How do we stay on target?*

<u>Stage 1 – What do we have?</u>

The Study Area is currently low density residential and agricultural land, but as the road and water infrastructure is in place in adjacent neighbourhoods, it can readily be extended into the ISMP area making it highly desirable for development. However, there are a number of concerns with increased development in the area, namely: erosion of ravine streams; loss of base flows in streams; flooding in lowland channels; loss of habitat (forests, streams, etc.) and habitat fragmentation.

Latimer Creek and Latimer Creek South Arm are the primary fish habitat within the watershed, although some smaller creeks also have the potential for providing fish habitat (76th Av B Creek, 76 Ave Creek, 193 Street Creek,192 Street Creek, Creek 274 and Creek 283). There are also several Class B tributaries that are contributing significantly to the downstream fish habitats. There are existing records of Coho Salmon and Cutthroat Trout within the Latimer Creek network, as well as field observations of Coho at the 196th Street culvert during July 2010.

The watercourses within the study area can be separated roughly into three categories: headwaters channels; Latimer Creek and ravine streams; and lowland channels. The locations and classifications of many of these watercourses are based on a Latimer Creek sensitive habitat inventory mapping (SHIM) study completed in February 2012. The area of this study not covered by the Latimer Creek SHIM study was assessed using background data, air photos and limited ground truthing.

Within the uplands area a shallow aquifer and a deep aquifer exist with an impermeable layer in between. Previous groundwater studies have estimated that developing this area without infiltration compensation could reduce aquifer recharge by as much as 20-40%. It was estimated that this could result in a 40-60% reduction in creek base flows. It is essential that base flows continue to be delivered to the small headwaters streams so that aquatic habitat is not lost.

The primary concern for terrestrial habitats is that encroachment and fragmentation will reduce or eliminate interior forest habitats and habitat corridors will be lost. There are many opportunities to increase the connectivity of the existing forest stands and wildlife corridors, which will contribute to the overall biodiversity potential of the Study Area and beyond. A total of 21 potential wildlife crossings along various roads within the study area were identified during the field program. The crossings associated with the main stem of Latimer Creek were identified as having the highest wildlife values and provided high rated habitat for a number of listed wildlife species.

A number of culverts have been identified as having potential issues even under existing conditions, as outlined in **Table 5.13** and shown in **Figure ES.2**. Design details for these culverts under future conditions will be determined as part of the NCP process.

Stage 2 – What Do We Want

As part of the stakeholder visioning process the following twelve (12) goals were identified as critical for facilitating development while preserving and enhancing the overall health of the watershed.

- Goal 1: Protect Agriculture and Agricultural Activities;
- Goal 2: Preserve, Maintain, and Enhance Streams;
- Goal 3: Preserve, Maintain, and Enhance Riparian Areas;
- Goal 4: Preserve, Maintain, and Enhance Latimer Wetlands;
- Goal 5: Preserve, Maintain, and Enhance Key Forest Habitats;
- Goal 6: Maintain Base Flow to Streams;
- Goal 7: Maintain Stream Water Quality;
- Goal 8: Reduce the Likelihood that Increased Development Will Increase Lowland Flooding;
- Goal 9: Reduce the Likelihood that Increased Development Will Increase Stream Erosion;
- Goal 10: Increase Density in Areas of Lower Environmental Value;
- Goal 11: Improve and Maintain Wildlife Connectivity; and,
- Goal 12: Connect Communities

An implementation plan for these twelve goals was developed in Stage 3 of this ISMP.

Stage 3 – How Do We Put This into Action

In order to determine how the Vision identified in Stage 2 could be implemented, a stormwater model was developed of the study area to quantify the following impacts from future development:

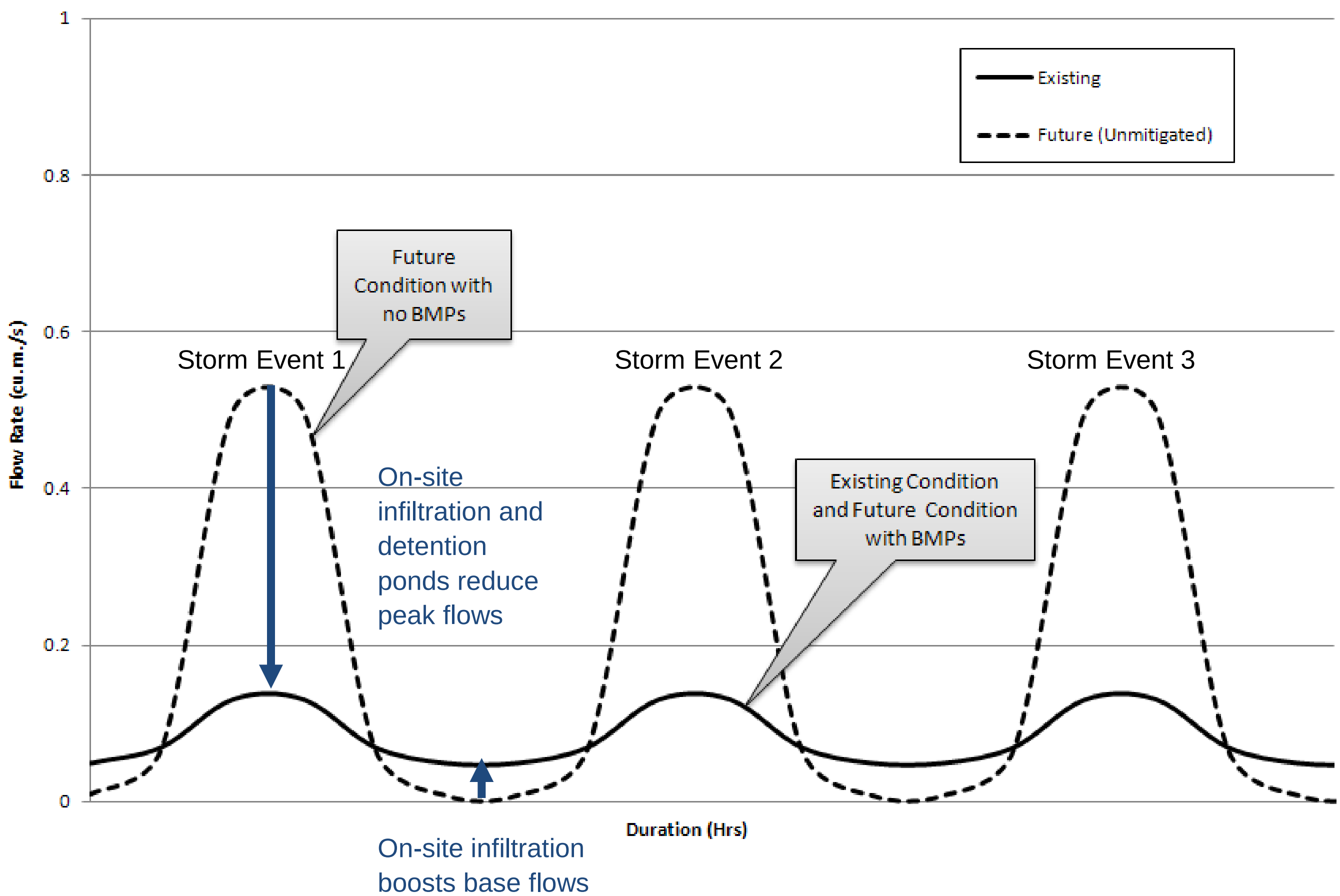
1. Changes to the flow regime that could result in increased stream erosion;
2. Changes in runoff volumes for the ARDSA event to the lowlands in order to determine increased pump times; and
3. Requirements for implementing measures such as infiltration devices, ponds or diversion sewers to mitigate against increases in stream erosion or flooding.

The study area for the Clayton ISMP currently has an overall imperviousness of approximately 12%. Under full build-out, imperviousness is expected to increase to 40%. If unmitigated, this increase in imperviousness will increase peak discharges from flood events, as well as change the duration of various discharges. Changes in the duration of the more frequent, yet lower discharge rates may have a more significant, cumulative impact on erosion in the streams than the infrequent, higher discharge events. These changes to the flow regime are best mitigated using stormwater best management practices such as infiltration devices, as they reduce the total runoff volume resulting from new/re-development. These infiltration devices will also contribute to aquifer recharge and maintain stream base flows that are critical for maintaining aquatic habitat.

Infiltration devices work well to manage flows from frequent, smaller rainfall events. The peak flows from larger rainfall events (i.e. 2 year to 100 year storms) will also need to be managed to prevent downstream flooding. Typically these flows are managed through the installation of detention ponds. **Figure ES.1** shows a graphical representation of how development can change the flow regime and how BMPs act to maintain natural flow conditions.

Using a combined strategy of infiltration and detention ponds has been used successfully in developments in other parts of Surrey, Township of Langley and City of Burnaby. Lessons learned from the East Clayton NCP have been considered when developing the implementation plan for this Clayton ISMP.

Figure ES.1 BMPs and Stream Health



Stage 4 – How Do We Stay on Target?

Planning for a 25, 50, or 100-year horizon is a challenge that all municipalities face. Due to economic, political, climatic, technological, and social changes as well as changes in our understanding of the watershed it is imperative that the ISMP adapt accordingly to ensure the watershed vision is met over time. As such, a key component to a successful ISMP is to develop a long-term adaptive management program that includes monitoring, operation, and maintenance strategies to verify that the vision and goals set out are met through the implementation plan.

The City of Surrey is a leader in using monitoring programs to assess on-going health of its watersheds. Information from these programs can be used to help the Clayton ISMP adaptive management program. However, the City does not currently collect water quality and quantity data within the southwest portion of the ISMP study area. This area is particularly important as this where development may occur in the short to medium term and this is also where the highest densities are expected to occur. It is important that information is collected to identify baseline conditions before further development occurs. Data from this station could then be used to determine the effectiveness of the stormwater strategy as development progresses.

The appointment of an ISMP coordinator would help the City successfully implement the Clayton ISMP and ensure that the ISMP is adapted as needed.

Recommendations

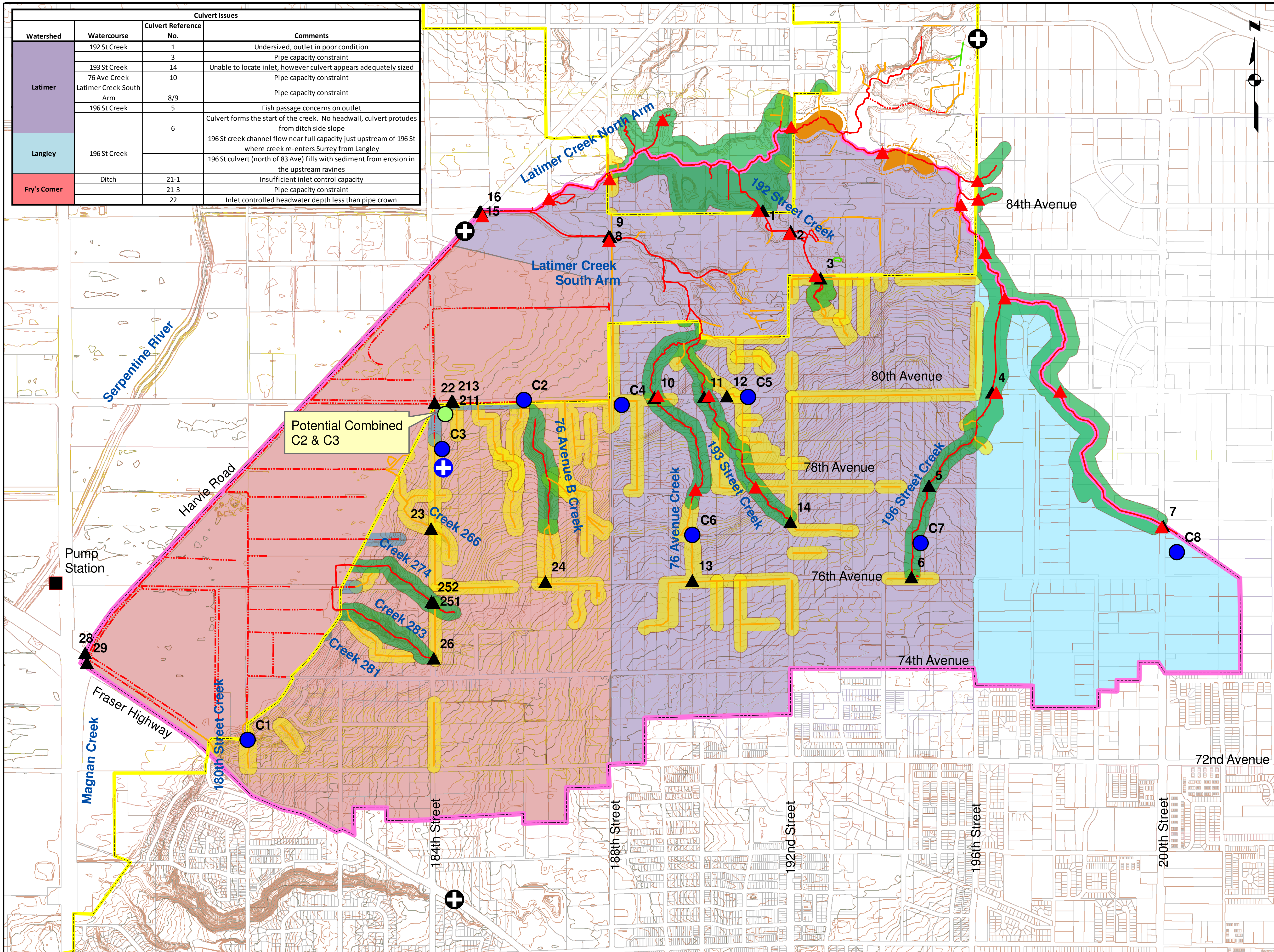
To prevent any negative impacts that future development may have on receiving watercourses, downstream agricultural lands or other properties, we recommend implementing a number of measures. A number of key recommendations are outlined below.

1. Preserve all Class A and B streams with a 30 metre riparian setback (see **Figure ES.2**).
2. Where Class B streams cannot be protected – mitigation shall be provided.
3. Implement on-lot infiltration requirements where on-lot infiltration devices have a consolidated contact area equal to 10% of the lot area with at least 800mm of pervious material (see **Figure ES.3**).
4. Implement street infiltration requirements where infiltration devices have a contact area equal to 50% of the impervious area within the street right-of-way (see **Figure ES.3**).
5. All pervious areas to have a minimum of 450 mm of topsoil.
6. Key culverts should be designed with consideration of aquatic and terrestrial wildlife passage (see **Figure ES.2**).
7. The City of Surrey, through the Lowland Schemes, should work with the agricultural community to protect the Latimer Wetlands and their riparian area (see **Figure ES.2**).
8. Detention ponds (see **Figure ES.2**) shall be constructed to provide peak flow storage. Specific pond requirements are outlined in **Section 7.7** and **Figure 7.13**.
9. All detention ponds shall be designed to provide water quality treatment.
10. Culverts with existing issues such as capacity constraints or blockages to fish passage should be addressed (see **Table 5.13** and **Figure ES.2).**
11. To protect wildlife habitat and connectivity, future NCPs in the area should consider preserving the:
    a. 77th Avenue corridor between the 193 Street and 196 Street Creeks;
    b. The interior forest habitat in the area between 76th and 80th Avenues and 184th and 192nd Streets and the interior forest habitat east of 194th Street and south of 76th Avenue.
12. Integrate and coordinate with directions arising out of the Anniedale-Tynehead NCP particularly around wildlife corridors and residential densities adjacent to the ALR.

13. Confirm if the culvert at 80th Avenue on the 196th Street Creek is passable to determine if the Class A designation can be extended upstream beyond 80th Avenue.
14. Install a new stormwater monitoring station on 184th Street near 80th Ave. (see **Figure ES.2**)
15. Appoint an ISMP Coordinator that would oversee the implementation and adaptation of the Clayton ISMP.

Culvert Issues

Watershed	Watercourse	Culvert Reference No.	Comments
Latimer	192 St Creek	1	Undersized, outlet in poor condition
		3	Pipe capacity constraint
	193 St Creek	14	Unable to locate inlet, however culvert appears adequately sized
	76 Ave Creek	10	Pipe capacity constraint
	Latimer Creek South Arm	8/9	Pipe capacity constraint
	196 St Creek	5	Fish passage concerns on outlet
		6	Culvert forms the start of the creek. No headwall, culvert protudes from ditch side slope
Langley	196 St Creek		196 St creek channel flow near full capacity just upstream of 196 St where creek re-enters Surrey from Langley
			196 St culvert (north of 83 Ave) fills with sediment from erosion in the upstream ravines
Fry's Corner	Ditch	21-1	Insufficient inlet control capacity
		21-3	Pipe capacity constraint
		22	Inlet controlled headwater depth less than pipe crown



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City of Surrey
Clayton ISMP

Legend

- Potential Pond Location
- Proposed Flow Monitoring Station
- Flow Monitoring Locations
- Key Culvert for Fish and Wildlife Passage
- Culvert With Existing Issue
- Proposed Detention Ponds

NewClass

- A
- AO
- B
- C
- ALR
- Key Wetlands Buffer
- Key Wetlands
- Study Area Boundary

Class

- A
- AO
- B

Watershed Boundaries

- Fry's Corner
- Latimer
- Langley

AECOM

0 100 200 400 600 800
Meters

Project No.	Date
60158414	July 2012

Clayton ISMP Summary

Figure ES.2

NOTES:

1) LOCATIONS OF UNDERGROUND UTILITIES SHOWN ARE BASED ON CITY OF SURREY STANDARD TYPICAL LOCAL ROAD SECTION DWG. NO. SSD–R.4. ACTUAL LOCATIONS CAN VARY AS REQUIRED.

2) CATCH BASINS HAVE SUMPS TO CAPTURE GRIT AND SAND. CATCH BASINS ALSO CONTAIN HOODED OUTLETS TO TRAP OIL AND FLOATABLES.

BMP SYSTEM FOR SMALLER FREQUENT STORMS:

1) LOT RUNOFF WILL DRAIN FROM IMPERVIOUS AREAS ONTO PERVIOUS AREAS, INFILTRATING INTO ENHANCED TOPSOIL AND POROUS CONCRETE SIDEWALK TOWARDS GRAVEL TRENCH, RECHARGING BASE FLOWS. FOOTING DRAINS ARE DIRECTLY CONNECTED TO MAIN STORM SEWER TO PREVENT BASEMENT FLOODING.

2) RUNOFF FROM ASPHALT ROAD WILL DRAIN TOWARDS CATCH BASIN AND INFILTRATING INTO GRAVEL TRENCH VIA PERFORATED PIPE TO RECHARGE GROUNDWATER.

OVERFLOWS:

1) WHEN ENHANCED TOPSOIL AND POROUS CONCRETE SIDEWALK IS SATURATED, STORM WATER IN GRAVEL TRENCH WILL BACKFLOW INTO CATCH BASIN VIA PERFORATED PIPE AND OVERFLOW INTO MAIN STORM SEWER SYSTEM.

2) RUNOFF FROM ASPHALT ROAD WILL DRAIN INTO CATCH BASIN, WHICH OVERFLOWS INTO MAIN STORM SEWER SYSTEM.

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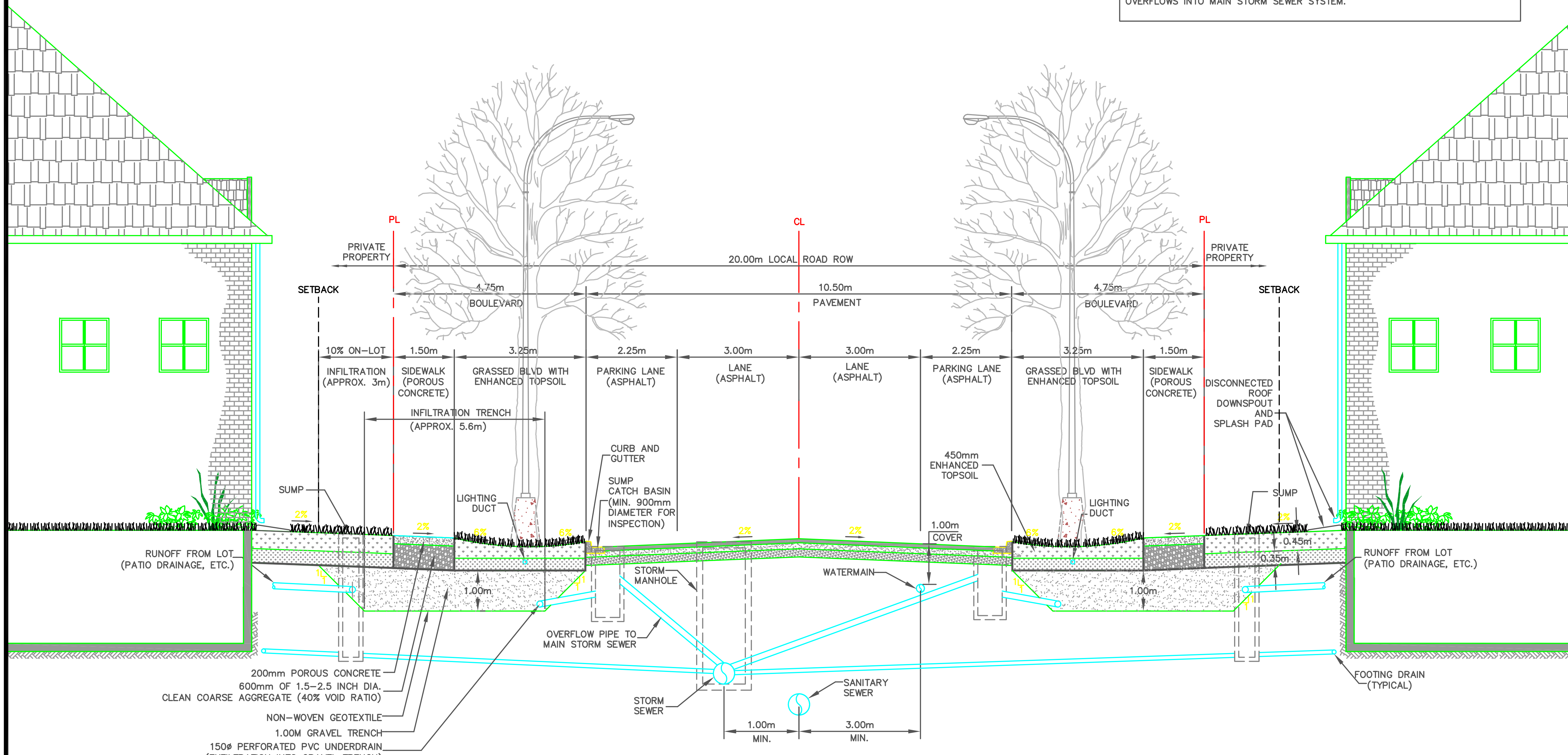

OPTION 1: TYPICAL SECTION

ENHANCED TOPSOIL, ASPHALT PARKING LANE, AND INFILTRATION TRENCH WITHIN FRONT YARD SETBACK

N.T.S.

0 250 1000m

Scale

Project No.	Date
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Local Road Section With BMPs Example 1

Figure ES.3

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1. Introduction

The City of Surrey is often considered to be a leader in terms of adopting progressive and innovative strategies for storm water, infrastructure and community planning. Surrey has grown to become the second largest city in BC, and has placed a priority on integrating this new density into its watersheds, rather than on top of it.

The Clayton Study Area is adjacent to the East Clayton Sustainability Initiative – a showcase project which rethought the traditional approaches to suburban neighbourhood design, incorporating a holistic methodology for storm water management using a water balance perspective. The adjoining Routley Neighbourhood in Langley has also included the successful implementation of Low Impact Development facilities that have met the requirements of DFO. Both of these projects have provided experience that can be built and improved upon.

Once again the community would like to grow. Building upon and continuing the successes gained from East Clayton, Routley, and other similar projects around Surrey and Langley, the Clayton Integrated Storm water Management Plan (ISMP) is the first step towards preserving and improving the overall health of the watershed while allowing for future development.

In addition, the City of Surrey adheres to the Agri-Food Regional Development Subsidiary Agreement (ARDSA) flood control criteria for the agricultural lowlands. These criteria recognize the importance of good drainage for productive agriculture and focus on flood duration and depth.

When initiating the Clayton ISMP, the City identified several goals which include:

- Protect and enhance the overall health and natural resources of the watershed;
- Promote participation from all stakeholders to achieve a common future vision of the watershed;
- Minimize risk of life and property damages 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;
- Protect the environment, wildlife, and habitat corridors;
- Identify areas of existing and future agricultural, residential, commercial, and recreational land uses;
- Develop a cost effective and enforceable implementation plan; and,
- Establish a monitoring and assessment strategy to ensure goals are achieved, maintained, and enforced.

This ISMP was developed using the following 4-step process established by the City.

1. Summarize existing conditions - *What do we have?*
2. Establish a vision for future development – *What do we want?*
3. Develop an implementation Plan with funding and enforcement strategies – *How do we put this into action?*
4. Develop a monitoring and assessment plan – *How do we stay on target?*

The existing conditions within the study area have been determined through field reviews, an analysis of the existing drainage system and a review of existing policy, reports and other documentation.

1.1 ISMP Context

1.1.1 What is an ISMP?

An Integrated Storm water Management Plan (ISMP) is a policy document that provides direction to local government and land owners to address community land use choices and determine best options to manage growth in light of the natural resources present in the area.

This ISMP is not just another engineering drainage study. Rather it must incorporate and balance the requirements of drainage and flood protection, terrestrial and aquatic ecosystems, the existing community and future development, watershed health, as well as aesthetic, recreational and downstream functions.

In May 2010, Metro Vancouver finalized its Liquid Waste Management Plan (LWMP) for the Greater Vancouver Sewerage & Drainage District and Member Municipalities. As a member municipality, the City of Surrey is committed to undertake and implement Integrated Storm water Management Plans (ISMPs) to better protect its watersheds. The LWMP stipulates that ISMPs should include managing rainwater at the site level, thereby minimizing storm water runoff. They should also integrate land use into their storm water management plans, and appropriate site-level rainwater management practices into their community development policies.

Storm water management is intricately linked to stream health in ways that are much more subtle than a traditional “pipe and pond” analysis. The ISMP is a road map for watershed health and neighbourhood development that includes a series of recommendations, strategies and standards that are sustainable with minimal operational and maintenance costs.

1.1.2 Where does it fit in?

This ISMP is part of the planning process that will provide input into the future Neighbourhood Concept Plans (NCPs) within the Clayton ISMP study area. The ISMP process has the potential to achieve significant benefits for the urban and rural environments. The liveability of the community may be enhanced as the quality of the natural environment is enhanced and higher levels of sustainability are achieved.

These benefits are only possible when the ISMP assumes a long-term perspective on growth and change as well as ensuring that plans and strategies coincide and recognize the pace and timing of development and redevelopment cycles. Planning for the future with a long term time horizon is challenging because of the number of variables involved and the inability to anticipate changes in personal attitudes, economic and market conditions, technology, scientific knowledge and politics. It is, therefore, critical that this ISMP be adaptable as information and conditions change.

1.2 ISMP Study Area Background

The Clayton ISMP study area lies to the south of Latimer Creek and to the east of Harvie Road. The study area drains northwest to the Serpentine River and covers an area of approximately 910 hectares between Fraser Highway and Harvie Road to 202 Street in Langley and 72 Avenue to 85 Avenue. **Figure 1.1** shows the Clayton ISMP study area.

The ISMP Area is located within two municipalities, the City of Surrey and the Township of Langley, and has been divided into three large subareas that include Langley, Latimer, and Fry’s Corner.

1. The Langley Subarea is the eastern catchment located within the Township of Langley and contains approximately 100 hectares. It accepts flows from Surrey and contributes flows to Latimer Creek upstream of the Surrey municipal boundary.

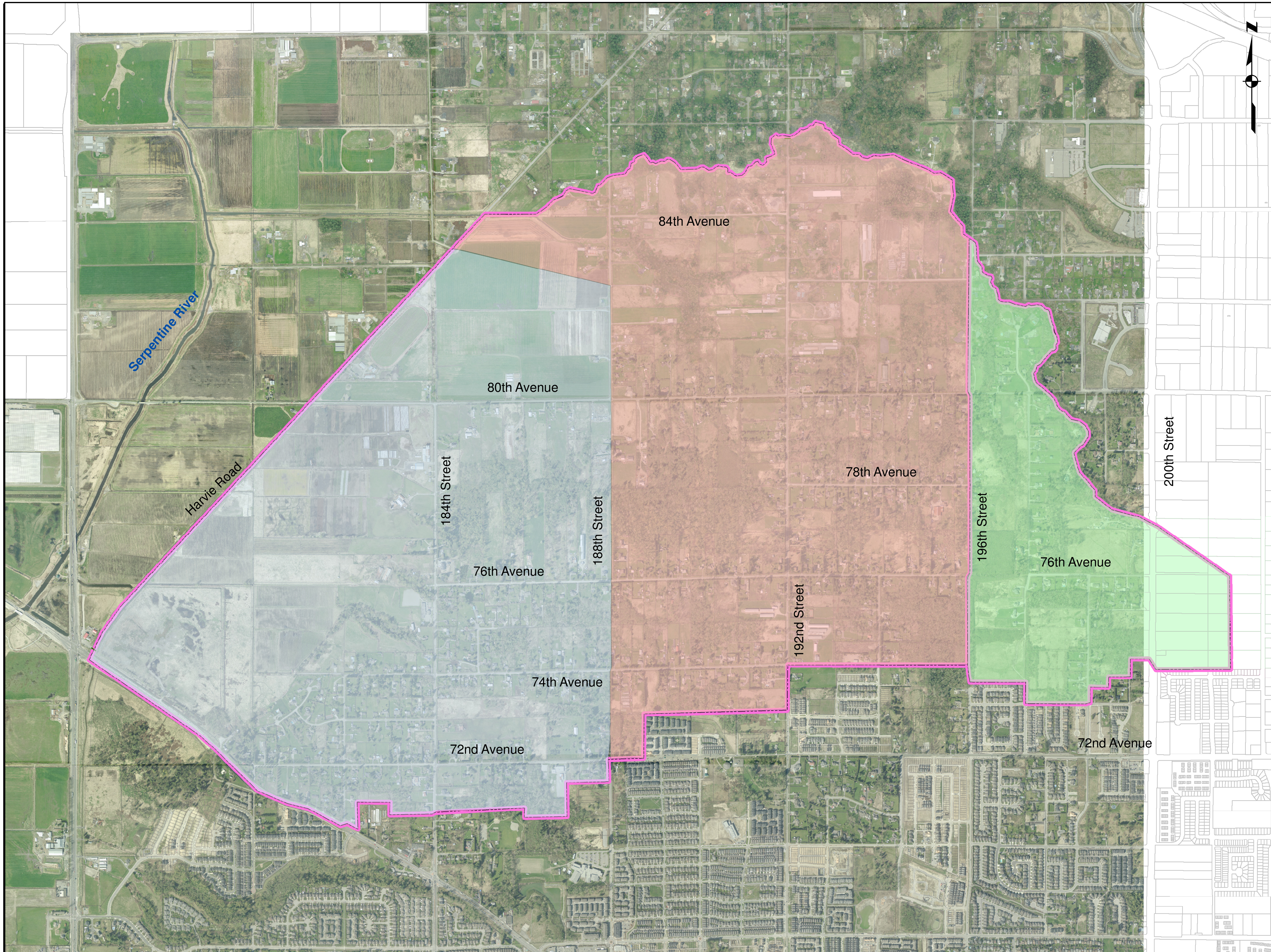
2. The Latimer Subarea is the central catchment and is a 400 hectare tributary to Latimer Creek. Only the portion of the Latimer Creek watershed lying to the south of the creek is included in this study.
3. The Fry's Corner Subarea is the western catchment of 410 hectares draining into the lowlands through watercourses tributary to Harvie Road Ditch and the Fry's Corner Pump Station and associated flood box. It should be noted that there are externally contributing catchments to this subarea. The lowlands are interconnected and several culverts are located beneath Harvie Road which exchange drainage between the catchments in the study area and outside of it.

The study area is comprised of approximately 330 hectares of lowlands and 580 hectares of uplands. The upland areas form the groundwater recharge zones and contain tributary watercourses. The lowland areas are part of the Agricultural Land Reserve and the Serpentine River’s designated 200 year floodplain. While it is the upland areas that will be developed, the lowland areas could be hydrologically and hydraulically impacted.

The study area is adjacent to the East Clayton Neighbourhood in Surrey and the Routley Neighbourhood Area in the Township of Langley. The road and water infrastructure is in place in these adjacent neighbourhoods and can readily be extended into the ISMP area making it highly desirable for development.

The land within the ISMP Area ranges from nearly sea level to an elevation of over 80 metres. A large number of headwater streams are found on private property within the area, a great many of these are red and yellow coded, which indicates their quality and importance for the fisheries in Surrey. As a majority of these streams are located on private property, site specific information for either the engineering or the biological assessments is limited to those portions of the streams which are on, or cross, public property.

The Latimer Creek Master Drainage Plan, which was completed in May 2003, provides direction as to the future infrastructure requirements needed to protect the creek from increased flooding and degradation. The focus of the Clayton ISMP is the tributary streams located within its own study area boundary.



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Clayton ISMP

Legend

Study Area Boundary

Watershed Boundary

Fry's Corner

Langley

Latimer

AECOM

0 105 210 420 630 840 Meters

Project No.	Date
60158414	February 2012

Clayton ISMP
Study Area

Figure 1.1

2. Current Environmental State of The Watershed

A substantial amount of planning and analysis has already been undertaken for portions within and adjacent to the study area. The upstream catchments of Latimer Creek have been delineated and modified as part of creating the East Clayton and Routley Neighbourhoods. The reaches of Latimer Creek and the drainage along Harvie Road have been examined with construction of containment dikes along the lower reaches of Latimer Creek and pump station upgrades at Fraser Highway. In reviewing what the current conditions are within the study area, we have drawn from previous work as well as conducted new reviews and analysis.

Towards the completion of this Clayton ISMP a Latimer Creek sensitive habitat inventory mapping (SHIM) study was conducted. The classification of some streams were modified as a result of the SHIM study and these new classifications have been considered in this final report.

2.1 Environment

The environmental assessment is to provide an inventory and assessment of existing terrestrial (wildlife habitats and corridors) and aquatic habitats (watercourses, wetlands) within the study area using available information and limited “ground-truthing” site reconnaissance. This assessment was conducted by Phoenix Environmental Services, a full report of which can be found in **Appendix E**. A summary of their findings is provided below.

2.1.1 Methodology

The methodology for the environmental assessment entailed:

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

2.2 Watercourses

Latimer Creek and Latimer Creek South Arm are the primary fish habitat within the watershed, although some smaller creeks also have the potential for providing fish habitat (76th Av B Creek, 76 Ave Creek, 193 Street Creek,192 Street Creek, Creek 274 and Creek 283). There are also several Class B tributaries that are contributing significantly to the downstream fish habitats. There are existing records of Coho Salmon and Cutthroat Trout within the Latimer Creek network, as well as field observations of Coho at the 196th Street culvert during July 2010.

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

- Headwaters channels;
- Latimer Creek and ravine streams; and
- Lowland channels.

2.2.1 Headwaters

The headwaters of the watershed are primarily located on the upper plateau of Clayton Hill and consist of roadside ditches, yard swales, and small channels. Many of these streams have been modified (straightened, culverted, etc.) and they often only convey seasonal flows.

Site reconnaissance during July 2010 verified that a majority of the headwater ditches are dry for a portion of the year and they offer little direct habitat value. Roadside swales are generally mowed with limited riparian vegetation and the channels are homogenous. However, there were areas with existing pooled water or minor flows, and some wetland vegetation such as rushes and sedges were often present at these locations. The headwater channels with year-round water are important sources of groundwater and base flows for the watershed during the summer.

The two key headwaters streams are:

- 192nd Street Creek - watercourse east of 192nd Street between 82A and 84th Avenue; and
- 196th Street Creek - watercourse west of 196th Street between 76th and 80th Avenue.

The 196th Street Creek may be upgraded to a Class A watercourse if all existing and future culverts remain passable. The Clayton Master Drainage Plan noted that this creek between 76th and 78th Avenues currently flows at full capacity during large storm events and could be negatively impacted by future development. Downstream of 78th Avenue, there is also the possibility of increased erosion where the grades are steep and within the ravine.

2.2.2 Ravine Streams and Latimer Creek

The ravine streams and Latimer Creek are characterized by cobble/gravel substrates, moderate gradients, forested riparian vegetation, and diverse in-stream habitat compared to the headwaters and lowland streams (see **Appendix E**, Site Photos). Due to the steeper gradient, the ravine stream channels are wider and deeper, often with riparian vegetation present to the top of ravine bank. Some of the key ravine streams include:

- Creek 274 – watercourse west of 184th Street and south of 76th Avenue (north of Clayton Elementary School);
- Creek 283 – watercourse west of 184th Street and north of 74th Avenue (south of Clayton Elementary School);
- The 76th Avenue B Creek – watercourse that flows north from 76th Avenue to join the roadside ditches along 80th Avenue;
- Latimer Creek South Arm – watercourse that joins the 76th Avenue and 193rd Street Creeks southeast of the intersection of 188th Street and 84th Avenue (not inspected); and
- 196th Street Creek – North of 80th Avenue, watercourse continuing into Langley before joining Latimer Creek.

Latimer Creek is similar to the ravine streams in that it still has much of its riparian vegetation remaining and has greater habitat complexity than either the upper headwaters or the lowland channels. Latimer Creek has a lower gradient than most of the ravine streams as it follows a longer path from Clayton Hill down to the Serpentine River agricultural areas. Latimer Creek has areas with high quality fish habitat, particularly where the riparian area is still intact.

2.2.3 Lowland Channels

The lower stream reaches of the watershed are within the wide, broad agricultural lands on the east side of the Serpentine River (see **Appendix E**, Site Photos). To maximize agricultural land uses, these channels have been straightened along roads, property lines, farm fields, and right-of-way corridors. The channels are very typical of the agricultural ditches throughout Surrey. There is very little natural vegetation except small patches of trees within some of the fields and in exceptionally wet areas and areas that are not under cultivation. Typical roadside channels are 0.5 - 1 meter deep and 1-2 meters wide with very homogenous channel dimensions and little habitat diversity.

2.2.4 Benthic Index of Biotic Integrity (B-IBI)

Three monitoring stations have been established within the study area by the City of Surrey to monitor the composition of the benthic macroinvertebrates. Station L1 is located on the headwaters of the south arm of Latimer Creek near the intersection of 192nd Street and 78th Avenue. This branch of the creek is also known as the 193rd Street Creek. Station L2 is located on the north arm of Latimer Creek, just downstream of 196th Street, which is the boundary between the Township of Langley and the City of Surrey. The third station, T1, is located on an unnamed tributary near the intersection of 184th Street and 76th Avenue. The creek at this location is near the transition point from headwaters channel to a ravine stream.

Benthic macro-invertebrate sampling over the past 10 years does not show a trend of improvement or degradation. Sampling at Station L1 (193rd Street Creek) had the lowest percentage of pollution sensitive individuals, as represented by the Percent EPT metric (percentage of individuals collected belonging to the orders Ephemeroptera, Plecoptera, and Trichoptera). This may indicate a water quality issue, but requires additional investigation. All sampling results were better than those for McLellan Creek, which is within the highly urbanized watershed to the south of the Study Area.

2.2.5 Watercourse Classification

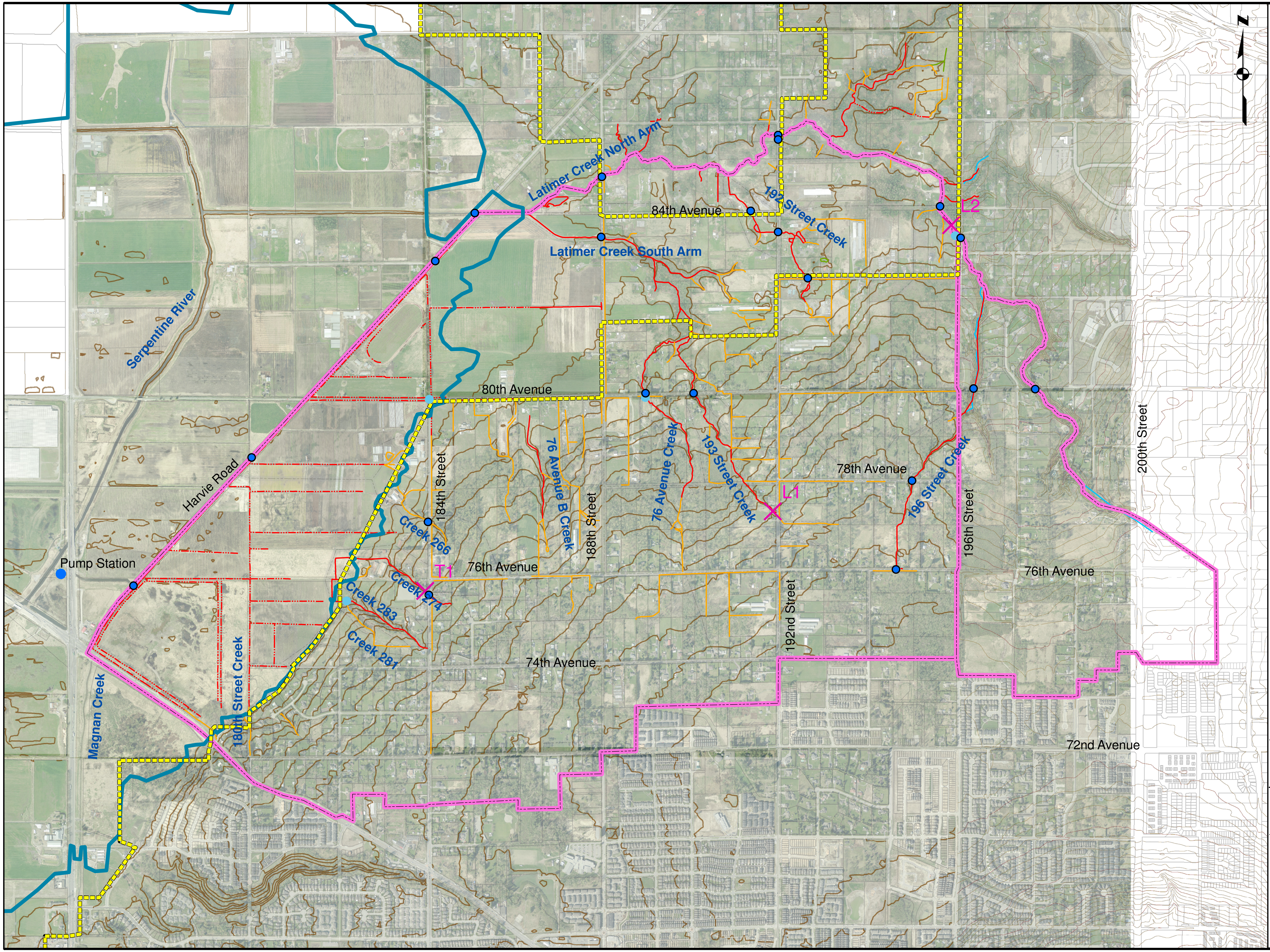
The City of Surrey has classified streams according to their ability to support fish populations. The stream classifications are described below.

- Class A – watercourses support fish populations year round or have the potential to support fish populations year round if migration barriers are removed
- Class A(O) – watercourses support fish populations generally only during the winter months; often roadside ditches that have very low flows and warm temperatures in the summer
- Class B – do not support fish populations, but provide food and nutrients to downstream fish habitats and often are supported year-round by groundwater
- Class C – do not support fish populations and generally only convey flows associated with rainfall events; often roadside ditches in headwater areas

In February 2012, Enkon Environmental completed a SHIM Study for Latimer Creek. The resulting stream classification is shown in **Appendix F**. For the areas outside the SHIM study, stream classification was reviewed based on background data, air photos, and limited ground truthing. Verification in the field consisted primarily of locating the reach breaks between Class A and Class B designations to see if fish barriers or flow restrictions were consistent with the classifications. In one case, the break between Class A and Class B watercourses should be revised to reflect current and potential conditions. The following revision should be considered.

- 196th Street Creek: Class 'A' designation may extend upstream beyond 80th Avenue if culvert crossing is confirmed to be passable.

Figure 2.1 shows the watercourses and their classifications.



City of Surrey
Clayton ISMP

Legend

- Study Area Boundaries
- ALR Boundary
- Floodplain
- Wildlife Crossings
- Salmonids observed summer 2010 or Salmonids collected (Dillon 1997)
- Benthic Macroinvertebrate Sampling Stations
- Contour 5m
- Contour 10m

Watercourse Classifications

- A
- AO
- B
- C

0 100 200 400 600 800
Meters

Project No.	Date
60158414	July 2012

Watercourse Classifications

Figure 2.1

2.3 Terrestrial Habitats

A majority of the study area is covered by large lot residential and agricultural lands. Several road right-of-ways have not been opened, resulting in the preservation of some large forest tracts on properties with no road access. Many of the rear yards of the large residential lots are also forested, creating habitat corridors relatively free of road crossings. A majority of the road network comprises of two lane roads with gravel shoulders, no sidewalks, and drainage swales.

The Ecosystem Management Study currently underway describes the Cloverdale area (Clayton is a subarea of Cloverdale) as 10% forest, 1.4% interior forest, 1.8% freshwater wetlands, and 8.6% old field habitat. A majority of these forests, wetlands, and old field habitats are within the Clayton subarea.

The Study Area has been plotted on four of the most relevant maps from the EMS including the Sensitive Species Occurrences, Green Infrastructure Opportunities, Habitat Hubs, and Habitat Corridors (see **Figures 2.2-2.5**). These maps highlight opportunities to plan for preservation and enhancement of some of the high quality habitat hubs and corridors during the redevelopment and densification of the Study Area.

2.4 Trees and Wooded Areas

Forest stands greater than 1 hectare in size were identified by ortho-photo (see Appendix E - *Figure 2: Sensitive Environmental Areas*). Many of these areas are along the interior property boundaries of the large residential lots (i.e. not along the roads) and along unopened road right-of-ways. The forest stands are essential for providing refuge for birds and small mammals, protecting water quality and aquatic habitat, and enabling wildlife movement between habitat hubs.

The largest forest within the Study Area is west of 192nd Street between 76th and 80th Avenues (roughly 42 hectares). The right-of-way for 78th Avenue has not been opened within this block, and as a result the interior of the block is predominantly forested and has nearly 6 hectares of forest that could potentially support interior bird species (species who require greater than 100 meter forest buffers). The forest block also includes portions of the South Arm of Latimer Creek (193rd Street Creek and 76th Avenue Creek). Creating forested corridor connections between this large forest block and nearby, smaller habitat fragments would greatly enhance the robustness of the habitat network within the Study Area **(see Figure 2.3).**

A second large forest block exists west of 196th Street between 74th and 76th Avenues. Similarly, the right-of-ways for 196th Street and 74th Avenue have not been opened at this location. There is approximately 1.6 hectares of interior forest habitat within the forest block. This interior habitat would be reduced at least to 1.2 hectares if both roads were opened, and would likely be further reduced with development along the new road frontages.

2.5 Old Fields

A large portion of the Study Area is within the Agricultural Land Reserve. Some of these lots are not currently under cultivation and provide very high quality foraging habitat for wildlife such as raptors and small mammals. These areas are not currently threatened by development and have not been highlighted as Sensitive Environmental Areas. One old field located at the intersection of Fraser Highway and Harvie Road has been identified as an SEA because it includes seasonally flooded areas (wetlands) that connect to Class A(O) fish habitat.

Figure 2.2 EMS: Sensitive Species Occurrences and Habitats

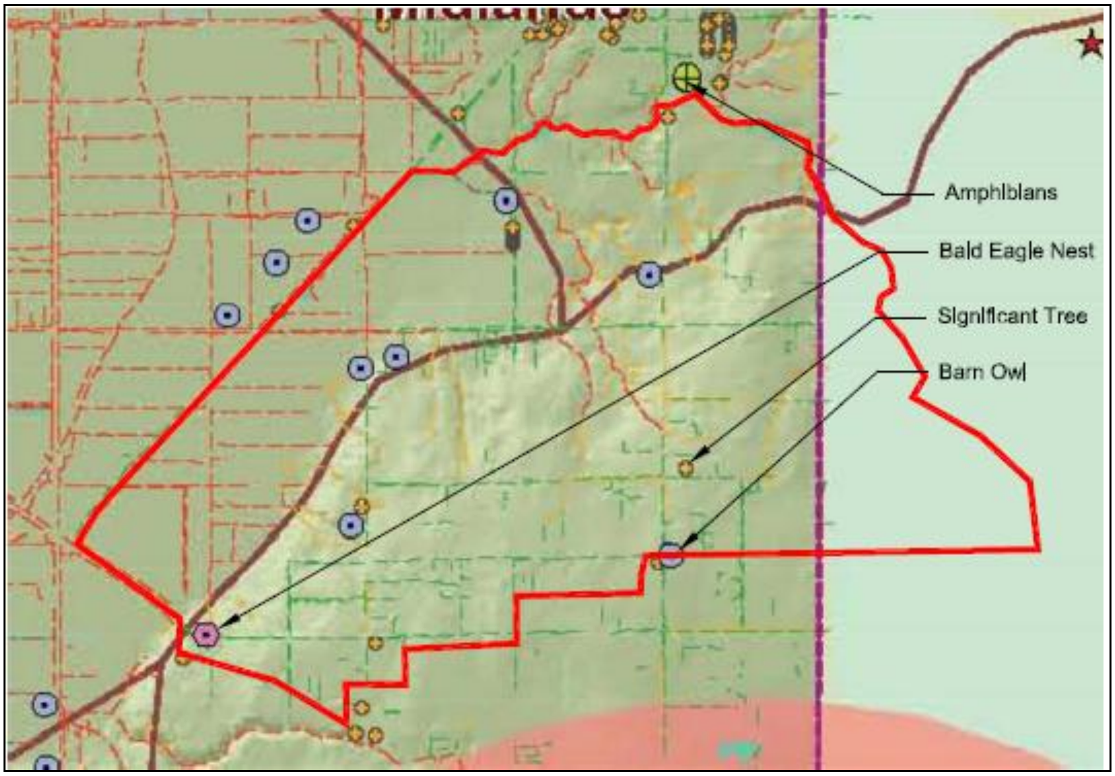


Figure 2.3 EMS: Green Infrastructure Opportunities

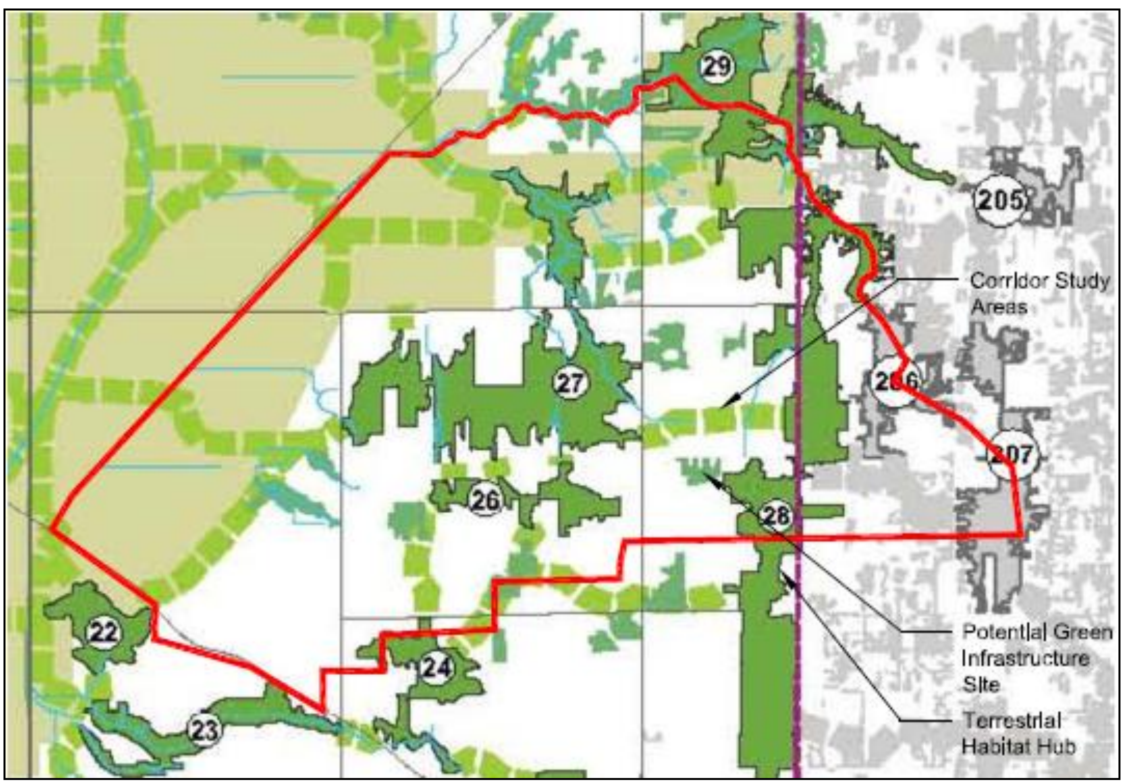


Figure 2.4 Habitat Hubs and Percent Ecological Significance

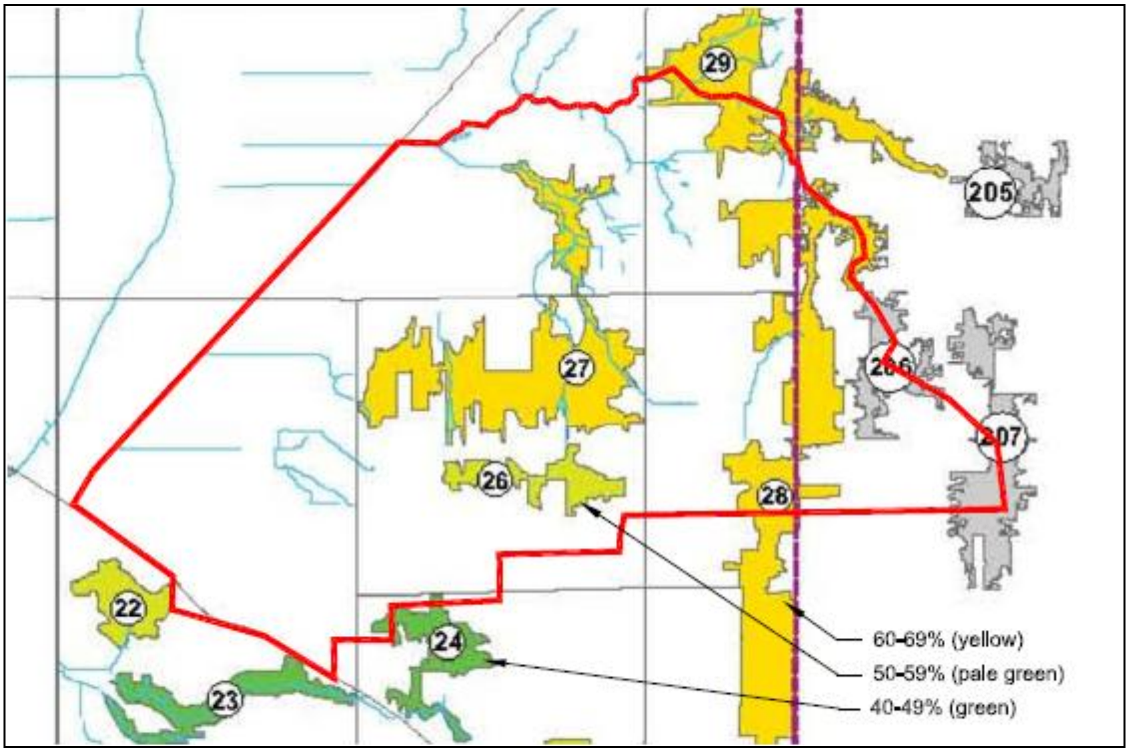
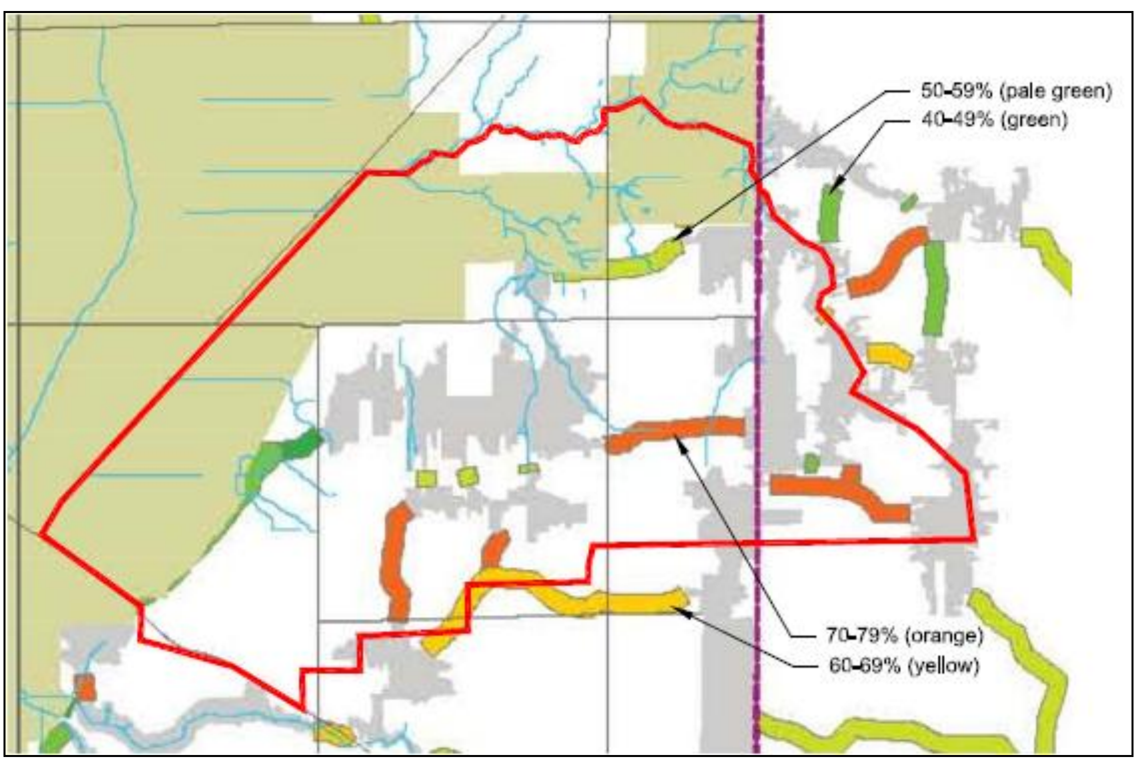


Figure 2.5 Habitat Corridors and Ecological Significance



2.6 Wildlife Tree

A wildlife tree is any standing dead or living tree with special features that provides present or future critical habitats for the maintenance or enhancement of wildlife. There are nine classifications of coniferous and six classes of deciduous wildlife trees in various successions from live and healthy with no decay, to stumps and debris (Fenger et al. 2006). Most of the trees observed in the study area were identified as Class 1 wildlife trees. Class 1 wildlife trees are described as live healthy trees with no decay. Many of the decayed trees identified were Class 2 to 4 wildlife trees.

A Red-tailed Hawk was observed foraging within the study area during the field survey. At least five Red-tailed Hawk nests were detected during the field investigations for the CANCPER (Dillon and Strix 1997). Potential nest cavities were detected within many of the wildlife trees observed. Most of the wildlife tree observations were recorded along the Latimer Creek main stem. Pileated Woodpecker (*Dryocopus pileatus*) foraging signs were observed on three of the wildlife trees. One Hairy Woodpecker (*Picoides villosus*) and one Northern Flicker (*Colaptes auratus*) were observed foraging throughout portions of Latimer Creek during the field assessment. These trees also provided habitat for many bird and mammal species including songbirds, squirrels and bats.

2.6.1 Coarse Woody Debris

Coarse Woody Debris (CWD) is typically described as woody debris greater than 0.3 m in diameter. CWD provides critical foraging, nesting, and cover components in the forested ecosystem for small mammals, amphibians, reptiles and invertebrates (Anonymous 1991). Many insectivorous small mammals, birds, and black bears feed on insects found in decomposing woody material. CWD provides a safe, moist environment in which species such as salamanders and shrews can forage and seek shelter.

Limited CWD cover (<0.1%) was recorded within most of the study area. Moderate to heavy CWD cover (5-10%) was recorded within many of the forested blocks and along portions of Latimer Creek and its tributaries. No CWD cover was recorded within the residential and agricultural areas.

2.7 Wildlife Inventory and Habitat

Prior to the field assessment, a literature search was conducted covering the Clayton ISMP study area of Surrey, including British Columbia Conservation Data Centre (BCCDC) searches, Wildlife Tree Stewardship Program (WiTS) and local knowledge. Past reports of the study area including the *Clayton Area Neighbourhood Concept Plan Environmental Report* (CANCPER) were also reviewed. The BCCDC website was searched for all species listed under SARA, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), Provincial Identified Wildlife and the Provincial *Wildlife Act* that are suspected to occur within habitats identified within the study area. In addition, species listed as Red and Blue-listed by the BCCDC but not specifically covered under legislation were also included. BCCDC Data within 10 km of the study area was also reviewed. Aerial photographs of the study area were examined and all potential habitats and wildlife corridors were stratified.

Each water crossing along the various roads within the study area were assessed for wildlife and vegetation values during the field survey. Sample sites were restricted to these locations as most of the study area is situated on privately owned lands. Vegetation species within each site were identified and recorded. In addition, the presence of coarse woody debris (CWD), wildlife trees, dens, burrows and other habitat features were also recorded. All wildlife trees were classified according to methodologies identified by Backhouse (1993) and Fenger et al. (2006).

Pacific water shrew habitat was assessed following methodologies described by Craig and Vennesland 2008. Potential raptor/heron nest trees were scanned visually with binoculars. All wildlife and wildlife sign encountered was recorded.

2.7.1 Federally and Provincially Listed Species of Concern

Fifteen Federally and/or Provincially listed species may occur within the Clayton ISMP study area. These species are listed in **Table 2.1**.

Table 2.1 Federally and/or Provincially Listed Species (SARA 2010; BCCDC 2010[1])

Species	Federal/Provincial Status		Legislation			Site Occurrence
Common/Scientific Name	**COSEWIC/SARA Status**	**BCCDC Status***	**SARA**	**Provincial Identified Wildlife**	**Provincial Wildlife Act**	**Expected Onsite Habitat Use**
Vegetation:						
California-tea (*Rupertia physodes*)	-	Blue	**-**	-	-	**Suitable** – Undisturbed portions of the forested blocks within the study area may provide habitat for this species.
False-pimpernel (*Lindernia dubia* var. *anagallidea*)	-	Blue	**-**	-	-	**Suitable** – The banks and shores of the wetlands and streams within the study area may provide habitat for this species.
Slender-spiked Mannagrass (*Glyceria leptostachya*)	-	Blue	**-**	-	-	**Suitable** – The ditches and watercourses within the study area may provide habitat for this species.
Vancouver Island Beggarticks *(Bidens amplissima)*	Special Concern (November 2001)	Blue	**X**	-	-	**Suitable** – the wetland areas along Harvie Road within the study area may provide habitat for this species.
Vertebrates:						
Barn Owl (*Tyto alba*)	Special Concern (November 2001)	Blue	**X**		**X**	**Suitable** – Suitable habitat occurs within the agricultural habitats of the study area. Incidental observations reported in CANCPER.
Great Blue Heron (*Ardea herodias fannini*)	Special Concern (November 2008)	Blue	**X**	**X**	**X**	**Suitable** – Observed foraging in ditches along Harvie Road. Suitable habitat occurs within the wetlands west of Harvie Road. Incidental observations reported in CANCPER.

Species	Federal/Provincial Status		Legislation			Site Occurrence
Common/Scientific Name	**COSEWIC/SARA Status**	**BCCDC Status***	**SARA**	**Provincial Identified Wildlife**	**Provincial Wildlife Act**	**Expected Onsite Habitat Use**
Vertebrates: (continued):						
Green Heron (*Butorides striatus*)	-	Blue	-	-	X	**Suitable** – Suitable habitat occurs within the wetlands west of Harvie Road.
Red-legged Frog *(Rana aurora*)	Special Concern (Nov 2004)	Blue	X	X	X	**Suitable** – Possible breeding habitat (ponds) within the study area. Rearing habitat occurs along most riparian areas. Unconfirmed sighting in a pond during the field assessment.
Pacific Water Shrew (*Sorex bendirii*)	Endangered (Apr 2006)	Red	X	X	X	**Suitable** – Moderate-high rated habitat detected along portions of Latimer Creek and its tributaries.
Short-eared Owl (*Asio flammeus*)	Special Concern (November 2008)	Blue	X	-	X	**Suitable** – Potential habitat occurs within the wetlands west of Harvie Road.
Snowshoe Hare (*Lepus americanus washingtonii*)	-	Red	-	-	X	**Suitable** – Potential habitat detected within forested blocks of the study area.
Trowbridge's Shrew (*Sorex trowbridgii*)	-	Blue	-	-	X	**Suitable** – Potential habitat detected within forested portions of the study area.
Invertebrates:						
Beaverpond Basskettail (*Epitheca canis*)	-	Blue	-	-	-	**Suitable** – Potential habitat within the Latimer Creek Wetland (East of 192nd Street).
Oregon Forestsnail *(Allogona townsendiana)*	Endangered (Nov 2002)	Red	X	-	-	**Suitable** – Suitable habitat occurred within the Forested Block located west of 19024 84 Avenue.
Pacific Sideband *(Monadenia fidelis)*	-	Blue	-	-	-	**Suitable** – Suitable habitat occurred within the Forested Blocks.

*Red= Extirpated, Endangered or Threatened *Blue= Special Concern

2.8 Vegetation Species and Ecological Communities

The following outlines potential vegetation species and ecological communities with special Federal/Provincial status that may occur in the study area.

2.8.1 California-tea

California-tea usually inhabits mesic open forests in portions of the lowland zones of the Coastal Douglas-fir (CDF) and CWH biogeoclimatic zones. It is considered rare on southern Vancouver Island and the lower Fraser River Valley. Outside of B.C. it is found south to California (Douglas et al. 2002).

This species was not detected during the field survey. One BCCDC record for this species occurred within 10 km of the study area (Appendix E; Figure C-3). This species was recorded in the Brookswood area of Langley (1975) and occurred on gravelly soil in a small second growth Douglas-fir stand with scrubby salal (*Gaultheria shallon*) (BCCDC 2010). Undisturbed portions of the forest blocks within the study area may provide habitat for this species.

2.8.2 False-pimpernel

The Provincially Blue-listed false-pimpernel occurs on wet, sandy or muddy banks and shores in the drier lowland and steppe subzones of the Bunch Grass (BG), CWH and Interior Douglas-fir (IDF) biogeoclimatic zones within B.C. It is considered rare in south-central B.C. and the lower Fraser Valley. Disjunct populations also occur east to Ontario and south to New Hampshire, New York, South Carolina, Florida, Missouri, Texas, Utah, Arizona, California, Mexico and South America (Douglas et al. 2002).

False-pimpernel was not observed during the field survey. One BCCDC record for this species occurred within 10 km of the study area near Latimer Pond (Appendix E; Figure C-3). The plants were situated in wet sandy gravel in an old gravel pit (BCCDC 2010). The banks and shores of the wetlands and streams within the study area may provide habitat for this Blue-listed species.

2.8.3 Slender-spiked Mannagrass

Slender-spiked mannagrass usually occurs in brackish tidal marshes, swamps, lakeshores, streamsides and wet meadows in the lowland subzones of the CDF and CWH. It is considered rare in coastal B.C. It also found north to southeast Alaska and south to California (Douglas et al. 2002).

Slender-spiked mannagrass was not observed during the field survey. One BCCDC record for this species occurred within 10 km of the study area near 104 Ave and 176 Street (Appendix E; Figure C-3). The record is of one large plant growing in shallow ditch, in moist dredged sand, near railway tracks (BCCDC 2010). The ditches and watercourses within the study area may provide habitat for this Blue-listed species.

2.8.4 Vancouver Island Beggarticks

The Vancouver Island beggarticks is listed under Schedule 1 (part 4) of SARA. Except for a single historical location on a research station in Brandon, Manitoba, the entire global range of the species occurs in the Pacific Northwest of North America. In Canada, it has been found in the Lower Fraser Valley and on Southern Vancouver Island, with one additional record on the mainland coast of British Columbia just north of Vancouver Island. The Vancouver Island beggarticks is a wetland species found occasionally in successional wetlands, but is generally limited to a very narrow band of habitat around pond, lake and stream margins, areas where annual and seasonal water level fluctuations are prevalent. It tends to occur in sites where waterfowl are common and shows a distinct preference for silty alluvial soils (EC 2009[1]).

Two BCCDC records for this species occurred within 10 km of the study area (Appendix E; Figure 3). One record occurred along the tidal portion of Douglas Island within the Fraser River and a historical record (1954) for this species occurred near Fleetwood (BCCDC 2010).

Although not detected during the field survey the wetland areas along Harvie Road within the study area may provide habitat for Vancouver Island beggarticks.

2.9 Ecological Communities

The BCCDC defines listed ecological communities as ecosystems identified in a Sensitive Ecosystems Inventory. These sites are generally old growth stands that are generally 500 m^2 or greater. These ecosystems are often the remnants of the natural ecosystems that once occupied a much larger area. Typically, mature and old growth upland ecological communities are of concern to the BCCDC. In addition, all listed riparian, wetland and estuarine communities at any growth stage are also of concern to the BCCDC (K.A. McIntosh pers. comm.). The listed ecological communities are classified using methodologies and nomenclature developed by Green and Klinka (1994).

The forested portions within the study area were second to third growth stands. These stands were at states that are not of concern to the BCCDC.

2.10 General Wildlife Observations

Wildlife sign and activity was recorded throughout the study area. Songbirds were observed flying and feeding in vegetation throughout the site. Sign of beaver, raccoon and coyote were observed along Latimer Creek. The federally and provincially listed Great Blue Heron was observed feeding along the ditches of Harvie Road.

2.10.1 Wildlife Habitat Assessment

Habitats were assessed for the eleven wildlife species listed in **Table 2.1**. The results of the habitat assessment for each of the eleven species can be found in **Appendix E**.

2.10.2 Wildlife Corridors

Moderately used wildlife trails, attributed to coyotes, were detected within the study area. Evidence of use by raccoon and beaver were also observed. These animals appeared to travel mainly along the riparian corridors. In addition to coyotes, raccoon and beaver these corridors may also be used by species such as Columbia black-tailed deer (*Odocoileus hemionus columbianus*) and Virginia opossum (*Virginia Opossum*) as well as many species of small mammals, birds, amphibians and reptiles.

2.11 Sensitive Environmental Areas

2.11.1 Watercourses and Riparian Habitat

The priority areas for protection include the Class A and B streams and their riparian areas, the wetlands along Latimer Creek, the interior forest areas, and the remaining forest stands of $\geq$ 1 hectare. These areas are shown on **Figure 2.6**.

Watercourses and their riparian areas are currently protected by the Land Development Guidelines for the Protection of Aquatic Habitat. Under this regulation, setbacks for streams range from 15-30 meters from the high water mark or from the top of ravine (if slopes steeper than 3:1 exist) depending on the density of development at a site. If a riparian area is to also function as a wildlife movement corridor, a 30 meter or greater vegetated setback is to be provided.

2.11.2 Interior Forest Habitat

Interior forests have special habitat conditions that enable them to support different wildlife species than forest edge habitats. Interior forest habitats are relatively uncommon in the City of Surrey. The ISMP Study Area to the south (Cloverdale – McLellan), for example, does not contain any interior forest habitat. The Clayton ISMP Study area contains two areas of interior forest. These areas have also been the location of wildlife sightings including Great Horned Owls and Red Tailed Hawks.

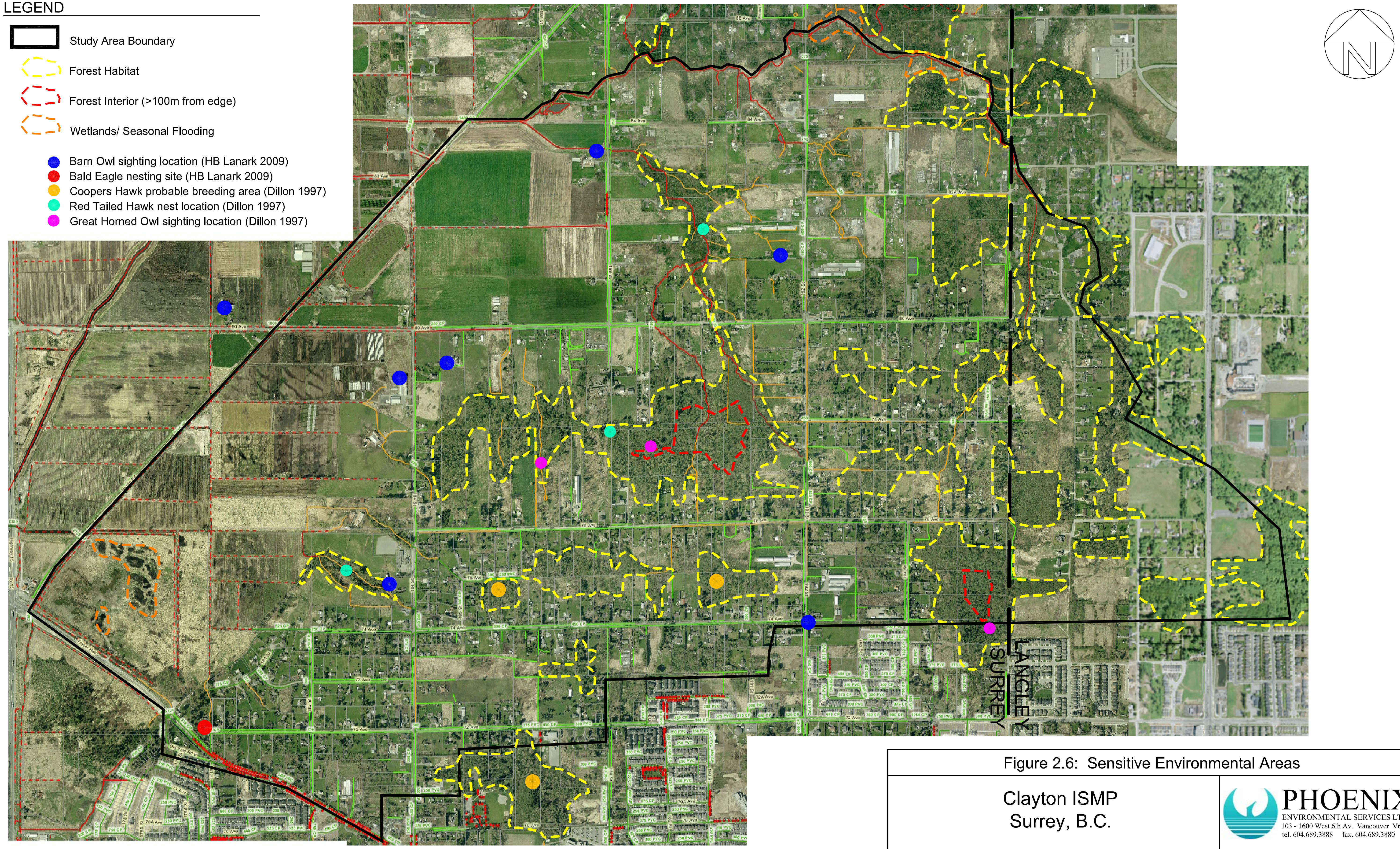


Figure 2.6: Sensitive Environmental Areas

Clayton ISMP
Surrey, B.C.

PHOENIX
ENVIRONMENTAL SERVICES LTD.
103 - 1600 West 6th Av. Vancouver V6J 1R3
tel. 604.689.3888 fax. 604.689.3880

DATE: Aug 2010	DRAWN BY: MBT	SCALE: N.T.S.	DWG: ClaytonISMP_Maps.dwg

3. Planning

The Clayton watershed encompasses lands within the Clayton General Land Use Plan (Surrey) and the Willoughby Community Plan (Township of Langley) as shown in **Figure 3.1**. The watershed itself is generally characterized by agricultural and low density residential land uses. The Clayton General Land Use Plan (GLUP) envisages Clayton to have a strong, unique community structure and identity that would be realized through the application of key sustainability principles. These principles are focussed on creating walkable neighbourhoods with a range of housing types arranged along interconnected road patterns with friendly streetscapes while preserving the natural environment. Principle No. 7 within the Clayton GLUP provides particular relevance to the ISMP process:

> "*Preserve the natural environment and promote natural drainage systems (in which storm water is held on the surface and permitted to seep naturally into the ground)."*

The Willoughby Community Plan (1998) also has an overriding principle to achieve sustainability. The concept of accommodating flexibility while maintaining responsibility to the natural environment is an important cornerstone of the Willoughby Plan.

A significant portion of the General Land Use Plan area south of the Clayton watershed has undergone detailed planning and is substantially developed (East Clayton Neighbourhood Concept Plan and extension areas). Just as the East Clayton NCP was based upon the application of important sustainable development principles, future planning within the Clayton watershed area will also be guided by a vision of sustainability. Since the adoption of the General Land Use Plan, the City of Surrey has continued to advance its sustainability goals. A new (2008) Sustainability Charter solidifies the City's commitment to place social, environmental and economic principles as the foundation for all decisions made by the City.

While this report comments on the planning context in both City of Surrey and Township of Langley, the Township of Langley may choose to adopt the recommendations of this report or provide alternative methods for managing development impacts in keeping with the requirements of the regional Liquid Waste Management Plan.

3.1 Existing Zoning and Land Use

The Clayton ISMP study area is primarily a rural community with relatively large residential lots, some parks and schools, treed areas, watercourses and agricultural activities. **Table 3.1** provides a summary of land use types and zoning in the watershed, for both Surrey and Langley. Within the City of Surrey, most of the watershed consists of One Acre Residential (RA) and General Agricultural (A-1) zoning, both within and outside of the Agricultural Land Reserve (ALR). The portion of the Clayton watershed within the Township of Langley consists largely of Suburban Residential (SR-2) zoning. Permitted non-residential uses within the SR-2 zone include agricultural uses, commercial greenhouses, and accessory buildings and uses. **Figure 3.2** shows the zoning within the Clayton ISMP study area.

Figure 3.1 Neighbourhood Plan Boundaries

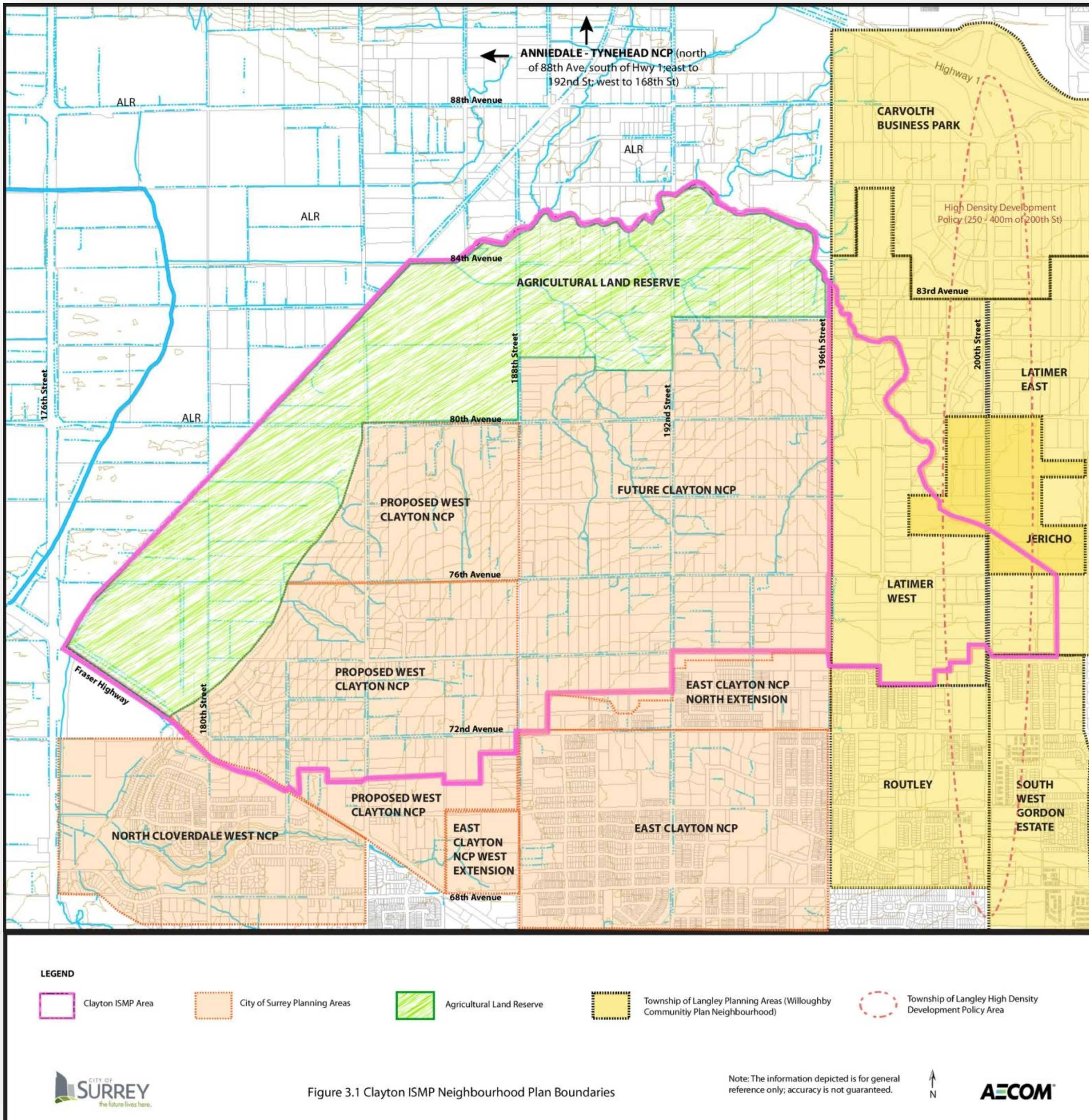


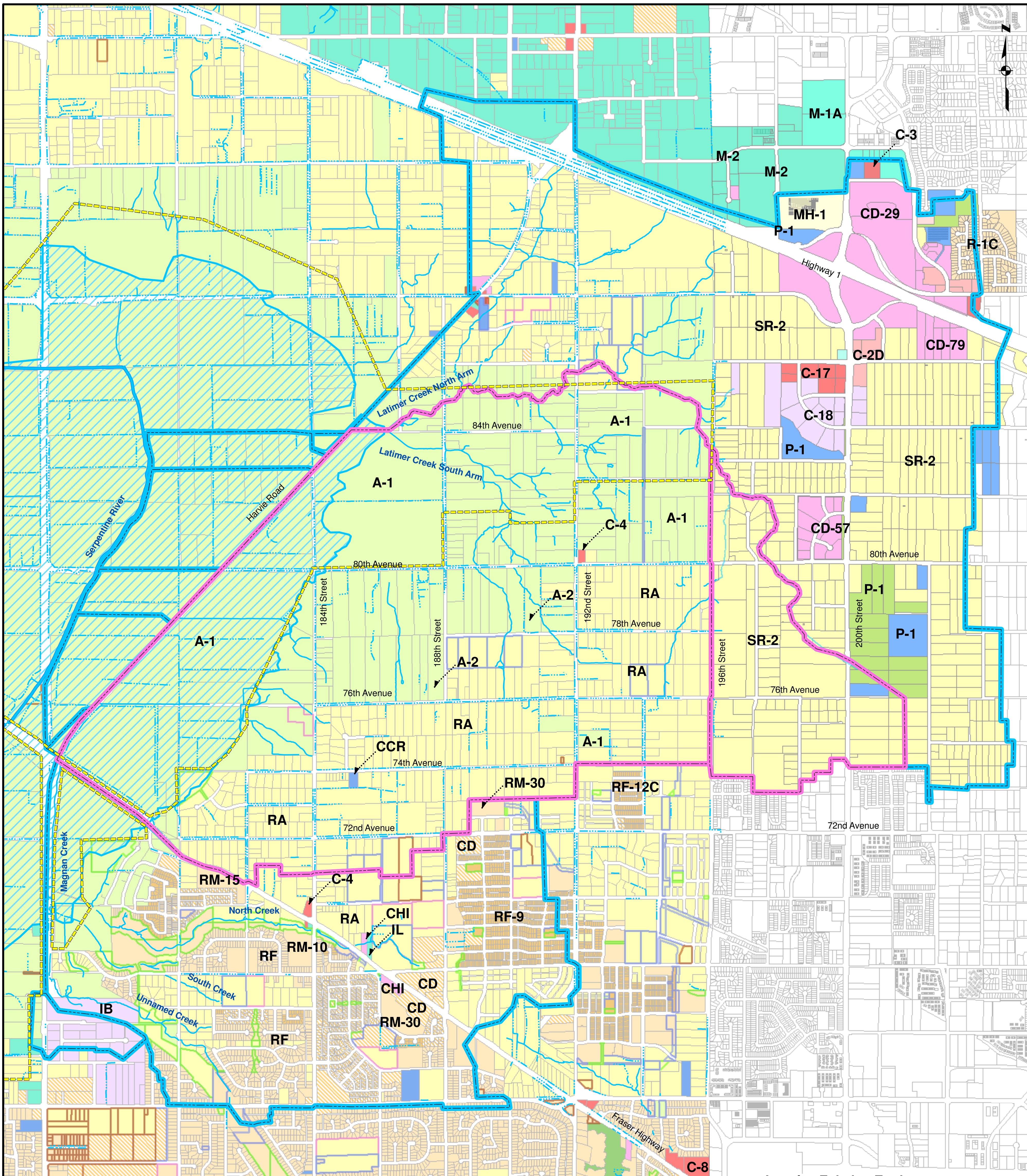
Figure 3.1 Clayton ISMP Neighbourhood Plan Boundaries

Table 3.1 Summaries of Existing Zoning and Land Use within the Clayton ISMP Study Area

Municipality	Existing Zoning	Percentage of Total Study Area
Langley	Civic Institutional Zone (P-1)	0.4%
	Suburban Residential Zone (SR-2)	12.5%
Surrey	General Agricultural Zone (A-1)	53.3%
	Intensive Agricultural Zone (A-2)	1.2%
	Local Commercial Zone (C-4)	0.0%
	Child Care Zone (CCR)	0.1%
	One-Acre Residential Zone (RA)	32.5%
TOTAL		***100%***
Municipality	**Land Use Type**	**Percentage of Total Study Area**
Langley	Civic Institutional	0.3%
	Park	0.2%
	Suburban Residential	12.5%
Surrey	Agriculture (outside of ALR)	19.4%
	Commercial	0.1%
	Institutional	0.2%
	Low Density Residential	32.5%
	Agriculture (in ALR)	34.8%
TOTAL		***100%***

Notes:

1. Surrey data is based on COSMOS data retrieved June 21, 2010
2. Langley Data is based on a Township base map from 2008, with zoning taken from Geosource July 27, 2010



Surrey Existing Zoning

- Agriculture, A-1; A-2
- Cemetary, PC
- Golf, CPG
- Commercial, C-15; C-4; C-8; CG-1
- Commercial/Industrial, CHI
- Commercial/Residential, CD
- Industrial, CG-2; I-P(2); IH; IL
- Institutional, CCR; PA-1; PA-2; RMS-1; RMS-1A
- Business Park, IB
- Low Density Residential, RA; RA-G; RH; RH-G
- Med Density Residential, R-F; RF; RF-G; RF-SD; RF-SS; RM-10; RM-15; RM-23; RM-30; RM-45; RM-70; RM-D; RS
- High Density Residential, RF-12; RF-12C; RF-9; RF-9C; RF-9S

- Study Area Boundaries
- External Catchments
- Floodplain
- ALR
- City Land
- Park - City Dedicated
- Park - City Purchased
- School

Langley Existing Zoning

- Park
- Civic Institutional, P-1
- Comprehensive Development
- Carvolth Business Park, C-18
- Service Commercial, C-3
- Carvolth Commercial, C-17
- Community Commercial
- Limited Commercial, C-8
- General Industrial, M-2
- Service Industrial, M-1A
- Service Station Zone, C-6
- Residential Mobile Home Park, MH-1
- Residential, R-1C
- Suburban Residential, SR-2

City of Surrey
Clayton ISMP

Project No: 60158414
Date: September 2010

Notes:
1. Surrey data is based on COSMOS data retrieved June 21, 2010
2. Langley Data is based on a Township base map from 2008, with zoning taken from Geosource July 27, 2010

AECOM

0 200 400 600 800 1,000 Meters

Existing Zoning

FIGURE 3.2

3.2 City of Surrey Plans and Policies

Official Community Plan

Surrey's Official Community Plan (OCP) contains a range of goals related to enhancing self-sufficiency, liveability and quality of life in the City of Surrey. The Clayton ISMP study area is designated for Agricultural and Suburban uses in the OCP. The suburban lands are generally limited to densities ranging from 5 to 10 units per hectare (2-4 upa). However, the Clayton suburban lands are identified as having potential long term development subject to land use planning with area residents. Future development in the Clayton ISMP area has the potential to contribute to all OCP policy areas, including:

- Managing growth for compact communities;
- Enhancing image and character;
- Protecting agriculture and agricultural areas;
- Protecting natural areas; and
- Improving the quality of community.

The key driver in the planning and development process is growth management. The ISMP enables growth that integrates into the watershed, protects environmental values and enhances recreational opportunities. The City of Surrey's Official Community Plan (OCP) advocates a compact and nodal development pattern.

> *"Efficient land use allows the City to continue growing while preserving open space and agricultural areas. A compact form of development contains future growth within planned areas, provides new opportunities for housing, business and mobility, and allows more efficient use of City utilities, amenities and finances. The City will strengthen the nodal development pattern of City Centre, Town Centres, Neighbourhood Centres and Workplace Areas as the framework for future growth."*

Planning and development have a key role in the economic sustainability of a city. Economic considerations and costs will be reflected in the ultimate vision and implementation of the Clayton ISMP.

Parks and natural spaces provide numerous benefits, opportunities and value to a community including: aesthetics, recreation, play space, health, habitat, tourism, gathering places, pollution abatement, microclimate regulation, and storm water management. The OCP recognizes the value of natural areas as noted below.

> *"Natural areas are to be preserved, protected and used where appropriate for park and recreational purposes. Measures are needed to reduce the impact of development on the natural environment."*

Greenhouse Gas Reduction Targets

The OCP was amended earlier in 2010 to provide targets and policies related to greenhouse gas emission reductions. The City will strive to reduce greenhouse gas emissions by 33% from 2007 levels by the year 2020 and 80% from 2007 levels by the year 2050. While targets exclude emissions from agriculture (and industrial sources), future development within the Clayton watershed can be expected to contribute to realizing these targets.

OCP Review

A major review of the OCP has been underway since 2008 and is focusing on a number of trends including a rapidly growing population, energy security and climate change, the use of green infrastructure, such as storm water best management practices, and triple bottom line accounting (considering social, economic and environmental sustainability in all decisions). Two further areas of review that may relate more particularly to Clayton include ALR buffers and density around transit corridors. The new OCP will also be aligned with other major planning initiatives such as the Sustainability Charter, Transportation Strategic Plan, and the Parks, Rec and Culture Strategic Plan. The revised OCP is tentatively scheduled for introduction to Council in the fall of 2012. The 2010 annual OCP review was completed and addressed issues such as population growth, City Centre, East Clayton, and general housing stock.

<u>Sustainability Charter</u>

Surrey adopted a Sustainability Charter in 2008. The Charter defines "Sustainability" as:

> *"Meeting the needs of the present generation in terms of socio-cultural systems, the economy and the environment while promoting a high quality of life but without compromising the ability of future generations to meet their own needs."*

The Charter identifies three Pillars of Sustainability (Socio-cultural, Economic, and Environmental), three time frames for implementing sustainable actions and processes (immediate/short- , medium- , and long-term), and three spheres of influence to achieve sustainable objectives (corporate operations, municipal jurisdiction, and external organisations). The ISMP process touches on all three pillars, but is focused more on planning in the medium-term (3 to 10 year period) to long-term (10 years or more).

In developing the Charter, stakeholders, including residents, employers and community groups, were asked to provide input to help define the goals and priorities. Key identified themes that are within the sphere of influence of the ISMP process include:

- *Raise awareness and provide education with regard to sustainability and sustainability initiatives;*
- *Provide incentives to the public to support "green" initiatives such as recycling and waste reduction, rainwater collection, urban gardens, anti-idling;*
- *Address housing affordability;*
- *Provide sidewalks, greenways, trails, bikeways, pathways and pedestrian corridors that promote interconnectedness in the community;*
- *Ensure accessibility and social inclusion for all;*
- *Protect trees, riparian areas, natural areas, and bio-diversity;*
- *Protect and support Surrey's agricultural land base and enhance food production;*
- *Protect the City's employment land base;*
- *Plan and build a beautiful city, that has a sense of place, with complete communities;*
- *Reduce energy and water consumption;*
- *Reduce the City's ecological foot print and promote and construct green buildings and building retrofit; and,*
- *Promote the elements of a child and youth friendly city, and a city that is responsive to the needs of seniors and people of all abilities.*

The Charter identifies specific goals for each of the three Pillars of Sustainability. Those within the sphere of influence of the ISMP process are shown in **Table 3.2**. Balancing the socio-cultural, environmental and economic needs and goals will be part of developing the Clayton ISMP.

Table 3.2 Select Goals of the Surrey Sustainability Charter

Pillar	Goal
Socio-Cultural Goals	Provide a range of accessible and affordable recreation services
	Promote the development of a range of affordable and appropriate housing to meet the needs of households of varying incomes and household compositions.
	Create a City that is, and is perceived as being safe and secure.
	Create neighbourhoods that have distinct identities and lively public spaces that promote social connections
	Incorporate high quality design and beauty in the public realm and built environment
	Provide opportunities for meaningful community engagement in civic issues.
Economic Goals	Protect the integrity of the City's ALR and industrial land base for food production, employment and agro-business services.
	Respect natural areas and minimize the impacts of economic activities on the environment
	Locate economic activities where they can be best serviced by a sustainable transportation network.
	Work towards a revenue base that balances commercial and residential property taxes.
Environmental Goals	1. Terrestrial Habitat and Life – Create a balance between the needs of Surrey's human population and the protection of terrestrial ecosystems, considering: a) Interconnecting Surrey and the areas outside Surrey through wildlife corridors, parks and natural areas; b) Protecting to the extent possible, existing urban forests and natural coverage, protecting trees and maximizing the City's tree canopy; and, c) Maintaining ALR farmland and promoting food self-sufficiency and production without negatively affecting existing natural areas.
	2. Water Quality / Aquatic Habitat and Life – Protect Surrey's groundwater and aquatic ecosystems for current and future generations, considering: a) Groundwater; b) Surface Water; c) Drinking water sources; d) Creeks, streams, and river systems; e) Sources of pollutants entering aquatic systems; f) Natural riparian systems; and, g) Native ocean and freshwater habitats.
	3. Air Quality – Preserve clean air for current and future generations
	4. The Built Environment – Establish a built environment that is balanced with the City's role as a good steward of the environment: a) Minimize the impacts of development on the natural environment; b) Promote the use of native plant species; c) Promote permeable surfaces where possible in new developments; d) Incorporate opportunities for natural areas and urban wildlife; e) Protect unique and valuable land forms and habitats; f) Minimize liquid waste; g) Express community environmental values in new developments

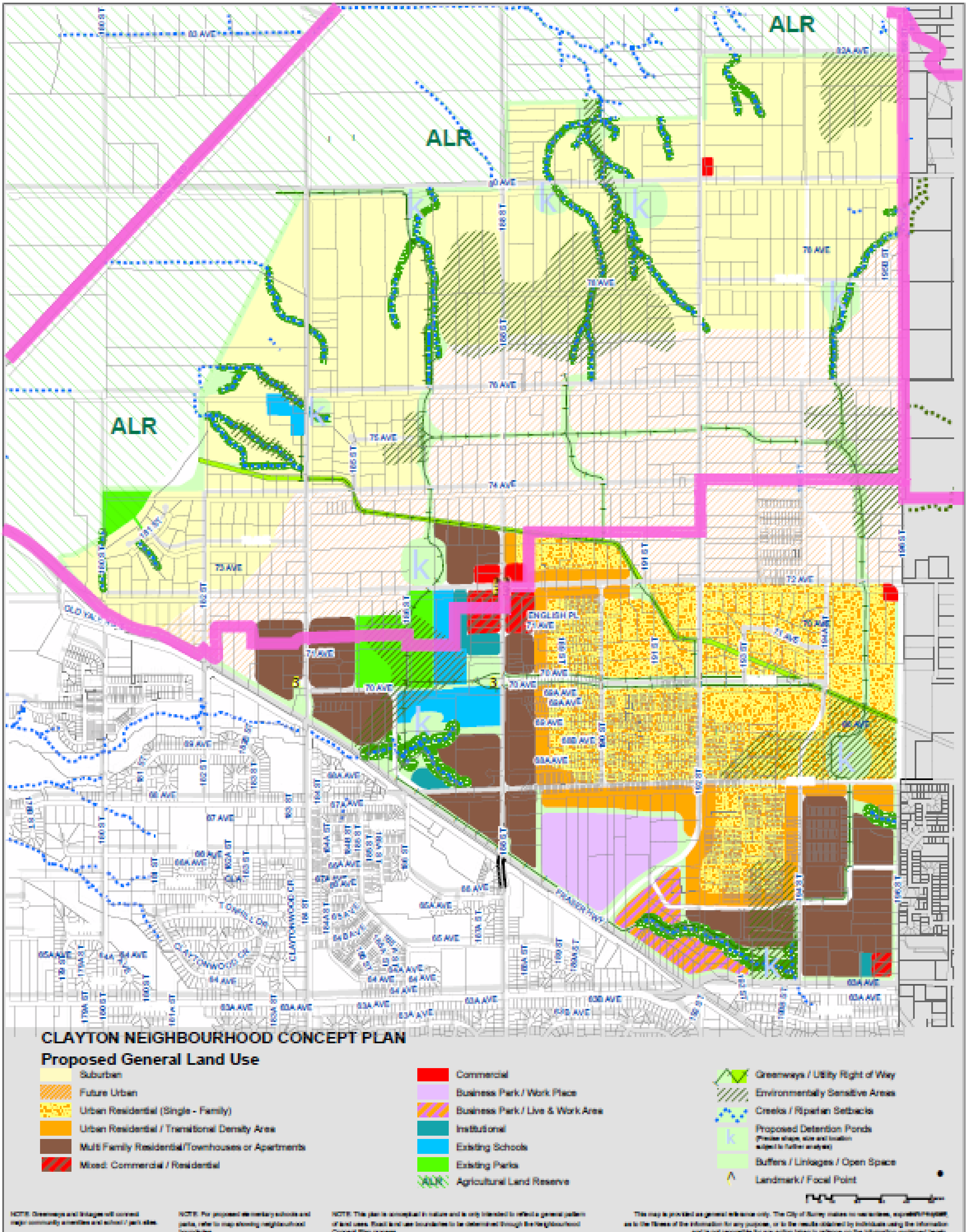
The City's ability to achieve its vision of sustainability requires the setting of targets, and the establishment of indicators with current baseline values to monitor progress toward meeting these goals. Several of the key actions outlined in the Sustainability Charter relevant to the Clayton ISMP are listed in **Appendix D**.

<u>Clayton General Land Use Plan</u> (1999)

The Clayton General Land Use Plan (GLUP) identifies Clayton as a complete community with a build-out population of 30,000 to 35,000 people. **Figure 3.3** shows the GLUP with the ISMP boundaries overlain. The General Land Use Plan provides the overall planning framework for the entire Clayton area and established the interrelationships between the various neighbourhoods within the plan area. The framework for the area is centred on a village concept (in the vicinity of 72 Avenue and 188 Street), surrounded by a range of residential, commercial, business park uses and an open space network including environmentally sensitive areas. East Clayton was to be the first neighbourhood developed, while the remainder of the area (within the current Clayton watershed study area) was to be retained in a suburban/rural condition given the (then) lack of current development interest and the desire of many residents to maintain a rural lifestyle for the medium term.

Of the eight sub neighbourhoods identified in the Clayton General Land Use Plan, five are included within the Clayton ISMP area. These neighbourhoods are identified for a range of land uses and future designations:

- Suburban (adjacent to the ALR);
- Future Urban (generally between Suburban area and south to 72 Avenue)
    - Type and form of urban development and adequate transition area between urban and permanent suburban areas would be addressed at future NCP stage;
- Schools and parks (on 184 Street and 72 Avenue);
- Proposed Detention Ponds (various locations);
- Environmentally Sensitive Areas and Creeks/Riparian Setbacks
    - Includes significant forest blocks north of 76 Avenue on both sides of 188 Street;
- Commercial
    - Three quadrants of the Village Centre at the corner of 72 Avenue and 188 Street; and
    - Small node consisting of the existing gas station and store at 192 Street and 80 Avenue.
- Multi Family Residential/Townhouses or Apartments (in the vicinity of 184 Street and on the north side of 72 Avenue, west of 188 Street).



Clayton ISMP boundary

Figure 3.3 Clayton General Land Use Plan and Watershed Boundary

Note: The information depicted is for general reference only; accuracy is not gauranteed

AECOM

East Clayton Neighbourhood Concept Plans (2003-2005)

The following East Clayton Neighbourhood Concept Plans (NCPs) provide context for future development within the Clayton ISMP area. The NCPs noted below are located adjacent to the ISMP area (see **Figure 3.1**). East Clayton is substantially built out with over 5,000 dwelling units approved/developed, and 1,200 additional units under application as of December 2009.

- *East Clayton NCP* (adopted in 2003)
  - Award-winning sustainable community, east of 188 Street, south of 72 Avenue
  - Features a range of residential, open space, school, business park and commercial uses
  - Lands adjoining the ISMP area at the southeast corner of 72 Avenue and 188 Street are designated “Commercial/residential” but are not yet developed

- *East Clayton NCP North Extension* (adopted in 2005)
  - Located north of 72 Avenue, between 188 and 196 Streets
  - Provides for residential densities ranging from 6 to 45 upa, public open space, multi-use pathways and pedestrian corridors
  - A portion of the NCP is located within the Clayton ISMP study area; these lands, along 72 Avenue are designated for commercial and residential uses and future urban landmarks.

- *East Clayton NCP West Extension* (adopted in 2005)
  - Small NCP area (45 hectares) located west of 188 Street, south of 70 Avenue;
  - Much of the plan area is occupied by the Clayton Heights Secondary School, North Creek and storm water detention facilities
  - Plan also provides for high density (22-45 units per acre) residential uses and institutional uses

Future Clayton Neighbourhood Concept Plans

The ISMP area includes lands that will be subject to future planning initiatives as described below.

- *West Clayton NCPs* (west of 188 Street)
  - On July 26, 2010, Surrey Council adopted a report which recommended commencing two NCPs in the Clayton West area.
  - Terms of Reference for these NCPs were forwarded to Council in the fall of 2010; City staff are leading these planning processes, with outside consulting assistance in specific areas.
  - While both NCPs will commence at the same time, the NCP situated to the north of 76 Avenue will proceed only to a Stage 1 approval (land use concept only), given servicing constraints.
  - New neighbourhoods at urban densities are anticipated.
  - The viability of a district energy system in the NCP will be explored.
  - A small portion of the proposed southern NCP lies outside of the ISMP study area (south of 72 Avenue, and west of 188 Street). Recommendations arising out of the ISMP may be relevant to this area as well.

- *Future Clayton NCP* (remainder of Clayton GLUP area, east of 188 Street)
  - While the ISMP will provide a framework for future planning in this area, an NCP process has not been authorized and is not expected to commence in the near future.

<u>Other Relevant Plans and Policies</u>

- *North Cloverdale West NCP* (adopted in 1996)
    - Townhouse clusters and an open space/liner/park buffer are located across from the ISMP on the south side of Fraser Highway

- *City Policy No. O-23 "Residential Buffering Adjacent to the ALR/Agricultural Boundary"*
    - Identifies a transition area of a minimum width of ¼ mile (400 metres) from the ALR/agricultural boundary and defines two sub-transition areas
    - Permits ½ acre lots within 200 metres of the ALR/agricultural boundary ("Outer Ring Transition area"), provided a row of one acre lots is proposed adjacent to the boundary
    - Permits 930 m^2 (10,000 sq. ft) lots within the Inner Ring Transition Area (between the Urban Designation boundary and the 200-metre line);
    - Requires a 37.5 metre (125 ft) separation distance between the ALR/agricultural boundary and nearest wall of principal building
    - Requires a minimum 15 metre (50 ft) wide landscaped buffer along the edge of proposed lots and the ALR/agricultural boundary
    - Requires a Restrictive Covenant registered on all lots adjacent to the boundary for the principal building setback, and to advise of agricultural practises & ensure landscaped buffer is maintained

- *Anniedale-Tynehead NCP* (in progress)
    - Proposes policies that would provide for urban cluster densities (e.g. 10-15 units per acre) adjacent to lands designated as agriculture
    - Requires the agricultural edge to be comprehensively planned to increase open space and vegetated buffers next to the ALR
    - Policies may be applicable for future planning in the Clayton ISMP area

- *Grandview Heights NCP #2/Fergus Creek ISMP* (adopted Nov 2010)
    - Hydraulic modelling identified the use of landscaped corridors (Low Impact Development) rather than detention ponds in the NCP area.
    - Detention ponds were shown not to maintain base flows to Fergus Creek and would have been located within the high density multi-family areas.
    - The ISMP called for 10% of the area to be set aside in the form of corridors ranging from 10 to 20 m in width. These corridors will be located along key existing and future roads within the NCP area.

- *Grandview Heights NCP #4/Erickson ISMP*
    - Suggests a possible combination of detention ponds and Low Impact Development (e.g. landscaping)

- *Ecosystem Management Study* (approved April 2011)
    - Provides an update to the City's environmental areas mapping as currently identified in the OCP for the purpose of identifying areas to be protected from development
    - Aims to strategically manage the ecosystems throughout the City by focusing on a City-wide Green Infrastructure Network.
    - Phase 2 will identify management guidelines and strategies to maximize the health and benefits of Surrey's green infrastructure.

3.3 Township of Langley Plans and Policies

Approximately 100 hectares (247 acres) of the Clayton watershed are located within the Willoughby Community Plan Area of the Township of Langley. While most of this area is currently characterized by suburban residential uses, it is anticipated that higher densities may be considered in the future, subject to more detailed planning. Within the 200 Street Corridor, for example, the Township is exploring densities in the range of 80 units per acre. With regards to residential densities adjacent to the ALR, Langley has generally permitted slightly higher densities than Surrey and may continue to explore further increases.

<u>Official Community Plan</u>

The Township of Langley's Official Community Plan was adopted in 1979 and sets the framework for planning in the Township, as well as for the component community plans which provide more detailed policies for specific areas of the Township (e.g. the Willoughby Community Plan). Langley, like Surrey, is a major agricultural community in the province. Approximately three-quarters of the municipality (23,784 hectares) are within the Agricultural Land Reserve. Langley's OCP protects agricultural lands within the designated Green Zone by identifying designated urban and industrial growth areas that are outside of the Green Zone. The Township supports agricultural activity and farming development in the Green Zone, while working to resolve conflicts between farm and non-farm uses.

The OCP Land Use Plan designates the majority of the Willoughby area lands within the ISMP area as an Urban Growth area. The north western portion (i.e. Carvolth Business Park plan area) is designated as an Industrial Growth area. Both the Designated Urban Growth Areas and Designated Industrial Growth Areas of the Land Use Plan are intended to provide sufficient lands to accommodate the projected growth demands for urban and industrial purposes, and thus avoid encroachment onto the ALR during the term of the OCP.

Climate Action Planning – Green Communities
The latest update to the OCP was in May 2010. This update included a Greenhouse Gas Reduction Target of 10% below 2007 levels by 2021, on a per capita basis. It also included a policy to: *"implement the Water Management Plan to ensure safe and sustainable groundwater for the community for generations to come",* which the Clayton ISMP can directly support.

<u>Sustainability Charter</u>

The Township of Langley's Sustainability Charter was adopted in 2008 and provides a high level policy framework for Council to integrate and balance competing community expectations in order to provide residents with the best quality of life. It outlines a Sustainability Vision – to build a legacy for future generations by leading and committing the community to a lifestyle that is socially, culturally, economically, and environmentally balanced – and a set of Principles, Goals and Objectives to achieve that Vision. The Charter is also considered to be an Integrated Community Sustainability Plan and emphasizes strategic planning approaches such as long-term thinking, integration, collaboration, public education, community engagement, monitoring and evaluation.

<u>Willoughby Community Plan</u>

The Clayton ISMP lands within the Township of Langley are located within the Willoughby Community Plan area (plan adopted June 11, 2001) (see previous **Figure 3.1**). Most of these lands are located within the Latimer West sub area and are designated for residential or greenbelt uses. A key aspect of the Willoughby Community Plan is achieving or maintaining some connectivity between critical green spaces to respect the natural setting. The Willoughby Community Plan also indicates that sub area plans will generally be based on storm drainage boundaries, but designed to be ultimate neighbourhoods.

A new neighbourhood planning process for Latimer West and East is expected to start later in 2010. The Willoughby Community Plan notes that areas adjacent to Clayton in Surrey are to be designed to offer compatible uses. The current residential designations of lands situated within the Clayton ISMP study area are described further below.

- "Suburban Residential": This is intended to accommodate larger country residential lots where similar housing exists or where nearby environmental constraints prevail (e.g. stream banks) or in areas of environmental sensitivity. Intended to be used as a protective measure over lands with close proximity to tributaries of Latimer Creek, this designation permits densities ranging from 2.5 to 5 units per hectare (1 -2 upa);

- "Residential Bonus 2": This permits up to 37 units per hectare (15 upa) if 36% or more land is secured for environmental features or open space amenities.

Other Willoughby sub-area neighbourhood plans, which are located adjacent to, or overlap with the Clayton ISMP area are described below.

- *Jericho Sub-Neighbourhood Plan*
  - Located on both sides of 200 Street, south of 80 Avenue
  - Small portion of Plan located within ISMP area
  - Plan received 3rd reading in July 2010
  - High density mixed-use development contemplated (e.g. up to 20 storeys) in some parts of the plan area
  - Conforms to High Density Development Policy (2008), which is described further, below
  - Storm water to be conveyed to an existing detention pond at 82 Avenue and 198 A Street
  - Full build-out will require detention pond to be built

- *Routley Neighbourhood Plan* (adopted 2001)
  - Located immediately south of the ISMP area on the east side of 196 Street, south of approximately 73 A Avenue
  - Permitted densities typically range from 15 to 25 units per hectare (6 - 10 upa)
  - Area is substantially developed

- *Carvolth Business Park Plan* (update in progress)
  - North of Clayton ISMP area
  - A process to update the Plan commenced in the spring 2010
  - Revised Plan is intended to respond to completion of the Golden Ears Bridge and a proposed new transit exchange on 202 Street
  - Township is interested in developing a more complete, mixed-use node as a gateway to Langley
  - Plan will explore Transit Oriented Development and compact residential forms

- *South West Gordon Estate* (adopted 2000, last updated in 2006)
  - This 103 hectare area (255 acres) is adjacent to the southeastern corner of the Clayton ISMP area and is bounded by 200th St. on the west and 74th Ave. on the north
  - Land in this area is largely zoned Suburban Residential (75% of the area) and Rural (25% of the area). The neighbourhood is characterized by large estate lots
  - The landscape features (predominantly the Jefferies Brook and the Escarpment) in the area are important as a defining element of neighbourhood character
  - The Jefferies Brook is an ephemeral watercourse with a main stem that runs north of 68th Ave. and is also the main focus of the natural drainage system, which is to remain protected by a riparian corridor north of 68th Ave
  - South West Gordon Estate shares sewer and water services with the Routely Neighbourhood;

- The northern half of this plan area (adjacent to the ISMP area) is dedicated to single-family housing, with bonus density provisions to implement public amenities and preserve outstanding natural features
- The majority of the Plan area continues to discharge to the 200th St. storm sewer system due to low opportunities for infiltration, particularly during the winter months, the relatively high level of development densities, and the steep slopes of the Plan area

- *North East Gordon Estate Neighbourhood Plan* (adopted 2006.)
  - Although not adjacent to the Clayton ISMP study area, the North East Gordon Estate demonstrates how the Township of Langley manages planning between urban and agricultural areas
  - The Plan designates a Development Permit Area for “Agricultural Edge and Escarpment Protection”. The DP area requires or permits:
    - dedication of a 15 metre landscaped area adjacent to the ALR boundary (or a 7.5 metre landscaped area where a road exists along the ALR boundary);
    - notifications provided on new property titles within the DP areas indicating proximity to ALR lands and the potential for sound, odour and airborne impact from natural farm activities (Surrey does this also);
    - Agricultural awareness signage to be provided advising of farm activities (Surrey has also erected signs at the entrance to agricultural areas);
    - Base density of 5 units per hectare (2 upa);
    - Densities up to 10 units per hectare (4 upa) (as per section 3.1.4C of the Willoughby Community Plan) are permitted provided that Stream setbacks, Ecological Greenways, and Urban/ALR interfaces are protected and dedicated; and
    - Alternate subdivision patterns (e.g. cluster) and housing types (e.g. duplexes) may be permitted if the above conditions are met.

<u>Other Township of Langley Plans and Policies</u>

- *Water Management Plan* (2009)
  - Provides policies and regulations to protect local groundwater resources for community use as well as to promote healthy habitat. Some key aspects of the WMP include:
    - Municipal planning initiatives to ensure that new land developments do not adversely impact groundwater availability and that new subdivisions are integrated with the WMP; and
    - Locally enforceable agricultural practices to minimize the risk of groundwater contamination.

- *High Density Development Policy* (2008)
  - Provision of high density development is consistent with overall Township objectives of creating a sustainable community by contributing to a greater range of housing choices and affordability, promoting compact neighbourhoods, and minimizing sprawl into agricultural areas.
  - Council may consider high-rise development proposals within 250-400 metres of the 200 Street Corridor, subject to more detailed community and neighbourhood planning.
  - Mid-rise residential development is considered as 5-12 storeys and 80 units per acre net.
  - High-rise residential development is defined as 12-20 storeys, greater than 80 units per acre net.
  - An adequate sized detention pond must be secured.

- *Agricultural Edge Planning*
  - The Township of Langley has been engaged in an Edge Planning Process with the Ministry of Agriculture and Lands for a number of years.
  - In the future, higher densities adjacent to the ALR may be explored. This may facilitate maintenance of ALR buffers by strata councils of multi-family development sites.

  - "Guide to Edge Planning" from the Ministry of Agriculture and Lands (June 2009 – working copy) provides additional information regarding promoting compatibility along the urban-agricultural edge (http://www.al.gov.bc.ca/resmgmt/sf/publications/823100-2_Guide_to_Edge_Planning.pdf).

- *Wildlife Habitat Conservation Strategy (2008)*
  - The strategy provides a framework for long term planning and management of wildlife habitat in the Township.
  - At the neighbourhood planning process, this will include determining patches to be protected and/or potential corridors to be connected to patches.

- *Streamside Protection Bylaw 2006 No. 448*
  - Amends the OCP to establish streamside protection and enhancement policies, guidelines and mandatory DP areas.
  - Community and neighbourhood boundaries shall be consistent with watershed or drainage catchment boundaries where feasible.
  - New plans need to have streamside protection and enhancement DP areas.

3.4 Regional Planning

Since 2007, Metro Vancouver has been working to prepare a Regional Growth Strategy (RGS) to replace the Liveable Region Strategic Plan. The RGS was adopted on July 29, 2011. Implications of the RGS on the Clayton ISMP area are summarized as follows:

- The RGS designates the Clayton watershed as "general urban" and "agricultural" (ALR lands).
  - "General Urban" refers to the developed portion of the region within the Urban Containment Boundary that will meet the region's urban development needs to the year 2040; it excludes areas within Urban Centres, Industrial and Mixed Employment areas.
  - General Urban areas include local neighbourhoods, communities, shopping areas, schools, institutions and recreation areas.
  - Residential densities in the General Urban area are generally lower than in the Urban Centres.
  - The Agricultural designation forms the urban containment boundary and is intended for agriculture and agricultural supporting services.

- Willoughby Town Centre (Township of Langley) is identified as a Regional City Centre
  - Regional City Centres are activity hubs for sub-regions within Metro Vancouver that provide large-scale, high density commercial uses, medium and high density housing forms, institutional, community and cultural services and activities serving the sub-regions.

TransLink - Transport 2040 (2008)

Transport 2040 is the long-range planning document that identifies key transportation goals up to the year 2040 for the region and sets out strategies to achieve them. The major implications for the Clayton ISMP area are outlined below.

- Proposed rapid transit (bus/rail) along 200th Street, Highway 1 and Fraser Highway as part of the regional Frequent Transit Network (FTN).
  - The FTN aims to provide frequent, reliable service on designated corridors throughout the day, every day.
  - The Frequent Transit corridors will be developed with communities through ongoing planning and consultation processes and will require agreement between TransLink and municipalities on supportive land uses to ensure success.

3.5 Planning Challenges and Opportunities

Review of land use patterns, plans and policies has identified a number of potential opportunities and challenges in the Clayton ISMP area. Some of these are outlined below..

- Jurisdiction - The Clayton watershed crosses the Surrey/Township of Langley municipal boundary. Watershed health will thus be dependent on actions on both sides of 196 Street. While findings and recommendations from the Clayton ISMP may have relevance and interest to Langley, their adherence is voluntary. Consistency across municipal borders (e.g. land use, density, watershed protection) will be an important consideration for future planning processes in both jurisdictions.

- Co-ordinating ISMP and NCP boundaries
  - A small portion of the future Clayton West NCP area is situated outside the southern boundary of the Clayton ISMP study area. It may be necessary to confirm if these lands were subject to prior storm water management review (e.g. Clayton MDP) or if further study or updating is needed as part of the West Clayton NCP process.
  - A portion of the approved East Clayton NCP North Extension (northeast corner of 188 Street and 72 Avenue) is included within the Clayton ISMP. Should the ISMP identify any potential recommendations for this area, an amendment to the existing NCP may be need to be considered.

- Enabling growth that integrates into the watershed, protects environmental values and enhances recreational opportunities; letting the landscape and environmental conditions guide land use planning.

- Protecting agricultural areas – ensuring that agriculture and agricultural activities are not negatively affected by future growth in the Clayton ISMP area. Surrey maintains a strong policy context for managing the urban/agricultural interface. Notwithstanding this, the exploration of appropriate residential densities adjacent to the ALR will need to be addressed in the Clayton ISMP area, given the long boundary with the ALR. ISMP findings will help frame the details of this discussion.

- Connecting communities and providing for compatible land uses (e.g. circulation networks, land use, wildlife corridors, place-making)
  - Connections to adjoining NCP areas, the Anniedale-Tynehead NCP, and the Township of Langley will need to be considered.
  - The Clayton ISMP study area includes three of the four corners of the major intersection of 72 Avenue and 188 Street. This intersection will serve as a key entry point to the neighbourhood and the village centre for the future Clayton NCPs. It is identified as a landmark/focal point in the Clayton General Land Use Plan.

3.6 Additional Bylaws related to the ISMP Process

3.6.1 Surrey Tree Protection Bylaw, 2006 No.16100

This bylaw defines “Significant” and “Protected” trees, how they are to be protected and managed, and a fee structure for tree cutting permits.

3.6.2 Surrey Storm water Drainage Regulation and Charges Bylaw, 2008, No. 16610

This bylaw is to *"regulate extensions, connections, and use of the storm water drainage system, to impose connection charges to the storm water drainage system and to prohibit the fouling, obstructing, or impeding the flow of any stream, creek, waterway, watercourse, ditch, or storm water drainage system."*

Part 5 of the bylaw describes the on-site storm water management requirements. These facilities are required on newly created parcels where prescribed by NCPs, Master Drainage Plans, ISMPs, Servicing Agreements or specific Service Connections. The property owner is required to maintain and ensure accessibility to the facilities. Commercial and industrial properties are required to submit maintenance and operation reports to the City with applications for new/renewed business licences.

Part 7 of the bylaw includes the requirement that grease, oil and sand interceptors are to be provided on the building drains for all industrial, commercial and multi-family sites, and are required on other businesses as required by the General Manager of Engineering. Maintenance of these interceptors is at the owner's expense; however specific maintenance requirements and proof of maintenance are at the discretion of the General Manager of Engineering.

Part 8 of the bylaw defines prohibited waste from all parts of the drainage system as those defined in the BC *Environmental Management Act,* sediment or sediment-laden water as outlined in the City's *Erosion and Sediment Control* by-law, any substance of sufficient quantity to be a safety hazard to a property, person or any life form, and any item that contravenes the *Fisheries Act*. This part of the bylaw also prohibits discharge of storm water to the sanitary sewerage system.

Every property owner with a service connection is required to allow the General Manager of Engineering (or representative) to enter the property to inspect and test the service connection and plumbing system for quantity and nature of the water being discharged. The owner may be required to sample and analyse the discharge at their own expense.

Accidental spills or discharges must be reported to the City, countermeasures and damage minimization and clean-up (as well as associated costs) are the responsibility of the property owner or responsible persons.

Part 9 outlines charges levied for new drainage service connections and the requirement to pay a drainage parcel tax as established in the *Drainage Parcel Tax* bylaw.

3.6.3 Erosion and Sediment Control By-law 2006 No. 16138

The Erosion and Sediment Control By-Law "*is to ensure that adequate protection of the City of Surrey drainage system is taken during any construction, by the implementation of erosion and sediment control measures."*

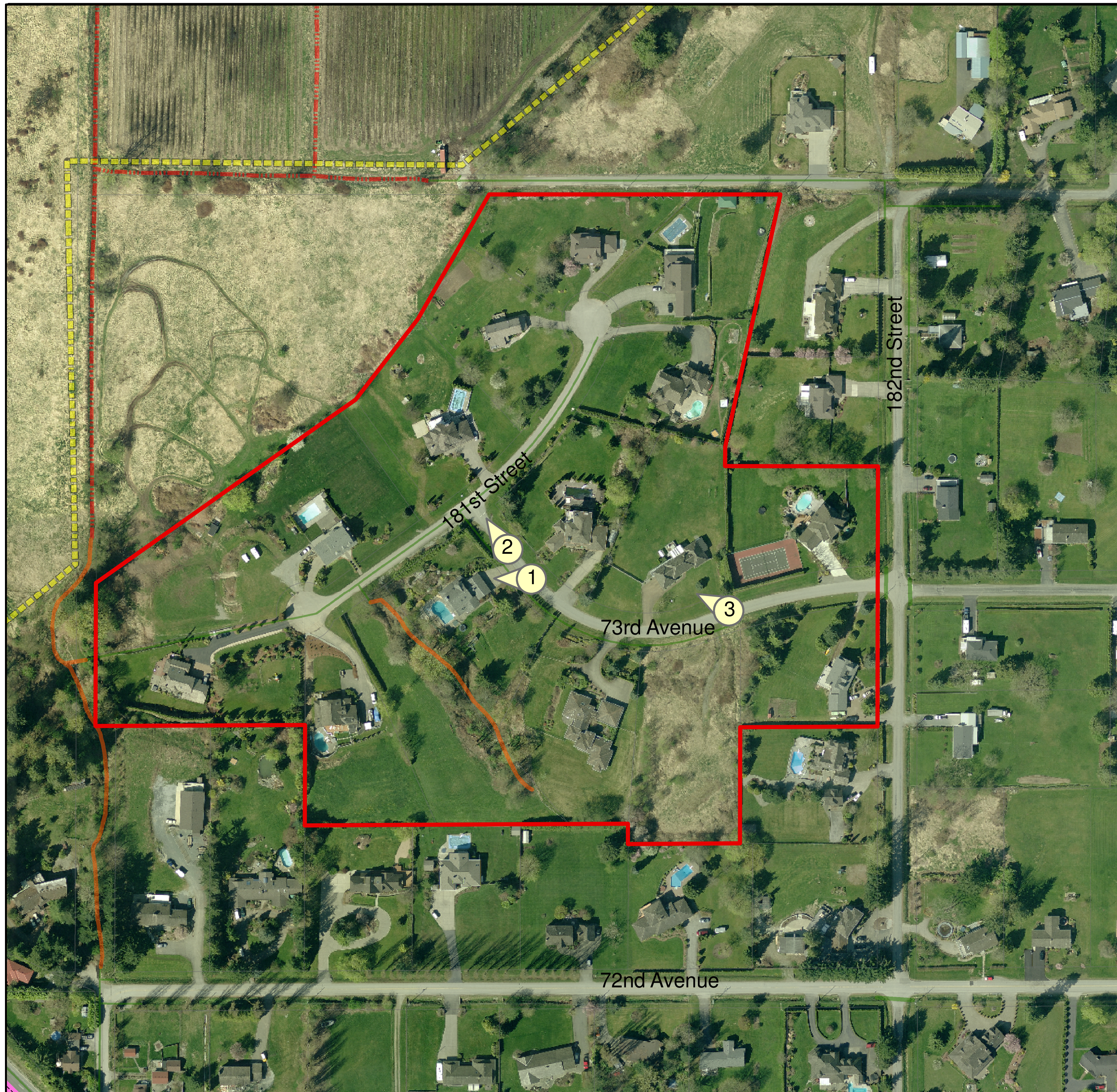
The maximum allowable TSS level for discharge to the drainage network from a construction site is 75mg/L.

3.6.4 Drainage Parcel Tax By-law, 2001, No. 14593

The Drainage Parcel Tax By-Law establishes the per parcel rate payable by property owners.

3.7 Land Use and Imperviousness

The Clayton Watershed Vision will allow the City to create a framework of rules and policies to preserve and enhance the Clayton watershed in accordance with the requirements outlined within the OCP and the future NCP. Land use type affects the level of imperviousness within a watershed, which in turn affects the volume, rate and quality of storm water run-off. A variety of existing land use types from within or adjacent to the Clayton ISMP study area are shown in **Figures 3.4 to 3.6**. As we identify areas for future development, we will need to address the resulting imperviousness and its impact on storm water run-off.



1

2

3

Zoning: RA - Non Strata, One and Two Family Dwellings

Number of Units: 15

Area: 22 acres

Units per Acre: 0.7

Average Floor Area (ft2) / Unit 4200 ft2

Imperviousness: 22%

CITY OF SURREY
the future lives here.

City of Surrey

Clayton ISMP

Legend

- Imperv Study Area
- ALR
- Culvert
- Forcemain
- Gravity
- Perforated
- Stub
- Proposed
- Abandoned
- History, Gravity

Watercourse Classification Drainage

- A
- AO
- B

AECOM

0 25 50 100 150
Meters

Project No.	Date
60158414	June 2012

Land Use and Imperviousness

Figure 3.4

Zoning: CD - Strata, Townhomes / Home Business.

Number of Units: 66

Area: 4.2 acres

Units per Acre: 16

Average Floor Area (ft2) / Unit 1600 ft2

Imperviousness: 83%

1

2

3

4

5

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City of Surrey
Clayton ISMP

Imperv Study Area
ALR
Culvert
Forcemain
Gravity
Perforated
Stub
Proposed
Abandoned
History, Gravity

Watercourse Classification Drainage

A
AO
B
C

AECOM

0 5 10 20 30 40
Meters

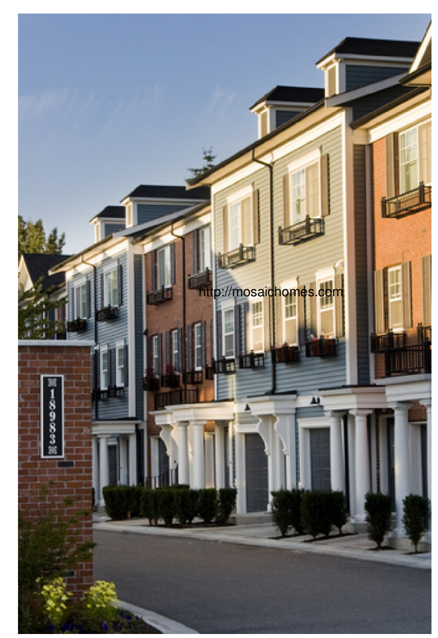
Project No.	Date
60158414	June 2012

Land Use and Imperviousness

Figure 3.5

1

2



3

Zoning:	RM-30 - Strata
Number of Units:	100
Area:	4.8 acres
Units per Acre:	21
Average Floor Area (ft2) / Unit	UNKNOWN
Imperviousness:	59%

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City of Surrey
Clayton ISMP

Legend
- Imperv Study Area
- ALR
- Culvert
- Forcemain
- Gravity
- Perforated
- Stub
- Proposed
- Abandoned
- History, Gravity

Watercourse Classification Drainage
- A
- AO
- B
- C

AECOM

0 10 20 40 60 80
Meters

Project No.	Date
60158414	June 2012

Land Use and Imperviousness

Figure 3.6

4. Soil and Groundwater

The Clayton ISMP study area is located in the Clayton Uplands/Willoughby Heights area of Surrey and Langley and bordered by Harvie Road, Fraser Highway, East Clayton NCP, and Latimer Creek. The study area is largely contained within the uplands area; however, a portion of the ISMP area is within the lowlands which form the Serpentine floodplain. The uplands are crossed by streams which originate in the uplands and discharge to the lowlands; some are tributaries to Latimer Creek, while others on the west side of the escarpment discharge to lowland ditches and ultimately the Fry's Corner Pump Station.

The soils, geology and hydrogeology of the Clayton area has been mapped and described previously in several studies including: *Soils of the Langley-Vancouver map area* (BC MOE 1980); Geological Survey sheet 92g2; *Comprehensive Groundwater Modelling Assignment for Township of Langley* (Golder, 2003); *The Quaternary Stratigraphy and History of South Central British Columbia* (Clague, 1994); *British Columbia (Quaternary Stratigraphy and History, Cordilleran Ice Sheet)* (Ryder and Clague, 1989); *Vashon Drift: definition of the formation in the Georgia Depression, Southwest British Columbia* (Hicock and Armstrong, 1985); *2009 Ravine Stability Assessment* (Web, 2009); and, *Hydrogeological Assessment for the Clayton Neighbourhood Concept Plan* (Dillon, 1997). These resources were consulted and provide the background material for this report chapter.

4.1 Surface Soils

Surficial soils are a key component of the hydrologic cycle. They form the interface between sky and ground, rainfall and infiltration/runoff. Soil is not a homogeneous material. It is composed of various mineral and organic components that may or may not be distributed and organised into vertical and horizontal patterns. The soil components and their distribution is a function of parent geological materials, topography, climate, biology, and geologic history.

An understanding of the surficial soils is important to developing knowledge of the watershed and its operation under a range of conditions. A review of the surficial soils was undertaken to establish an understanding of the potential engineering constraints relating to drainage and possible infiltration as it relates to storm water management BMPs.

The climatic and biological factors in soil development are the normal forces of change. The surface soils found within the study area have been highly disturbed from their pre-development state. In the uplands area, logging, farming, and most recently, urban development, have all had an impact on the soils and their ongoing formation processes.

The upland area soils are of glaciomarine origin of moderately finely textured material; while the lowland area soils are of marine, floodplain, or deltaic origin with a large organic component. Upon these primary characteristics was imposed the effect of a humid and temperate climate. The large but unevenly distributed rainfall, together with moderately high temperatures and long growing season, combined to produce forest cover typical of the coastal western hemlock forest zone. The uplands supported a heavy forest of Douglas Fir and Western hemlock. In wetter soil locations and where seepage occurred, the Western red cedar was abundant. The lowlands were frequently inundated with salt and freshwater creating flood tolerant vegetation zones.

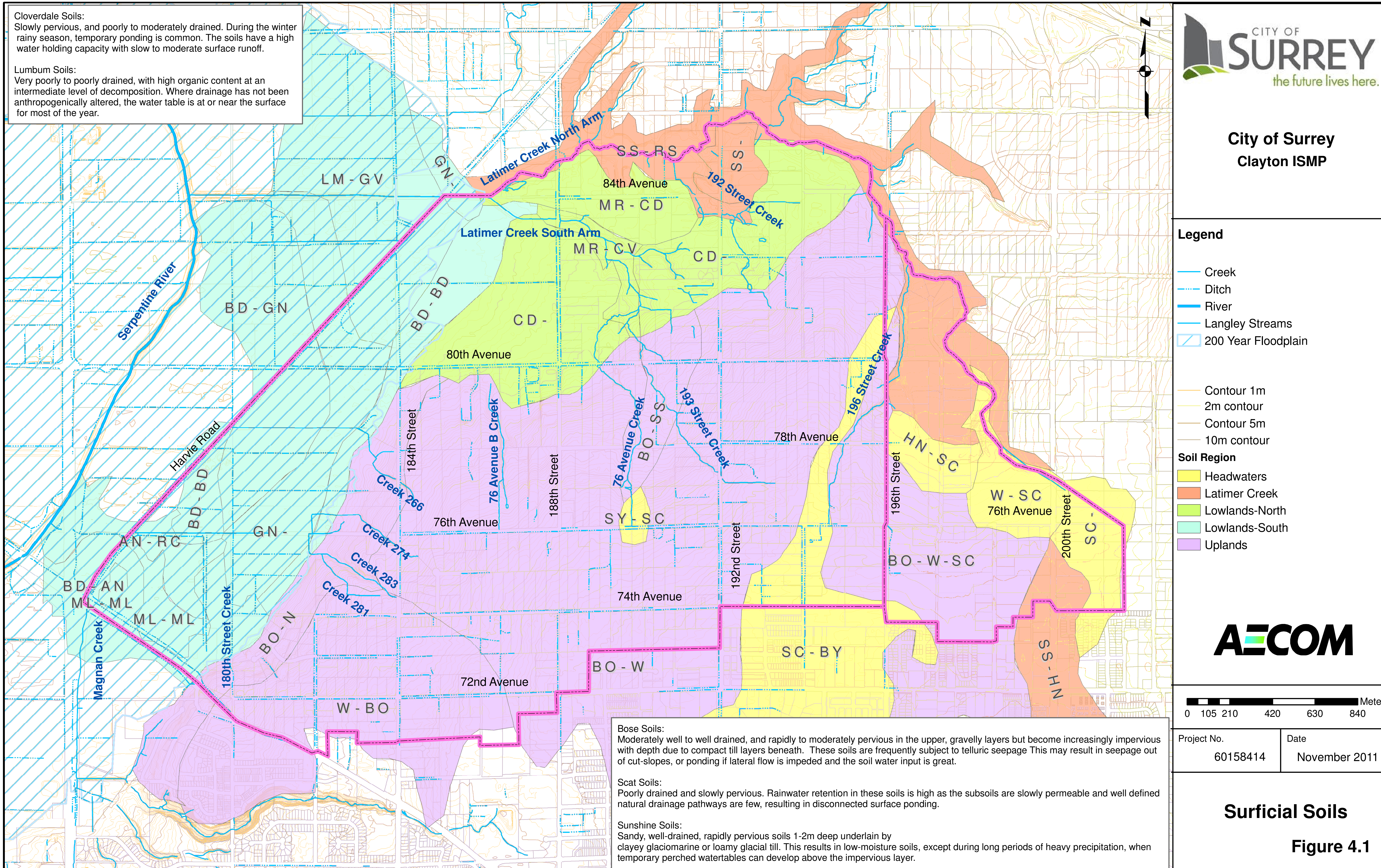
Since the onset of urban development there has been a pattern of removal of large contiguous portions of the organic soil horizon combined with the replacement of the native vegetation with species more desirable in a rural-residential setting. The lowlands have been altered by agriculture and flood management. The long term soil genesis under these conditions will ultimately result in soil types that are far different than those found during pre-development conditions.

Surface soils in the ISMP study area are shown in **Figure 4.1** and summarised in **Table 4.1**. The soils can be loosely grouped into five regions characterised by a common soil: Uplands (Bose); Headwaters (Scat); Latimer Creek (Sunshine), Lowlands-North (Cloverdale); and, Lowlands-South (Banford). The Upland area soils, as typified by the Bose group, are moderately well to well drained (i.e. the upper meter of soil is not saturated for long durations), and rapidly to moderately pervious in the upper, gravelly layers but become increasingly impervious with depth due to compact till layers beneath. These soils are frequently subject to telluric seepage: the lateral flow of soil water due to more impervious horizontal layers in the soil profile. This may result in seepage out of cut-slopes, or ponding if lateral flow is impeded and the soil water input is great. The soils of the Bose group are classified using the Canadian System of Soil Classification (CSSC) as Duric Ferro-Humic Podzols, and are approximately 0.5 to 1m depth (Dillon, 1997).

The Scat soil group of the headwater area is poorly drained (i.e. saturated for long durations) and slowly pervious. Rainwater retention in these soils is high as the subsoils are slowly permeable and well defined natural drainage pathways are few, resulting in disconnected surface ponding. The Scat soils are Orthic Humic Gelysols.

The Sunshine soil group immediately adjacent to Latimer Creek is sandy, well-drained, rapidly pervious soils 1-2m deep underlain by clayey glaciomarine or loamy glacial till. This results in low-moisture soils, except during long periods of heavy precipitation, when temporary perched watertables can develop above the impervious layer. Therefore, wetlands would not be expected in this area. The Sunshine soils are classified as Orthic Ferro-Humic Podzols.

The lowlands are located in the Agricultural Land Reserve and are typified by the Cloverdale group in the north, and the Lumbum group in the south. The Cloverdale group soils are slowly pervious, and poorly to moderately drained. During the winter rainy season, temporary ponding is common. The soils have a high water holding capacity with slow to moderate surface runoff. The Lumbum group is very poorly to poorly drained, with high organic content at an intermediate level of decomposition. Where drainage has not been anthropogenically altered, the water table is at or near the surface for most of the year. This is consistent with the poor drainage reported in this area. The Cloverdale soils are classified as Humic Luvic Gleysol, while the Banford soils are Terric Humisols.



City of Surrey
Clayton ISMP

Surficial Soils

Figure 4.1

Table 4.1 CLAYTON ISMP Study Area Soil Types

	Soil Name	Symbol	Soil Material	Drainage	Classification
Uplands	**Bose**	**Bo**	30-160cm 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	Duric Ferro-Humic Podzol
	Whatcom	W	Moderately fine textured glaciomarine deposits	Moderately well; telluric seepage	Luvisolic Humo-Ferric Podzol
	Nicholson	N	Moderately fine textured glaciomarine deposits	Moderately well	Podzolic Gray Luvisol
Headwaters	**Scat**	**SC**	Moderately fine textured glaciomarine deposits	Poor, perched water table	Orthic Humic Gleysol
	Seymour	SY	Coarse-textured alluvial deposits	Imperfect; telluric seepage; fluctuating water table	Gleyed Humo-Ferric Podzol
	Heron	HN	Coarse-textured littoral deposits over moderately coarse textured glacial till or moderately fine textured glaciomarine deposits	Poor, perched water table	Rego Gleysol
	Whatcom	W	Moderately fine textured glaciomarine deposits	Moderately well; telluric seepage	Luvisolic Humo-Ferric Podzol
Latimer Creek	**Sunshine**	**SS**	Sandy littoral and glacial outwash deposits	Well to moderately well	Orthic Ferro-Humic Podzol
	Ross	RS	Medium to moderately fine textured local stream deposits	Very poor; subject to flooding	Rego Gleysol
	Whatcom	W	Moderately fine textured glaciomarine deposits	Moderately well; telluric seepage	Luvisolic Humo-Ferric Podzol
	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
Lowlands-North	**Cloverdale**	**CD**	Moderately fine to fine-textured marine deposits	Poor, perched water table	Humic Luvic Gleysol
	Milner	MR	Fine to moderately fine-textured marine deposits	Moderately well	Luvisolic Humo-Ferric Podzol
	Carvolth	CV	Moderately fine textured local stream deposits	poor to very poor; perched water table, susceptible to flooding	Rego Humic Gleysol
Lowlands-South	**Banford**	**BD**	40 to160cm of well-decomposed organic material over medium and moderately fine textured floodplain deposits	Poor to very poor; high groundwater table	Terric Humisol
	Gibson	GN	40 to 160cm of partially decomposed organic material over floodplain deposits	Very poor; high groundwater table	Terric Mesisol
	Lumbum	LM	More than 160cm of partially decomposed organic material	Very poor; high groundwater table	Typic Messisol
	Glen Valley	GV	more than 160cm of partially undecomposed organic material, mainly reeds, sedges and grasses	Very poor; high groundwater table	Typic Fibrisol
	Annis	AN	15 to 40cm of organic material over moderately fine textured floodplain deposits	Poor to very poor; high groundwater table	R. Gp
	Richmond	RC	40 to 160cm of well-decomposed organic material over moderately fine textured deltaic deposits	Very poor; high groundwater table	Terric Humisol
	McLellan	ML	Fine to moderately fine-textured, mixed deltaic and floodplain deposits	Poor to moderately poor; high groundwater table	Orthic Gleysol

The soil names listed in **Table 4.1** are typically used to aid in describing the soil type without undue use of the more rigorous system established in the Canadian System of Soil Classification (CSSC). Use of the CSSC descriptors and review of the underlying soil formation processes will allow us to more fully understand the physical properties of the soils. The often missed information is the correlation of the common soil name with the more precise soil descriptor that defines the sequence and depths of the soil layers or horizons. Of particular importance are the chemical and physical characteristics that are associated with the soil horizon.

The numerous identified soils can be grouped into four (4) soil orders that, by definition, describe the physical and chemical properties in the soils as they evolved in response to climatic and biologic influences. These include the Podzols, Gleysols, Luvisols and Organics.

4.1.1 Podzols

The Podzol soils have developed under the influence of a coniferous forest. A major factor in soil genesis is the midsummer drought in July and August, which brings about dehydration and chemical precipitation processes, an upward movement of water and a slight decrease in the acidity of the soil. Chemical precipitation centres in the formation of numerous iron concretions, which have the appearance of small rusty gravel, in the first foot or more of the soil horizon. The pellets of iron oxide thus formed absorb and hold substantial amounts of other minerals.

Although the trees shed a large amount of organic material the accumulation on the ground is seldom more than one or two inches thick. Decomposition is very rapid, but only a very small amount of organic matter becomes intermixed with the mineral soil below.

The colours of the zonal soils beneath the layer of forest litter range from reddish brown to yellowish brown. The reddish brown colour is due to unhydrated iron oxide (hematite). The entire weathered layer or solum of the azonal soils seldom extends beyond a depth of two or two and a half feet. Below this layer the parent materials are generally grey, mottled with grey or rusty brown, or bluish grey depending on whether the drainage is good, restricted or poor.

The majority of the surface soils within the ISMP study area that are outside of the ALR are either Ferro-Humic Podzols (FHP) or Humo-Ferric Podzols (HFP). As described above these soils have developed under a coniferous forest cover. The Humo-Ferric Podzol (HFP) with the typical soil horizon sequencing of a leaf litter LFH, a lightly coloured eluviated Ae, a podzolic Bf with an accumulation of material, elevated iron content, and is coarser than clay, and overly a BC and C parent material. The Bf horizon of an Orthic HFP/FHP soil may be cemented but not as strongly as in the Duric HFP/FHP soils. These soils would tend to be well drained but may have some resistance to flow resulting from the cemented Bf horizon. A Luvisolic HFP may have mottles that indicate gleying at depth. A Gleyed HFP has distinct mottles within 1m of the surface, which indicates extended periods of soil saturation. The common descriptive names included within this soil series include Bose, Sunshine, Seymour, Milner and Whatcom.

4.1.2 Gleysols

A Gleysol is a soil that has experienced extended durations of saturation under anoxic conditions. The most significant feature is the lowest soil horizon, or layer, the Cg which exhibits gray colours, prominent mottling, or both, indicative of permanent or periodic intense reduction, characterize the Cg horizon resulting from extended periods of saturation. The saturation can be the result of poor drainage combined with low infiltration rates, or groundwater discharge. The common names associated with these characteristics include Scat, Heron, Ross, Cloverdale, Carvolth, and McLellan soils.

4.1.3 Luvisols

Development conditions for these soils include well to imperfectly drained sites in sandy loam to clay. The Luvisol soils have developed under the influence of a coniferous, deciduous, or mixed forest in humid climates Luvisols have a distinctive Bt horizon which has an clay content higher than the horizon above. Suspended clay from the surface has been transported downwards in the soil column. It becomes deposited at depth where percolation becomes slow due to the increasing clay concentration. The common names associated with these characteristics include Nicholson and Whatcom soils

4.1.4 Organics

Soils of the Organic order include Fibrosol, Mesisol and Humisol great groups. These soils are characterised by a lack of defined mineral layer (A,B,C horizon). Most organic soils are located in areas with poor to very poor drainage and may be saturated for extended periods. The organic source material is derived from vegetation growing in-situ. The soils within the south lowlands portion of the study area are of the Organic soil order.

4.2 Geology

Geology refers to the mineral layers that are found below the soil profile. The ground profile typically consists of three layers. At the surface is the soil profile, below that is the unconsolidated mineral deposits (also known as the quaternary or surficial geology), and below both of these are the bedrock layers.

4.2.1 Bedrock

The bedrock of the ISMP study area is similar to that found across the Fraser River delta area and is known as the Kitsilano formation. This formation consists of undivided sedimentary rocks including conglomerates, sandstones, and shales with thin lignite, with igneous inclusions consisting of lesser basalt flows, sills and minor pyroclastics. The formation is of Eocene age, which is younger than the adjacent formations.

4.2.2 Surficial Geology (Unconsolidated Deposits)

As shown in **Figure 4.2**, two quaternary deposits dominate the upland areas of the ISMP study area: Vashon Drift and Capilano. The Vashon Drift sediments are associated with the most recent ice sheet glaciation period known as the Fraser glaciation, which began approximately 29,000 year before present (BP) and lasted until approximately 10,000 BP (Ryder and Clague, 1989). Vashon drift sediments comprising silty sand till and sandy/gravelly glacio-fluvial and glacio-lacustrine sediments were deposited in the area via direct glacial runoff or in-situ directly from the ice (Hicock and Armstrong, 1985). As the glaciers began to retreat under warming weather after 15,000 BP, Capilano Sediments consisting of glacio-fluvial, glacio-marine and marine sediments were deposited in the region when the relative sea level was higher than present.

The Capilano deposits of the ISMP area, found in the upper elevations are classified as *Cd*, with smaller areas of *Cb*, and are defined by the Geological Survey of Canada (GSC) as defined below.

Cd: Marine and glaciomarine stony (including till-like deposits) to stoneless silt loam to clay loam with minor sand and silt normally less than 3 m thick but up to 30m thick containing marine shells. These deposits thicken from west to east. This unit may form an aquitard layer above the lower Clayton Upland aquifer (Dillon, 1997).

Cb: Raised beach medium to coarse sand 1 to 5m thick containing fossil marine shell casts. This unit may represent an important recharge area for the underlying, lower Clayton Upland aquifer (Dillon, 1997).

Along the hillslopes dividing the upland from the lowland areas, Vashon Drift deposits are exposed. Well logs from the upland area indicate that the bottom of this layer may persist below sea-level and that the drift is overlain by Ce sediments near the base of the Upland slopes (Dillon, 1997). The Vashon Drift deposits form permeable, groundwater transmitting layers, and are defined below.

> *Va*: Lodgement till (with sandy loam matrix) and minor flow till containing lenses and interbeds of glaciolacustrine laminated stony silt.
>
> *Vb*: Glaciofluvial sandy gravel and gravelly sand outwash and ice-contact deposits.

At the base of the hillslopes, Capilano, *Ce,* sediments are exposed. These are defined as:

> *Ce:* Mainly marine silt loam to clay loam with minor sand, silt, and stony glaciomarine materials Up to 60+m thick.

The postglacial sediments found in the lowlands of the Serpentine River floodplain are known as the Salish sediments and are defined as lowland peat up to 14m thick overlying Fraser River Sediments in some areas.

4.3 Slope Stability

Preliminary reviews for slope stability were conducted by Dillon and documented in the report titled, *Hydrogeological Assessment for the Clayton Neighbourhood Concept Plan* (1997). Recommendations for preliminary development planning included in the report are listed below.

1. Construction setbacks should be established by calculating the horizontal distance from the toe of the stream gully/channel slope as a distance of 4H:1V. Detailed site investigations by a qualified geotechnical engineer are recommended as part of any detailed planning or construction approval process.

2. Riparian areas should be retained to minimize erosion of stream banks.

3. Storm sewer outfalls should be designed such that flow rates and water depths are minimized through the gullied portions of stream channels.

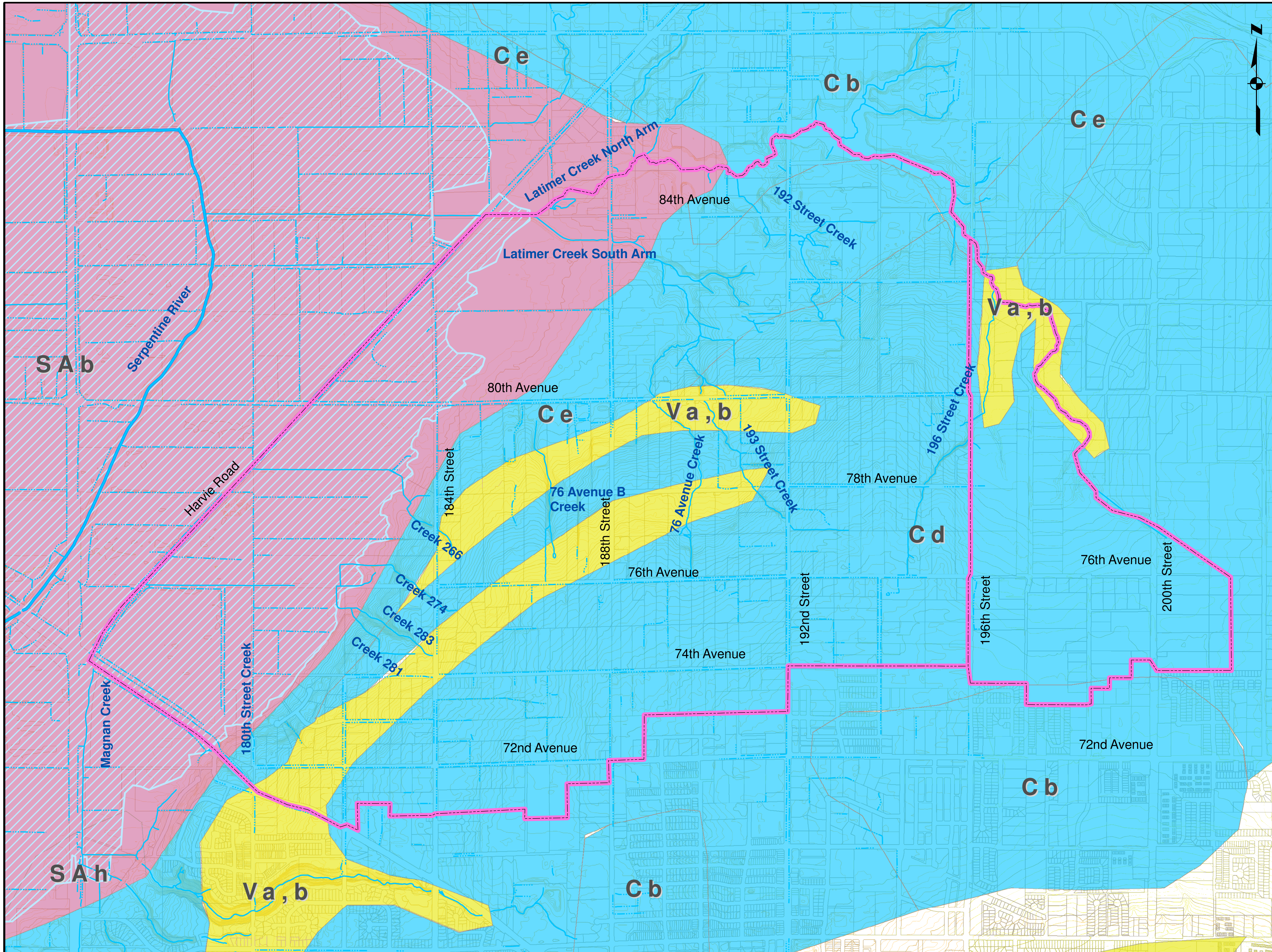
A city-wide ravine stability assessment was carried out by Web Engineering in 2009. Field Investigations were conducted on specified creeks and instability issues were identified where any of the following was an issue: erosion; bank instability; exposed pipe; failing or damaged headwall; damaged or plugged culvert; debris accumulation; and/or, damaged erosion protection works. A composite risk level was assigned to each identified issue based on a risk matrix of probability, consequence and cost to mitigate. Overall Risk is defined as follows:

- High Risk: Likely or immediate risk (within 1 year) to public safety or damage to structures or infrastructure.

- Medium Risk: No anticipated risk to structures and no significant risk to public safety, but increasing risk may develop over time (beyond 1 year). May involve some impact to yard area, but no immediate risk to structures.

- Low Risk: Minimal risk of impact to private property or public safety in the near or foreseeable future.

Five creeks in the ISMP study area were included in this study. A summary of the findings for these creeks is included in **Table 4.2.**



City of Surrey
Clayton ISMP

Legend

- Study Area Boundaries
- Creek
- Ditch
- River
- Langley Streams
- 200 Year Floodplain
- Contour 1m
- 2m contour
- Contour 5m
- 10m contour
- Capilano Sediments
- Salish Sediments
- Vashon Sediments
- Vashon and Capilano Sediments

AECOM

0 105 210 420 630 840 Meters

Project No.	Date
60158414	November 2011

Surficial Geology

Figure 4.2

Table 4.2 2009 Ravine Stability Assessment Summary

Creek	Number of Sites	2009 Risk Level	Type
Latimer Creek	No instability Sites Identified		
76 Avenue B Creek	3	Low (3)	Erosion on Vegetated Bank (2) Erosion on Bank (1)
76 Avenue Creek	5	Low (5)	Erosion on Vegetated Bank (2) Erosion (not recent) on Vegetated Bank (2) Undermining Tree. No increase in erosion since 2007 assessment. (1)
193 Street Creek	13	Low (13)	Erosion on Vegetated Bank (4) Active Erosion Evident (4) Culvert Inlet, new house near site(1) Erosion, (not recent) (1) Erosion (not recent) on Vegetated Bank (1) Abutment of private bridge undermined (1) Undermining Trees (1)
196 Street Creek	12	Low (12)	Erosion, no change in status (11) Man-made dam, culvert installation (1)

4.4 Hydrogeology

The hydrogeology of the ISMP study area has been described previously by Dillon in the 1997 report titled, *Hydrogeological Assessment for the Clayton Neighbourhood Concept Plan,* and by AECOM in the 1999 Phase 1 and 2004 Phase 2 reports titled, *Surrey Ground Water Supply Study*. A summary of the findings from these reports is included below.

The ISMP study area has been found to include an upland groundwater recharge area, a lowland discharge area, and, at least three aquifers. These aquifers are known as the Upper Clayton Upland aquifer, the Lower Clayton Upland aquifer (also known as the Pre-Semiahmoo aquifer), and the Pre-Westlynn aquifer. Well records for the area show depths to range considerably from 4-8m to as deep as 100m, while well yields ranged in capacity from 0.6 to 250 gpm. Artesian (free flowing) wells are found throughout the lowland areas; however, few are in use today.

Figure 4.3 shows a copy of the schematic profile provided in the *Assessment*. In this schematic, 4 general units have been identified and are described below from the surface, downwards.

1. Thin, relatively well drained sediment layer 1-2m thick, composed of geologic unit Ce and Bose/Whatcom soils which form an unconfined, near-surface, aquifer in many of the upland areas. This unit supplies shallow wells in the area. Portions of this unit may dry out in summer; but above 20m elevation, the unit contributes base flows to streams on a year-round basis. The velocity of groundwater in this unit is estimated to be 50-100 m/month.

2. Thick, upper silty cap of geologic unit Ce sediments which thin towards the east. This is an aquitard layer that does permit some downwards percolation. It confines the aquifer below, generating artesian (free flowing) wells in the lowland area. Where this unit is thin or absent (eastern portions of the study area), important groundwater recharge areas are found. These are generally located in the Willoughby area of Langley.

3. A moderately extensive deep regional aquifer unit composed of hydraulically interconnected sand and gravel units. There is a high degree of variation in the substrate and definitive boundaries are not possible to delineate. It is possible to identify a consistent northwest gradient with a minor flow gradient to the southeast. The estimated travel time for groundwater entering the significant recharge areas in Langley and discharging to the west via the deep aquifer is 90-150 years.

4. Silty clay aquitard unit.

The report recommends identifying groundwater seepage areas in the upland area as these springs provide baseflows for the numerous creeks. Development and drainage planning for these areas should ensure that these sources are maintained.

The report estimates that developing this area without infiltration compensation could reduce aquifer recharge by as much as 20-40%. It was then estimated that this could result in a 40-60% reduction in creek base flows. Infiltration should be a key component of the storm water management for this area.

The small scale surficial geology map shows the deep aquifer recharge areas to be just outside of the ISMP study area, while large areas of the uplands within the ISMP study area are underlain by a generally impervious cap which sits above the aquifer. A shallow, unconfined aquifer would be expected above this impervious layer, which retains moisture for slow release. Evidence of this shallow aquifer was seen in the fact that vegetated upland ditches and watercourses, which were empty, remained green despite the lack of rain and surface flow.

4.5 Base Flows

Site visits were conducted on August 3rd and 4th, 2010. The weather over the preceding month had been hot and dry with an unusually low amount of precipitation. From June 12th to August 2nd, the Port Kells rain gauge recorded only 4mm of precipitation occurring over 4 days. **Figure 4.4** identifies site visit locations where no flow, stagnant flow and base flow were found in ditches and watercourses.

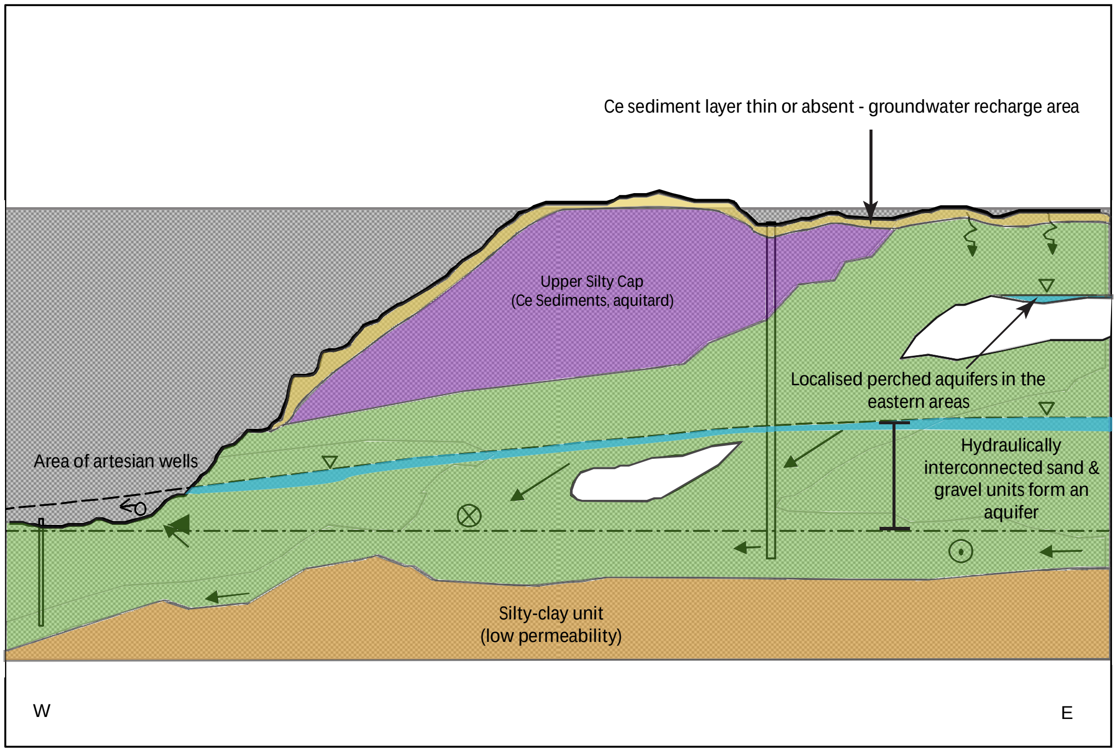
4.6 Infiltration Testing

Soil mapping of Surrey shows similar soil conditions for the ISMP study area as those found in the East Clayton NCP area. The primary soil unit for both areas is the Bose soil unit; which when undisturbed and uncompacted, is typically able to absorb 1mm/hr in winter conditions and 1-2 mm/hr in summer condition. Pockets of the underlying surficial geology in the East Clayton NCP area are thought to be more favourable to deep infiltration, than the soils found within the Clayton ISMP study area.

To confirm soil conditions and infiltration rates in the Clayton ISMP study area, on-site soil infiltration tests were conducted at four locations. These four locations are shown in **Figure 4.5**. A summary of the soil conditions at the four test sites are provided in **Table 4.3**.

Table 4.3 Summary of Soil Conditions at the Four Test Sites

	Anthropogenic (fill) material	Native Soil
Site1	- 1.3 m thick mixed fill material - first 0.5 m very gravely sandy clay fill and lower portion mix of gleyed clay and clay loam material - surface gravely layer highly compacted , not suitable for surface testing	- upper and mid soil sections, well developed, medium to fine textured (sandy loam to clay loam) - strongly mottled silty clay glaciomarine parent material at 1.6 m depth - seepage at 1.6 m depth - test conducted at 1.4 m mark to avoid saturated seepage layer below
Site 2	None	- upper soil well developed, and medium textured; strongly mottled glaciomarine deposit at 0.8 m depth - no seepage noted to 1.0 m depth
Site 3	- 0.6 m deep, very gravely fill materia; - surface layer very compacted, not suitable for surface testing	- upper soil horizon, well developed, well drained, medium textured (sandy loam to silt loam) - thick (~15 -20 cm) organic enriched native Ah horizon (surface soil) - middle soil layers, well developed, well drained, slightly coarser texture - strongly mottled silty clay glaciomarine parent material at 1.2 m depth - no seepage noted to 1.8 m depth
Site 4	None	- upper soil horizon, well developed, well drained, medium textured (sandy loam to silt loam) - 10 cm organic enriched native Ah horizon (surface soil) - middle soil layers, well developed, well drained, slightly coarser texture - strongly mottled silty clay glaciomarine parent material at 0.7 m depth - no seepage noted to 1.0 m depth



LEGEND

- Aquifer piezometric surface
- Groundwater flow, in plane of section (Length of arrow indicates relative flow magnitude)
- Unsaturated groundwater flow
- Groundwater flow; in to plane of section
- Groundwater flow; out of plane of section
- Spring
- Thin, relatively well drained sediment layer 1 - 2 m thick, composed of geologic unit Ce, and Bose/Whatcon soils. This forms an unconfined aquifer in many upland areas that supplies shallow wells in the area.
- Ground surface; with 0.5 to 2m thick permeable sediments over low permeability sediments (see Fig. 6)

Note: Drawing not to scale

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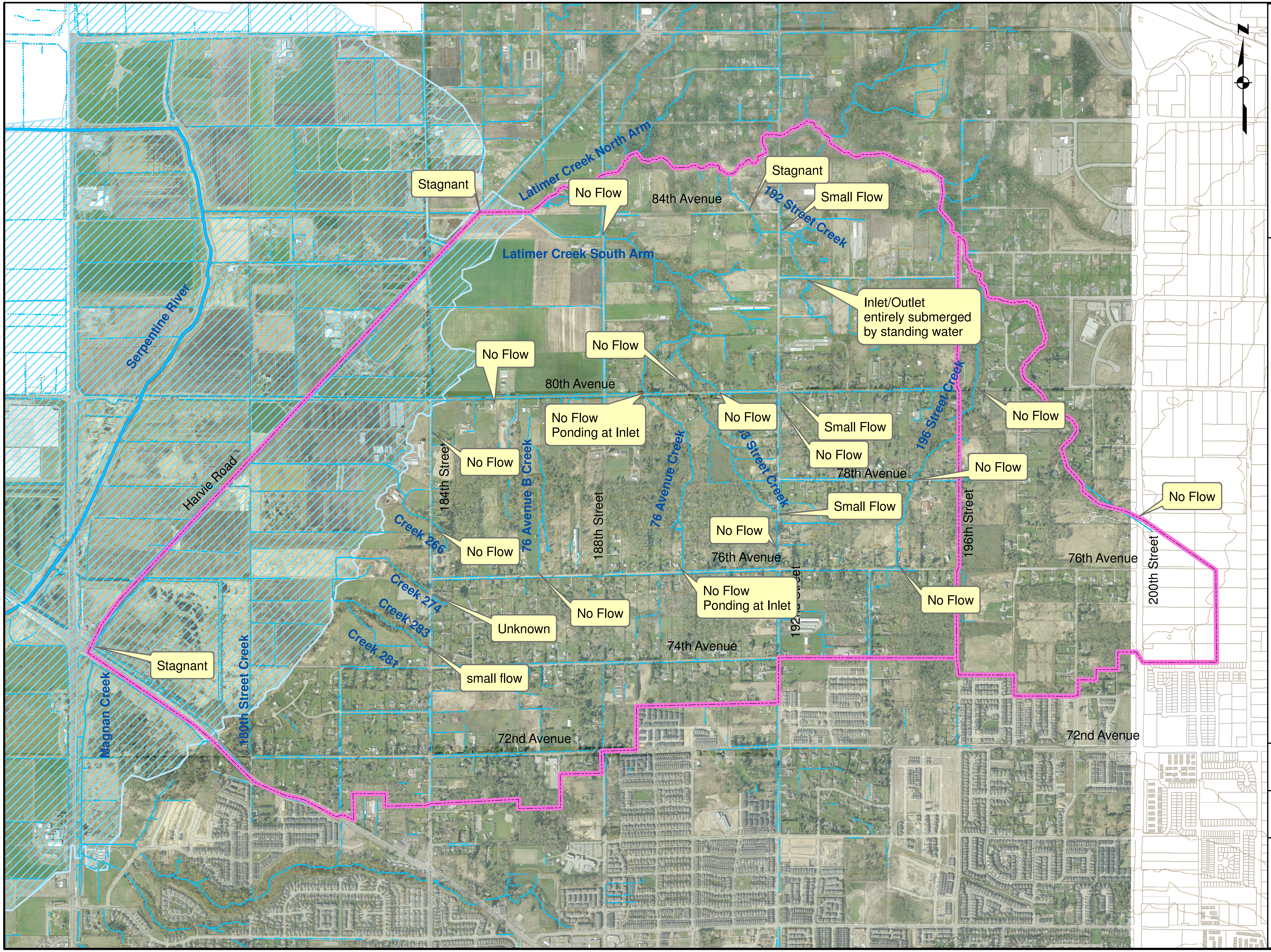
DILLON CONSULTING LIMITED

PITEAU ASSOCIATES
HYDROGEOLOGICAL & GEOTECHNICAL CONSULTANTS
VANCOUVER CALGARY

HYDROGEOLOGICAL ASSESSMENT FOR CLAYTON MASTER DRAINAGE PLAN, SURREY, B.C.

SCHEMATIC WEST - EAST HYDROGEOLOGIC PROFILE OF CLAYTON UPLAND



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Clayton ISMP

Legend

- Study Area Boundaries
- Creek
- Ditch
- River
- Langley Streams
- 200 Year Floodplain
- Contour 5m
- 10m contour

Base flow (observed surface flow) conditions as noted during site visits on August 3 and 4, 2010 following an extended period of dry weather.

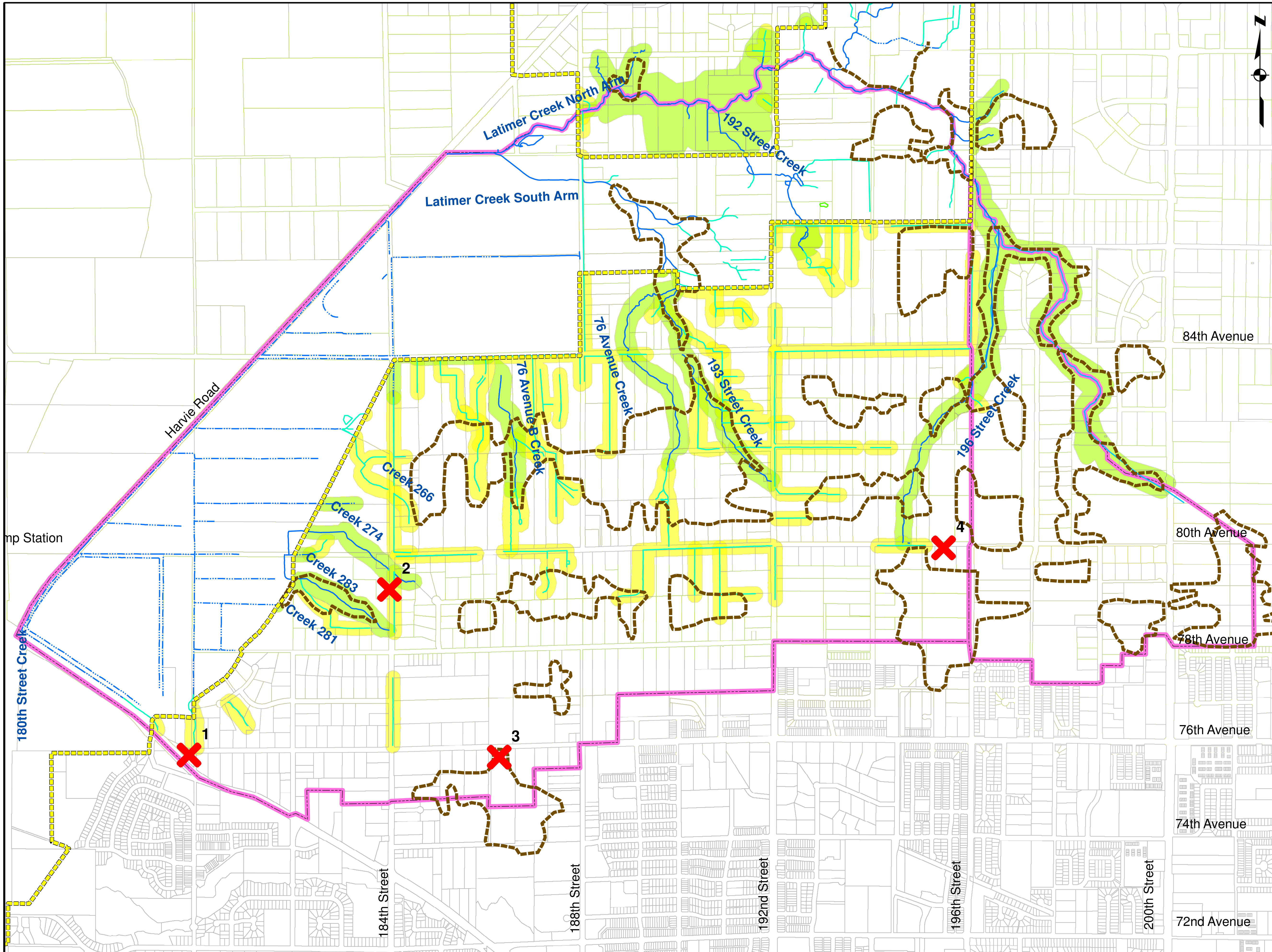
AECOM

Meters
0 105 210 420 630 840

Project No.	Date
60158414	November 2011

Base Flow

Figure 4.4



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Legend

- Infiltration Testing Locations
- ALR Boundary
- Study Area Boundary
- Class A 30m Setback from Top of Bank
- Class B 30m Setback from Top of Bank
- Forest Habitat

AECOM

0 100 200 400 600 800
Meters

Project No.	Date
60158414	June 2012

Infiltration Testing Locations

Figure 4.5

A summary of the infiltration test results at each site is provided in **Table 4.4**. The lowest rate of 2 mm/hr obtained at 0.8 m (Site 2), and 1.8 m (Site 3) depths are not unexpected as the native soil layer at these locations was strongly mottled suggesting periodic saturation. In fact, the rates at this site could be below the reported 2 mm/hr rate since low readings (i.e. 1 mm or less) were given a value of 0.99 mm in order to calculate the infiltration rate above. A 24-hour or longer infiltration test is required for low permeability soils, such as those found at sites 2 and 3, for design purposes.

Infiltration rates > 300 mm/hr is not uncommon for undisturbed native forest soils (e.g., Gregory *et al.*., 2006). The highest infiltration rate at Site 3 signifies that disturbance to the native soil particularly in terms of compaction was minimal. In addition, the observed presence of high organic matter accumulation and abundance of roots are considered to be the major contributing factors for the observed high infiltration rate at this location. Additional details of the infiltration tests are provided in the report in **Appendix A**.

Table 4.4 Clayton Study Area Soil Infiltration Test Results

Location	Infiltration Rate (mm/hr)	Remarks
Site 1		
surface	n/a	very gravely and compacted fill layer, not suitable for test
0.8 m	10	soil at this depth is fine clay and clay loam material, however there is abundant evidence this material is not native and has been brought from other sources during nearby construction activities
1.4 m	10	seepage at 1.6 m mark, test could not be conducted at the desired 1.8 m mark
Site 2		
surface	n/a	
0.8 m	2*	test on strongly mottled native parent material; highly compacted silty clay, very impervious
Site 3		
surface	n/a	very gravely and compacted fill layer, not suitable for test
0.8 m	338	test conducted on organic enriched native sub soil; medium textured (silt loam), less than 10% gravel content; abundant fibrous roots present
1.8 m	2*	test on strongly mottled native parent material; highly compacted silty clay, very impervious
Site 4		
surface	128	test conducted on organic enriched native surface soil; medium textured (silt loam) , less than 10% gravel content
0.8 m	88	test on strongly mottled native parent material; this layer is not as compacted as other sites, because of the presence of gravely coarse glacial outwash deposit on top of it

*constant less than 1 mm head fall was observed over more than 2 hr period at these sites. A default value of 0.99 mm reading was assumed for rate calculation.

In conclusion, the test results signifies that soils are inherently highly variable and other external factors such as disturbances from human activities can greatly influence their properties. In consultation with the City of Surrey, an infiltration rate of 1 mm/hr was assumed for modelling purposes and to identify BMP requirements. A rate of 1mm/hr is consistent with compact, native material at greater depths (as per sites 2 and 3) and is similar to the rate that has been measured in East Clayton after development. Where site specific soil conditions are proven to have higher infiltration rates, the proposed BMPs should be adjusted to best utilize the available soil infiltration.

5. Hydrology and Hydraulics

5.1 Drainage Area Overview

The Clayton ISMP study area does not cover a single watershed, rather it is made up of several drainage areas which are all ultimately tributary to the Serpentine River. The study area is bounded by the Latimer Creek North Arm to the north and east; 74th Avenue, 72nd Avenue and Fraser Highway to the south; and Harvie Road to the west. The study area spans the border between the Township of Langley and the City of Surrey, with a large part of the area being tributary to Latimer Creek. The remaining area forms part of the Fry's Corner drainage area; the uplands of which, discharge to the Harvie Road lowlands and the Serpentine River floodplain via numerous small, unnamed creeks.

The topography rises dramatically from the Serpentine Lowlands around 0m a.s.l. to the Clayton Uplands around 80m a.s.l. along a northeast trending escarpment. The uplands of the study area are predominantly rural suburban developments where drainage is in open ditches, and creeks and tributaries cut down through the escarpment towards the interconnected ditches surrounding the farms of the lowlands. The lowlands are generally within the Serpentine River floodplain and the Agricultural Land Reserve (ALR) boundaries. Drainage in the lowlands is controlled by dikes, pump stations and floodboxes. Development in the uplands has progressed rapidly in recent years: East Clayton and Cloverdale south of the ISMP area; and, Willoughby and Carvolth along 200th Street to the east in Langley. This ISMP covers area not included in the Latimer Creek Master Drainage Plan and precedes a neighbourhood concept plan. As Latimer Creek has already been examined and the study boundaries exclude large portions of that watershed, the creeks shown in **Figure 5.1** will be the focus of this ISMP. Catchment areas for the ISMP study area are also shown in **Figure 5.1**, and are summarised in **Table 5.1**.

Table 5.1 Clayton ISMP Sub-Catchments

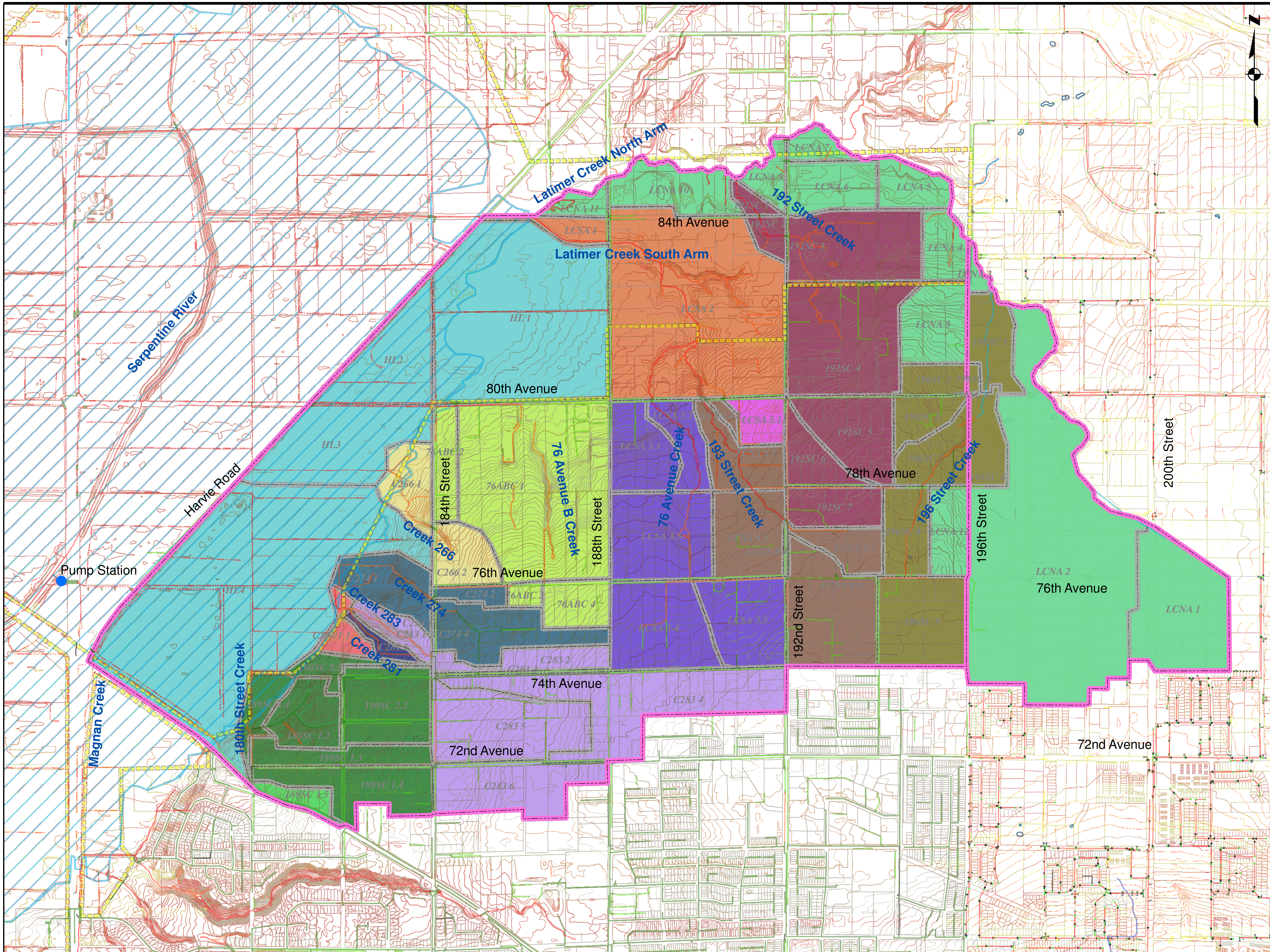
Study Sub-Area	Watercourse	Tributary to:	Contributing Area (ha)
Latimer	Latimer Creek North Arm	Latimer Crk	60.84
	Latimer Creek South Arm	Latimer Crk	67.69
	76th Avenue Creek	Latimer Crk S. Arm	67.58
	193rd Street Creek Tributary	193rd Street Creek	4.90
	193rd Street Creek	Latimer Crk S. Arm	49.43
	192nd Street Creek	Latimer Crk N. Arm	78.82
	196th Street Creek	Latimer Crk N. Arm	42.62
Langley	196th Street Creek	Latimer Crk N. Arm	15.80
	Latimer Creek North Arm	Latimer Crk	110.25
Fry's Corner	180th Street Creek	Harvie Road Lowlands	56.36
	76th Avenue B Creek	Harvie Road Lowlands	65.80
	Creek 266	Harvie Road Lowlands	15.45
	Creek 274	Harvie Road Lowlands	26.98
	Creek 281	Creek 283 / 281	2.42
	Creek 283	Creek 283 / 281	78.52
	Creek 283 / 281	Harvie Road Lowlands	3.85
	Harvie Lowlands	Harvie Road Lowlands	188.95
Total:			**936.26 ha**

Notes: This study is limited to publically accessible portions of the watercourses only

Runoff from outside of the Clayton ISMP study area flows to the lowland areas in the Fry's Corner sub-area at several locations via culverts under Harvie Road and Fraser Highway. This increases the area directly contributing to the ditch on Harvie Road. On Fraser Highway at 180th Street, there is a flow diversion manhole which distributes flows between the 180th Street Creek (within the Clayton ISMP) and the Fraser Highway ditching (part of the Magnan Creek catchment). Additionally, there is a large area from outside the Clayton ISMP boundaries which contributes flows to Latimer Creek. These externally contributing areas are shown in **Figure 5.2** and described in **Table 5.2**.

Table 5.2 Externally Contributing Areas

Reference	Contributes to:	Contributing Area (ha)
Latimer Creek – Offsite	Latimer Creek Sub-Area	708
Magnan Creek	Fry's Corner Sub-Area	456
Serp 1	Fry's Corner Sub-Area	22
Serp 2	Fry's Corner Sub-Area	50
Serp 3	Fry's Corner Sub-Area	19
Serp 4	Fry's Corner Sub-Area	30
Serp 5	Fry's Corner Sub-Area	1.59
Total:		**1286 ha**



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Clayton ISMP

Legend

Study Area
Floodplain
ALR
A
AO
B
C
UN
Contour 1m
2m contour
Contour 5m
10m contour

Catchments
- 180 Street Crk
- 180 Street Crk FC
- 192 Street Crk
- 193 Street Crk
- 193 Street Crk Trib
- 196 Street Crk
- 76 Avenue B Crk
- 76 Avenue Crk
- Creek 266
- Creek 274
- Creek 281
- Creek 281/283
- Creek 283
- Harvie Lowlands
- Latimer Crk N Arm
- Latimer Crk S Arm

AECOM

Meters: 0 105 210 420 630 840

Project No.	Date
60158414	November 2011

Study Area Catchments

Figure 5.1

Flow into and out of the ISMP study area from these externally contributing areas is controlled in several ways. Harvie Road, Fraser Highway, and the Latimer dykes act as barriers against Serpentine River floodwaters, while also creating barriers to runoff from the study area. Culverts beneath Harvie Road provide an interconnection between the lowland areas on either side. A summary of the study boundary area controls is shown in **Figure 5.2** and summarised in **Table 5.3**.

Table 5.3 Flow Controls

Ref	Location	Control Type	Control Description
1	Fraser Hwy and 180th Street	Flow Control Manhole	375 dia to 180th St at invert 24.02m. Design Q5= 0.131m3/s, Q100= 0.161m3/s. 100-yr HGL=25.40m 375 dia to Fraser Hwy at invert 24.80m, Design Q5= 0.065 m3/s, Q100=0.231 m3/s
2	Fraser Highway at Harvie Rd	Magnan Creek Culvert (Ref 29)	1200 approx dia, Corrugated Metal Pipe, 60m approx Length
3	Harvie Road at Fraser Hwy	Culvert (Ref 28)	1400 dia, Wood Stave Pipe, 25m approx Length, 0.5% approx Slope
4	Harvie Rd at 78th Ave	Culvert (Ref 20)	1200 dia, Corrugated Metal Pipe, 21m in Length, 0.2% Slope
5	Harvie Rd at 80th Ave	Culvert (Ref 18)	1800 dia Corrugated Metal Pipe, 24m in Length, 1.6% Slope
6	Latimer Creek Watershed	-	-

Notes: Control Descriptions obtained from as-built records and confirmed in the field where possible

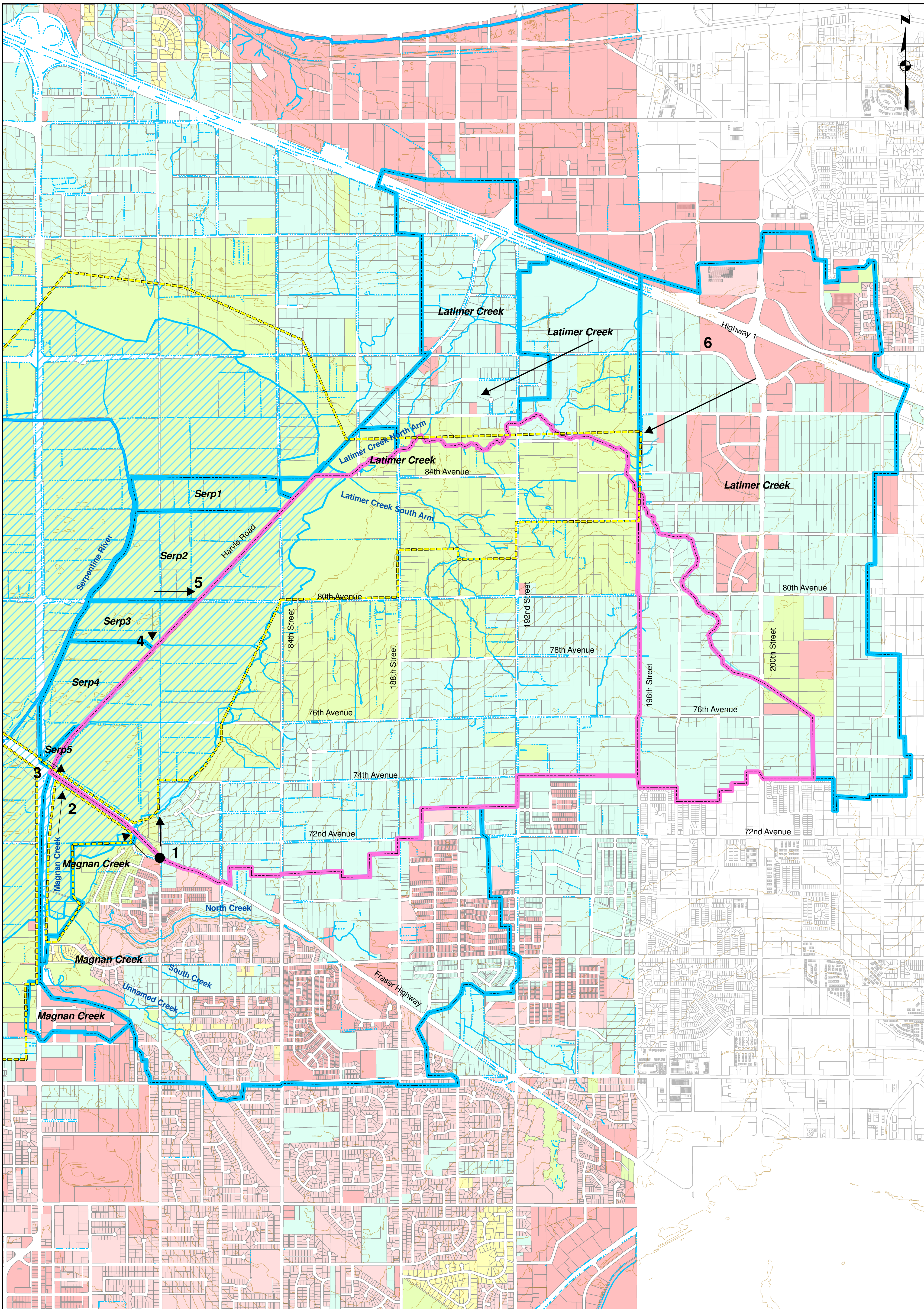
Existing zoned land use within both the study area and the externally contributing catchments was examined. Imperviousness values were assigned based on the existing Surrey Design Criteria, the results of which are shown in **Figure 5.2** and **Table 5.4**.

Table 5.4 Existing Zoned Imperviousness

Catchment	Area (ha)	Total Existing Zoned Imperviousness
Latimer Creek (Study Area)	498	41%
Latimer Creek (External Area)	708	62%
Fry’s Corner	438	35%
Magnan Creek	456	65%
Serpentine Floodplain	122	25%

Notes: Surrey data is based on COSMOS data retrieved June 21, 2010. Langley data is based on Township base mapping from 2008, with existing zoning taken from Geosource July 27, 2010.

It should be noted that the zoned imperviousness may not equate to the actual imperviousness. This may be due to inherent assumptions in the design criteria about the land coverage, or that the individual property owners have not built out the lot to the maximum allowable density. Actual existing imperviousness in the upland areas, based on aerial photos, is around 20%.



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City of Surrey Clayton ISMP

Project No.	Date
60158414	November 2011

Legend

- ALR
- Study Area Boundaries
- External Catchments
- Creek
- Ditch
- River
- Floodplain
- 5m Contour
- 10m contour

Current Zoning - Percent Impervious
- 20
- 50
- 55
- 65
- 80 - 90

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0 175 350 525 700 875
Meters

Imperviousness Values For Existing Zoned Land Use

Figure 5.2

5.1.1 Discharge to the Serpentine River

The Fry's Corner lowland and Serpentine Floodplain drainage discharges into the Serpentine River via culverts located beneath the Serpentine River dykes. During high river water levels, flap gates on the culverts close and drainage is directed to the Fry's Corner Pump Station which discharges directly into the river.

Two spillways are located on the Serpentine left dyke within the study area: one is south of 83rd Avenue; the other is located around 78th Avenue. A third spillway is located on the Latimer Creek tie-in dyke, immediately upstream of Harvie Road, on the south side. The purpose of these spillways is to allow flooding at the 15-year peak river flood level of areas behind the dyke that historically flood. While the design protection objective is the 10-year design storm event, the 15-year event was used in the dyke design to provide additional freeboard. Based on record drawings the spillways can be described as follows:

Table 5.5 Serpentine River Dyke Spillways

Ref	Location	Crest Elevation (m)	Length (m)	Design Dyke Elevation (m)	Thalweg Elevation (m)	Discharges into Catchment:
1	South of 83rd Avenue	2.72	40	3.30	-3.28	Serp 2
2	78th Avenue	2.62	45	3.20	-2.94	Serp 4
3	Latimer Crk: U/S of Harvie Rd	3.27	20	4.24	0.25	HL 1

Notes: Data summarised from record drawings.

Dyke tie-ins on Latimer Creek provide a direct discharge route for Latimer Creek into the Serpentine River.

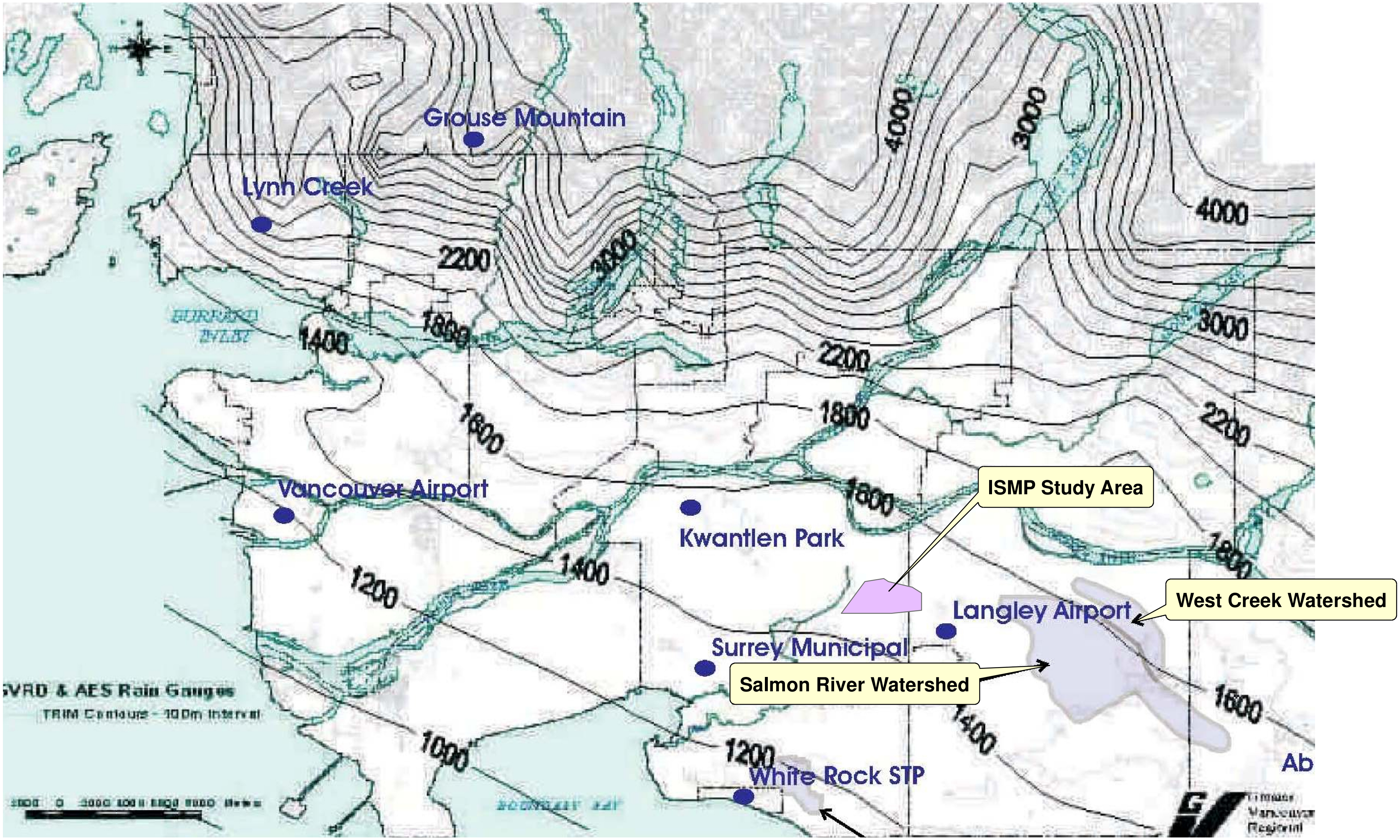
The Fry's corner pump station has two screw pumps with a combined maximum discharge of $3.9 m^3/s$ (KWL, 1998), which operate between the elevations of -1.70m and -1.0m (drawing *SS-056-416 (PM)*). The design Serpentine River elevations are between -2.60m and 2.53m.

5.1.2 Climate

The west coast of BC is a maritime climate that is strongly influenced and regulated by the ocean. Winters are dominated by storms which travel across the Pacific Ocean delivering a good portion of the annual precipitation. Summer weather is typically brought by weather systems from the south, which delivers warmer and drier weather. The ocean provides a regulatory effect on temperature as well. There are strong gradients for temperature and precipitation with distance from, and elevation above, the ocean (Moore,*et al.* Hydrologic Processes 23, 42-61, 2009).

The BC Ministry of Forests assigns the study area to the Biogeoclimatic Ecosystem Classification (BEC) zone, CWH xm. The BEC system classifies an area based on climate, vegetation and site (soil and topographic) variables. Within the subzone, there are more detailed site series classifications that can be made based on variations in soil nutrient and moisture combinations. The CWH xm subzone (Very Dry Maritime Coastal Western Hemlock) can be found along the south side of the Fraser River as far as Chilliwack, as well as select areas of Vancouver Island and the Sunshine Coast. It is found from sea level to as high as 700m elevation in drier parts, but in the Lower Mainland, it extends only as high as around 150m elevation. The summers are typically warm and dry; while winters are mild with high rainfall but relatively little snowfall. The growing seasons are long and may be subject to water deficits. The forests are predominantly douglas fir with western hemlock, and minor amounts of western red cedar (Green and Klinka 1994).

Strong rainfall gradients are seen across the Metro Vancouver area. **Figure 5.3** shows how mean annual precipitation varies across the region. The Salmon River and West Creek watersheds in Langley show similar values to the Clayton ISMP area, as well as the Kwantlen Park gauge. The Surrey Design Criteria locate the Clayton ISMP study area within the Kwantlen Park rain gauge area for precipitation input to hydrologic modeling.



Project No: 60158414 Date: September 2010	**City of Surrey** **Clayton ISMP**	Source of Base Map: Climate Change and the Greater Vancouver Regional District Environment Canada,June 22, 2000	AECOM	Variations In Mean Annual Precipitation Across Metro Vancouver **FIGURE 5.3**

5.2 Previous Drainage Studies

5.2.1 Clayton MDP (Dillon, 1999)

The Clayton Master Drainage Plan (MDP) was initiated as a response to the new Official Community Plan (OCP) for the Clayton neighbourhood and was conducted in parallel with the Neighbourhood Concept Plan (NCP) study. The study area included approximately 1200 Ha which encompassed all of the East Clayton NCP areas as well as the study area of this Clayton ISMP.

As some storm water from this area discharges first to Langley before being released to Latimer Creek, discussions were undertaken with Township staff. At that time, it was identified that the receiving storm drainage system in Langley was unable to accept any increases in peak runoff unless capacity upgrades are completed.

The report notes that in 1978, (the definition of "pre-development" as per the City Design Criteria), the majority of the area was either agricultural or rural residential, with a small portion being suburban ½ acre lots. By 1996, some of the rural residential and agricultural lands had been converted into other uses including commercial/institutional, multi-family residential and urban residential. The majority of the development had occurred on 72 Ave, 184 Street, Fraser Highway, and 192 Street.

One of the major constraints to development of the Clayton ISMP uplands is the risk of flooding in the Serpentine Lowlands. While the lowlands are in the Serpentine River floodplain, development occurring in the uplands should not exacerbate the problem. The Clayton MDP identified various runoff control opportunities. Despite emphasis on the need for infiltration as a key portion of the storm water management requirements, the MDP recommendations include only detention ponds, erosion protection (all but two of the sites are located on private property), storm water diversions, and culvert improvements.

Within the Clayton Master Drainage Plan a large section of City-owned property located on 78th Avenue from 188th Street towards 192nd Street, was identified as a possible location for a community drainage facility. The value of this location for a community drainage facility is limited by the fact that it is located in the upper reaches of the study area and is currently part of a small catchment.

5.2.2 Latimer Creek MDP (Associated Engineering, 2003)

This study was a joint venture between the City of Surrey and the Township of Langley and allows the two municipalities to have a joint strategy for storm water management within the watershed. As part of the study, the following was completed:

- Drainage structure and channel features inventory;
- Fish and habitat inventory;
- Hydrologic model of the creek; and
- Storm water management plan for the watershed.

The study area included the main stem of Latimer Creek, the Latimer Creek North Arm, Old Sawmill Creek, as well as the smaller tributaries. The study did not include the Latimer Creek South Arm watershed to which a large portion of the Clayton ISMP study area belongs.

Recommendations from this report included the construction of community storm water detention ponds which were sized to control 2 and 100-year post development flows to predevelopment levels as well as 5-year post development flows to either 50% of the 2-year post development or 100% of 5-year pre-development runoff rates, whichever is the more stringent. The use of on-site best management practices is encouraged, but no specific requirements are made. Riparian areas are also encouraged: 15m setbacks for low-density development and 30m setback for high density development. A number of storm water diversions are also recommended. **Figure 5.4** shows the recommendations applicable to the Clayton ISMP study area.

5.2.3 Latimer Creek Dyke Tie-in Functional Plan (Urban Systems, Sept 1998)

This ISMP report follows the completion of the *Nicomekl and Serpentine River – Strategic Plan for Lowlands Flood Control* report. This report examined options for relocating Latimer Creek and how the creek and river should be dyked at their confluence.

5.2.4 Lessons learned from Routley Neighbourhood Plan (Langley) and East Clayton NCP (Surrey)

One of the key lessons from the Routley Neighbourhood Plan is that success can be had if all parties work together. The NCP received a Section 35 Authorization from DFO based upon the Township's enforcement of development requirements. The Township implemented administrative policies and procedures to ensure successful implementation of the requirements.

One of the key lessons from East Clayton was that too much flexibility and a lack of enforcement allowed developers to ignore the objectives of the Plan. Additional enforcement through standardized procedures would help ensure compliance with the stated objectives of the Plan.

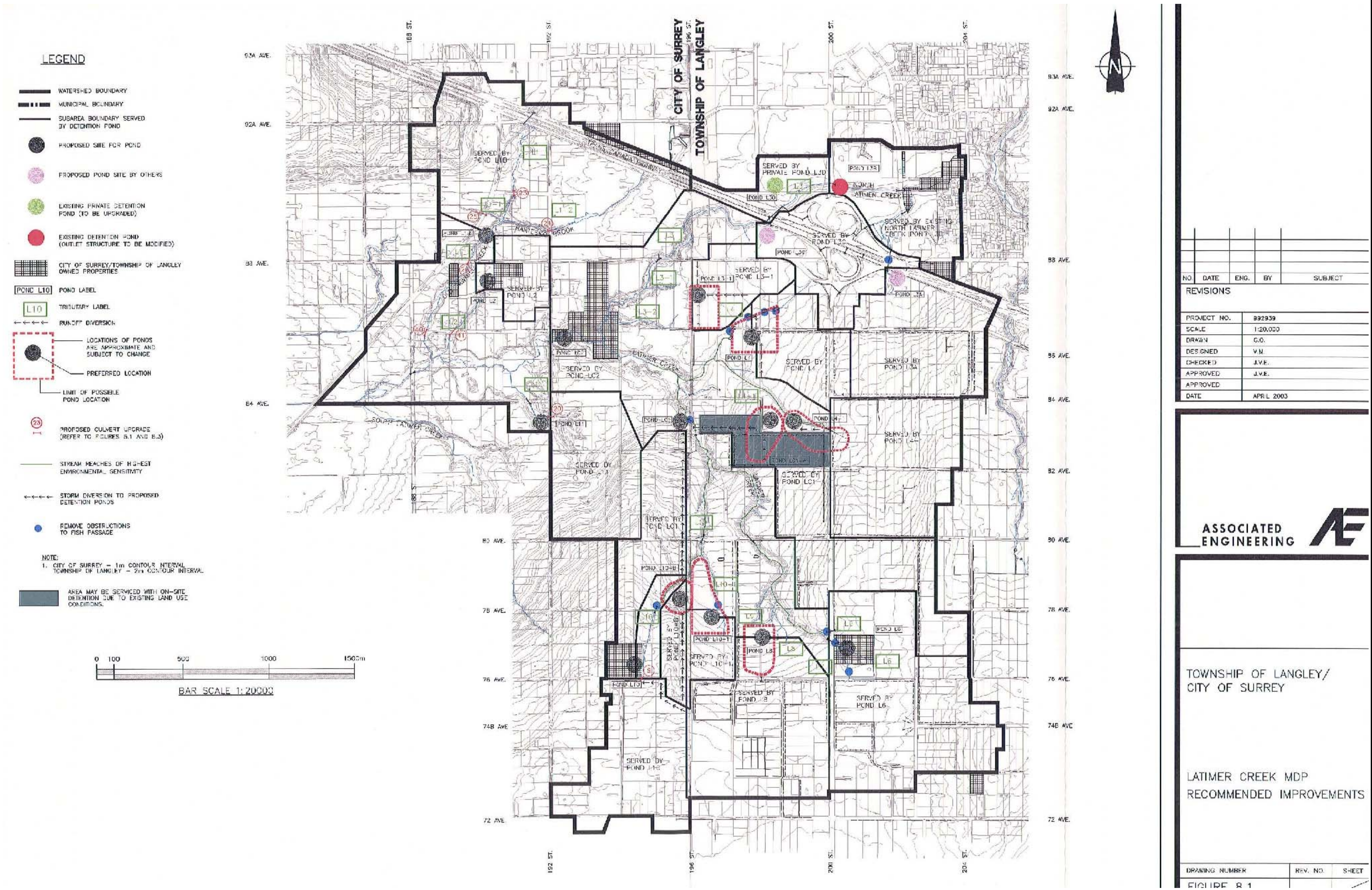
5.3 Storm water Management Guidelines

5.3.1 City of Surrey Design Criteria (2004)

The City's existing 2004 Design Criteria for storm water management focuses on flood control with a pipe and pond philosophy. Emphasis is placed on the 5 and 100-year design storm events. For catchments less than 20 hectares, the rational method may be used for pipe sizing; for larger catchments and for pond sizing, single-event hydrologic models are required.

Storm sewer minimum pipe capacity is the 5-year event. The 100-year flow hydraulic grade line must be located safely below the minimum building elevation. In practice, if the development is to include basements, sewers are often sized for the 100-year event. Trunk storm sewers are classified as those which serve catchment areas larger than 20 hectares.

Predevelopment conditions are defined in this document as those existing in 1978. Post-development flow rates from developed areas are to be controlled to the lesser of: 100% of the 5-year predevelopment flow rate; or 50% of the 2-year post-development rate. For 100-year (major) flows, overland routing should safely accommodate and convey these flows without impact to downstream areas in terms of erosion and flooding.



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Meters
0 25 50 100 150 200

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Latimer Creek Master Drainage Plan Recommendations

Figure 5.4

Percent impervious values as outlined in the Surrey's Design Criteria are shown in **Table 5.6**.

Table 5.6 Surrey Design Criteria Impervious Values

Land Use	% Impervious
Commercial / Industrial	90%
Institution, School, Religious Assembly	80%
Residential – Acreage	50%
Residential – Half Acreage	55%
Residential – Suburban / Medium Density	65%
Residential – Multi Family / High Density	80%
Parks, Cemeteries, Agricultural	20%

As we consider the implementation of this ISMP in Stage 3, we will review the City's Design Criteria to determine its applicability to the Clayton study area.

5.3.2 Township of Langley Subdivision and Development Servicing Bylaw (2011) No. 4861

The Township recently updated its Subdivision and Development Servicing Bylaw, which addresses storage release rates, municipal infiltration facilities, municipal detention ponds, on-site infiltration and detention and stormwater quality control. The Bylaw states that as a condition of Subdivision, the Owner shall register a covenant to provide infiltration measures on each lot in a residential subdivision.

The minor drainage event is the peak 5-year runoff event, while the major drainage is defined as the 100-year runoff event. The rational method can be used for pipe sizing for tributary areas 10 hectares or less, otherwise a hydrograph method is required. Percent impervious values, as shown in Table 5.6, are similar to those presented in Surrey's Design Criteria Manual.

Table 5.7 Township Of Langley Bylaw Impervious Values

Land Use	% Impervious
Commercial / Industrial	90%
Institution, School	80%
Suburban Residential	20%
Residential, Multi-family, CD	75%
Parks / Grasslands	20%
Cultivated Fields	30%
Woodlands	5%

Rainfall records to be used in the calculation of runoff are geography dependent. The ISMP study area is located in the west region and therefore requires the use of the Surrey Kwantlen Park AES station precipitation data, as per the Township's Subdivision and Servicing Bylaw.

Storm sewers should be sized to accommodate, at minimum the 5-year return period flow. The 100-year HGL must be at least 0.35m below the lowest MBE of adjacent buildings. Culverts must be sized to convey the 100-year runoff event. Driveway culverts should be sized for the 5-year event without surcharge. New driveway culverts should ensure no adverse impact to adjacent properties for the 100-year event.

Storm water detention must be provided to limit post development peak release rates to the 2-, 5-, and 100-year return period predevelopment runoff rates. It must be shown that all downstream drainage facilities for a distance of 1.5km are capable of handling the projected increase in runoff.

5.3.3 ARSDA Drainage Criteria

Flood control requirements within the Serpentine lowlands have been set by the Agri-Food Regional Development Subsidiary Agreement (ARDSA) program. The ARDSA criteria are listed below.

- In the growing season (March 1 to October 31), flooding should be restricted to a maximum of 2 days in duration in the 10-year, 2-day storm.
- In the remainder of the year (November 1 to February 28), flooding should be restricted to a maximum of 5 days in duration in the 10-year, 5-day storm.
- Between storms, and in periods when drainage is required, the base flow level in ditches should be maintained at 1.2 m below field elevation to provide a free outlet for drains.

These criteria were derived from the on-farm drainage information presented in the BC Agricultural Drainage Manual. This manual identifies the critical factor for drainage to be the period of time that the soil is saturated. The duration of saturation is dependent upon the crop type and its health, season and a number of factors associated with the soils. These have been condensed to a single standard that suggests that the duration of soil saturation be not more than 48 hours during the summer growing season and 120 hours during the winter dormant season. Economic considerations would imply that this should not occur more than once in 10 years.

The 1.2m freeboard was selected on the assumption that most on-farm subsurface drainage systems are installed with the pipe outlet 1.0-1.1m below the field surface. Therefore, to ensure free flow in the drains, 1.2m was selected (MAFF, 2002).

The common interpretation of this is removal of the runoff resulting from the 1 in 10 year return period 2 day summer and 5 day winter storms. There is no clear distinction of when the period would start in conjunction with the storm and it might be interpreted as starting when the storm starts or even at the end of the storm. Additional considerations must include the conclusion that a 1 in 10 year storm may not result in a 1 in 10 year runoff event. Factors such as antecedent rainfall and soil moisture at the start of the storm must be assumed and can significantly alter the volume of runoff from individual storms.

To avoid any misinterpretations or assumptions regarding starting conditions it is proposed for this project to return to the original standards of 2 and 5 day durations of saturation having a return period of recurrence of not more than 1 in 10 years. This can be determined through the use of the calibrated continuous simulation model.

In addition to the ARDSA land flood control criteria, the regulatory floodplain for the Serpentine is delineated for the 200-year flood by the Ministry of Environment, Lands and Parks. Filling and/or development within the flood line are allowed only after review by the City and the Ministry (*Surrey Design Criteria*, 2004).

5.3.4 Storm water Guidebook for BC (MWLAP 2003) and Beyond the Guidebook (IGP 2007)

The Guidebook brought a new approach for storm water to the attention of municipalities across the province. It introduced the three-stage approach of:

1. *Retain* smaller, frequent storm event runoff on-site for infiltration;
2. *Detain* larger, infrequent storm event runoff to prevent flooding; and

3. *Convey* safely the released flows

While the detain (also known as “rate control”) and convey stages were already a part of many municipalities’ approach to storm water management, the “retain” portion was new. The only prescriptive part of the guidebook was the recommendation to retain one half of a mean annual 24 hour rainfall event, approximately 30 mm, falling onto impervious surfaces to mitigate environmental impacts.

Beyond the Guidebook: Context for Rainwater Management and Green Infrastructure in British Columbia takes this idea further with more rigorous analytical techniques for examining the hydrologic impact on watercourses from development.

Volume reduction (retention/infiltration) systems should be designed to match the:

- Predevelopment volumetric infiltration rates; and,
- Predevelopment discharge duration relationships.

Beyond the Guidebook provides a watercourse-centric, site-specific approach to storm water management. It introduces the concept of discharge duration; that is, the amount of time that flow rates exceed benchmark values. It was developed by an intergovernmental partnership including participants from municipalities, Ministry of Environment, and the Department of Fisheries and Oceans.

5.4 Watercourse Identification

The drainage and watercourse assessment started through information gathering on previous reports and analysis of the City’s Geographic Information System (GIS) information. GIS data provided by the City were used to identify upland watercourses and their contributing watersheds. Site visits were conducted on August 3rd and 4th, 2010, at which time catchment boundaries and drainage pathways were confirmed, channel cross sections were dimensioned, and critical, in-stream culverts were inventoried and visually assessed. As many of these watercourses are located on private property, site visits were limited to public property locations. **Figure 5.5** shows the location of culvert, ditch and watercourse assessment locations.

Table 5.7 provides a culvert summary, while **Table 5.8** provides a ditch and watercourse summary.

The lowlands are within the agricultural land reserve and are therefore not directly subject to development pressures; however, development of the upland areas, which drain to the lowland areas, should not negatively impact the lowland drainage. Lowland drainage will not be studied in detail in this ISMP; however, checks against the ARSDA criteria will be made.

Table 5.8 Culvert Summary

Sub-Area	Water-course	Culvert Ref	D/S Culvert:	Shape	Material	Dim (mm)	Length (m)	Approx Slope	Headwall Type	Comments
Latimer	192 St Creek	3	2	Circ	UNK	600	15	0.1%	UNK	Inlet/outlet completely submerged
Latimer	192 St Creek	2	1	Circ	Conc	900	18	1.2%	Sandbag	U/S channel overgrown. Ponding created by debris, Old barbed wire fence across stream
Latimer	192 St Creek	1	15	Circ	Conc	750	12	1.2%	Sandbag with wing walls	Outlet not located, large cottonwood growing where it should be. Ponding and stagnant D/S
Latimer	193 St Creek	14	11	Circ	Conc	750	29	3.9%	UNK	Rip rap at outlet could be fish passage issue. Unable to locate inlet
Latimer	193 St Creek	11	8	Box	Conc	1800 x1200	22	3.7%	Lock Block with Guidewall	Specially designed culvert and creek to enhance fish passage.
Latimer	193 St Creek Trib	12	8	Circ	Conc	675	14	2.0%	Conc Block with Guidewall	Outlet overgrown and fenced off
Latimer	76 Ave Creek	13	10	Circ	Conc	675	11	7.1%	Conc Block	ponding at inlet
Latimer	76 Ave Creek	10	8	Circ	Conc	750	14	1.0%	Conc Block and Sandbag	Standing water at inlet and outlet (but below invert). U/S "creek" heavily overgrown and no defined channel.
Latimer	Latimer Crk. South Arm	8 / 9	15	Circ	CMP	2-900	17	1.3%	N/A	U/S heavily overgrown, D/S is adjacent to field and is completely overgrown with tall grasses
Latimer	196 St Creek	6	5	Circ	Conc	600	11	1.1%	none	No dry weather flow
Latimer	196 St Creek	5	4	Circ	Conc	900	10	5.0%	Protruding Pipe, Sandbag wall	Potential fish passage on outlet.
Latimer	196 St Creek	4	15	Circ	Conc	1200	35	2.0%	Lock Block	Culvert appears to sag near outlet
Langley	Latimer Crk North Arm	7	15	Circ	Conc	2-1200	60	4.0%	Wing-wall, conc	No dry weather flow
Latimer	Latimer Crk North Arm	15 / 16	Serp. River	Box	Conc	2-2400 x3050	28	0.33% / 0.57%	Lock Block with wing wall	Boundary culvert
Fry's Corner Uplands	76 Ave B Creek	24	211	Circ	Conc	600	13	3.0%	Conc headwall, with ditches forms T-junction	Outfall heavily vegetated
Fry's Corner Uplands	Ditch	21-1	213	Circ	Conc	600	16	4.2%		No flow
Fry's Corner Uplands	Ditch	21-2	213	Circ	Conc	250	27	UNK		No flow
Fry's Corner Uplands	Ditch	21-3	Lowlands	Circ	Conc	750	14	UNK	N/A	
Fry's Corner Uplands	Ditch	22	Lowlands	Circ	Conc	450	14	1.3%		
Fry's Corner Uplands	Creek 266	23	Lowlands	Circ	Conc	600	29	5.0%	UNK	Not accessible - deep canyon, heavily overgrown, steep
Fry's Corner Uplands	Creek 274	25-1	252	Circ	Conc	375	13	3.5%	UNK	Fenced-no access, very overgrown
Fry's Corner Uplands	Creek 274	25-2	Lowlands	Circ	Conc	525	12	3.8%	N/A	Fenced -no access, very overgrown
Fry's Corner Uplands	Creek 283	26	Lowlands	Circ	Conc	750	17	11.4%	UNK	Fenced outlet, inlet on Private Prop outlet discharges to conc spillpad

Sub-Area	Water-course	Culvert Ref	D/S Culvert:	Shape	Material	Dim (mm)	Length (m)	Approx Slope	Headwall Type	Comments
Fry's Corner Lowlands	Ditch	19	-	Circ	CMP	1650	17	0.1%		Boundary culvert
		18	-	Circ	CMP	1800	24	1.6%		Boundary culvert
		20	-	Circ	CMP	1200	21	0.2%		Boundary culvert
		28	-	Circ	Wood Stave	1400	55	0%	none	Fraser Highway Construction is altering drainage routing. Pipe is deflecting Boundary
	Magnan Crk	29	-	Circ	CMP	1200	60	0%	None	Fraser Highway Construction is altering drainage routing. Boundary Culvert
	Ditch	27	-	Circ	CMP	2155	27	0%		Boundary Culvert
		17-1	-	Circ	CMP	1650	19	1.7%	Sandbag	Boundary Culvert
		17-2	-	Circ	CMP	1650	19	2.5%	Sandbag	Boundary Culvert
		17-3	-	Circ	CMP	1650	19	0.1%	Sandbag	Boundary Culvert

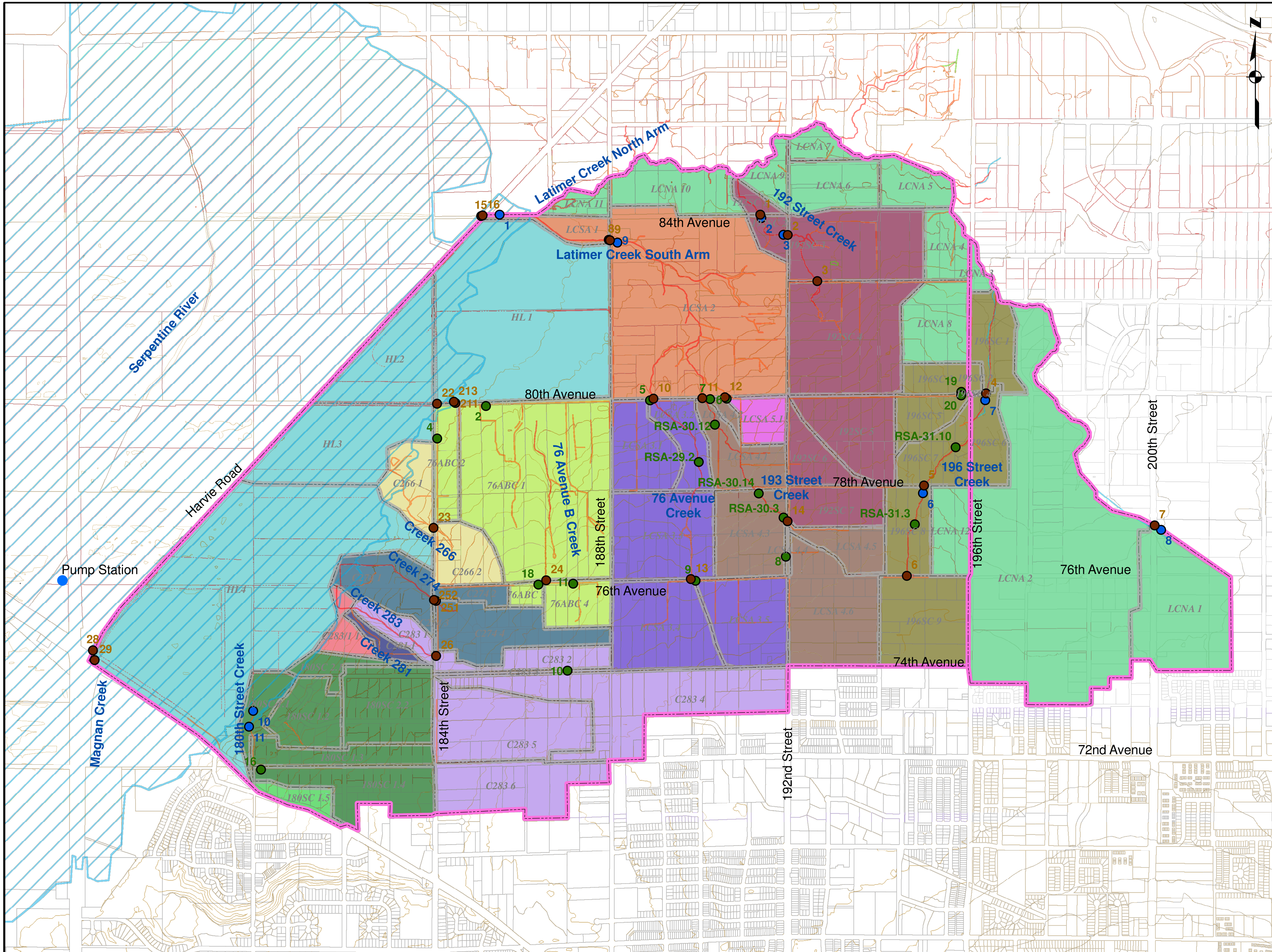
Table 5.9 Ditch and Watercourse Summary

Watershed	Watercourse	Ref	Geometry					Discharge Rate at Maximum Channel Capacity (m^3/s)	Total Contributing Area (ha)
			Bottom Width (m)	**Average Side Slope (XH:1V)**	**Max Channel Depth (m)**	**Approx Channel Slope (%)**	**Manning's n***		
Latimer	192 Street Creek	WC 3	0.9	2	1.25	1.2%	0.110	3.19	74.1
		WC 2	1.4	2	1	1.2%	0.025	10.3	76.9
	193 Street Crk	D 8	0.6	1	0.6	3.2%	0.027	2.20	0.5
		RSA-30.3	1.5	1.165	1.2	8.9%	0.030	26.5	26.4
		RSA-30.14	1.6	1.65	2.3	8.9%	0.030	138	39.1
		RSA-30.12	1.5	1	1.5	2.3%	0.030	19.3	48.3
		D 7	0.6	1	0.6	2.8%	0.027	2.06	1.1
	193 Street Crk Trib	D 6	0.6	0.67	1.5	5.3%	0.027	14.1	4.9
	76 Avenue Crk	D 9	0.6	0.5	0.9	0.5%	0.027	1.26	31.8
		RSA-29.2	1.1	1.65	1	4.8%	0.030	13.6	50.1
		D 5	0.6	0.5	1.5	0.9%	0.027	4.55	60.7
	Latimer Crk S Arm	WC 9	2	2	1.5	0.3%	0.035	10.6	185.6
	196 Street Crk	RSA-31.3	1.2	1.5	1.4	4.3%	0.030	26.1	16.1
		WC 6	1.5	0.75	2	4.3%	0.050	23.6	24.6
		RSA-31.10	1.5	1.5	4	9.0%	0.030	458	32.9
		WC 7	4	2	5	2.0%	0.030	633	39.5
		D 19	0.6	0.71	0.7	4.3%	0.027	2.82	4.2
		D 20	0.5	2	0.5	4.9%	0.027	2.59	5.5
Langley	Latimer Creek	WC 8	1.5	2	3	5.7%	0.03	236	23.2
Latimer		WC 1	3	2	2.5	0.1%	0.029	27.4	1205.6
Fry's Corner	180th Street Crk	D 16	0.6	1	0.9	6.2%	0.027	7.08	13.0
		WC 11	1	1.5	0.45	8.0%	0.050	1.86	38.3
		WC 10	1	2	0.65	1.0%	0.029	2.72	38.3
	76 Avenue B Crk	D 11	0.6	1	0.6	3.2%	0.027	2.20	6.5
		D 18	0.6	0.71	0.7	1.7%	0.027	1.78	1.8
		D 2	0.6	2	0.4	2.0%	0.027	1.12	59.7
		D 4	0.6	1	1	1.5%	0.027	4.37	6.1
	Creek 283	D 10	0.6	1	0.6	3.7%	0.027	2.37	1.1

Notes: **Manning's n was selected from recommended values from Chow 1959, based on observations of channel material and vegetation.*

***RSA geometry was obtained from 2009 Ravine Stability Assessment by Web.*

****WC10 and WC11 geometry was obtained from As-built drawings*



City of Surrey

Clayton ISMP

Legend

- Study Area
- Floodplain
- 10m contour
- Contour 5m

Stream Class

- A
- AO
- B
- C

- Field Study - Culvert
- Field Study - Ditch
- Field Study - Watercourse

Catchments

- 180 Street Crk
- 180 Street Crk FC
- 192 Street Crk
- 193 Street Crk
- 193 Street Crk Trib
- 196 Street Crk
- 76 Avenue B Crk
- 76 Avenue Crk
- Creek 266
- Creek 274
- Creek 281
- Creek 281/283
- Creek 283
- Harvie Lowlands
- Latimer Crk N Arm
- Latimer Crk S Arm

AECOM

0 100 200 400 600 800
Meters

Project No.	Date
60158414	June 2012

Conveyance Assessment Locations

Figure 5.5

5.5 Watercourse Hydrology

A regional hydrologic analysis was used to establish the anticipated magnitude of discharges and anticipated flood frequencies for the identified watercourses. These values are based upon a clear understanding of the rainfall and runoff relationships within nearby similar watersheds with available stream gauging. Similarly the volumes of surface runoff and base flows have been estimated on an annual basis. This information was then used to create a verified hydrologic and hydraulic model that can be used for evaluation of the existing and potential future Study Area conditions as a whole.

As there are no long-term (10+ years) stream flow records of discharge and volume for any of the creeks within the ISMP study area, a proxy stream was selected for the regional analysis. The records chosen are from the Water Survey of Canada gauges for the Salmon River at 72 Avenue (08MH090) and for West Creek near Fort Langley (08MH098). These watersheds have an area of 49km^2 and 11.4 km^2, respectively, and are shown on **Figure 5.6**. Based on the similarities in topography, West Creek was chosen as the proxy stream for this analysis.

The flood frequency values calculated in the regional hydrologic analysis are shown in **Table 5.10** below.

Table 5.10 Flood Frequency Analysis

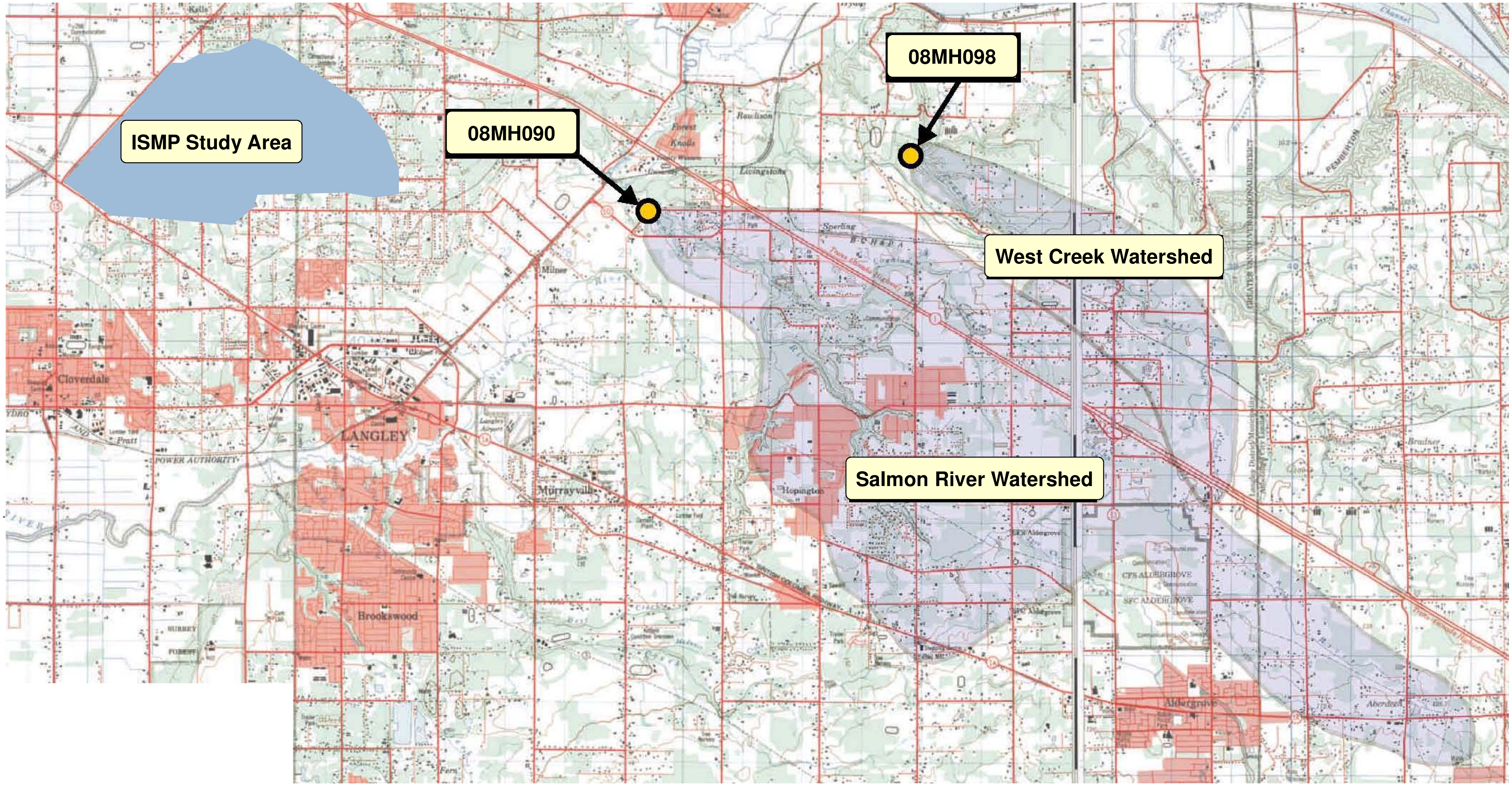
Return Period (Years)	Regional Analysis Runoff (L/s/ha)
100	21.0
10	13.7
5	11.5
2	8.1

5.6 Hydraulics

As the ISMP is proceeding in advance of the NCP, where streets and utility corridors would be defined, detailed modelling at this stage would be unwise. Therefore, a more simplified model was developed that allows for the comparison of different development visions and their impact on the watershed using the existing condition as a basis for the comparison.

5.6.1 Lowland Drainage Characterization

The QUALHYMO model was developed as a lumped watershed model with simplified storage and discharge functions. While this may not be a precise demonstration of what is occurring in the lowlands, it provides a comparison for future upland changes. It is the comparison that is of the most interest, as it is the intent to not exacerbate any existing drainage issues.



Project No:
60158414

Date:
September 2010

City of Surrey

Clayton ISMP

AECOM

Salmon River and West Creek Watersheds

FIGURE 5.6

5.6.2 Erosion Analysis

Traditionally, storm water management has examined peak runoff rates only. However, chronic stream erosion problems are associated with frequent, small discharges (i.e. less than 2 year return period) and the vast majority of the runoff volume can be attributed to these smaller events. These are not rates that cause flooding, but do result in the majority of sediment transport processes. Therefore, to control erosion, it is the small discharges that should be examined. The method used to examine the erosion potential in each of the identified upland creeks is tractive force and impulse.

Tractive force is a measure of the energy available to cause erosion, based on an assessment of shear stress as applied to the stream bed and banks over time. A simplified approach to erosion estimates uses a critical, or minimum, shear stress required to initiate movement of the bed or bank material. Shear stress may be calculated as:

$\tau = \sigma Rs$, where
τ = shear stress (Pascals or Newtons / m^2),
σ = unit weight of water (1000kg / m^3),
R = hydraulic radius of flow (m), and
s = slope of channel (m / m).

Impulse values are a qualitative indicator of the potential for stream erosion (degradation) or sediment accumulation (aggradation). It is defined as a force (shear stress) applied to a surface (submerged bed and banks) over time (simulation period). The Impulse is calculated as:

$I = \tau PT$, where
I = Impulse (kg-seconds / m),
τ = shear stress (Pascals / m^2),
P = wetted perimeter (m), and
T = time (seconds).

(Ontario Ministry of Natural Resources, 1982)

A critical component of stream health and aquatic habitat is the duration of the various magnitudes of flow in the stream. The method used to examine flow duration in each of the identified upland creeks is flow exceedance. Flow exceedance uses the continuous model to determine the amount of time that stream flows exceed a range of threshold values. Comparisons between runoff scenarios can be made to see how development will change the existing flow durations.

5.7 Hydrologic Analysis

A regional hydrologic analysis was conducted to establish existing peak runoff rates for each of the catchments previously identified. Using the values established in **Table 5.10**, peak runoff rates for catchments outside the Study area are summarised in **Table 5.11**, and for catchments within the study area are summarised in **Table 5.12**.

Table 5.11 Existing Peak Runoff Rates beyond ISMP Boundaries

Catchment	Area (ha)	Regional Runoff (m^3/s)		
		Q_5	Q_{10}	Q_{100}
Latimer - Offsite	707.71	8.139	9.696	14.862
Magnan Creek	455.6	5.239	6.242	9.568
Serp 1	22.27	0.256	0.305	0.468
Serp 2	50.01	0.575	0.685	1.050
Serp 3	18.88	0.217	0.259	0.396
Serp 4	29.69	0.341	0.407	0.623
Serp 5	1.59	0.018	0.022	0.033
Total:	**1285.75**	**14.79**	**17.61**	**27.00**

Table 5.12 Existing Peak Runoff Rates within ISMP Boundaries

Watershed	Watercourse	Catchment	Area (ha)	Regional Runoff (m^3/s)		
				Q_5	Q_{10}	Q_{100}
Latimer	192 Street Crk	192SC 1	1.90	0.022	0.026	0.040
		192SC 2	2.86	0.033	0.039	0.060
		192SC 3	19.53	0.225	0.268	0.410
		192SC 4 - 192SC 7	54.53	0.627	0.747	1.145
	196 Street Crk	196SC 3	4.23	0.049	0.058	0.089
		196SC 5	5.48	0.063	0.075	0.115
		196SC 7	8.33	0.096	0.114	0.175
		196SC 8	8.44	0.097	0.116	0.177
		196SC 9	16.13	0.186	0.221	0.339
	Latimer Crk North Arm	LCNA 4 – LCNA 12	60.85	0.699	0.833	1.276
	Latimer Crk South Arm	LCSA 1	4.00	0.046	0.055	0.084
		LCSA 2	63.69	0.732	0.873	1.337
	76 Avenue Crk	LCSA 3.1	10.60	0.122	0.145	0.223
		LCSA 3.2	6.85	0.079	0.094	0.144
		LCSA 3.3	18.33	0.211	0.251	0.385
		LCSA 3.4	17.68	0.203	0.242	0.371
		LCSA 3.5	14.12	0.162	0.193	0.296
	193 Street Crk	LCSA 4.1	9.22	0.106	0.126	0.194
		LSCA 4.2	1.12	0.013	0.015	0.023
		LSCA 4.3	12.72	0.146	0.174	0.267
		LSCA 4.4	0.50	0.006	0.007	0.011
		LSCA 4.5	6.07	0.070	0.083	0.127
		LSCA 4.6	19.80	0.228	0.271	0.416
	193 Street Crk Trib	LSCA 5.1	4.90	0.056	0.067	0.103
Langley	196 Street Crk	196SC 1, -2, -4	9.23	0.107	0.127	0.193
		196SC 6	6.56	0.075	0.090	0.138
	Latimer Crk North Arm	LCNA 1	23.16	0.266	0.317	0.486
		LCNA 2, -3	87.09	1.001	1.193	1.829
Fry's Corner	180 Street Crk	180SC 1.1 – 1.3	21.84	0.251	0.299	0.458
	180 Street Crk	180SC 1.4	13.05	0.150	0.179	0.274
	180 Street Crk FC	180SC 1.5	3.38	0.039	0.046	0.071
	180 Street Crk	180SC 2.1 – 2.2	18.10	0.208	0.248	0.380
	76 Avenue B Crk	76ABC 1	51.43	0.591	0.705	1.080
		76ABC 2	6.10	0.070	0.084	0.128
		76ABC 3	1.75	0.020	0.024	0.037
		76ABC 4	6.52	0.075	0.089	0.137
	Creek 266	C266 1	7.75	0.089	0.106	0.163
		C266 2	7.70	0.089	0.105	0.162
	Creek 274	C274 1 - 2	13.00	0.150	0.178	0.273
		C274 3	0.29	0.003	0.004	0.006
		C274 4	13.69	0.157	0.188	0.288
	Creek 281	C281 1	2.42	0.028	0.033	0.051
	Creek 283	C283 1	4.41	0.051	0.060	0.093
		C283 3	1.09	0.013	0.015	0.023
		C283 2, C283 4 - 6	73.01	0.840	1.000	1.533
	Creek 281/283	C283/1 1	3.852	0.044	0.053	0.081
	Harvie Lowlands	HL1	59.00	0.679	0.808	1.239
		HL2	16.62	0.191	0.228	0.349
		HL3	22.09	0.254	0.303	0.464
		HL4	91.24	1.049	1.250	1.916
		TOTAL:	**936.25**	**10.77**	**12.83**	**19.66**

5.8 Hydraulic Analysis

The results of this analysis will be used to establish existing conditions to which proposed future conditions may be compared. The baseline can also be used for comparing the effectiveness of mitigation measures.

5.8.1 Conveyance Capacity

The Surrey Design Criteria Manual requires culverts crossing roads to be designed to accommodate the 100-yr discharge. Surcharging is permitted so long as the road is not overtopped and neighbouring properties are not impacted. **Table 5.13** provides a summary of the upland culverts and a comparison between their estimated existing peak flow and the pipe capacity and inlet and outlet controlled headwater depths.

Table 5.14 examines upland channel conveyance capacity for the existing estimated peak runoff. This table also provides a summary of those channels which were observed to contain dry-weather baseflows.

5.8.2 Erosion Analysis

The continuous simulation model is used to analyze of the amount of time that stream flows exceed a range of threshold values for lumped catchments. These threshold flow rates are scaled down by area, and re-apportioned to the upstream catchments for each of the channel cross-sections shown previously. The durations and exceedances are entered into a spreadsheet which uses the channel geometry and characteristics to calculate Shear Stress and Impulse for each benchmark flow rate. Comparisons of the Impulse values for each of the channel cross-sections are made between the existing scenario and multiple future scenarios.

5.9 Water Quality

Water quality of the watercourses within the Clayton ISMP study area has not been previously examined in detail. A data gathering and possibly a monitoring program is needed to establish the existing quality of the water and to determine any trends in the quality over time. A data acquisition and monitoring program must be effective but must also be pragmatic and cost effective. On-going monitoring is addressed further in **Section 9**.

The current design guidelines for the City do not specifically address water quality issues other than those associated with construction sediment control. However, water quality can be impacted beyond the construction period.

5.9.1 Background

The water quality characteristics of the streams are dynamic (that is, they change over time). Two definitions are used to discuss the time variance of water quality in streams. The term *chronic* is used to describe long term (i.e. over a year) average water quality conditions, and the term *acute* is used with respect to short term (i.e. over hours or days) significant changes in water quality conditions. Generally chronic loadings are a part of the baseflow and may be a result of groundwater discharges. The acute loadings could result from storm events and would include surface runoff from both developed and natural portions of the watersheds.

In assessing the significance of the level of any particular contaminant, with respect to water quality, it is important to note that average long term concentrations of the contaminant may well be acceptable, while there will be periods of time when the contaminant's concentration is many times higher, possibly exceeding acceptable levels.

Table 5.13 Culvert Capacity

Sub-Area	Watercourse	Culvert Ref	Pipe Capacity (m^3/s)	Approx. Headwall Elevation (m)	Q_{100} Inlet /Outlet Control			Existing Peak Flow (m^3/s)		Peak Discharge Conveyed?		Comments
					Inlet Headwater Depth (m)	Outlet Headwater Depth (m)	Control?	Q_5	Q_{100}	Q_5	Q_{100}	
Latimer	**192 St Creek**	**3**	0.19	1.20	2.4	2.5	outlet	0.63	1.15	No	**No**	Pipe Capacity Constraint
		2	1.99	1.40	1.4	1.2	in	0.85	1.56	Yes	**Yes**	
		1	1.22	1.25	2.2	1.8	in	0.88	1.62	Yes	**No**	Culvert undersized. Culvert outlet in poor condition.
	193 St Creek	**14**	2.20	UNK	0.7	-0.2	in	0.30	0.54	Yes	**Yes**	Unable to locate inlet in the field. Culvert adequately sized
		11	106	4	0.7	negligible	in	0.56	1.01	Yes	**Yes**	New culvert with fish passage design.
	193 St Creek Trib	**12**	1.19	1.0	<0.3	negligible	in	0.06	0.10	Yes	**Yes**	
	76 Ave Creek	**13**	2.25	0.85	0.9	0.2	in	0.37	0.67	Yes	**Yes***	*Inlet controlled headwater 0.05m above top of headwall
		10	1.11	1.95	2.0	1.6	in	0.78	1.42	Yes	**No**	Pipe Capacity Constraint
	Latimer Crk. South Arm	**8/9**	1.52	1.0	1.7	1.6	in	2.13	3.90	No	**No**	Pipe Capacity Constraint
	196 St Creek	**6**	0.65	0.60	0.8	0.8	in	0.19	0.34	Yes	**No**	Culvert forms the start of the creek. No headwall, culvert protrudes from ditch side slope.
		5	4.05	1.40	0.6	negligible	in	0.28	0.52	Yes	**Yes**	Fish passage concerns on outlet.
Langley		**4**	5.52	2.40	0.7	negligible	in	0.52	0.94	Yes	**Yes**	
	Latimer Crk North Arm	**7**	15.61	1.80	negligible	negligible	N/A	0.27	0.49	Yes	**Yes**	
Latimer	**Latimer Crk**	**15 / 16**	318	3.2	negligible	3.2	outlet	13.86	25.32	Yes	**Yes**	
Fry's Corner Uplands	**76 Ave B Creek**	**24**	1.07	0.60	0.4	negligible	in	0.10	0.17	Yes	**Yes**	
	Ditch	**21-1**	1.25	UNK	very large	2.1	in	0.69	1.25	Yes	**No**	Insufficient inlet control capacity
		21-3	1.11	N/A	N/A	N/A	N/A	0.69	1.25	Yes	**No**	Pipe Capacity Constraint
		22	0.33	UNK	0.4	negligible	in	0.07	0.13	Yes	**Yes**	Inlet controlled headwater depth less than pipe crown
	Creek 266	**23**	1.37	UNK	0.4	negligible	in	0.09	0.16	Yes	**Yes**	
	Creek 274	**25-1**	0.33	UNK	1.1	0.8	in	0.16	0.29	Yes	**Yes**	Culvert beneath 184th Street composed of pipes 25-1 (U/S) and 25-2 (D/S). Located in deep ravine.
		25-2	0.84	N/A	N/A	N/A	N/A	0.16	0.29	Yes	**Yes**	
	Creek 283	**26**	3.77	N/A	N/A	N/A	N/A	0.85	1.56	Yes	**Yes**	

Table 5.14 Upland Channel Capacity

Watershed	Upland Watershed	Dry Weather Base Flows Observed?	Ref	Maximum Channel Discharge Capacity (m^3/s)	Existing Estimated Peak Flow (m^3/s)		Existing Q_{100} contained within Channel?
					Q_5	Q_{100}	
Latimer	192 Street Creek	Yes	WC 3	3.19	0.85	1.56	Yes
		Stagnant Ponding	WC 2	10.35	0.88	1.62	Yes
	193 Street Crk	No	D 8	2.20	0.01	0.01	Yes
		n/a	RSA-30.3	26.50	0.30	0.55	Yes
		n/a	RSA-30.14	138	0.45	0.82	Yes
		n/a	RSA-30.12	19.34	0.56	1.01	Yes
		No	D 7	2.06	0.01	0.02	Yes
	193 Street Crk Trib	No	D 6	14.14	0.06	0.10	Yes
	76 Avenue Crk	No	D 9	1.26	0.37	0.67	Yes
		n/a	RSA-29.2	13.56	0.58	1.05	Yes
		No	D 5	4.55	0.70	1.28	Yes
	Latimer Crk S Arm	No	WC 9	10.62	2.13	3.90	Yes
	196 Street Crk	n/a	RSA-31.3	26.11	0.19	0.34	Yes
		No	WC 6	23.59	0.28	0.52	Yes
		n/a	RSA-31.10	458	0.38	0.69	Yes
		No	WC 7	633	0.45	0.83	Yes
		No	D 19	2.82	0.05	0.09	Yes
		No	D 20	2.59	0.06	0.12	Yes
Langley	Latimer Creek	No	WC 8	236	0.27	0.49	Yes
Latimer		Stagnant Ponding	WC 1	27.43	13.86	25.32	Yes
Fry's Corner	180th Street Crk	No	D 16	7.08	0.15	0.27	Yes
		n/a	WC 11	1.86	0.43	0.76	Yes
		n/a	WC 10	2.72	0.43	0.76	Yes
	76 Avenue B Crk	No	D 11	2.20	0.07	0.14	Yes
		No	D 18	1.78	0.02	0.04	Yes
		No	D 2	**1.12**	0.69	**1.25**	**No**
		No	D 4	4.37	0.07	0.13	Yes
	Creek 283	No	D 10	2.37	0.01	0.02	Yes

The primary concern with the acute loadings is the potential for short term degradation of water quality to a degree sufficient to pose a public health risk or risk to the fish and other aquatic life. One possible cause of an acute loading is a spill resulting from a traffic accident. The storm sewers provide a pathway through which spilled toxic contaminants can rapidly reach the streams. Although storm sewers can be blocked in times of low flow, adequate warning may not be possible. While accidental occurrences are rare, there are a variety of measures that municipalities take to strengthen their source control program: an emergency response program, the installation of oil-grit separators (OGS) at high accident intersections, and the inspection of OGS on private property (ICI).

In addition to accidental spills of toxics, illicit dumping of contaminants such as engine oil, paints, herbicides and other materials, is a significant risk. Deliberate spills require a different management program that may include public education and the availability of facilities where residents can properly dispose of contaminated materials.

5.9.2 Contaminants of Concern

Urban runoff contains five kinds of pollutants that must be considered when determining monitoring and treatment alternatives:

1. Sediments;
2. Nutrients (nitrogen and phosphorus);
3. Heavy metals;
4. Organics (including oil and grease); and
5. Pathogens (bacteria, viruses, infectious protozoan).

From the perspective of source control and treatment, these five kinds of pollutants sort into two classes: particulate and dissolved. Sediments are the main member of the particulates class, but other hydrophobic constituents, including hydrocarbons, bacteria, most heavy metals (such as lead) and some nutrients (such as phosphorous), are commonly delivered to receiving waters adsorbed to sediments. For instance, oil washed off City streets is hydrophobic and is readily absorbed by sediments before the water reaches the end of the sewer.

It follows that controlling sediment levels in urban runoff is tantamount to controlling bacteria, oil and grease, metals, and to some extent phosphorus. To reduce loads of dissolved nutrients, especially nitrogen, requires a different approach. Hence, from these two classes of pollutant have arisen two different methods of treatment. Detention methods (dry ponds, wet ponds, storm tanks) rely upon holding back and slowing down the storm water to let sediments settle out. The ultimate detention basin is an infiltration basin in which the water is not released at all, but allowed to percolate slowly into the soil. In contrast, control of dissolved nutrients relies almost exclusively on biological methods.

Nutrients may be removed by plant uptake (including algal uptake) in wet ponds and wetlands, or by soil organisms in infiltration basins. In all cases, however, it is still necessary to detain and still the water, to give biological processes a chance to act.

5.10 Envisioning Future Hydrology

As re-development of the Clayton neighbourhood occurs, maintaining the hydrologic relationships will be a key component of the development layout and design. The hydrologic cycle involves several pathways for rainfall: back into the air through evaporation; infiltration into the soil for use by plants or contributing to local groundwater flow; deep ground infiltration contributing to regional groundwater flow; or, surface runoff. Maintaining this water balance can be achieved through:

1. Identifying existing watercourses and key surface flow pathways;
2. Identifying existing aquatic and terrestrial inhabitants and key habitat areas and requirements;
3. Identifying land use planning goals and objectives;
4. Identifying hydrogeological opportunities and constraints;
5. Obtaining input from City and Stakeholders to identify priorities;
6. Overlaying the above information to maximize land use for multiple opportunities; and
7. Implementing a retain-detain-convey approach to rainwater management using Best Management Practices (BMPs).

The *retain-detain-convey* approach to storm water, or more accurately, rain water management works to manage two types of events in different ways as described below.

1. Smaller, more frequent rainfall events, which deliver the majority of the annual volume, are controlled by BMPs which seek to retain runoff on site by enhancing evaporation, infiltration, and groundwater recharge.
2. Larger, infrequent rainfall events, which deliver only a small percentage of the annual volume at high rates in a short amount of time, are detained to reduce the run-off rate. These are then safely conveyed at lower rates over a longer period of time to prevent flooding from high flow rates.

Rainwater best management practices, or Low-Impact Development techniques, fall into three categories: surface enhancement, engineered facilities for retention and engineered facilities for detention. Examples of these three types of techniques are listed below.

Surface Enhancement
- Increased top soil depth
- Enhanced soil porosity or moisture holding capacity
- Modified surface infiltration rates
- Increased vegetation and ground cover
- Decreased overall imperviousness including roof leader disconnection
- Increased surface roughness

Engineered Facilities for Retention
- Infiltration galleries
- Rain gardens
- Retention ponds
- Some forms of green roofs
- Most bio-filtration swales
- Permeable pavements

Engineered Facilities for Detention
- Constructed wetlands
- Underground storage
- Surface storage in ponds or parking lots

Water quality is often enhanced using these systems since most of them involve the settling or filtering out of sediments. Sediments themselves are a form of contaminant, which also have additional forms of contamination including nutrients, pathogens and heavy metals adhered to them. Reducing runoff volumes may also reduce the erosion potential in downstream watercourses as described previously in **Section 5.6.2**. In many cases, these facilities are designed to provide multiple functions (i.e. detention, retention and water quality enhancement).

Detention may be achieved through various forms of engineered facilities including constructed wetlands, underground storage, and surface storage in ponds or parking lots. Some of these facilities can be combined with certain BMPs to provide a dual function facility. The reasons for including detention facilities in a storm water management plan include: water quality improvements through settling out of solids; decrease in pipe diameter for downstream storm sewers; and reduction in erosion from low-frequency, high-rate events. The Fry's Corner drainage area is atypical of urban drainage basins. The upland area drains to numerous small creeks which discharge to the lowland area. Flooding is more of a concern for the lowland areas, where runoff volume is more of a concern than runoff rate.

Many of the channels examined in the previous section appear to have the geometric capacity to convey the existing 100-year runoff, while 7 of the 22 culverts examined were undersized for the existing 100-year runoff event. Many of these will be upgraded and modified with the new roads that will be built as part of the development. Several key concerns were identified through this report, and many of them have drainage planning solutions. These can be summarized in **Table 5.15.**

Table 5.15 Key Concerns for Watershed Drainage Planning

Concern	Common Mitigation Techniques
Stream Erosion	Volume Reduction
Lowland Flooding	Volume Reduction, Detention, Increased Pump Station Capacity
Base Flow Preservation	Infiltration, Ensuring groundwater connectivity through corridor preservation
Habitat Connectivity	Planning

As re-development of the Clayton neighbourhood occurs, maintaining the hydrologic relationships and integrity of the aquatic and terrestrial habitat will be a key component of the development layout and design. The key areas for concern for the study area are erosion of ravine streams, flooding in lowland channels, loss of habitat (forests, streams, etc.) and habitat fragmentation.

Due to a number of natural and anthropogenic factors drainage in the lowland areas has always been challenging. Improvements have been made over the years – most recently with the Fry's Corner Pump Station and Serpentine dykes. Many of the agricultural and roadside ditches in the western portion of the Study Area are already subject to flooding during large storm events under the low density development conditions in the watershed.

6. What Do We Want? (Creating The Vision For The Watershed)

The following twelve (12) goals were identified as critical for facilitating development while preserving and enhancing the overall health of the watershed.

- Goal 1: Protect Agriculture and Agricultural Activities;
- Goal 2: Preserve, Maintain, and Enhance Streams;
- Goal 3: Preserve, Maintain, and Enhance Riparian Areas;
- Goal 4: Preserve, Maintain, and Enhance Latimer Wetlands;
- Goal 5: Preserve, Maintain, and Enhance Key Forest Habitats;
- Goal 6: Maintain Base Flow to Streams;
- Goal 7: Maintain Stream Water Quality;
- Goal 8: Reduce the Likelihood that Increased Development Will Increase Lowland Flooding;
- Goal 9: Reduce the Likelihood that Increased Development Will Increase Stream Erosion;
- Goal 10: Increase Density in Areas of Lower Environmental Value;
- Goal 11: Improve and Maintain Wildlife Connectivity; and,
- Goal 12: Connecting Communities

These goals were presented to City staff on December 17, 2010 and representatives from key stakeholder groups on January 28, 2011. In order to accomplish the twelve goals listed above a number of recommendations were developed as outlined below.

6.1 GOAL 1: Protect Agriculture and Agricultural Activities

Over half of the study area is zoned as agriculture; 33% within the Agricultural Land Reserve (ALR) and 21% outside of the ALR. ALR lands within the study area are located in the Serpentine River lowlands/floodplain. From here the topography rises dramatically up the escarpment to the Clayton Uplands. The ALR boundaries are shown in **Figure 3.2**.

One of the Challenges and Opportunities for land use planning identified in Stage 1 is ***protecting agricultural areas***, to ensure that agriculture and agricultural activities are not negatively affected by future growth in the Clayton ISMP area. Surrey maintains a strong policy context for managing the urban/agricultural interface and for managing drainage from the uplands to the lowlands. Not only will this protect agricultural areas but will help protect future development from any negative effects from agriculture (i.e. smell, noise etc). Therefore, the exploration of appropriate residential densities adjacent to the ALR will need to be addressed in the Clayton ISMP area, given the long boundary with the ALR. ISMP findings will help frame the details of this discussion.

Currently, a significant portion of the lands within the study area, adjacent to the ALR, are zoned agriculture (A-1). However, as the zoning for these areas may change from agricultural to residential in the future, for the purposes of this ISMP, “agriculture” and “agricultural activities” are defined as those within the ALR. Therefore, considerations for buffers and “edge planning” in this ISMP are focused on the boundary of the ALR and not on agricultural lands outside of the ALR. It should also be noted that agricultural activities under consideration are not only those occurring in the present in the ALR but also those that may occur in the future.

Considerations for drainage in the ALR are dealt with in Goal 8: Reduce the Likelihood that Increased Development Will Increase Lowland Flooding.

6.1.1 Guiding Policy Documents

The City of Surrey has made commitments to protecting the ALR in its ***Sustainability Charter***, as well as in City ***Policy No. O-23***. The Charter's economic goals include protecting the integrity of the City's ALR and industrial land base for food production, employment and agro-business services. The Charter's environmental goals include creating a balance between the needs of Surrey's human population and the protection of terrestrial ecosystems.

City Policy No O-23 relates to residential buffering adjacent to the agricultural boundary. The key points of this policy are outlined in **Section 3**. "Edge Planning", as ALR buffering is referred to, is presently under review as part of the 2010 Surrey Official Community Plan (OCP) Review. The Ministry of Agriculture and Lands' *Guide to Edge Planning* (June 2009 – working copy) provides information regarding promoting compatibility along the urban-agricultural edge (http://www.al.gov.bc.ca/resmgmt/sf/publications/823100-2_Guide_to_Edge_Planning.pdf). Other examples of edge planning are outlined below.

The **Anniedale-Tynehead NCP** (in progress) requires the agricultural edge to be comprehensively planned to increase open space and vegetated buffers next to the ALR. The **Turnberry development by Polygon (Cloverdale)** was mentioned by participants of the Stakeholder meeting as an example of good development adjacent to the ALR. Restrictive covenants on buffering were used.

The **NE Gordon Estate Neighbourhood Plan (ToL)** designates a Development Permit Area for "Agricultural Edge and Escarpment Protection". The DP area requires or permits:

- Dedication of a 15 metre landscaped area adjacent to the ALR boundary (or a 7.5 metre landscaped area where a road exists along the ALR boundary;
- Notifications provided on new property titles within the DP areas indicating proximity to ALR lands and the potential for sound, odour and airborne impact from natural farm activities (Surrey does this also);
- Agricultural awareness signage to be provided advising of farm activities (Surrey has also erected signs at the entrance to agricultural areas);
- Base density of 5 units per hectare (2 upa);
- Densities up to 10 units per hectare (4 upa) (as per section 3.1.4C of the Willoughby Community Plan) are permitted provided that Stream setbacks, Ecological Greenways, and Urban/ALR interfaces are protected and dedicated; and
- Alternate subdivision patterns (e.g. cluster) and housing types (e.g. duplexes) may be permitted if the above conditions are met.

Metro Vancouver's draft Regional Growth Strategy designates the Clayton watershed as a "general urban" and "agricultural" area.

6.1.2 Stakeholder Consultation

Harvie Road was identified as key to agricultural connectivity and access to it should be discouraged for non-agricultural traffic. Stakeholders also noted the importance of preventing conflict between the agricultural and urban communities through edge planning. Edge planning defines a setback from the ALR boundary within which development is controlled to minimize conflicts over noise and smell. Participants in the stakeholder consultation process identified the following key considerations for edge planning:

- Agricultural **noise and smells** can become **magnified** in upland areas that overlook farmland;
- **Topography** can be a guide for determining ALR-Residential buffer size and restrictions. Existing developments adjacent to the ALR stop at the escarpment. and the escarpment offers a natural boundary for geotechnical reasons;

- A **site-specific** ALR edge planning setback (rather than a set, standard distance) would better reflect the variable topography, development needs, agricultural needs, riparian areas, etc;
- Increased density in **pockets** may better protect agricultural and environmental buffers;
- If increasing the **density** and clustering next to the ALR, then perhaps the 37.5m **setback** should be **increased**;
- Other options for conflict mitigation include specifying double or triple **glazed windows**, **orienting the bedrooms** away from the ALR, and **restrictive covenants** to ensure continuing compliance; and
- The edge planning process for the Anniedale-Tynehead NCP worked well.

6.1.3 Recommendations

In order to protect agriculture and agricultural activities, two recommendations came out of the visioning process, which are outlined below.

Recommendation #1*: As part of future NCPs for this area, we recommend that City staff coordinate with the AAC to develop a comprehensive edge plan that will outline setback requirements, densities and other conflict mitigation tools adjacent to the ALR. This model was successfully implemented as part of the Anniedale-Tynehead NCP and is currently being reviewed in the Official Community Plan.*

Recommendation #2*: Preserve Harvie Road as a drainage corridor so that the quantity and quality of flows are protected.*

6.2 GOAL 2 and 3: Preserve, Maintain, and Enhance Streams and Riparian Areas

The City of Surrey has classified streams according to their ability to support fish populations. The stream classifications are described in **Section 2**.

As stream protection strategies within the ALR are being dealt with as part of the Lowland Schemes, this ISMP will only be addressing streams outside the ALR. The priority areas for protection include the Class A and B streams and their riparian areas.

The watercourses within the ISMP study area, and their classification, are shown in **Figure 2.1.** A summary of wildlife found within the watershed can be found in **Section 2**. In summary Latimer Creek provided high rated habitat for a number of listed wildlife species including Pacific water shrew, red-legged frog and beaver pond baskettail. Latimer Creek also provided important habitat for other wildlife including beavers, coyotes, racoons, as well as a number of bird, amphibian, reptile and invertebrate species.

6.2.1 Guiding Policy Documents

Under the provincial ***Riparian Areas Regulation*** (RAR), enacted under Section 12 of the Fish Protection Act (July 2004), local governments are called to protect riparian areas and to have potential land developers engage a Qualified Environmental Professional to conduct an environmental assessment. Streams to which the RAR applies are any watercourse (whether or not it usually contains water), pond, lake, river, creek or brook; and a ditch, spring or wetland that is connected by surface flow to a watercourse, pond, lake, river, creek or brook that provides fish habitat. Riparian assessment areas include the 30m strip on both sides of the stream:

- measured from the high water mark;
- measured from the top of bank for a ravine less than 60m wide; or,

- for ravines more than 60m wide, the assessment area is the10m strip on both sides of the stream measured from top of bank.

Watercourses and their riparian areas are also protected by the provincial ***Land Development Guidelines for the Protection of Aquatic Habitat***. Under this regulation, setbacks for streams range from 15-30 meters from the high water mark or from the top of ravine (if slopes steeper than 3:1 exist) depending on the density of development at a site. If a riparian area is to also function as a wildlife movement corridor, a 30 meter or greater vegetated setback would be preferred.

The ***Drainage Management Guide*** (B.C. Ministry of Agriculture, Food and Fisheries, 2005) provides information to farmers and local governments on how to develop and implement an Agricultural Drainage Management Plan while being effective stewards of fisheries resources.

The City of Surrey has made commitments to protecting its terrestrial and aquatic habitats in its ***Sustainability Charter*** and through the Green Infrastructure Network that was developed as part of Surrey's ***Ecosystem Management Study***. The Township of Langley would apply their ***Streamside Protection Bylaw*** to development along the 196 St. Creek.

6.2.2 Stakeholder Consultation

The priority areas for protection include the Class A and B streams and their riparian areas as shown in **Figure 6.1**. Consultations with Stakeholders identified several considerations in planning riparian protection:

- Installing culverts and bridges suitable for wildlife passage at all road crossings of Latimer Creek and its tributaries within the study area would improve habitat connectivity to the existing forested areas for all wildlife;
- Public access to riparian setback areas should be considered;
- Generally 30m setbacks for Class A streams, and 15m setbacks for Class B streams meet the intended environmental purpose; however, setback requirements should consider the specifics of the stream and the adjacent development; and,
- Mechanisms for compensating property owners should be in place if watercourse riparian setbacks are site-specific and extended in some areas in compensation for reductions at other locations.

6.2.3 Recommendations

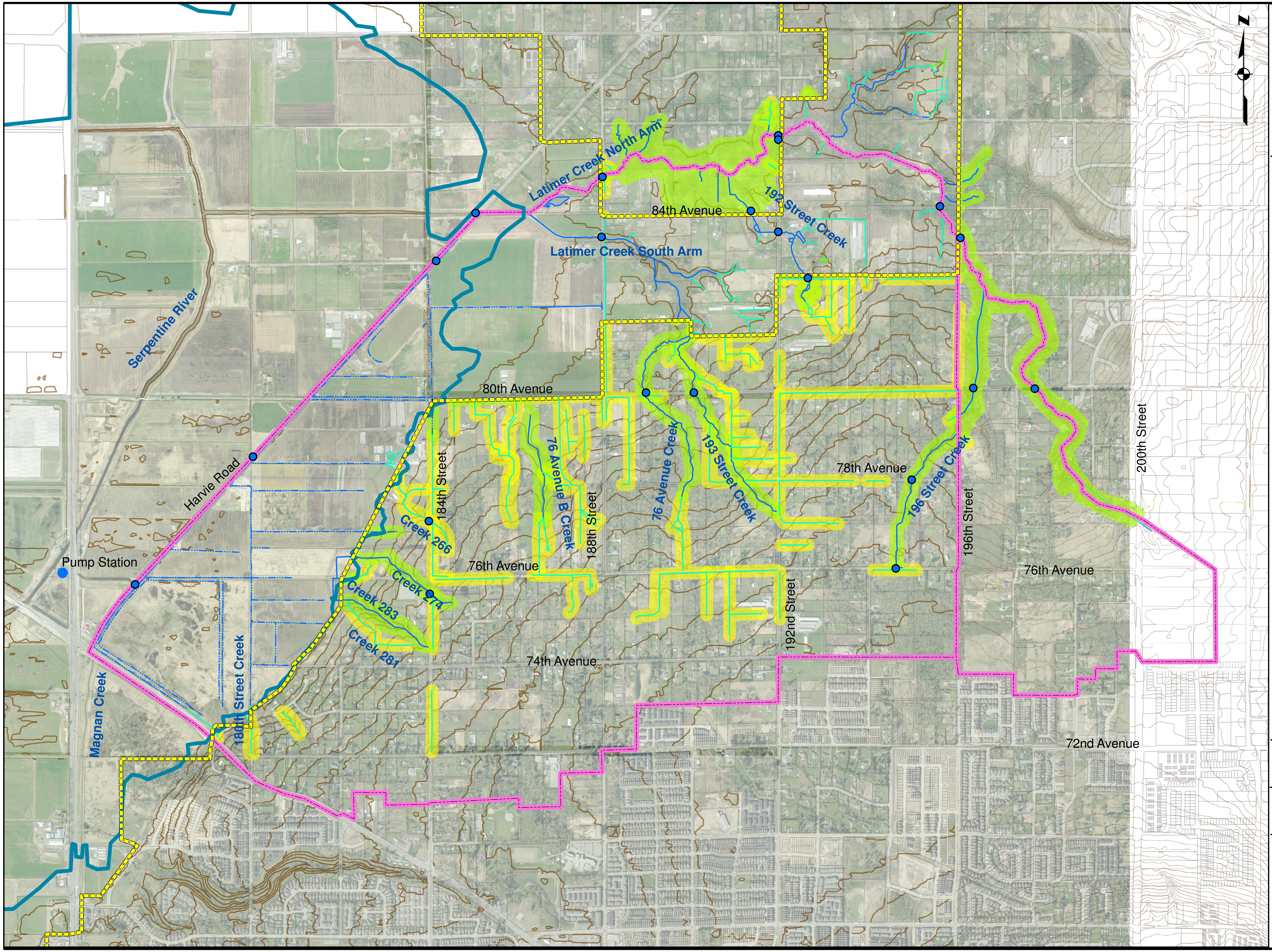
In order to achieve Goals 2 and 3 (protection of streams and their riparian areas), four key recommendations came out of the visioning process, which are outlined below.

Recommendation #1*: All Class A and B streams shall be protected. Otherwise compensation (for example along 192nd Street) shall be provided.*

Recommendation #2*: Where suitable, culverts should be designed with consideration of aquatic and terrestrial wildlife passage.*

Recommendation #3: *The City shall modify or engage an Environmental Professional to confirm the transition between from Class A to Class B for the 196 Street Creek at 80th Avenue.*

Recommendation #4*: All Class A and B streams are to have a minimum designated riparian setback of 30 metres, otherwise a comprehensive assessment is required.*



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Legend

- Study Area Boundaries
- ALR Boundary
- Floodplain
- Wildlife Crossings
- Class A 30m Setback from Top of Bank
- Class B 30m Setback from Top of Bank
- Contour 5m
- Contour 10m

Watercourse Classifications

- A
- AO
- B
- C

AECOM

0 100 200 400 600 800
Meters

Project No.	Date
60158414	June 2012

Streams & Riparian Setbacks
Figure 6.1

6.3 GOAL 4: Preserve, Maintain and Enhance Latimer Wetlands

The Surrey Ecosystem Management Study describes the Cloverdale area (Clayton is a subarea of Cloverdale) as 10% forest, 1.4% interior forest, 1.8% freshwater wetlands, and 8.6% old field habitat. A majority of these forests, wetlands, and old field habitats are within the Clayton subarea.

The Preliminary Environmental Assessment for the Clayton ISMP highlighted two wetlands adjacent to the lower portions of Latimer Creek as Sensitive Environmental Areas, as shown in **Figure 6.2**. Within these wetlands there are 2 vegetation species, 3 vertebrate species, and 1 invertebrate species that have been identified as federally and/or provincially-listed species of concern; including the: False-pimpernel; Vancouver Island Beggarticks; Great Blue Heron; Green Heron; Short-eared Owl; and, Beaverpond Baskettail.

The two wetlands are located inside the Agricultural Land Reserve (ALR). As stream/wetland protection strategies within the ALR are being dealt with as part of the Lowland Schemes, this ISMP will not be developing requirements for the protection of these wetlands.

6.3.1 Guiding Policy Documents

Section 3 (Streams and Riparian Areas) of the provincial ***Riparian Areas Regulation*** (RAR), enacted under Section 12 of the Fish Protection Act (July 2004), requires protection of stream riparian areas which includes wetlands that are connected by surface flow to a watercourse that provides fish habitat. Riparian areas for wetlands are also protected by the provincial ***Land Development Guidelines for the Protection of Aquatic Habitat***.

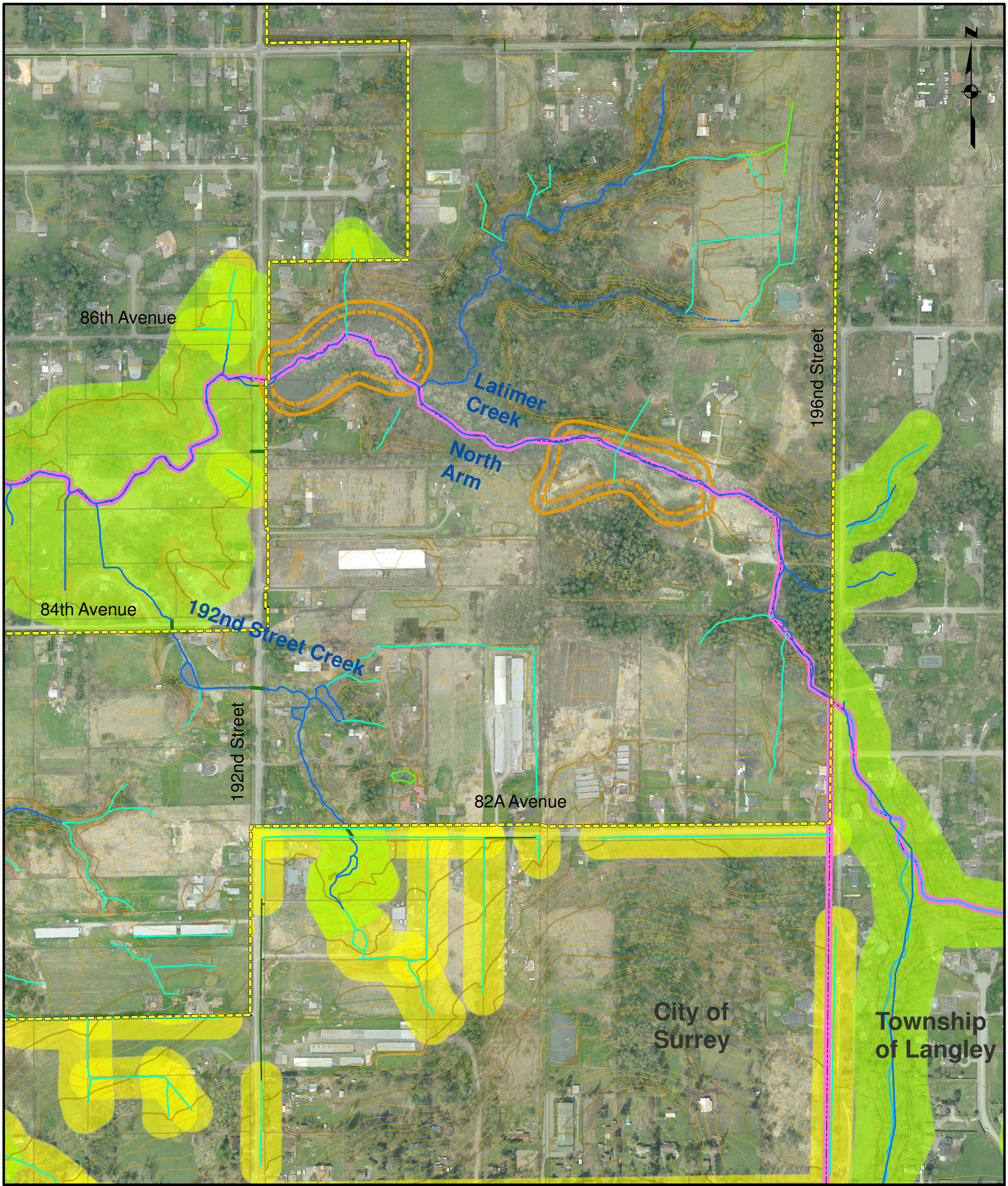
6.3.2 Stakeholder Consultation

Although all Stakeholders at the consultation meetings agreed that the preservation, maintenance, and enhancement of the Latimer wetlands was an important goal; the jurisdictional limitations of the ISMP within the ALR was acknowledged. It was recommended that this ISMP provide a methodology that works with farmers and creates buy-in. It was suggested that this could potentially be achieved through educational campaigns or possibly a form of compensation in exchange for preservation.

6.3.3 Recommendations

In order to achieve Goal 4 of this ISMP, one key recommendation came out of the visioning process, which is outlined below.

Recommendation #1: *The City of Surrey, through the Lowland Schemes, shall coordinate with the agricultural community to protect the Latimer Wetlands.*



City of Surrey
Clayton ISMP

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Date: June 2012

Legend

Study Area Boundaries
ALR Boundary
Key Wetlands / Seasonal Flooding
Key Wetlands 15m Buffer

Watercourse Class
A
AO
B
C

Class A 30m Setback from ToB
Class AO 30m Setback
Class B 30m Setback from ToB
Contour 1m
Contour 5m

AECOM

Meters
0 50 100

Latimer Creek Wetlands

FIGURE 6.2

6.4 GOAL 5: Preserve, Maintain and Enhance Key Forest Habitats

The ISMP Study Area contains primarily low density residential and agricultural land use. There are unopened road rights-of-way, which have contributed to the conservation of significant interior forest habitats within the Study Area

(greater than 1 hectare). Many of the rear yards of the large residential lots are also forested, creating habitat corridors relatively free of road crossings. Based on previous studies, existing data, and field verification, the key wildlife habitats in the Study Area include the interior forest habitat in the area between 76th and 80th Avenues and 184th and 192nd Streets and the interior forest habitat east of 194th Street and south of 76th Avenue. These key forest habitats are shown as area #1 and area #2, respectively on **Figure 6.3**.

The forested portions within the study area are second to third growth stands. These stands are at seral states that are therefore not listed ecological communities by the BC Conservation Data Centre (BCCDC). Despite this, the forest stands are essential for providing refuge for birds and small mammals, protecting water quality and aquatic habitat, and enabling wildlife movement between habitat hubs. See Section 2.4 for more information on the forest hubs.

Interior forests have special habitat conditions that enable them to support different wildlife species than forest edge habitats. Interior forest habitats are relatively uncommon in the City of Surrey.

The primary concern for terrestrial habitats is that encroachment and fragmentation will reduce or eliminate interior forest habitats and habitat corridors will be lost. There are many opportunities to increase the connectivity of the existing forest stands, which will contribute to the overall biodiversity potential of the Study Area and beyond.

6.4.1 Guiding Policy Documents

The City of Surrey has made commitments to protecting its terrestrial habitats in its ***Sustainability Charter***. Environmental goals include creating a balance between the needs of Surrey's human population and the protection of terrestrial ecosystems, specifically, interconnecting natural areas by way of wildlife corridors.

Forest habitat and corridors within riparian areas are protected by the provincial ***Land Development Guidelines for the Protection of Aquatic Habitat*** and under Section 3 of the ***Riparian Areas Regulation*** (RAR).

6.4.2 Stakeholder Consultation

Although all Stakeholders at the consultation meetings agreed that the preservation, maintenance, and enhancement of key forest habitat is an important goal, it was acknowledged that the location of these habitats presented challenges to preservation most notably:

- That existing road rights-of-way cross through the identified forest habitat;
- There is an incompatibility between trees and overhead power lines;
- Developments in Langley and adjacent communities, and their associated traffic patterns influence arterial road routing; and
- Much of the forest habitat is currently on private property with the exception of a block of 5 lots located on the 78th Avenue right-of-way between 188th and 190th Streets, and 2 lots on the 77th Avenue right-of-way in the vicinity of 194th Street, which have been purchased by the City Parks Department.

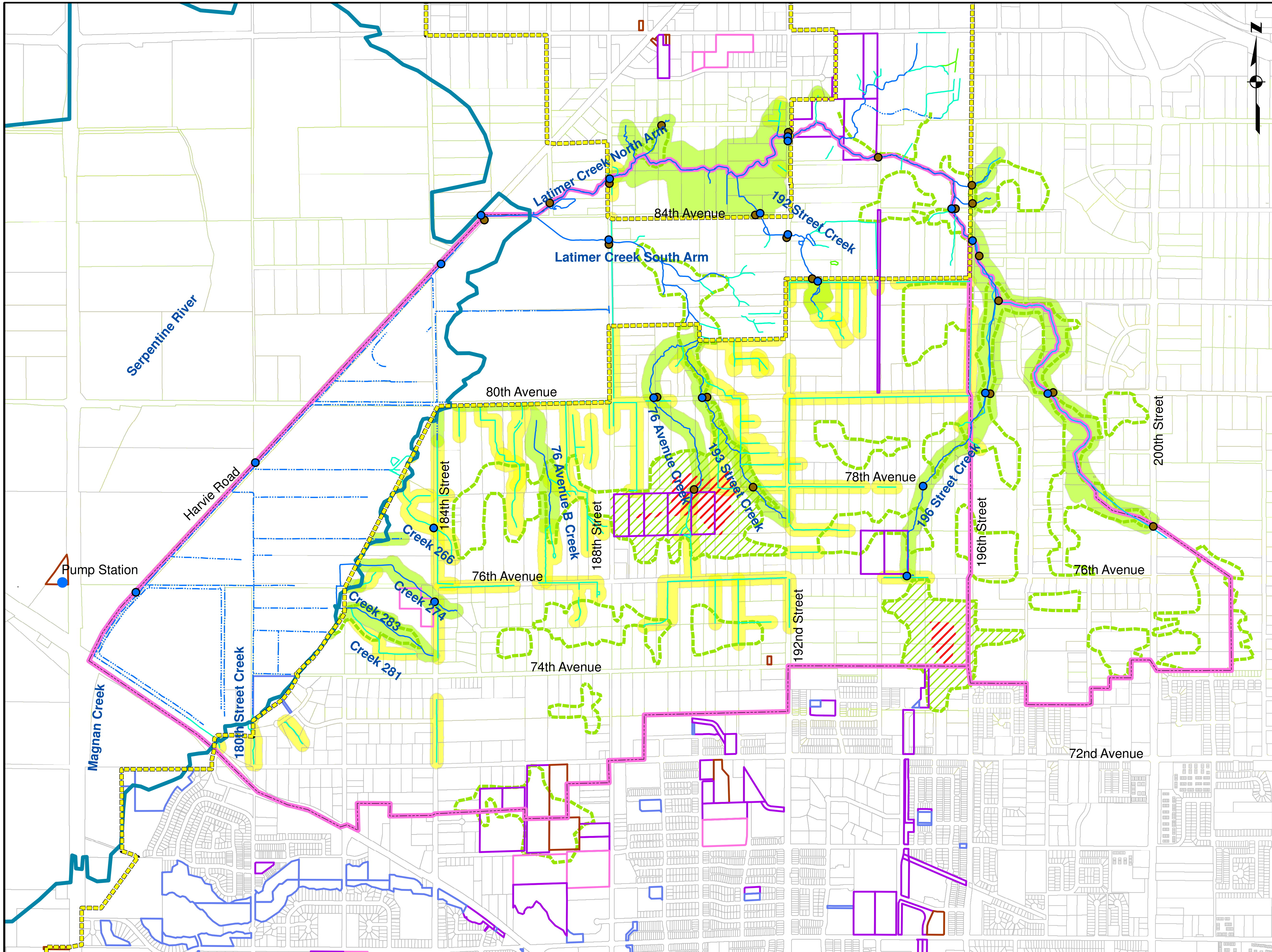
During Stakeholder consultations it was noted that a large portion of Surrey's greenspace in located in the ALR. Retaining greenspace outside of the ALR which is fully within the City's jurisdiction and control is important. Concerns were raised regarding the future wildlife/urban interface and any safety issues this may pose for future residents. Based on the results of the environmental study, the forested areas were not seen as posing a safety risk to residents due to the presence of large animals.

The corridor area along 77th Avenue between 192nd Street and the 196 Street Creek was identified as being a potentially important wildlife corridor between two significant tributaries to Latimer Creek. This is shown as area #3 in **Figure 5.1** and will be discussed further under Goal 10 "Wildlife Connectivity".

6.4.3 Recommendations

In order to achieve Goal 5 of this ISMP, one key recommendation came out of the visioning process, which is outlined below.

Recommendation #1: *It is recommended that strategies to preserve the two (2) key interior forest habitats be identified.*



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Legend

- Wildlife Crossings
- Bottomless Culverts on Class A
- City Land
- Park - City Dedicated
- Park - City Purchased
- School
- ALR Boundary
- Floodplain
- Forest Habitat
- Forest Habitat (edge required to preserve interior habitat)
- Forest Interior (>100m from the edge)
- Study Area Boundaries
- A
- AO
- B
- C
- Class A 30m Setback from Top of Bank
- Class B 30m Setback from Top of Bank

AECOM

0 100 200 400 600 800
Meters

Project No.	Date
60158414	July 2012

Forest Habitat

Figure 6.3

6.5 GOAL 6, 7, 8, and 9: Base Flows, Water Quality, Lowland Flooding, and Erosion

Land use type affects the level of imperviousness within a watershed, which in turn affects the volume, rate and quality of storm water runoff. As areas for future development are identified, the resulting imperviousness and its impact on storm water runoff will need to be addressed. The primary concerns for the aquatic habitats are:

1) Erosion, particularly of the small creeks within steep gullies along the escarpment resulting from future increases in peak flow volume and velocity;
2) Flooding in the lowland channels;
3) Preservation of base flows, for which groundwater recharge and connectivity is important; and,
4) Water quality.

6.5.1 Guiding Policy Documents

A number of drainage studies have been conducted either adjacent to or within the ISMP study area and are described in Section 5.2. The City of Surrey is also committed to the flood control requirements for the Serpentine Floodplain as outlined by the Agri-Food Regional Development Subsidiary Agreement (ARDSA) program.

The ***Storm water Guidebook for BC*** (MWLAP 2003) and ***Beyond the Guidebook*** (IGP 2007) require a three-stage approach to rain (storm) water management:

1. *Retain* smaller, frequent storm event runoff for on-site for infiltration;
2. *Detain* larger, infrequent storm event runoff to prevent flooding; and
3. *Convey* safely the released flows

These *Guidebooks* recommend volume reduction (retention/infiltration) systems be designed to match the:

- Predevelopment volumetric infiltration rates; and,
- Predevelopment discharge duration relationships.

The current design guidelines for the City do not specifically address water quality issues other than those associated with ***construction sediment control***. However, water quality can be impacted beyond the construction period.

Slope stability is of concern, particularly in the many steep ravines found across the ISMP study area. The ***Hydrogeological Assessment for the Clayton Neighbourhood Concept Plan*** (Dillon, 1997) provides preliminary recommendations for construction setbacks, riparian areas, and storm sewer outfalls. A city-wide ***ravine stability assessment*** was carried out by Web Engineering in 2009, which included five creeks within the ISMP study area.

The City of Surrey has made commitments to protecting its water resources and aquatic habitats in its ***Sustainability Charter*** considering: groundwater; surface water; drinking water sources; creeks, streams, and river systems; sources of pollutants entering aquatic systems; and, native freshwater habitats. In addition, the City has committed to establishing a built environment that is balanced with the City's role as a good steward of the environment by: minimize the impacts of development on the natural environment; promoting permeable surfaces where possible in new developments; incorporate opportunities for natural areas and urban wildlife; protecting unique and valuable land forms and habitats; minimizing liquid waste; and expressing community environmental values in new developments.

6.5.2 Stakeholder Consultation

In developing the Vision for the Clayton ISMP, the following four goals were presented to stakeholders for their consideration:

- Maintain base flow to streams;
- Maintain stream water quality;
- Reduce the likelihood that increased development will increase lowland flooding; and,
- Reduce the likelihood that increased development will increase stream erosion;

These goals can be addressed through Storm water Best Management Practices (BMP) or Low Impact Development strategies. As these goals are interlinked a given strategy will often address more than one goal at a time. A list of strategies that can be drawn on for achieving these goals is shown in **Table 6.1**.

Stakeholders commented that storm water ponds for detention are not favourable due to their high cost and land requirements; however, they would be favourable for water quality. Although DFO does not typically recognize storm water ponds as compensation habitat, it has been shown that wet ponds and bioswales can increase the productivity and diversity of the Class B streams (ie roadside ditches) that they replace. (Ken Lambertsen)

City staff noted that french drains may be required behind sidewalks adjacent to a steep slope with groundwater discharge. Surfacing groundwater has been a problem in other neighbourhoods in Surrey with similar hydrogeological settings.

The Township of Langley highlighted a few storm water issues in their area of this ISMP, which are listed below.

- The 196 St Creek channel flows near full capacity just upstream of 196 St where the creek re-enters Surrey from Langley. Both the Township of Langley and the City of Surrey receive complaints from a local resident regarding this issue.
- The 196 St. Culvert (north of 83 Ave) fills with sediment from erosion in the upstream ravines. The Township of Langley has had discussions with DFO about the possibility of locating a sediment sump somewhere along the 196 St. Creek to have a permanent clean out location if erosion cannot be controlled.
- The Carvolth area in the Township of Langley is currently undergoing development. As per the Latimer Master Drainage Plan, this area was to be serviced by Pond LC2, which has not been built yet. The Township has been requiring infiltration and on-site detention for the lots currently being developed to reduce downstream impacts prior to construction of the pond. Ongoing communication and co-ordination with Langley on shared drainage planning (for example Latimer Creek MDP) is required as planning moves into implementation. Put on map of culvert issues.

6.5.3 Recommendations

In order to achieve Goals 6-9 of this ISMP, two key recommendations came out of the visioning process, which are outlined below.

Recommendation #1*: Development in the uplands are to be designed to maintain the base flows and water quality of streams, and to not cause any increases in stream erosion or lowland flooding.*

Recommendation #2*: Mechanisms for achieving recommendation #1 as well as addressing drainage issues from existing development need to be determined through hydrological and hydraulic modelling, consultation with City of Surrey staff, and consultation with Township of Langley staff, where applicable.*

Table 6.1 Storm water Best Management Practices and Low Impact Development Options

Description	Option	On Lot Option	Off Lot Option	Goal: Base Flows	Goal: Stream Water Quality	Goal: Lowland flooding	Goal: Stream erosion
Underground Infiltration Unit	Pervious Stormsewers		x	x	x	x	x
	Pervious Catchbasins		x	x	x	x	x
	Pre-fab Infiltration Chambers	x (not for Single Family)	x	x	x	x	x
	Drainrock Infiltration Trenches	x (Single Family)	x	x	x	x	x
	Groundwater Injection Well		x	x		x	x
Infiltration & Enhanced Pervious Surface	Infiltration Swale	x	x	x	x	x	x
	Raingarden	x	x	x	x	x	x
Reduced Impervious Surface Area	Concentrated Development	x	x	x	x	x	x
	Disconnected Roof Leaders	x		x	x	x	x
	Green Roof	x				x	x
Enhanced Pervious Surface	Permeable Pavement	x	x	x	x	x	x
	Absorbant Landscaping / Enhanced Topsoil	x	x	x	x	x	x
	Infiltration Pond / Constructed Wetland		x	x	x	x	x
	Planter Boxes	x			x	x	x
	Rainbarrels	x			x	x	x
Maintain Groundwater Connectivity	Identify and protect hydraulically connected corridors of groundwater flow that connect infiltration areas to seepage areas at stream headwaters		x	x			
Water Quality: Policy	Spill Response Program	x	x		x		
	Fertilizer By-law	x	x		x		
	Source control requirements for ICI sites	x			x		
Water Quality: Engineering Solution	Oil-Water Separator (Parking Lots and key intersections)	x	x		x		
	Hydro-dynamic Separators	x	x		x		
	Filter Inserts for Catchbasins	x	x		x		
Storm water Rate Reduction	Detention Pond		x	x	x	x	
	Storm water Bypass		x			x	x
Lowland Flood Reduction	Increased Pump Capacity		x			x	

6.6 GOAL 10: Increase Density in Areas of Lower Environmental Value

Increased development density is a policy generally supported by the City as it can provide numerous benefits, some of which are outlined below:

- ***Environmental*** - smaller footprint per capita, less sprawl into farmland and greenspace, and more transportation options.
- ***Liveability*** - less commuting, lower housing costs, increased housing diversity, improved health and well-being through greater community and increased "walkability".
- ***Economic*** - more efficient land-use, reduced servicing costs, decreased transportation costs, and development of local businesses to support the local community.

The Ecosystem Management Study (EMS) is currently underway and provides a guide for determining the environmental value of different areas. **Figures 6.4** and **6.5** overlay the most relevant EMS layers including the habitat hubs and potential corridors, with relevant study area data, such as stream setbacks and ALR interfaces. These maps highlight opportunities to plan for preservation and enhancement of some of the high quality habitat hubs and corridors during the redevelopment and potential densification of the Study Area. As discussed in Chapter 8 "Wildlife Connectivity", the potential corridors shown could be preserved through the clustering of development.

The EMS identifies several areas of ecological significance within the ISMP study area, all of which are of medium significance (51-70 points). The areas of moderately high (61-70 points) significance are located around Latimer Creek South Arm and upstream tributaries, as well as around 76 Avenue B Creek. The EMS notes that the ownerships of many of these significant areas are privately owned.

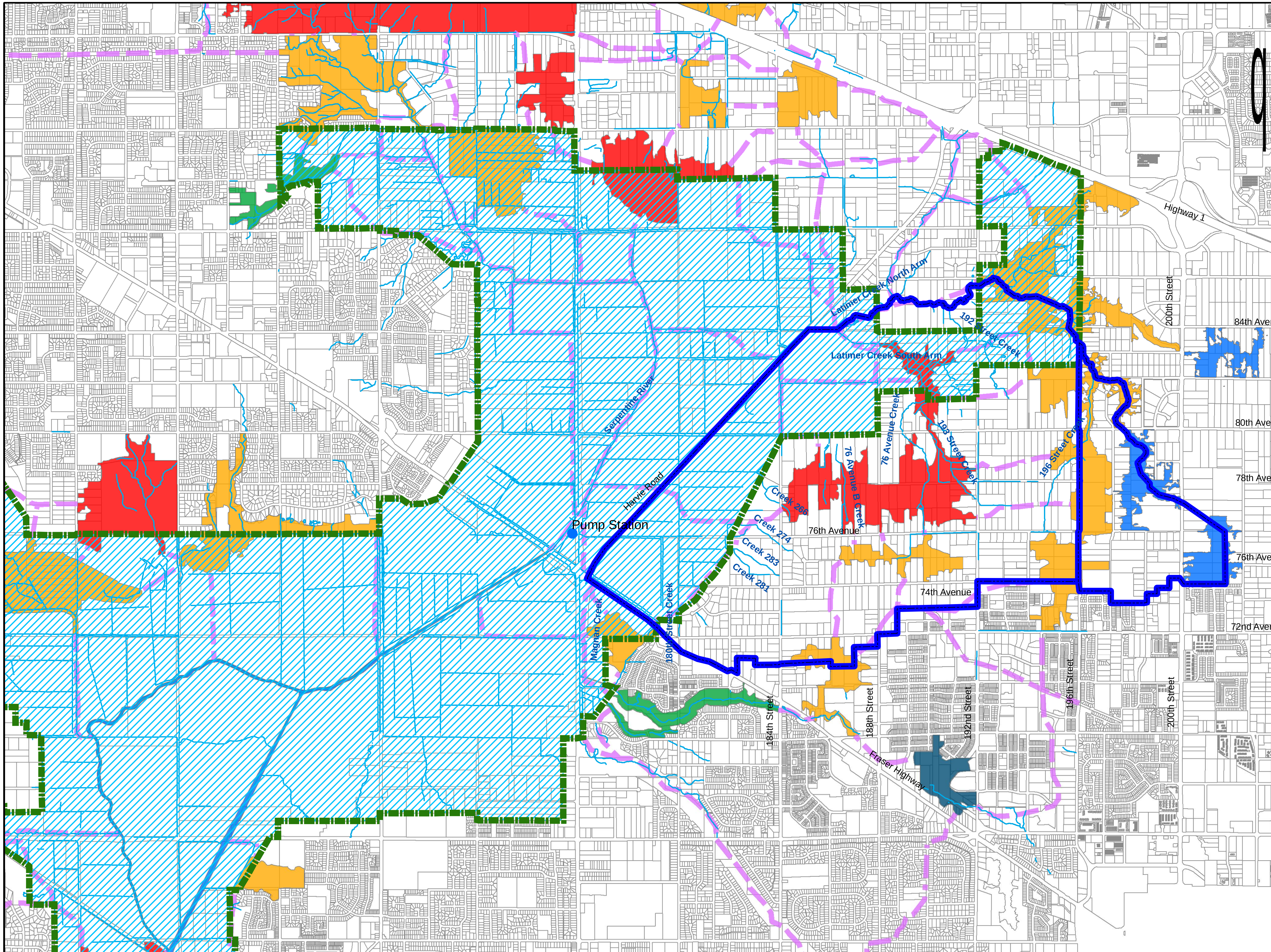
6.6.1 Guiding Policy Documents

Increased density (units per acre) is supported in a number of existing policies of the City of Surrey, Translink, and Metro Vancouver. Determining the comparative environmental value of land is a process that was undertaken by the City's ***Ecosystem Management Study*** (EMS). Momentum for the EMS originated from the Sustainability Charter which directs the City to strategically mange the ecosystems throughout the City.

The ***Official Community Plan*** (OCP) encourages growth management by using compact and nodal communities that enhance image and character, protect agriculture and agricultural areas; protect natural areas; and, improve the quality of community. The ***Sustainability Charter*** contains many goals that favour compact communities and environmental protection to meet socio-cultural, economic, and environmental needs.

Adjacent Neighbourhood Concept Plans (***NCP***s) in Surrey and Neighbourhood Plans (***NP***s) in Langley are requiring increased densities. Planning in Langley is currently underway for the 200th Street corridor, and close communication between the City and the Township should be a priority.

Metro Vancouver's ***Regional Growth Strategy*** (RGS) to promotes Willoughby Town Centre, adjacent to the ISMP area, as a "Regional City Centre", while the Clayton watershed is designated as "general urban" and "agricultural" (within the ALR lands).



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City of Surrey
Clayton ISMP

Legend

- Study Area Boundaries
- ALR Boundary
- EMS Potential Corridor

EMS Ecological Significance of Hubs

- 81 - 88
- 71 - 80
- 61 - 70
- 51 - 60
- 41 - 50
- 34 - 40
- Outside of Surrey

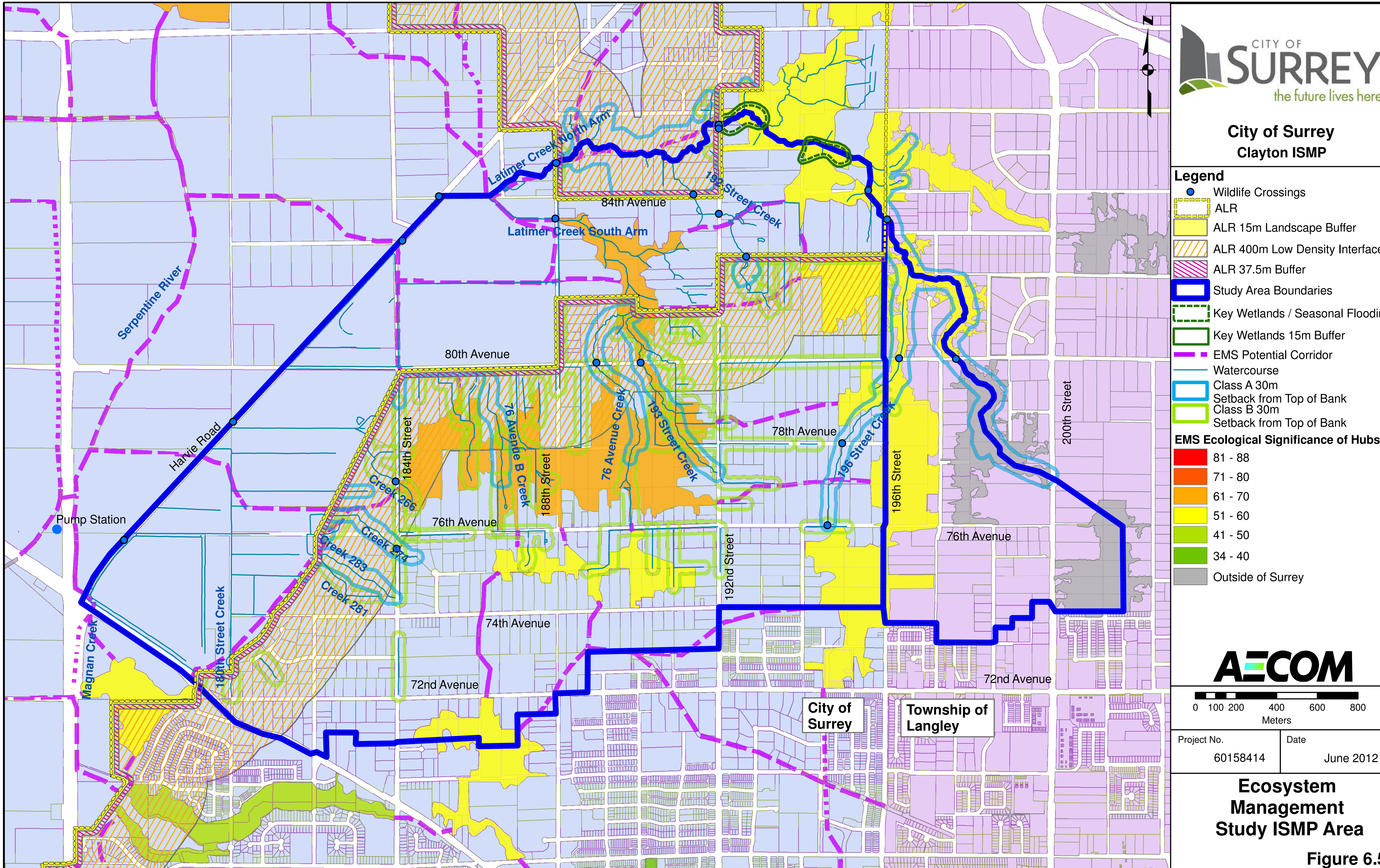
AECOM

0 250 500 1,000 1,500
Meters

Project No.	Date
60158414	July 2012

Ecosystem Management Study Overview

Figure 6.4



City of Surrey
Clayton ISMP

Ecosystem Management Study ISMP Area

Figure 6.5

6.6.2 Stakeholder Consultation

The ***Clayton General Land Use Plan*** (GLUP) has identified a village hub at 188th Street at 72nd Avenue. Nodal, compact development and effective, accessible community connections around this point would support the village hub concept. During consultation, Stakeholders noted that clustering building footprints together has the benefit of clustering greenspace fragments into larger, more useable spaces for recreation and nature. Stakeholders also reinforced that land use planning should be consistent with the Surrey Environmental Management Study (EMS) to ensure that key corridors are preserved and that connectivity is maintained.

During the stakeholder consultation it was noted that BC Hydro does not upgrade its facilities unless necessary. Generally spot loads can be incorporated, but large-scale developments may require an area capacity assessment. The densities proposed in the Clayton area are higher than those of other Neighbourhood Community Plans (NCP). It was also noted that The Township of Langley is currently conducting a district energy study. There may be opportunities for collaboration between the City and Township.

6.6.3 Recommendations

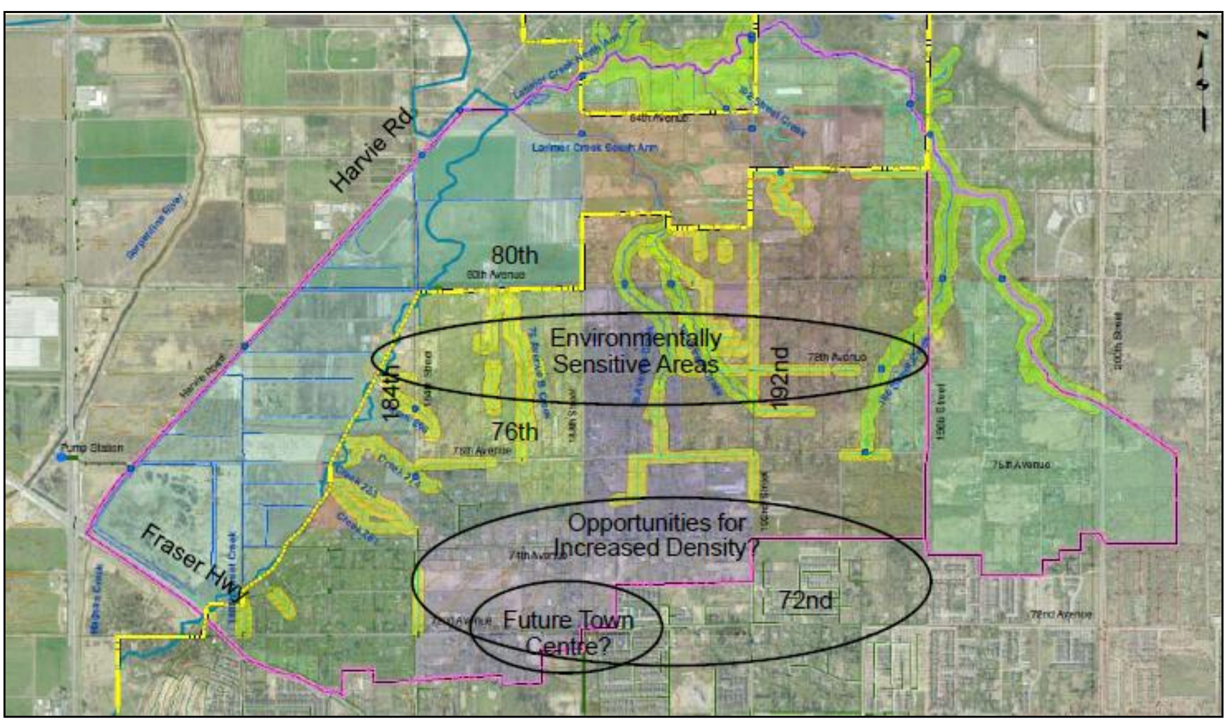
In order to achieve Goal 10 of this ISMP, three key recommendations came out of the visioning process, which are outlined below.

Recommendation #1*: Areas within the Clayton ISMP that should be considered for increased densities in future NCP (Neighbourhood Concept Plans) are along the southern edge and adjacent to 188th Street and 72nd Avenue.*

Recommendation #2*: As planning in Langley is currently underway for the 200th Street corridor and the Latimer Neighbourhood, close communication between the City of Surrey and the Township of Langley is a priority.*

Recommendation #3*: The City must ensure sufficient utilities (energy, communications, water and sanitary) are available for the densities and development locations planned in the Clayton ISMP study area.*

Figure 6.6 Opportunities For Increased Density



6.7 GOAL 11: Improve and Maintain Wildlife Connectivity

The Ecosystem Management Study (EMS) is currently underway and provides a mapped inventory and classification of environmentally valuable areas. As previously described, wildlife signs and activity were recorded throughout the study area. Signs of coyote, raccoon, beaver, woodpecker and passerines were detected within the study area. One Red-tailed Hawk was foraging within the project area. Most of the treed portions within the study area provided potential breeding/roosting habitat for raptors, passerines, woodpeckers and a number of bat species. Songbirds were observed flying and feeding in vegetation throughout the site. Moderately used wildlife corridors were observed along the forested portions of the banks of Latimer Creek and its tributaries during the field survey.

The primary concern for terrestrial habitats is that encroachment and fragmentation will reduce or eliminate interior forest habitats and habitat corridors will be lost. There are many opportunities to increase the connectivity of the existing forest stands, which will contribute to the overall biodiversity potential of the Study Area and beyond. Installing culverts and bridges suitable for wildlife passage at all road crossings of Latimer Creek and its tributaries within the study area would improve habitat connectivity to the existing forested areas for all wildlife, including Pacific water shrew and Trowbridge's shrew. This habitat enhancement would also provide a secure wildlife corridor for all wildlife species.

As shown previously, a total of 21 potential wildlife crossings along various roads within the study area were identified during the field program. These crossings were part of potential wildlife corridors that may be used by at least 13 federally or provincially listed terrestrial wildlife and vegetation species. The crossings associated with the main stem of Latimer Creek were identified as having the highest wildlife values and provided high rated habitat for a number of listed wildlife species.

6.7.1 Guiding Policy Documents

The ***Ecosystem Management Study*** (EMS) updates and provides increased detail to existing mapping included in the Official Community Plan. The Sustainability Charter directs the City to strategically mange the ecosystems throughout the City, to create a balance between the needs of Surrey's human population and the protection of terrestrial ecosystems, and to interconnect natural areas by way of wildlife corridors.

In the Township of Langley, the ***Willoughby Habitat Status Report*** (LEPS 2004) identifies important habitat hubs and corridors and provides recommendations for protection. The high priority areas within the ISMP study area have been included in the current Surrey EMS database.

Forest habitat and corridors within riparian areas are protected by the provincial ***Land Development Guidelines for the Protection of Aquatic Habitat*** and under Section 3 of the ***Riparian Areas Regulation*** (RAR).

6.7.2 Stakeholder Consultation

Stakeholders stated that consistency between the ISMP and the EMS will be important to ensure wildlife connectivity across the ISMP study area and across the City and Region. **Figure 6.5** shows potential EMS corridors that need to be defined and preserved, as necessary, through careful land use planning. Some of these corridors may be addressed through the preservation of stream riparian areas and a buffer at the ALR interface. It was acknowledged by stakeholders that through the clustering of development, the remaining habitat corridors can be preserved, even in areas where the overall density of development is increased.

Although Stakeholders at the consultation meetings generally agreed that improving and maintaining wildlife connectivity is an important goal, it was acknowledged that the location of these habitats presented challenges to preservation most notably:

- That existing road rights-of-way cross through the identified habitat corridors of ecological significance;
- Developments in Langley and adjacent communities, and their associated traffic patterns influence arterial road routing; and
- Some of the habitat is on private property. Mechanisms for preserving this land may require compensation to land owners.

6.7.3 Recommendations

Achievement of Goals 1, 3, 5 and 10; namely providing a buffer at the ALR interface, protecting riparian areas, preserving key forest areas and promoting increased densities in areas of lower environmental value, will contribute to the protection of habitat corridors and hubs. In addition to the recommendations outlined in previous goals, are four recommendations that came out of the visioning process that are specific to improving and maintaining wildlife connectivity.

Recommendation #1: *It is recommended that strategies to preserve the 77th Avenue corridor between the 193 Street and 196 Street Creeks be identified.*

Recommendation #2*: Cluster development is encouraged to maximise green space and corridors between them. Potential EMS corridors need to be defined and preserved, as necessary, through the NCP process.*

Recommendation #3*: City owned property should be planted with native species that enhance habitat quality and act as transition areas. The City should also encourage residents to do the same on private property.*

Recommendation #4*: Culverts and bridges suitable for wildlife passage at appropriate road crossing locations of Latimer Creek and its tributaries within the study area should be installed.*

6.8 GOAL 12: Connecting Communities

How and where communities are connected is a question of land use patterns and policies, transportation objectives, and environmental objectives. Challenges and opportunities for urban planning associated with this ISMP are outlined in **Section 3.5**. Information on the Transport 2040 planning document and the Frequent Transit Network can also be found in **Section 3**.

A fundamental responsibility of municipalities, and one of the most effective tools for achieving sustainability, is land use regulation and the control of land development practices. The location of the various types of land uses, transportation choices, density, and the mix of land uses, along with development practices, are key determinants in the ecological footprint of the City. As part of the Sustainability Charter, the City will require land use densities and mixes of land use and activities that allow local access to goods and services and support high levels of walking, cycling and transit use for residents and employees.

Other objectives and considerations must be made in choosing arterial routing including: the protection of agriculture and agricultural activities; and, preserving maintaining and enhancing streams, riparian areas, and wildlife habitat and corridors.

Connecting communities is a not only about ***inter-connectedness*** but also ***inner-connectedness***. Creating neighborhoods that have distinct identities and lively public spaces for social connections is important. Placemaking builds on a local community's assets, inspiration, and potential, to create public spaces that promote health, happiness, well being, and civic involvement. It incorporates high quality design and beauty in the public realm and built environment which visually and aesthetically connects the community.

6.8.1 Guiding Policy Documents

Land use patterns and policies are based on the ***Official Community Plan***, ***Neighbourhood Concept Plans***, ***Neighbourhood Plans***, and ***General Land Use Plans***.

The ***Official Community Plan*** (OCP) was amended earlier in 2010 to provide targets and policies related to greenhouse gas emission reductions. While targets exclude emissions from agriculture (and industrial sources), future development within the Clayton watershed can be expected to contribute to realizing these targets.

Some of the key identified themes of the ***Sustainability Charter*** that are within the sphere of influence of the ISMP process and support the goal of connecting communities include:

- *Provide sidewalks, greenways, trails, bikeways, pathways and pedestrian corridors that promote interconnectedness in the community;*
- *Ensure accessibility and social inclusion for all;*
- *Protect the City's employment land base;*
- *Plan and build a beautiful city, that has a sense of place, with complete communities; and,*
- *Locate economic activities where they can be best serviced by a sustainable transportation network.*

The ***Clayton General Land Use Plan*** (GLUP) identifies Clayton as a complete community with a build-out population of between 30,000 and 35,000 people. The GLUP provides the overall planning framework for the entire Clayton area and established the interrelationships between the various neighbourhoods within the plan area.

Approximately 100 hectares (247 acres) of the Clayton watershed are located within the ***Willoughby Community Plan*** Area of the Township of Langley. While most of this area is currently characterized by suburban residential uses, it is anticipated that higher densities may be considered in the future, subject to more detailed planning. The **Master Transportation Plan** for the Willoughby Area, as shown in **Figure 6.8,** shows 72nd Avenue, 80th Avenue and 200th Street as the main arterials leading into the Clayton ISMP. This is consistent with the City of Surrey's Road Classification Map, as shown in **Figure 6.9**, which also shows 80th and 72nd Avenues as arterials.

Figures 6.9 and **6.10** show the City of Surrey's Bike Routes and their 2011 Greenways Plan. A compilation of these is shown in **Figure 6.11**.

Figure 6.7 Master Transportation Plan for the Willoughby Area

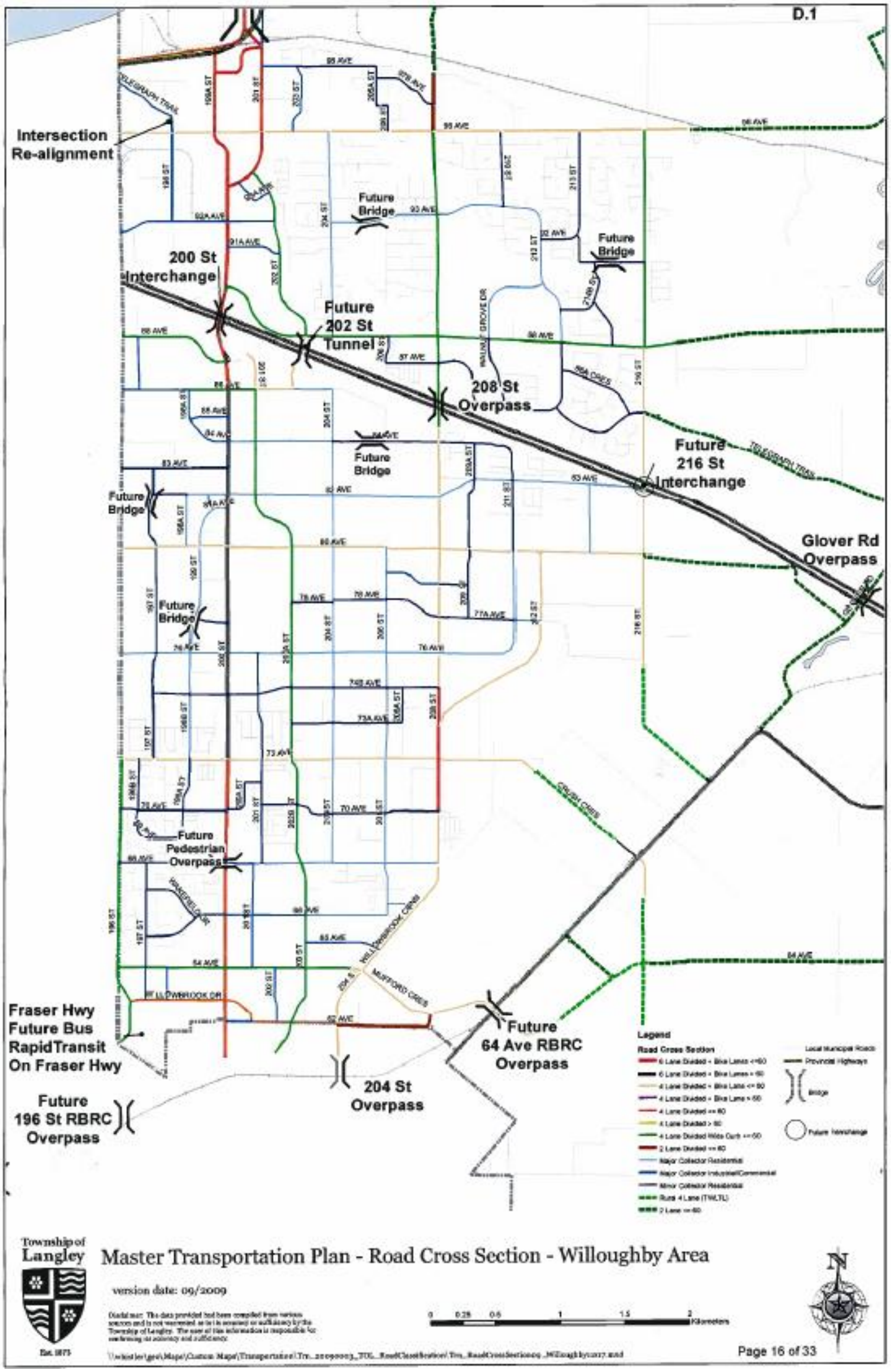


Figure 6.8 City of Surrey Road Classification

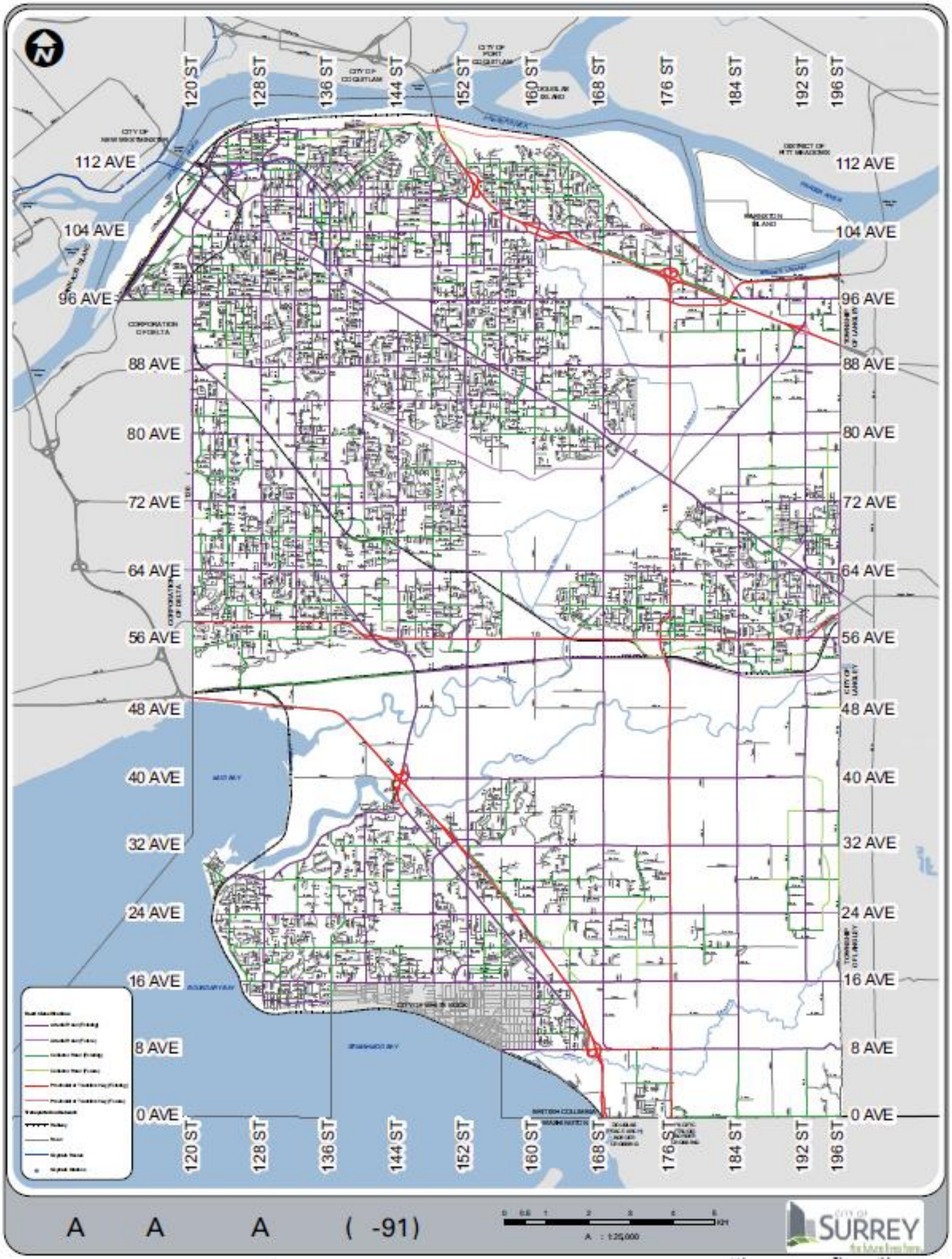
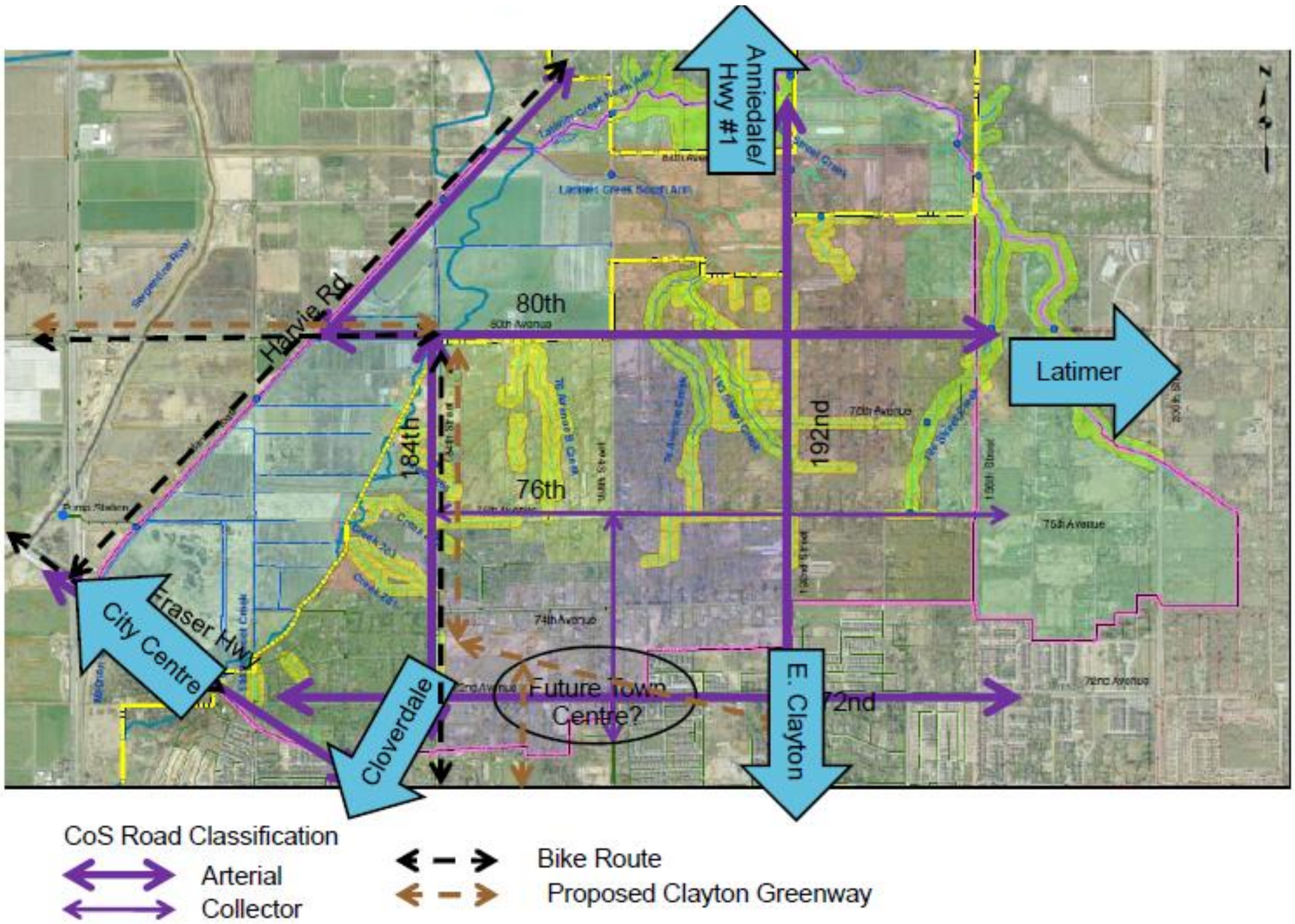


Figure 6.9 City of Surrey Bike Routes

Figure 6.10 City of Surrey 2011 Greenways Plan

Figure 6.11 Transportation Planning in the Clayton ISMP



6.8.2 Stakeholder Consultation

During consultations, Stakeholders noted that many existing right-of-ways in the study area have not yet been opened. This, along with adjacent, undeveloped, backyards has left large habitat areas of ecological significance. In selecting future transportation corridors, the impact on these habitats, their fragmentation and future connectivity must all be carefully considered and mitigated where possible.

Stakeholders also noted the following considerations:

- Stakeholders have varying opinions as to whether 72nd Avenue should connect with Fraser Highway;
- Consideration of future Highway 1 planning for new interchanges, etc. should be given when looking at future transportation networks in the ISMP area. A new interchange at 192nd Street is anticipated, but not confirmed;
- Harvie Road should not be an arterial roadway. It is key to agricultural connectivity and access to it should be discouraged for non-agricultural traffic. Recommendations also include directing traffic away from 184th Street and towards 196th Street instead;
- At present, the intersection of 76th Avenue and 192nd Streets disconnects the key interior forest habitats;
- 80th Avenue and 72nd Avenue will likely remain key corridors in Langley;

- The Township of Langley is considering limiting pedestrian crossings of 200th Street with lights at 72nd and 80th Avenues and possible overhead crossings at select locations; and
- BC Hydro has an existing agreement with the City that every 4 city blocks there is a right-of-way corridor for overhead lines.

6.8.3 Recommendations

In order to achieve Goal 12 of this ISMP, two key recommendations came out of the visioning process, which are outlined below.

***Recommendation #1**: It is recommended that the City pursue a village concept along the southern edge of the ISMP boundary (i.e. 72nd Avenue), as shown in the City's General Land Use Plan. It is also recommended that the City assess forest stands near 72nd Avenue and 188th Street to determine if key tree stands can be incorporated into the village concept, in combination with the proposed Clayton greenway, to emphasize this community's values of environmental stewardship and strong rural ties.*

***Recommendation #2**: It is recommended that the City incorporate wildlife corridors, key forest habitats, all Class A and B streams and their riparian areas, the presence of agricultural vehicles along Harvie Road, Langley's Transportation Plan, future transit routes, utility corridors, connections to adjacent communities and the interconnectedness of the Clayton community when planning corridors within the ISMP area.*

7. How Do We Put This Into Action? (The Implementation Plan)

The key for the success of an ISMP is to develop an implementation plan that will achieve the ultimate study area vision. We conducted hydrologic and hydraulic modelling assessments of the Clayton area to determine how development in the uplands should be designed to maintain the base flows and water quality of streams, and not cause any increases in stream erosion or lowland flooding.

7.1 Hydrologic and Hydraulic Assessment

A storm water model was created for the Study area in order to quantify the following:

1. Changes to the flow regime that could result in increased stream erosion;
2. Changes in runoff volumes for the ARDSA event to the lowlands in order to determine increased pump times; and
3. Requirements for implementing measures such as BMPs, ponds or diversion sewers to mitigate increases in stream erosion or flooding.

Figures 7.1 and 7.2 show the proposed future land uses, watershed boundaries and future flow routing used for modelling the watershed. The three different scenarios that were modelled for this assessment are:

- Existing (2010) conditions;
- Future (full build-out) conditions; and,
- Future conditions with BMP options for mitigation.

The future potential land uses identified by the City are shown in **Table 7.1**, which were provided by the City based on preliminary work on the West Clayton NCP at the time that Stage 3 (Implementation Plan) was being conducted. Impervious ratios and runoff coefficients were assigned based on City of Surrey 2004 Design Criteria.

Table 7.1 Future Land Use Summary

Future Land Use	Area within the ISMP Study Area (ha)	Impervious (%)	Runoff Coefficient (100 year)
High Density (Langley)	107	85	0.9
Commercial	10	90	0.95
Mixed Res - Commercial	6	90	0.95
RF-9	63	80	0.84
RF-12	39	80	0.84
City Land (potential park)	14	20	0.3
RM-30 to RM-45	22	65	0.72
RM-15 to RM-30	105	65	0.72
Existing RA	22	50	0.54
RF-12 to RF-9 Clustering	150	50	0.54
Park	7	20	0.3
Preserve	108	5	0.13
ALR/Preserve^*	95	4	0.13
ALR*	188	4	0.13

Notes: ^ The ALR/Preserve land use designation is for land located within the ALR that contains environmentally significant features.

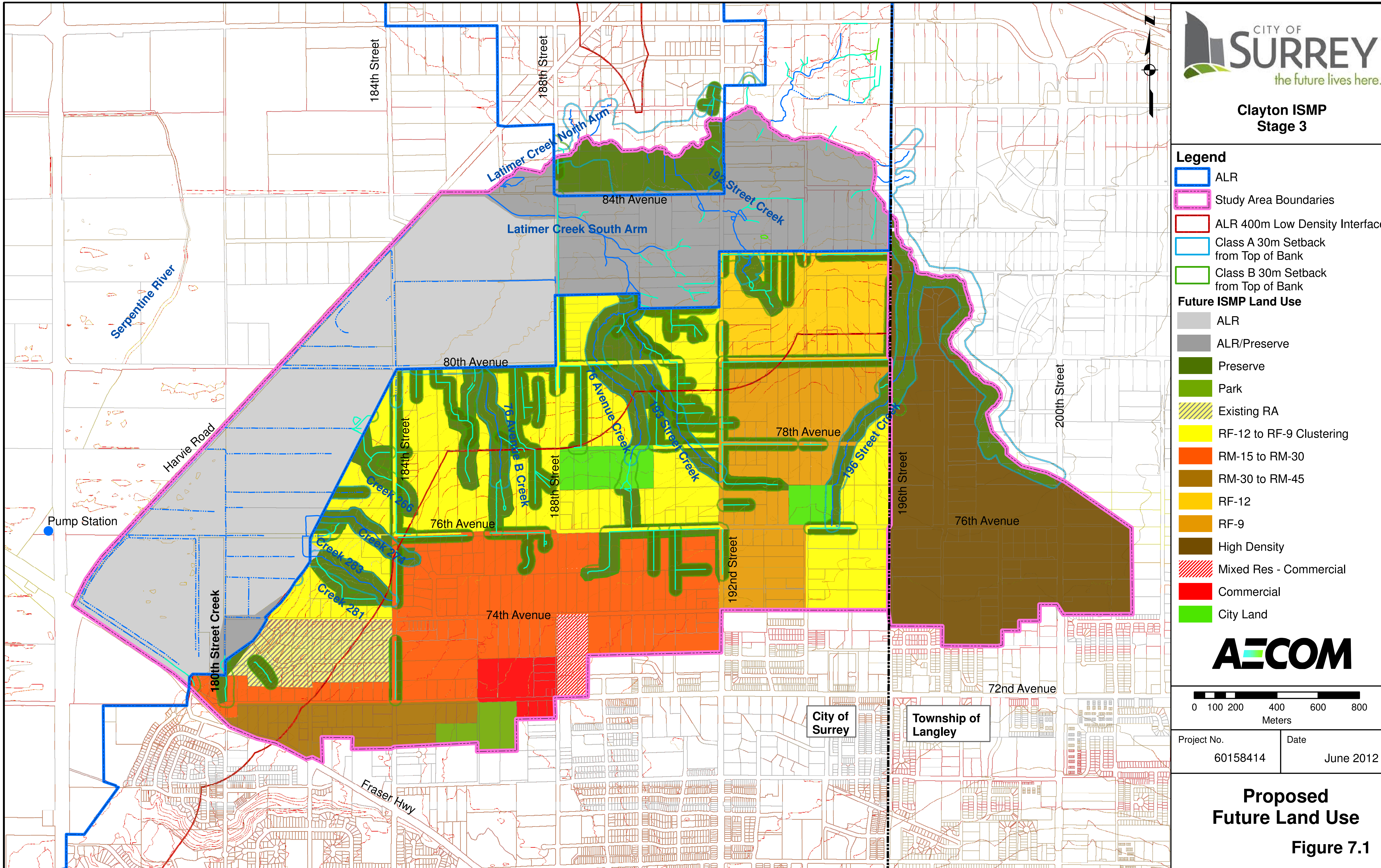
** The percent impervious reflects the existing impervious. As this document does not examine development in the ALR, this value is used in the future scenario as well.*

The study area was broken up into a number of catchments for modelling purposes. These catchments are summarized in **Table 7.2**.

Table 7.2 ISMP Study Area Catchment Summary

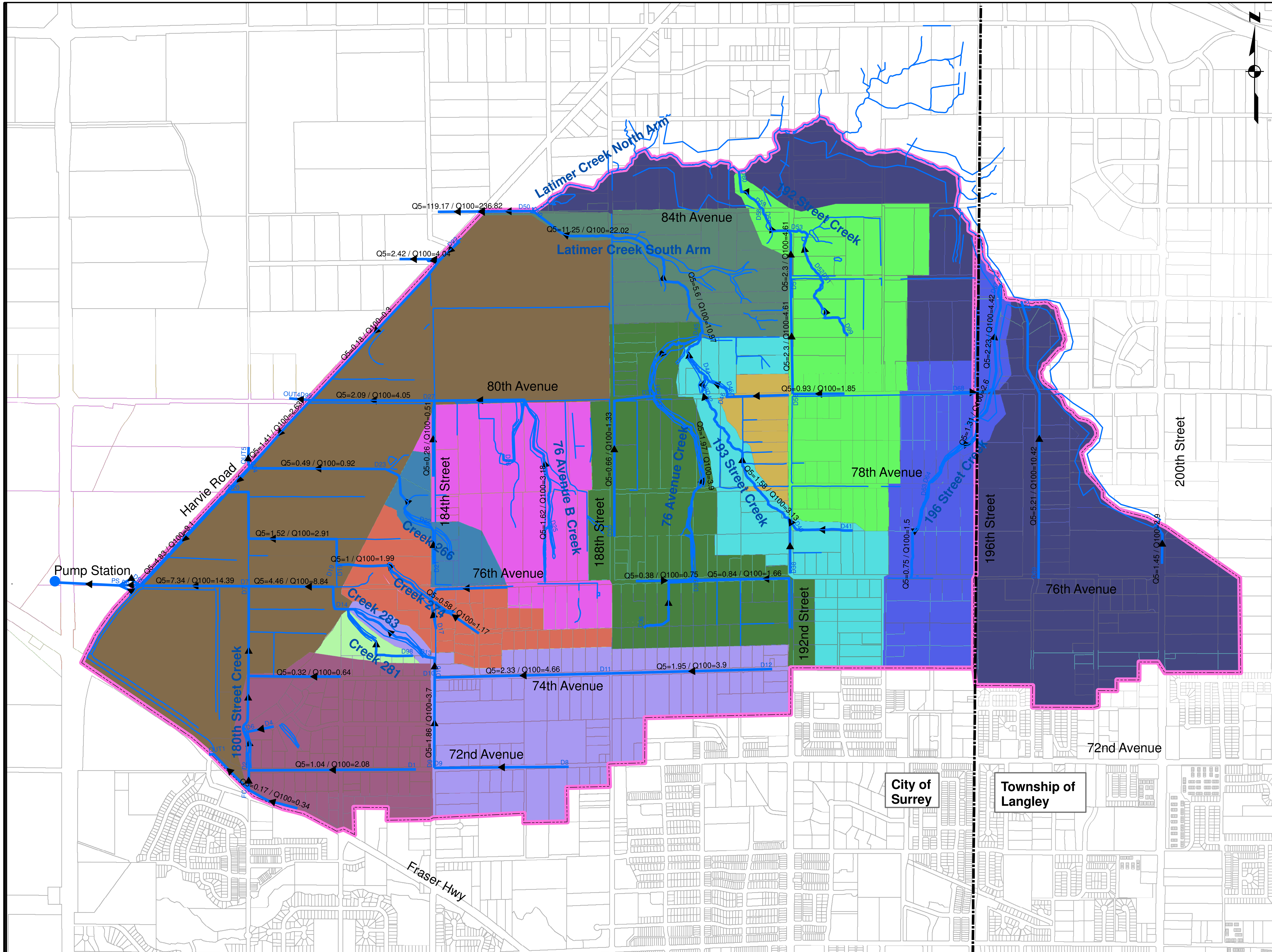
Catchment	Future		Existing	
	Contributing Area (ha)	% Impervious	Contributing Area (ha)	% Impervious
Harvie Road East				
180th Street Creek	56	52%	53	20%
76th Avenue B Creek	57	41%	66	8%
Creek 266	13	32%	15	12%
Creek 274	31	50%	27	16%
Creek 281	5	26%	2	0%
Creek 283	86	64%	83	19%
Harvie Lowlands	190	4%	189	4%
Total:	**438 ha**	**31%**	**438 ha**	**11%**
Latimer North Arm				
192nd Street Creek	66	47%	79	15%
196th Street Creek	60	50%	58	12%
Latimer Creek N. Arm	172	56%	171	12%
Total:	**298 ha**	**53%**	**308 ha**	**13%**
Latimer South Arm				
193rd Street Creek	45	52%	49	13%
193rd Street Creek Trib	27	68%	5	13%
76th Avenue Creek	85	50%	68	14%
Latimer Creek S. Arm	42	4%	68	8%
Total:	**200 ha**	**43%**	**190 ha**	**11%**
OVERALL ISMP STUDY AREA:	**936 ha**	**40%**	**936 ha**	**12%**

Since the analysis was completed for the Implementation Plan, the City of Surrey completed a SHIM study, in which a number of streams that were previously unclassified or Class C streams were now considered Class B streams. As a result, the area of land within the watershed to be preserved as stream or stream riparian area, will likely increase. We did not adjust the modelling analysis; however, as it was felt that the overall imperviousness of all the catchments will not change greatly. If there are a greater number of Class A/B streams to be preserved, then the remaining areas available for development will likely be denser to compensate for the loss in developable lands. Therefore the decrease in imperviousness from additional riparian areas will likely be counterbalanced by the increase in imperviousness from the developed areas.



Proposed Future Land Use

Figure 7.1



Clayton ISMP
Stage 3

Legend

- Study Area Boundaries
- Future Drainage

Sub-Watershed

- 180SC
- 192SC
- 193SC
- 193SCTrib
- 196SC
- 76ABC
- 76AC
- C266
- C274
- HL
- C283
- C281
- LCNA
- LCSA
- Stream

0 100 200 400 600 800
Meters

Project No.	Date
60158414	June 2012

Proposed Future Drainage Network
Figure 7.2

7.1.1 QUALHYMO

QUALHYMO is a continuous simulation package and is the engine behind the Water Balance Model. More information about this model can be found at the following web-site: www.waterbalance.ca.

Hourly rainfall records and evaporation records were developed from the Kwantlen Park weather station for the years 1962 to 1998. These records were used to simulate the response of the Study area to the different scenarios, allowing a better understanding of the system's response to extended wet weather.

Validation of the model was conducted using a regional hydrologic analysis to establish the anticipated magnitude of discharges and anticipated flood frequencies for the ISMP catchments. These values are based upon a clear understanding of the rainfall and runoff relationships within nearby similar watersheds with available stream gauging. Similarly the volumes of surface runoff and base flows have been estimated on an annual basis. This information was then used to create a verified hydrologic and hydraulic model that can be used for evaluation of the existing and potential future Study Area conditions as a whole. As there are no long-term (10+ years) stream flow records of discharge and volume for any of the creeks within the ISMP study area, a proxy stream was selected for the regional analysis. The records chosen are from the Water Survey of Canada gauge for West Creek near Fort Langley (08MH098).

Modelling was conducted for the ISMP study area only. Any impacts due to changes in development in contributing areas/ portions of watersheds, outside of the study area have not been assessed. Additionally, development within the ALR has not been considered as activities here are governed by the Agricultural Land Commission as well as the City.

7.1.2 XPSWMM

A model of the study area was also developed in XPSWMM to identify 5 and 100 year flows for the sizing of the trunk sewers. This model will be used as part of the West Clayton NCP for a more detailed analysis of servicing requirements, storm sewer sizing and detention pond sizing.

7.2 Flow Regime

Across the entire ISMP study area imperviousness is expected to increase from approximately 12% under existing conditions to around 40%, under future full build out conditions based on the proposed future land use and drainage plan as shown on **Figures 7.1 and 7.2**. This would result in changes to peak discharges, as established by the XPSWMM model, and shown in **Table 7.3**.

Table 7.3 Modelled Peak Runoff from Total ISMP Study Area

Return Period (years)	Existing Runoff (m^3/s)	Future Runoff (Unmitigated) (m^3/s)
100	10.7	29.0
5	5.2	15.5

In addition to changes in peak discharges from flood events, changes also occur to the duration of various discharges. Changes in the duration of the more frequent, yet lower discharge rates may have a more significant, cumulative impact on erosion in a stream than the infrequent, higher discharge events. Lumped watershed models were developed for each of the three main watersheds shown on **Figure 7.3**: Harvie Road East; Latimer North Arm; and, Latimer South Arm.

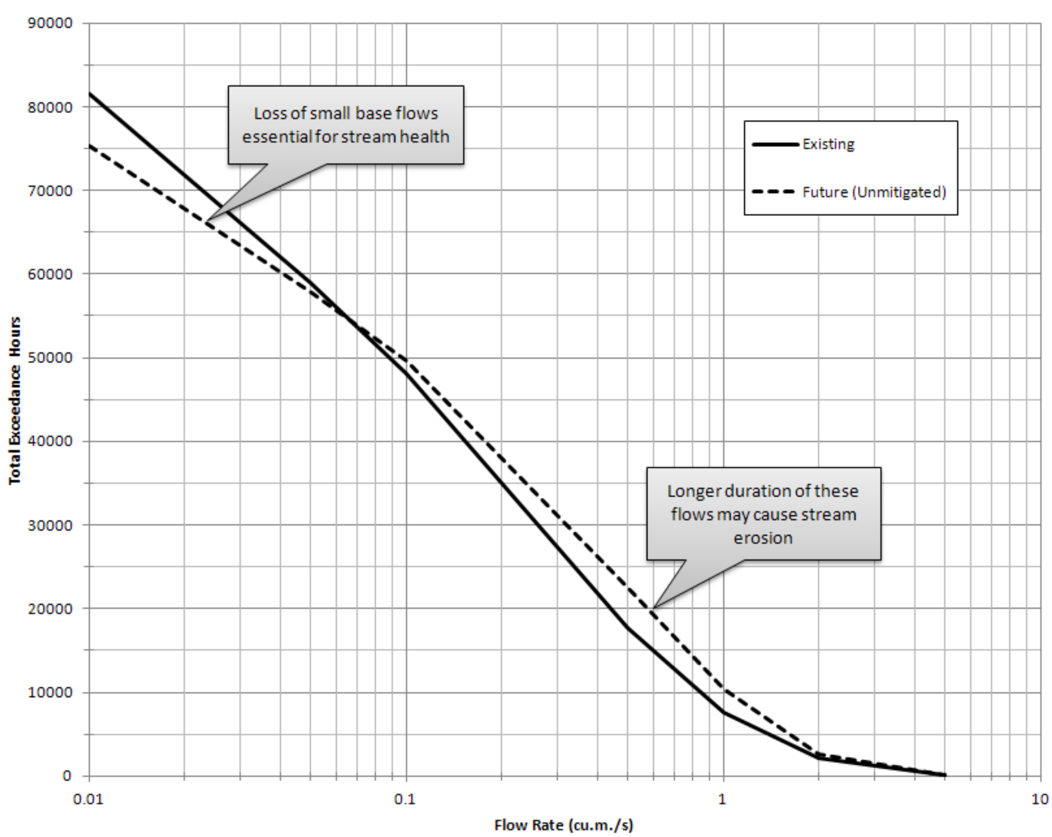
The impact that the increase in imperviousness has on runoff rate durations is shown in **Table 7.4** and **Figure 7.4**, using Harvie Road East as an example.

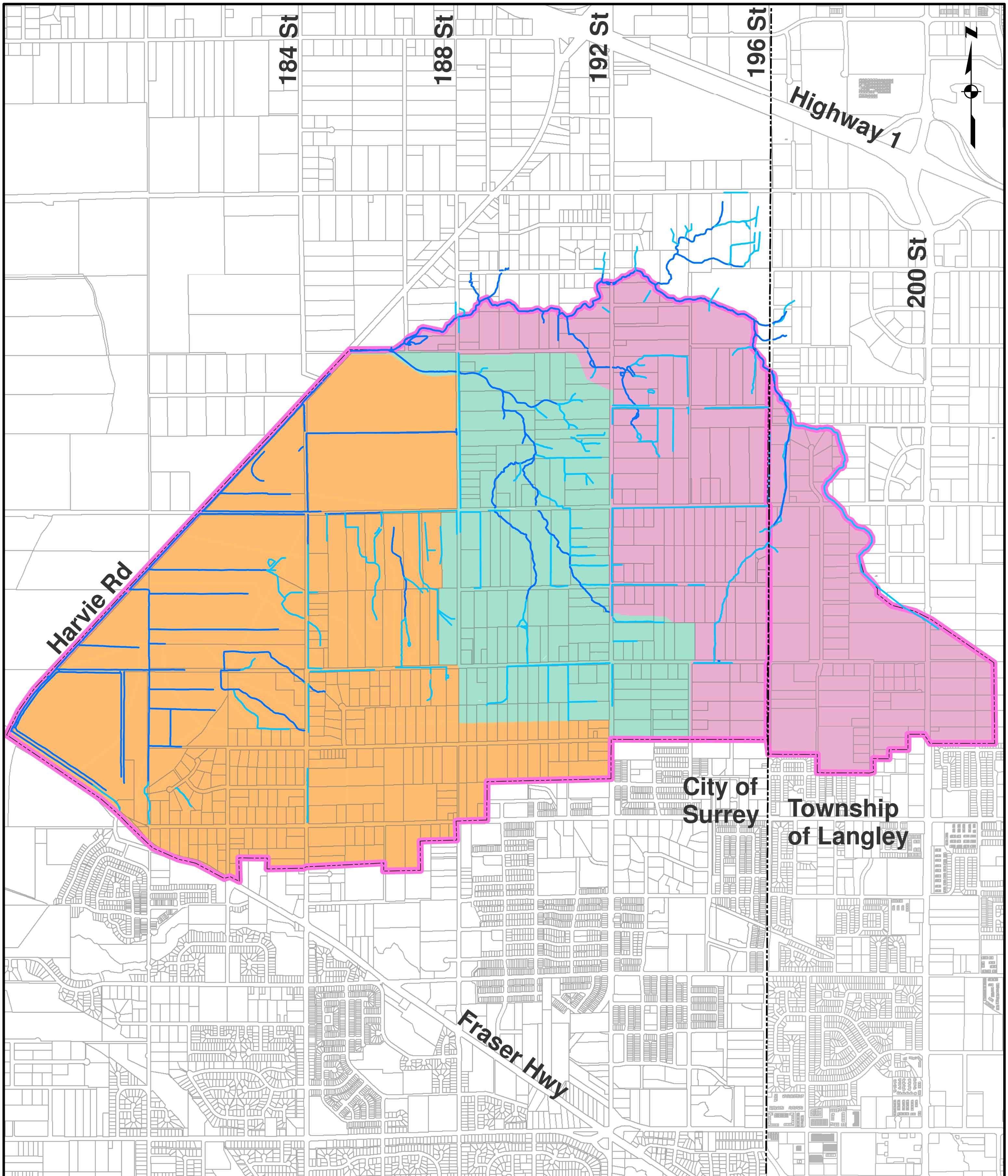
Table 7.4 Harvie Road East – Changing Flow Regime

Exceedance Flow Rate (m^3/s)	Total Exceedance Hours (1962-1998 inclusive)		Change
	Existing	Future (unmitigated)	
0.01	81554	75275	-6279
0.05	58971	57929	-1042
0.1	48043	49598	+1555
0.5	17680	22524	+4844
1.0	7662	10479	+2817
2.0	2137	2677	+540
5.0	85	83	-2

Note: The statistical return period runoff for this catchment is: Q_5 Existing = 5.43 m^3/s, Q_5 Future = 5.96 m^3/s

Figure 7.4 Comparing Durations of Flow under Existing vs Future Conditions





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Clayton ISMP - Stage 3

Project No.	Date
60158414	June 2012

Legend

Study Area Boundaries

Watercourse
- Major
- Minor

Future ISMP Watersheds
- Harvie Road East
- Latimer Creek North Arm
- Latimer Creek South Arm

AECOM

Meters
0 250 500

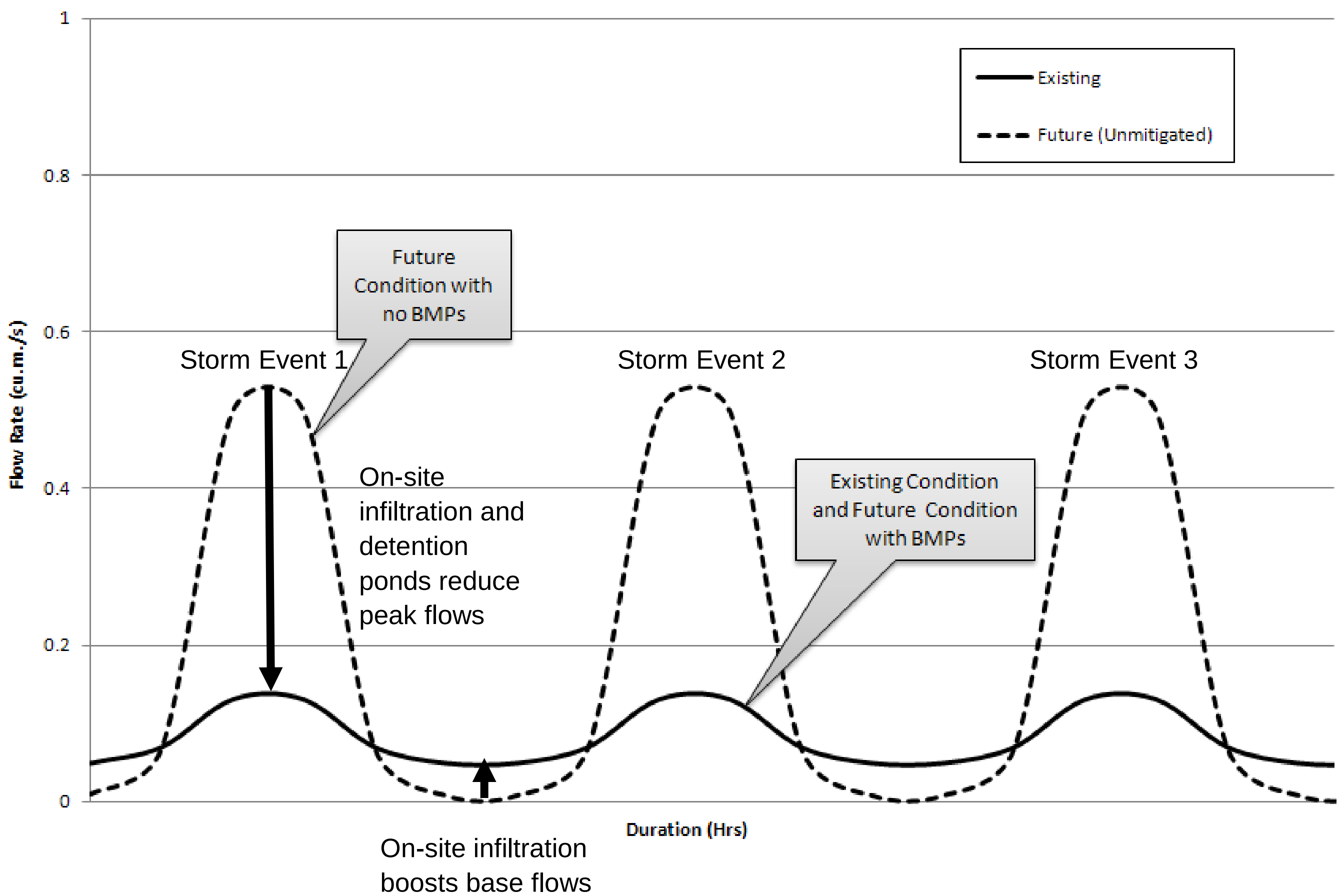
ISMP Major Watersheds

FIGURE 7.3

These changes to the flow regime are best mitigated using storm water best management practices such as infiltration, as they reduce the total runoff volume resulting from new/re- development. The East Clayton NCP has been used as a guide for infiltration facility requirements for the Clayton ISMP.

As development continues and imperviousness increases, streams will typically have reduced base flow, which is essential to stream health, and begin to experience higher flows (due to more runoff) occurring at shorter durations (due to a shorter time of concentration). These changes in the natural flow pattern can lead to a watercourse becoming periodically dry, while also subjecting it to higher flow rates that may cause erosion. The objective of BMPs is to maintain natural “pre-development” flow regimes even as development occurs within the watershed. **Figure 7.5** shows a graphical representation of how the flow regime changes and how BMPs act to maintain natural flow conditions.

Figure 7.5 BMPs and Stream Health



7.3 Leveraging the East Clayton Experience

The East Clayton NCP area is south of, and adjacent to, the Clayton ISMP study area. The East Clayton NCP incorporated sustainable development objectives and green infrastructure performance standards and guidelines. Infiltration BMPs are one of the critical components of the drainage system. Storm water monitoring of the East Clayton area has shown that peak flows have in fact been attenuated and base flows have been maintained despite the development within the East Clayton area.

Infiltration requirements for the East Clayton area can be summarised as follows:

- For single family units, infiltration devices will have a contact area equal to 5% of the lot area and storage volume equivalent depth of 0.33 (e.g. a rock pit chamber, 1m deep with 33% porosity);

- For multi-family and commercial sites, infiltration devices will have a contact area equal to 6% of the lot area and storage volume equivalent depth of 0.33;

- For all local roads and for 192nd Street, runoff is to be directed to exfiltration systems, instead of conventional storm sewer systems. For all other roads, barrier curb and gutter are to be used. A perforated storm sewer system will convey flows up to the 5-year event and increase the infiltration from these areas; and,

- Eliminate direct connections from lots to street drainage. Disconnect roof leaders.

The following additional components are mandated:

- Urban forestry component that on building sites, trees should be planted which will provide canopy coverage equal to 40% of the lot area at maturity;

- Existing top soil preservation requirements;

- All pervious areas will have a minimum 800mm pervious material. Where topsoil is applied, a minimum depth of 450mm topsoil over a minimum 350mm depth of pervious material is required;

- Parking areas for commercial sites have additional requirements for urban forestry, runoff routing and landscaped islands; and,

- Street rights-of-way (excluding lanes) will have a minimum of 30% permeable area. Urban forestry mature canopy requirements are for 60% of right-of-way coverage.

7.3.1 Model Results with Infiltration Devices

Of the twelve (12) goals that were identified as part of the visioning process four of them are interlinked and would be best addressed through BMPs. These four goals are:

- Maintain base flow to streams;
- Maintain stream water quality;
- Reduce the likelihood that increased development will increase lowland flooding; and
- Reduce the likelihood that increased development will cause stream erosion.

The QUALHYMO model was then used to determine the impact that various levels of BMPs would have on mitigating the downstream impact from increased development. It should be noted that the assumed developable area for this study excludes the ALR and future land use designated as “preserve” in **Figure 7.1**.

QUALHYMO provides the option of applying a number of BMPs (such as increased top soil, absorbent landscaping, pervious paving, infiltration swales, rain gardens, box planters, retention ponds and green roofs), in order to determine their impact on reducing runoff. Based on the experience in East Clayton and through discussions with City of Surrey staff on-lot infiltration devices, road right-of-way infiltration devices, addition topsoil and detention ponds were considered within the watershed model to determine the extent of BMPs required to manage the impact of future development.

Four BMP scenarios were developed within the QUALHYMO model:

- **BMP Scenario 1**: On-lot infiltration devices have a contact area equal to 5% of the lot area;
- **BMP Scenario 2**: On-lot infiltration devices have a contact area equal to 7% of the lot area in addition to a 600mm layer of pervious material on all pervious surfaces in the developable area;
- **BMP Scenario 3**: On-lot infiltration devices have a contact area equal to 7% of the lot area as well as 1m of pervious material on all pervious surfaces in the developable area; and,
- **BMPScenario 4**: On-lot infiltration devices have a contact area equal to 10% of the lot area as well as 800mm of pervious material on all pervious surfaces in the developable area.

For all BMP scenarios, the road right-of-way has infiltration devices with a contact area equal to 50% of the area of the right-of-way. For pervious surfaces that require topsoil, a minimum 450mm depth of topsoil shall be provided and is considered as part of the required depth of pervious material. **Table 7.5** provides the infiltration diversion rates under the various scenarios.

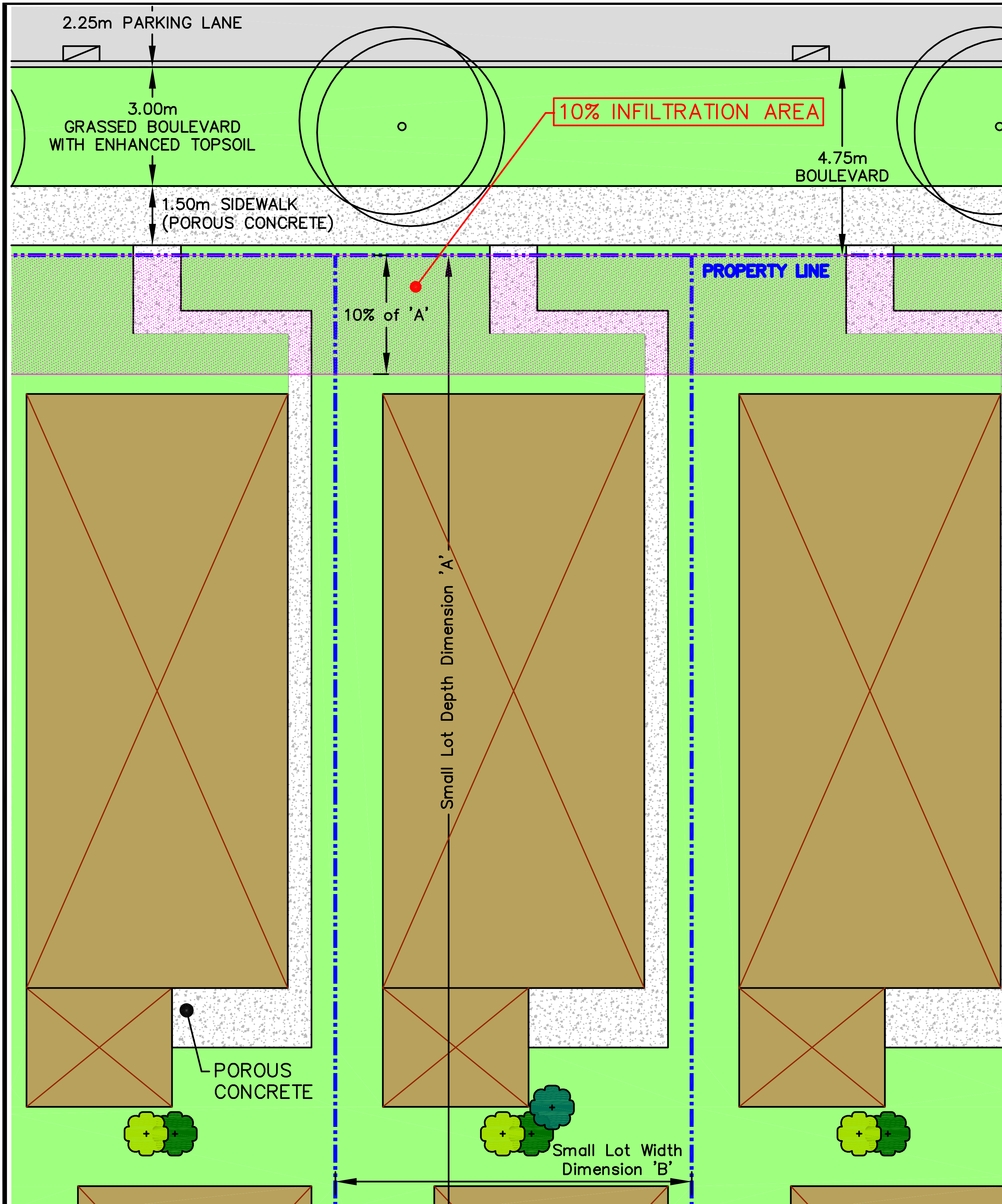
Table 7.5 Infiltration Sizing

Catchment	Future with BMP Scenario	Type	Developable Area (ha)	Infiltration Footprint	Target Infiltration Diversion Rate – Catchment Total (L/s)
Harvie Road East	1	Lot	194 ha	5%	27 L/s
	2 and 3	Lot	194 ha	7%	38 L/s
	4	Lot	194 ha	10%	54 L/s
	all	Road	20.2 ha	50%	28 L/s
Latimer North Arm	1	Lot	198 ha	5%	28 L/s
	2 and 3	Lot	198 ha	7%	39 L/s
	4	Lot	198 ha	10%	55 L/s
	all	Road	21.6 ha	50%	30 L/s
Latimer South Arm	1	Lot	107 ha	5%	15 L/s
	2 and 3	Lot	107 ha	7%	21 L/s
	4	Lot	107 ha	10%	30 L/s
	all	Road	10 ha	50%	14 L/s

Figure 7.6 illustrates the infiltration footprint on a typical row of small lots for BMP Scenario 4. A consolidated contact area equal to 10% of the lot area within the front yard is devoted to on-lot infiltration devices. **Figures 7.7 to 7.9** show the flow duration exceedance graphs from QUALHYMO for the Harvie Road East catchment for all six scenarios (existing, future unmitigated and four future scenarios with BMP). **Tables 7.6 to 7.8** show the same information within a table format.

These figures and tables show that the model estimates that BMPs can mitigate the impacts to the flow regime (i.e. the total exceedance hours by flow rate) due to development and increasing imperviousness. For Harvie Road East, only BMP Scenarios 3 and 4 meet or exceed existing conditions. For Latimer South Arm, BMP Scenario 4 meets or exceeds existing conditions, while BMP Scenario 3 meets or exceeds for all flow rates except 0.2m^3/s. For Latimer North Arm, BMP Scenarios 3 and 4 meet or exceed existing conditions for all flow rates except for 0.5m^3/s.

Therefore, with the objective of meeting or exceeding existing conditions, the recommended storm water management strategy is BMP scenario 4. However, if some lots had difficulty achieving 10% contact area then the City could consider a smaller contact area but with a greater depth of pervious material.



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Project No.	Date
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Typical Small Lot With 10% Infiltration Footprint

Figure 7.6

Figure 7.7 Flow Duration Exceedance Graph for Harvie Road East Catchment

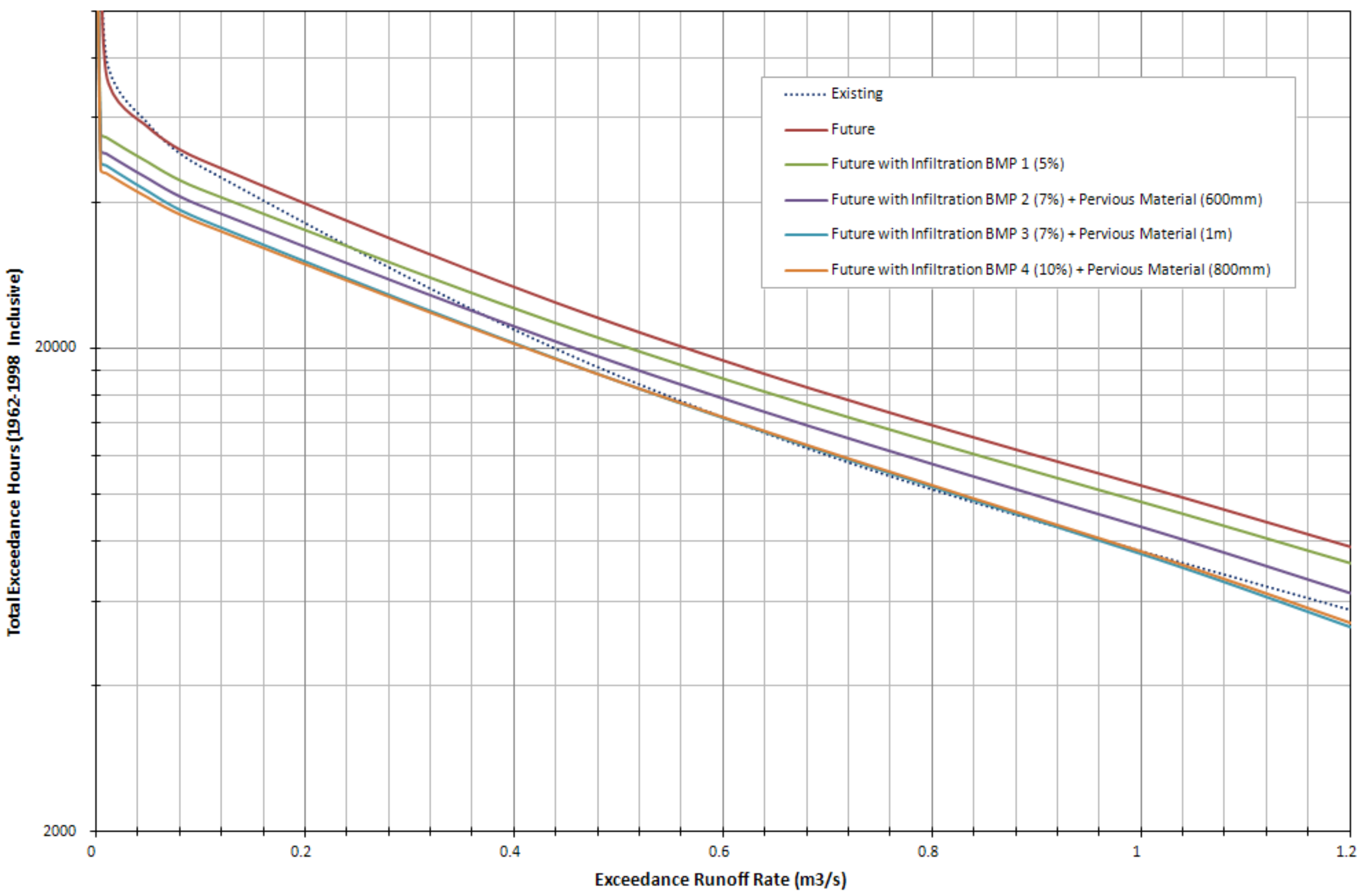


Table 7.6 Flow Duration Exceedance Values for Harvie Road East Catchment

Exceedance Flow Rate (m^3/s)	Total Exceedance Hours (1962-1998 inclusive)					
	Existing	Future (unmitigated)	Future + BMP 1 (5%)	Future + BMP 2 (7%) + Pervious Material (600mm)	Future + BMP 3 (7%) + Pervious Material (1m)	Future + BMP 4 (10%) + Pervious Material (800mm)
0	324336	324336	324336	324336	324336	324336
0.005	324336	324336	56107	51808	48981	47182
0.01	81554	75275	55190	51018	48199	46448
0.05	58971	57929	49025	45325	42621	41338
0.1	48043	49598	43081	39831	37292	36587
0.5	17680	22524	20540	18747	17201	17203
1.0	7662	10479	9699	8599	7553	7643
2.0	2137	2677	2471	1993	1560	1621
5.0	85	83	78	61	52	52

Figure 7.8 Flow Duration Exceedance Graph for Latimer North Arm Catchment

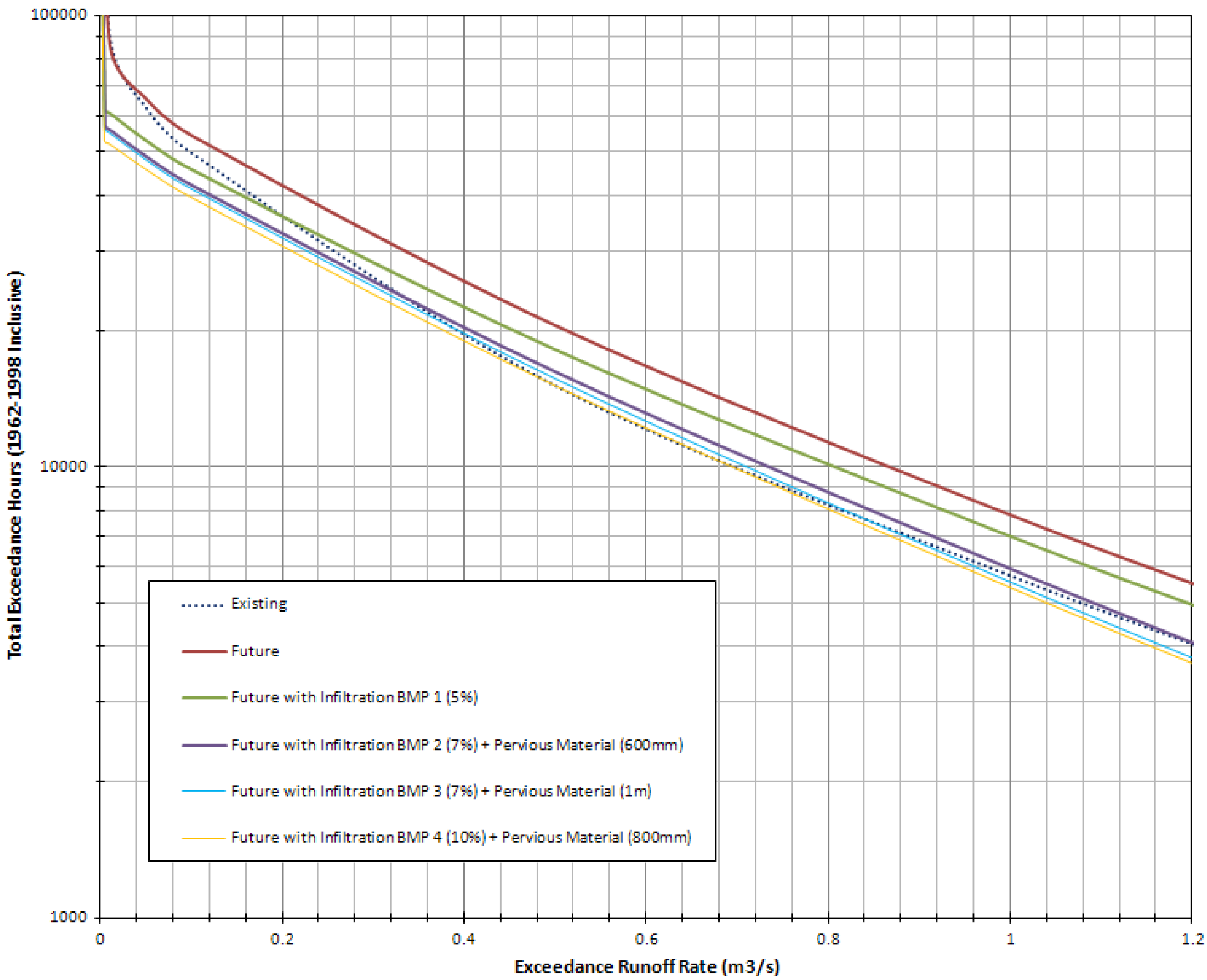


Table 7.7 Flow Duration Exceedance Values for Latimer North Arm Catchment

Exceedance Flow Rate (m^3/s)	Total Exceedance Hours (1962-1998 inclusive)					
	Existing	Future (unmitigated)	Future + BMP 1 (5%)	Future + BMP 2 (7%) + Pervious Material (600mm)	Future + BMP 3 (7%) + Pervious Material (1m)	Future + BMP 4 (10%) + Pervious Material (800mm)
0	324336	324336	324336	324336	324336	324336
0.005	324336	324336	62613	57625	56770	53304
0.01	90398	86793	61442	56455	55529	52412
0.05	62930	65886	53411	49235	48385	46070
0.1	49920	54589	46058	42496	41670	39863
0.5	15203	20668	18323	16358	15788	15232
1	5763	7850	7059	5976	5589	5434
1.5	2409	3303	2959	2334	2127	2071
2	866	1305	1174	853	750	734

Figure 7.9 Flow Duration Exceedance Graph for Latimer South Arm Catchment

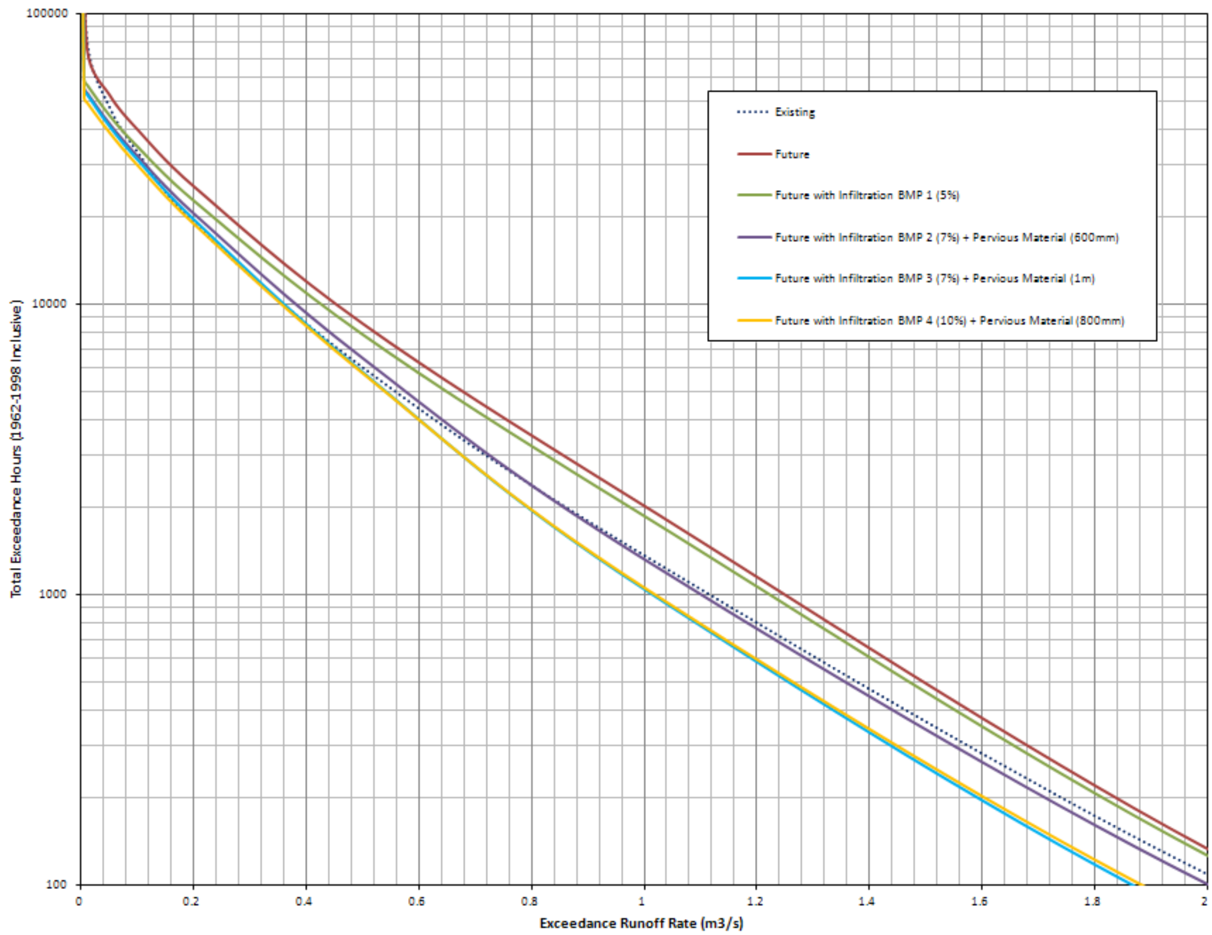


Table 7.8 Flow Duration Exceedance Values for Latimer North Arm Catchment

Exceedance Flow Rate (m^3/s)	Total Exceedance Hours (1962-1998 inclusive)					
	Existing	Future (unmitigated)	Future + BMP 1 (5%)	Future + BMP 2 (7%) + Pervious Material (600mm)	Future + BMP 3 (7%) + Pervious Material (1m)	Future + BMP 4 (10%) + Pervious Material (800mm)
0	324336	324336	324336	324336	324336	324336
0.005	324336	324336	59795	55934	55279	51641
0.01	81308	76001	57397	53838	53206	49856
0.05	48024	52956	44987	42135	41279	39277
0.1	33560	40187	35079	32522	31647	30259
0.2	19138	25606	22864	20633	19701	19017
0.5	6076	8621	7907	6550	5865	5822
1	1368	2033	1875	1329	1050	1062
2	109	134	127	101	74	77

7.4 Erosion Potential Analysis

Erosion potential within a creek due to changes in flow regimes may be qualitatively measured using “Impulse” calculations as described in **Section 5.6**.

In order to determine if the flow exceedance hours in the Latimer North Arm watershed for the four mitigation scenarios (all of which are greater than the existing condition exceedance hours at a flow rate of 0.5 m^3/s) result in a potential increase in erosion, the exceedance hours were used to calculate an Impulse value for each scenario. For this, a representative stream cross-section is required, as well as the velocity threshold for the stream bed material.

City-wide ravine stability assessments conducted previously by Web Engineering in 2009 examined five creeks in the ISMP study area. Latimer Creek had no instability sites identified, while 76th Avenue B Creek, 76th Avenue Creek, 193rd Street Creek and 196th Street Creek were all given a risk level of low. Examining the available cross section data, a representative cross section on 196th Street Creek located between 78th Avenue and 80th Avenue was chosen to determine erosion potential under various development scenarios. The characteristics of the chosen representative cross section are outlined in **Table 7.9**.

Table 7.9 196th Street Creek Cross Section

Parameter	Value
Bottom Width*	1.5m
Depth above Bed*	4m
Side Slope*	1.5 H to 1 V
Longitudinal Bed Slope	0.09 m/m
Bed Material*	Gravels, Cobles, fines in undercut bank
Upstream Contributing Area	40 ha
Existing Imperviousness	8%
Future Imperviousness	48%

*Note: *Obtained from Ravine Stability Assessment (Web Engineering, 2009), Reference RSA-31.10*

A QUALHYMO model was developed for the contributing catchment, and the flow exceedance duration curves for the four BMP scenarios are presented in **Figure 7.10**. The impulse calculation results are presented in **Table 7.10**. As can be seen in **Figure 7.10**, the impulse under BMP Scenarios 4 is the same as or less than the impulse under existing conditions. Therefore there is no expected increase in erosion if BMP Scenario 4 is implemented.

Figure 7.10 196th Street Creek – Flow Exceedance by Scenario

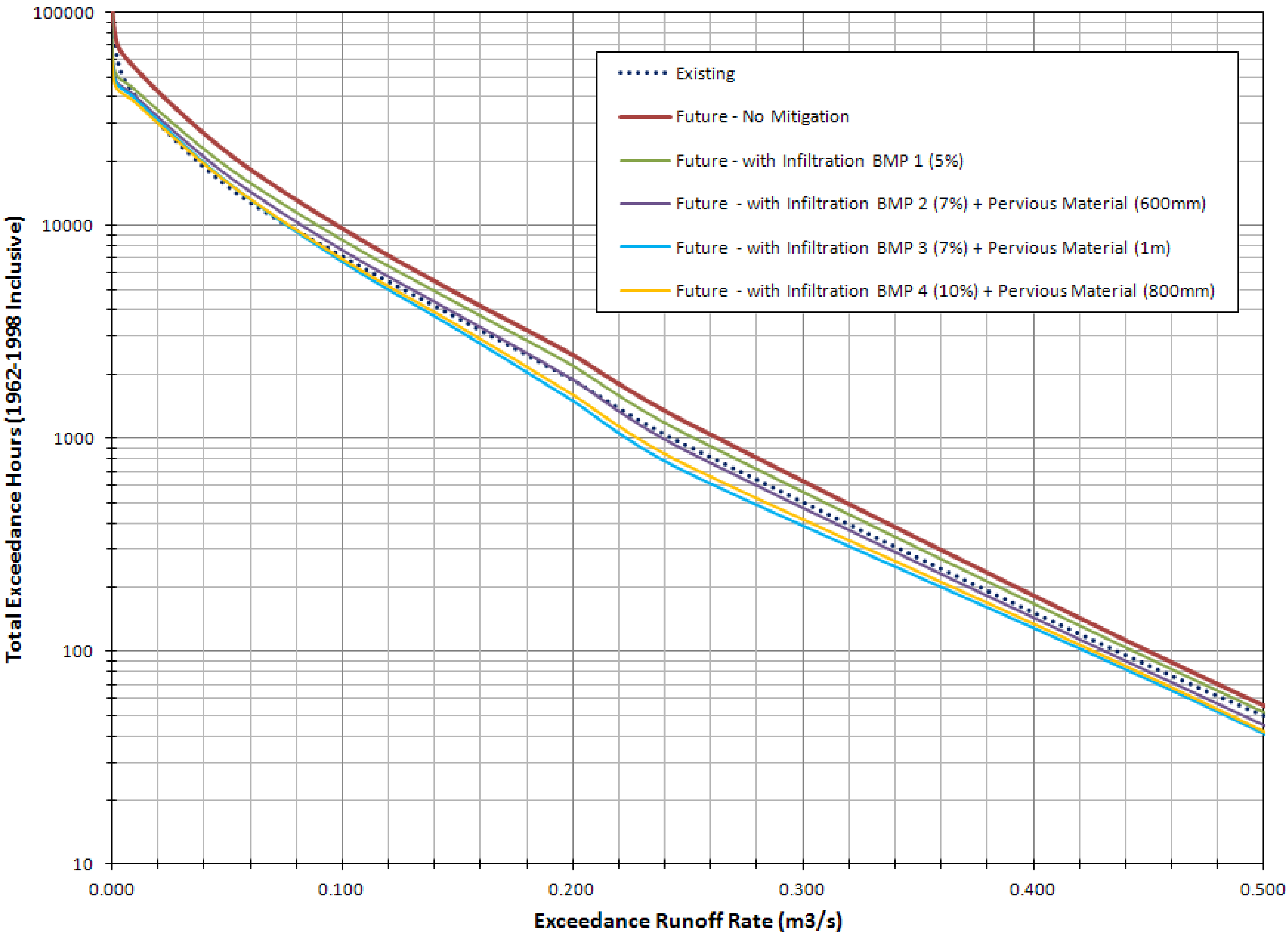


Table 7.10 196th Street Creek – Erosion Potential Scenario Comparison

Scenario	Impulse	% Change from Existing Conditions
Existing	140,000	-
Future Runoff (Unmitigated)	200,000	43 %
Future with Infiltration BMP 1 (5%)	170,000	21 %
Future with Infiltration BMP 2 (7%) + Pervious Material (600mm)	150,000	7 %
Future with Infiltration BMP 3 (7%) + Pervious Material (1m)	140,000	0 %
Future with Infiltration BMP 4 (10%) + Pervious Material (800mm)	140,000	0 %

All four mitigation scenarios are shown to reduce the Impulse values, and thereby the overall erosion potential of the future scenario. The third and fourth options, however, meet existing conditions. Therefore, future development with either Mitigation Scenario 3 or 4 is calculated to have no net impact on the erosion potential of 196th Street Creek.

7.5 BMP Infiltration Options

There are a number of on-lot and on-street infiltration strategies that could be considered for implementation within the Clayton area. The City of Surrey has successfully implemented the following on-lot infiltration strategies:

- Disconnected roof leaders
- Additional topsoil; and
- Infiltration trenches.

The City of Surrey has successfully implemented or is considering implementation of the following road right-of-way infiltration strategies:

- Porous sidewalks;
- Catch basins to Infiltration trenches;
- Grassed boulevards with additional topsoil;
- Pervious pavement;
- Reduced street width; and
- Rain gardens.

There are a number of issues that must be considered when developing BMP requirements for the Clayton area, which are outlined below.

- On-lot infiltration devices will only work if they are maintained by residents. It is particularly difficult for the City to monitor on-lot infiltration devices within backyards. The City would like to see infiltration devices within or adjacent to the street right-of-way.
- Within East Clayton, residents have indicated that there is insufficient parking. As a result, the City would like to have parking on both sides of the street within the Clayton area, even if it means reducing the travel lanes so that some streets are one-way.
- The added topsoil within East Clayton appears to have contributed to reducing storm water run-off. The biggest challenge is working with developers to ensure that they place the required depth of topsoil and that it is not compacted during construction. Topsoil depth and aeration should be confirmed prior to occupancy.
- The roadside swales in East Clayton did not work as well as planned and they are not viewed favourably by some residents.
- Infiltration measures are site specific and require geotechnical investigations during the development permit stage to verify soil conditions, infiltration capacity and local ground water table.
- Base flows to creeks needs to be preserved, which may require infiltration systems to have a low-flow drain (very small diameter) to the storm sewer.
- All infiltration systems should have an overflow to the storm sewer (or ditch) system.
- The target percolation rate is 1mm/hr. Developers should identify alternative sustainability measures for sites where testing has shown the percolation rate to be lower than 1 mm/hr.
- Urban forestry should be encouraged by requiring a minimum of 35-60% of canopy coverage at maturity.
- Parking lots shall have vegetated curb-less islands set below pavement grade to provide bio-retention and conveyance of parking lot run-off.
- All topsoil from a site should remain on site, being stockpiled for redistribution following construction.
- Re-used top soil must be amended such that the enhanced soil will increase moisture retention capabilities through organic matter and textural properties.

Two examples of BMP strategies that meet the requirements of BMP scenario 4 are shown in **Figures 7.11** and **7.12**. **Figure 7.11** shows infiltration requirements if the roadway is impervious whereas **Figure 7.12** shows infiltration requirements if the parking strip of the roadway consists of pervious pavers. This is a similar strategy to what is used at UniverCity on Burnaby Mountain.

NOTES:

1) LOCATIONS OF UNDERGROUND UTILITIES SHOWN ARE BASED ON CITY OF SURREY STANDARD TYPICAL LOCAL ROAD SECTION DWG. NO. SSD–R.4. ACTUAL LOCATIONS CAN VARY AS REQUIRED.

2) CATCH BASINS HAVE SUMPS TO CAPTURE GRIT AND SAND. CATCH BASINS ALSO CONTAIN HOODED OUTLETS TO TRAP OIL AND FLOATABLES.

BMP SYSTEM FOR SMALLER FREQUENT STORMS:

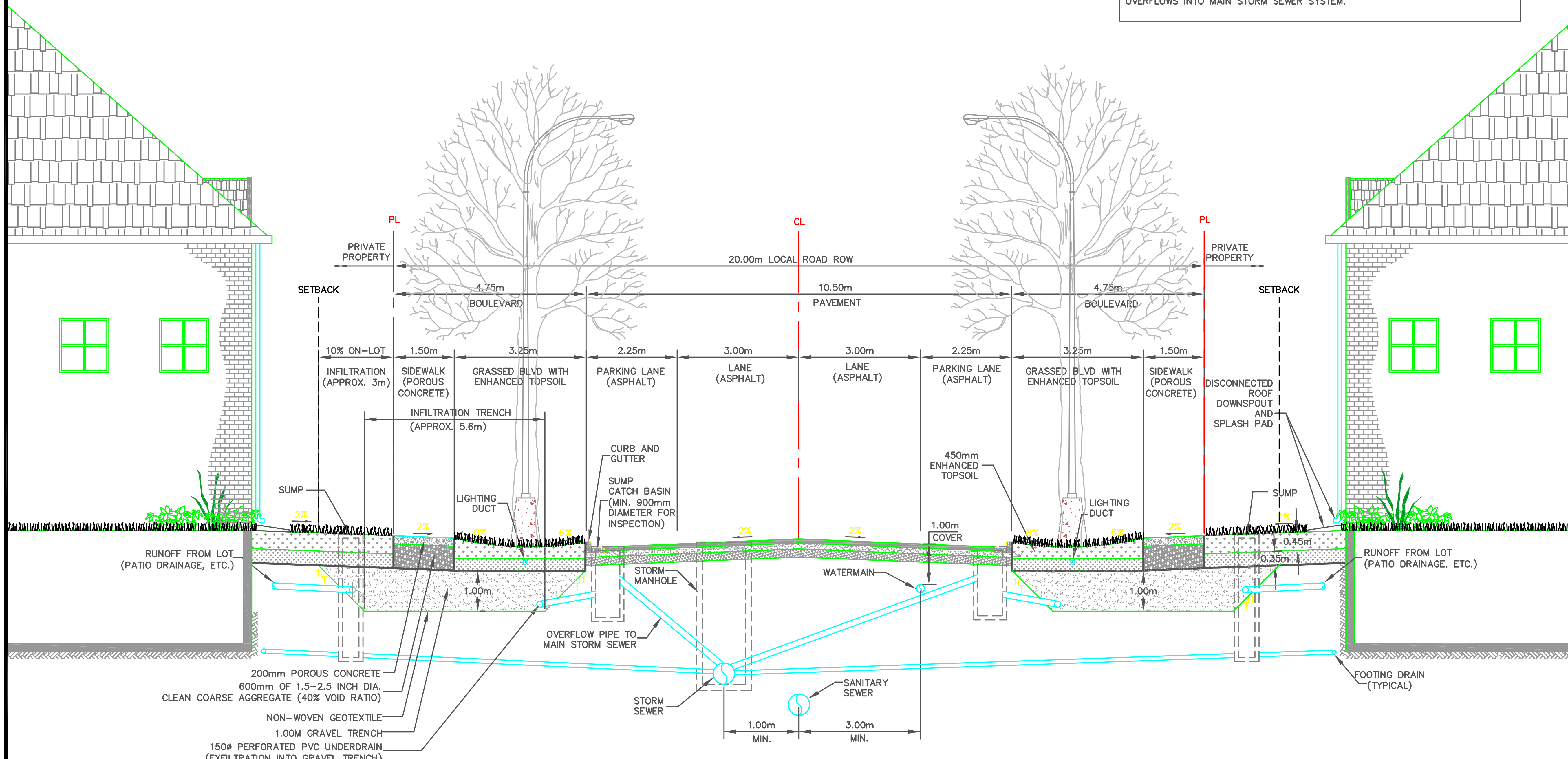
1) LOT RUNOFF WILL DRAIN FROM IMPERVIOUS AREAS ONTO PERVIOUS AREAS, INFILTRATING INTO ENHANCED TOPSOIL AND POROUS CONCRETE SIDEWALK TOWARDS GRAVEL TRENCH, RECHARGING BASE FLOWS. FOOTING DRAINS ARE DIRECTLY CONNECTED TO MAIN STORM SEWER TO PREVENT BASEMENT FLOODING.

2) RUNOFF FROM ASPHALT ROAD WILL DRAIN TOWARDS CATCH BASIN AND INFILTRATING INTO GRAVEL TRENCH VIA PERFORATED PIPE TO RECHARGE GROUNDWATER.

OVERFLOWS:

1) WHEN ENHANCED TOPSOIL AND POROUS CONCRETE SIDEWALK IS SATURATED, STORM WATER IN GRAVEL TRENCH WILL BACKFLOW INTO CATCH BASIN VIA PERFORATED PIPE AND OVERFLOW INTO MAIN STORM SEWER SYSTEM.

2) RUNOFF FROM ASPHALT ROAD WILL DRAIN INTO CATCH BASIN, WHICH OVERFLOWS INTO MAIN STORM SEWER SYSTEM.



OPTION 1: TYPICAL SECTION

ENHANCED TOPSOIL, ASPHALT PARKING LANE, AND INFILTRATION TRENCH WITHIN FRONT YARD SETBACK

N.T.S.

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0 250 1000m
Scale

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Local Road Section With BMPs Example 1

Figure 7.11

NOTES:

1) LOCATIONS OF UNDERGROUND UTILITIES SHOWN ARE BASED ON CITY OF SURREY STANDARD TYPICAL LOCAL ROAD SECTION DWG. NO. SSD–R.4. ACTUAL LOCATIONS CAN VARY AS REQUIRED.

2) CATCH BASINS HAVE SUMPS TO CAPTURE GRIT AND SAND. CATCH BASINS ALSO CONTAIN HOODED OUTLETS TO TRAP OIL AND FLOATABLES.

BMP SYSTEM FOR SMALLER FREQUENT STORMS:

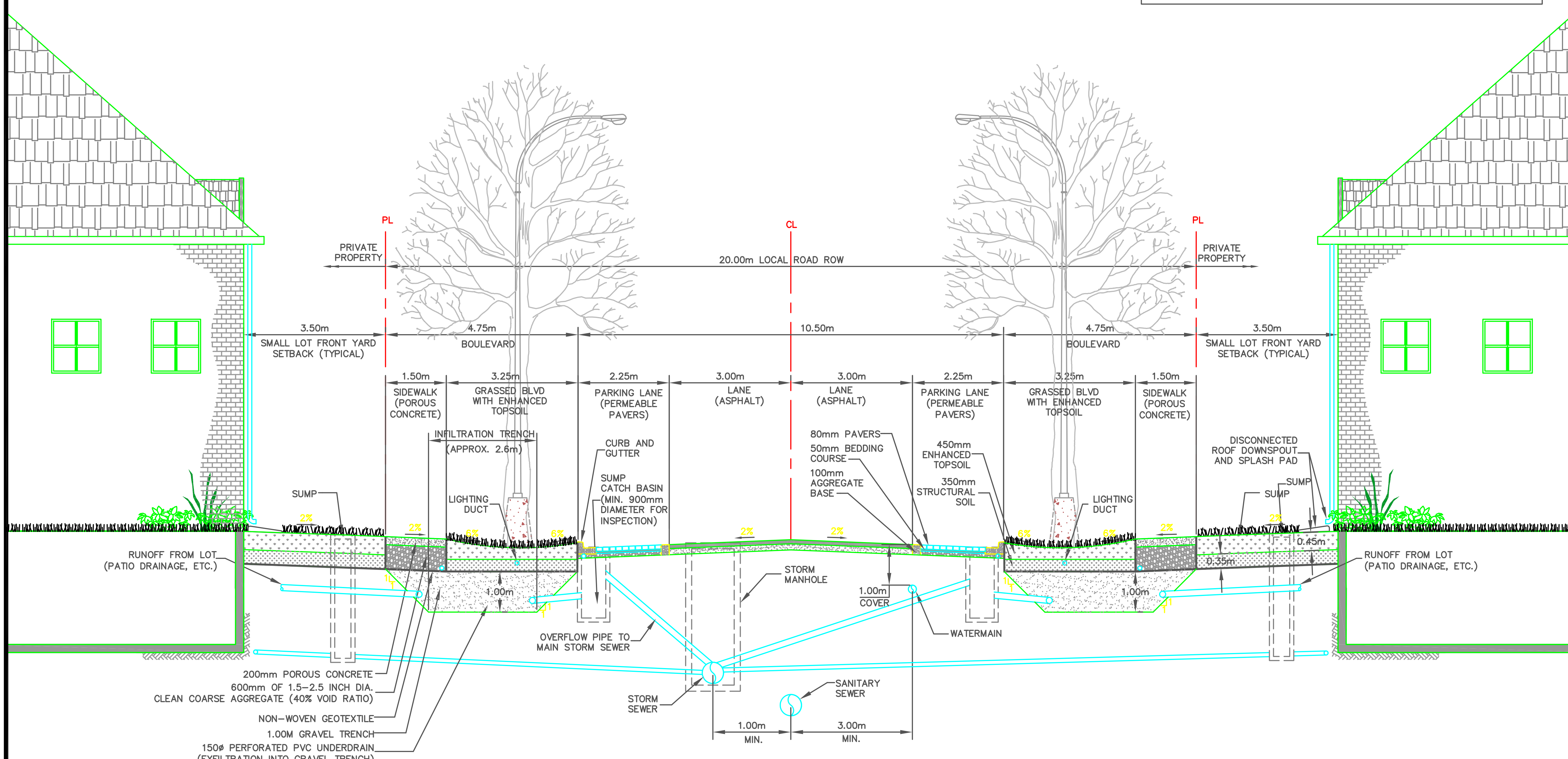
1) LOT RUNOFF WILL DRAIN FROM IMPERVIOUS AREAS ONTO PERVIOUS AREAS, INFILTRATING INTO ENHANCED TOPSOIL AND POROUS CONCRETE SIDEWALK TOWARDS GRAVEL TRENCH, RECHARGING BASE FLOWS. FOOTING DRAINS ARE DIRECTLY CONNECTED TO MAIN STORM SEWER TO PREVENT BASEMENT FLOODING.

2) RUNOFF FROM ASPHALT ROAD WILL DRAIN ONTO PERMEABLE PAVERS IN PARKING LANES, INFILTRATING INTO GRAVEL TRENCH TO RECHARGE GROUNDWATER.

OVERFLOWS:

1) WHEN ENHANCED TOPSOIL AND POROUS CONCRETE SIDEWALK IS SATURATED, STORM WATER IN GRAVEL TRENCH WILL BACKFLOW INTO CATCH BASIN VIA PERFORATED PIPE AND OVERFLOW INTO MAIN STORM SEWER SYSTEM.

2) RUNOFF FROM ASPHALT ROAD WILL SATURATE PERMEABLE PAVERS AND DRAIN INTO CATCH BASIN AND OVERFLOW INTO MAIN STORM SEWER SYSTEM.



OPTION 2: TYPICAL SECTION

ENHANCED TOPSOIL, PERMEABLE PAVERS IN PARKING LANE, AND INFILTRATION TRENCH WITHIN BOULEVARD

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0 250 1000m

Scale

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Local Road Section With BMPs Example 2

Figure 7.12

7.6 Lowland Impacts

Development in the Clayton ISMP study area will increase the surface imperviousness which, if not mitigated, will result in increased runoff volume and potential flooding. The Harvie lowlands discharge to the Fry's Corner pump station which has a total maximum capacity of 3.9m^3/s.

The QUALHYMO model for the Harvie Road East Catchment was used to quantify the impact of upland development for the ARDSA rainfall event.

The ARDSA criteria storms, as set out in the Surrey Design Criteria, were inserted into the precipitation file at 4 different times. These storms, which are outlined below, were chosen based on high peak monthly runoff volumes and rates to examine a conservative situation:

1. Sept 22-26, 1967: Late September of 1967 was a dry period prior to a very wet October. 1967 and 1968 were particularly high years for runoff volume;
2. January 7-11, 1975;
3. April 20-21, 1996;
4. July 14-15, 1972.

The following two tables show the increase in pumping hours due to the upland development both with and without mitigation measures. The impact of unmitigated development on the number of additional pumping hours required during a period of rainfall based on ARDSA design events is minimal when compared with existing conditions. The worst case scenario shows an additional 11 hours over a 2 month period. With BMP Scenarios 2, 3 and 4, no additional pumping hours are required for these four rain events.

Table 7.11 Harvie Road East Pumping Hours - Future Conditions No Mitigation

Year	**Month**	**Runoff Volume from Contributing Portion of ISMP Study Area (m^3)**			**Increased Pumping Hours (over 2 month period)**
		Existing	Future (no mitigation)	Comparative Impact	
1967	September - October	1,931,360	2,080,350	148,990	11 hrs
1975	January – February	1,294,270	1,310,340	16,070	1.1 hrs
1972	July - August	708,147	714,129	5,982	0.4 hr
1996	April - May	949,290	982,080	32,790	2.3 hrs
				AVERAGE INCREASE FOR WINTER:	**6 hrs**
				AVERAGE INCREASE FOR SUMMER:	**1.4 hrs**

Table 7.12 Harvie Road East Pumping Hours - Future Conditions with Infiltration BMP Scenario 1

Year	Month	Runoff Volume from Contributing Portion of ISMP Study Area (m^3)			Increased Pumping Hours (over 2 month period)
		Existing	Future With Infiltration BMP 1	Comparative Impact	
1967	September - October	1,931,360	1,954,450	23,090	2 hrs
1975	January – February	1,294,270	1,294,590	320	0.02 hrs
1972	July - August	708,147	699,095	0	0 hrs
1996	April - May	949,290	960,040	10,750	0.8 hrs
				AVERAGE INCREASE FOR WINTER:	**1 hrs**
				AVERAGE INCREASE FOR SUMMER:	**0.4 hrs**

Table 7.13 Harvie Road East Pumping Hours - for Future Conditions with Infiltration BMP Scenario 2

Year	Month	Runoff Volume from Contributing Portion of ISMP Study Area (m^3)			Increased Pumping Hours (over 2 month period)
		Existing	Future With Infiltration BMP 2 + Pervious Material (600mm)	Comparative Impact	
1967	September - October	1,931,360	1,773,260	0	0 hrs
1975	January – February	1,294,270	1,180,000	0	0 hrs
1972	July - August	708,147	654,361	0	0 hrs
1996	April - May	949,290	873,040	0	0 hrs
				AVERAGE INCREASE FOR WINTER:	**0 hrs**
				AVERAGE INCREASE FOR SUMMER:	**0 hrs**

These results are based on the model output and actual future conditions may vary. Seepage and groundwater discharge patterns under future development may result in the need for some increased pumping even with the implementation of BMPs.

7.7 Peak Flow Management

For the ISMP study area, where infiltration BMPs do not sufficiently reduce peak flows to pre-development levels, particularly for the larger less frequent storms (i.e. 5-100 year storms); additional measures such as detention ponds or diversion sewers are needed. As the NCPs move forward, future land use will be more defined, as well as flow routing and flow control. To guide the NCP process, the recommended storage volumes in cubic meters per developed hectare (including road rights-of-way, excluding ALR and “preserve” lands) for the four BMP scenarios are shown in **Table 7.14**. Alternatively, if a diversion sewer was installed instead of a detention pond to control the 5-year through 100-year return period runoff then it would need to be sized to convey the flows outlined in **Table 7.14**.

Table 7.14 Peak Flow Reduction Requirements by Scenario

Sub-catchment	BMP Scenario	Future Conditions With Pond (m^3 / developed hectare)		Future Conditions With Diversion (L/s/Developed hectare)
		5-Year Storage	100-Year Storage	
Harvie Road East	No BMPs	79	110	
	BMP 1	75	106	2.3
	BMP 2	42	60	1.4
	BMP 3	27	40	0.7
	BMP 4	15	22	0.7
Latimer North Arm	No BMPs	133	196	
	BMP 1	127	190	2.6
	BMP 2	51	66	0.8
	BMP 3	33	44	0.7
	BMP 4	31	41	0.7
Latimer South Arm	No BMPs	191	301	
	BMP 1	176	288	2.1
	BMP 2	91	133	0.6
	BMP 3	20	37	0.6
	BMP 4	20	26	0.6

From our analysis, BMP Scenario 4 requires the least amount of detention ponds. The volume and estimated area of detention ponds required per catchment for BMP Scenario 4 is summarized in **Table 7.15**. In addition to reducing peak flow, detention ponds, if properly designed, can improve the quality of the storm water runoff, provide community amenities, and provide habitat for aquatic or terrestrial wildlife.

Table 7.15 Required Pond Volume And Area For Each Sub-Catchment Outside the ALR

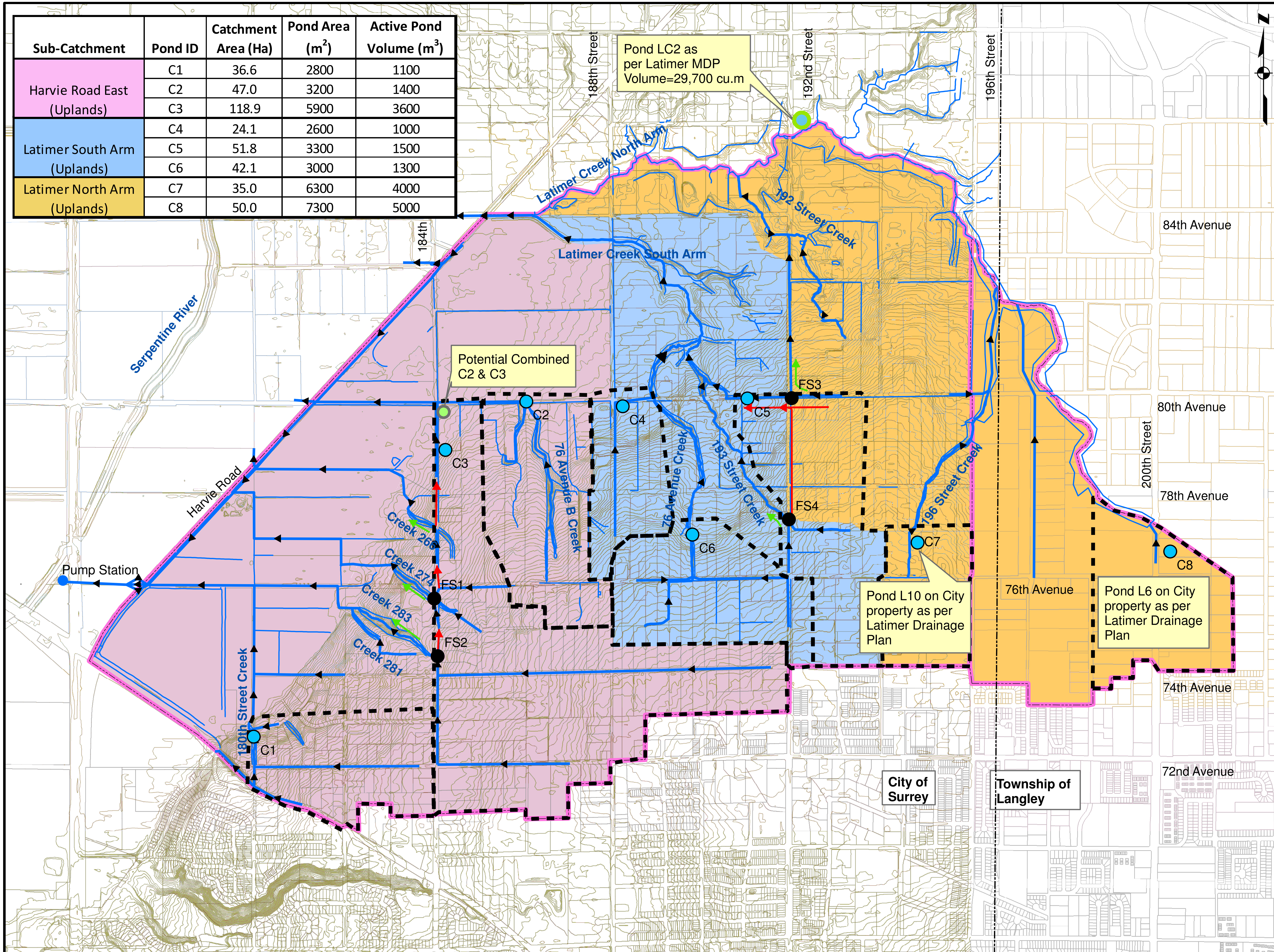
Sub-catchment	Sub-catchment Area (ha)	Pond VOLUME Required (cubic metres) (For 100-yr storm)		Pond AREA Required (square metres) (For 100-yr storm)	
		No BMPs	BMP 4	No BMPs	BMP 4
Harvie Road East (Uplands)	214	23,500	6,100	24,000	14,400
Latimer North Arm (Uplands)	220	43,100	9,000	23,300	27,400
Latimer South Arm (Uplands)	117	35,200	3,800	95,200	10,500
TOTAL	**551**	**101,900**	**18,900**	**142,600**	**52,300**
Average		**185 m^3/ha**	**34 m^3/ha**	**259 m^2/ha**	**95 m^2/ha**

Figure 7.13 shows proposed detention pond locations and their relative sizes. A total of seven (7) proposed ponds are located within the City of Surrey boundaries and one (1) proposed pond is within the Township of Langley. These locations consider the ponds proposed in the Latimer Creek Master Drainage Plan and the 1999 Clayton Master Drainage Plan. Because pond C1 services a smaller area relative to the other ponds, there may be an

opportunity to convert C1 into a bio-ditch with detention. As well, there may be an opportunity to combine ponds C2 and C3. However, actual pond requirements and locations should be confirmed at the NCP stage.

As shown on **Figure 7.13**, we are not proposing a pond upstream of each creek tributary. Instead we propose flow-splitter manholes upstream of each creek tributary which directs natural base flows to the creek but conveys peak flows to the closest detention pond. The objective of this is to limit the number of ponds in order to minimize the cost of constructing and maintaining these ponds. The ponds should be designed with multiple controls (i.e. orifices) in order to have different release rates, depending on the size of storm (i.e. 2 yr, 5 yr and 100 yr). The ponds should also be designed to address water quality.

Sub-Catchment	Pond ID	Catchment Area (Ha)	Pond Area (m^2)	Active Pond Volume (m^3)
Harvie Road East (Uplands)	C1	36.6	2800	1100
	C2	47.0	3200	1400
	C3	118.9	5900	3600
Latimer South Arm (Uplands)	C4	24.1	2600	1000
	C5	51.8	3300	1500
	C6	42.1	3000	1300
Latimer North Arm (Uplands)	C7	35.0	6300	4000
	C8	50.0	7300	5000



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Clayton ISMP

Legend

- Study Area Boundaries
- Pond Catchment
- Flow Splitter Manhole
- Peak Flow
- Base Flow
- POND ID
- Proposed Pond
- Potential Pond Location
- Future Drainage
- Creek

Future Pond Catchments

- Harvie Road East
- Latimer Creek South Arm
- Latimer Creek North Arm

AECOM

0 62.5 125 250 375 500
Meters

Project No.	Date
60158414	June 2012

Proposed Future Detention Pond Locations

Figure 7.13

7.8 Offsite Constraints

The ISMP study area encompasses many small streams that are part of three major watersheds: Harvie Road Pump Station, Latimer Creek South Arm, and Latimer Creek North Arm. With the exception of Latimer Creek South Arm, the watershed areas studied are only a portion of the total contributing area. A large portion of the contributing catchment areas to Latimer Creak North Arm are external to the ISMP study area. This area was previously examined as part of the Latimer Creek MDP, however many changes to development assumptions have occurred since. As such, detailed designs affected by flow from catchments outside of this ISMP study area must review the actual proposed changes that will affect the design.

In addition, part of the ISMP study area is located within the Township of Langley. NCPs are in the process of being developed for areas on both sides of the municipal boundary. While the Township is aware of this study, they may choose to adopt the recommendations or provide alternative methods to manage development impacts in keeping with the requirements of the regional Liquid Waste Management Policy.

The ISMP deals with upland development impacts. The lowlands drainage system within the ALR is interconnected and complex, and even though they are not studied here, they are assumed to remain largely agricultural. This report assumes that existing land uses, water levels, and flows within the ALR are established, and that the ISMP is to provide recommendations to mitigate negative impacts to this area. Further studies of the drainage and flood control operations for the Serpentine-Nicomekl floodplain may be required.

7.9 Option Comparison

Storm water can be managed in a variety of ways and through our analysis we have looked at various options (i.e. BMPs, detention ponds and diversion sewers). In order to fully support the ISMP vision developed in Stage 2, our analysis concludes that BMP 4 with detention ponds should be implemented. For comparative purposes, **Table 7.16** provides a summary of how BMP 4 with detention ponds is the best storm water management strategy that can achieve all of the four (4) goals previously identified, whereas other storm water management strategies such as detention ponds or diversion sewers do not.

Table 7.16 Benefit Comparison of Three Storm water Management Options

	NO BMPS WITH PONDS	BMP SCENARIO 4 WITH PONDS	NO BMPS WITH DIVERSION SEWER
Goal 1: Maintains base flows to streams	No	**Yes**	No
Goal 2: Maintain stream water quality	**Yes** **Only in ponds**	**Yes** **By infiltration BMPs and in ponds**	**Yes** **if water quality units installed**
Goal 3: Mitigate lowland flooding as development increases	**Yes**	**Yes**	**Yes**
Goal 4: Mitigate erosion in creeks through reduced run-off volumes as development increases	No	**Yes**	No It will protect the larger creeks but not every Class B stream

BMP Scenario 4 with ponds achieves the goals of the ISMP, meets the objectives of the Fisheries Act and supports the City of Surrey's Sustainability Charter. As this can be achieved at a cost of less than $100,000 per ha we recommend that the City pursue BMP Scenario 4 with ponds for the Clayton area.

7.10 Recommendations

As part of the vision developed of the Clayton ISMP a number of recommendations were made. These recommendations were further defined through the hydrologic and hydraulic assessment, and requirements associated with their implementation are provided below in **Table 7.17**.

Table 7.17 Summary of Goals and Recommendations

#	Recommendation	Driver
Goal 1: Protect Agriculture and Agricultural Activities		
1-1	*As part of future NCPs for this area, we recommend that City staff coordinate with the AAC to develop a comprehensive edge plan that will outline setback requirements, densities and other conflict mitigation tools adjacent to the ALR. This is being implemented as part of the West Clayton NCP.*	Planning
1-2	*Preserve Harvie Road as a drainage corridor so that the quantity and quality of flows are protected.*	Planning/Drainage
Goals 2 / 3: Preserve, Maintain, and Enhance Streams and Riparian Areas		
2-1	*All Class A and B streams are to be protected. Where they cannot be protected (i.e. along 192nd Street or 76th Avenue) compensation shall be provided.*	Transportation/ Drainage/ Land Development
2-2	*The City should revise its 2004 Design Criteria Manual with respect to culverts (Section 5.4.H) to include consideration of aquatic and terrestrial wildlife passage where suitable.*	Drainage
2-3	*The City should review the classification of the 196th Creek south of 80th Avenue.*	Drainage
2-4	*All Class A and B streams are to have a minimum designated riparian setback of 30 metres, otherwise a comprehensive assessment is required.*	Drainage/ Land Development
Goal 4: Preserve, Maintain, and Enhance Latimer Wetlands		
4-1	*It is recommended that the City of Surrey, through the Lowland Schemes, coordinate with the agricultural community to protect the Latimer Wetlands (5 ha).*	Drainage/ Planning
Goal 5: Preserve, Maintain, and Enhance Key Forest Habitats		
5-1	*It is recommended that the City consider the viability of purchasing additional 14 ha of land to sufficiently preserve the key forest habitat near 78th Avenue and 190th Street.*	Planning/ Parks/ Environment
5-2	*It is recommended that the City consider the viability of purchasing 12 ha of land to sufficiently preserve the forest habitat at 74th Avenue and 196th Street.*	Planning/ Parks/ Environment
Goals 6, 7, 8, 9: Maintain Base Flow to Streams and Stream Water Quality, Reduce the Likelihood that Increased Development Will Increase Lowland Flooding and Stream Erosion		
6-1	*It is recommended that the City adopt the following strategy for controlling run-off in the Clayton Area:* • *Each lot conveys its run-off to infiltration devices with a contact area equal to 10% of the lot area.* • *The road r-o-w would have infiltration devices with a contact area equal to 50% of the area of the r-o-w.* • *All pervious areas have a minimum depth of 450 mm pervious material.* • *Within the Harvie Road East sub-catchment detention ponds shall be constructed to provide 28.5 m^3 of storage per hectare.* • *Within the Latimer North Arm sub-catchment detention ponds shall be constructed to provide 41 m^3 of storage per hectare.* • *Within the Latimer South Arm sub-catchment detention ponds shall be constructed to provide 32.5 m^3 of storage per hectare.* • *All detention ponds shall be designed to also provide water quality treatment.*	Planning/ Drainage/ Transportation
Goal 10: Increase Density in Areas of Lower Environmental Value		
10-1	*Areas within the Clayton ISMP that should be considered for increased densities in future NCP (Neighbourhood*	Planning

	Concept Plans) are along the southern edge and adjacent to 188th Street and 72nd Avenue.	
10-2	*As planning in Langley is currently underway for the 200th Street corridor and the Latimer Neighbourhood, close communication between the City and the Township should be a priority.*	Planning
10-3	*The City must ensure sufficient utilities (energy, communications, water and sanitary) are available for the densities and development locations planned in the Clayton ISMP study area*	Planning/ Engineering
Goal 11: Improve and Maintain Wildlife Connectivity		
11-1	*Within the future NCP, the City should consider preserving the 77th Avenue corridor between the 193 Street and 196 Street Creeks as a natural corridor.*	Planning/ Environment/ Transportation
11-2	*Development should be clustered to maximise green space and corridors between them. Potential EMS corridors need to be defined and preserved, as necessary, through the NCP process.*	Planning
11-3	*City owned property should be planted with native species that enhance habitat quality and act as transition areas. The City should also encourage residents to do the same on private property.*	Environment
Goal 12: Connecting Communities		
12-1	*It is recommended that the City pursue a village concept along the southern edge of the ISMP boundary (i.e. 72nd Avenue), as shown in the City's General Land Use Plan. It is also recommended that the City assess forest stands near 72nd Avenue and 188th Street to determine if key tree stands can be incorporated into the village concept, in combination with the proposed Clayton greenway, to emphasize this community's values of environmental stewardship and strong rural ties.*	Planning
12-2	*It is recommended that the City incorporate wildlife corridors, key forest habitats, all Class A and B streams and their riparian areas, the presence of agricultural vehicles along Harvie Road, Langley's Transportation Plan, future transit routes, utility corridors, connections to adjacent communities and the interconnectedness of the Clayton community when planning corridors within the ISMP area.*	Transportation/ Planning

The recommendations where the Drainage group will be one of the key drivers are 2-1, 2-2, 2-3, 2-4, 4-1 and 6-1. Associated costs, enforcement strategies, policy and procedural changes, departmental responsibilities, and timing of implementation are described in **Sections 7.11** to **7.14**.

7.11 Cost of Implementing Recommendations

The most significant cost implications for implementing the recommendations of this ISMP are outlined below.

- Land acquisition, as required (approx $2,500,000 per hectare).
- Providing compensation where the City decides to remove or relocate Class B streams (possibly along 184thSt, 76th Ave and 192nd Street.
- Detention ponds (approx. Cost of $5,000/ha)

7.12 Enforcement

In order for this ISMP to be successfully implemented a number of enforcement and design review activities will need to occur. These activities are outlined below.

1. To ensure that all Class A and B streams and their riparian areas are protected all road designs and building permits will need to be reviewed. These projects should also be reviewed during and after construction to ensure that the streams and their riparian areas have indeed been protected. The City may also want to have the capacity to periodically review sites in the future to ensure that they continue to respect the streams and their riparian setbacks.
2. To ensure that all culverts are designed for aquatic and terrestrial wildlife passage all culvert designs will need to be reviewed by the City.
3. To ensure that on-lot BMPs are implemented, all building permits will need to be reviewed. These projects should also be reviewed during and after construction to ensure that they have been properly constructed.

7.13 Policy and Procedural Changes

In order for this ISMP to be successfully implemented a number of policy and procedural changes will need to occur. These changes are outlined below.

1. If proposed densities adjacent to the ALR are greater than that recommended in O-23 in the Official Community Plan, then the AAC should be consulted.
2. If preserving Harvie Road as a drainage corridor impacts its ability to act as an arterial then it may need to be re-classified to a collector north of 80th Avenue.
3. The City of Surrey's 2004 Design Criteria should include modifying culverts where suitable to allow for fish and wildlife passage (see **Section 7.15**).
4. The City of Surrey's 2004 Design Criteria should state the need for a riparian setback beyond the top-of-bank of 30 metres, otherwise a comprehensive assessment is required.
5. Approved on-lot and on-street BMP design criteria are required for development in this area.
6. In arriving at the proposed densities in the ISMP area, the GLUP provided reference for some of the key land use elements such as the location of the village centre, higher density residential near the village centre, and Fraser Highway with some green infrastructure. Generally, the proposed densities are higher than the densities anticipated in the GLUP. The densities reflect Surrey's emerging growth patterns, increased awareness about the need for energy conscious planning, and the experience gained from development of East Clayton and other more recent NCPs.

7.14 Timing

A proposed schedule for the implementation of the proposed recommendations, where the City of Surrey's drainage group is a key driver is shown in the table below.

Table 7.18 Implementation Schedule

Recommendation	Short Term 2011-2013	Longer term/ On-going
Protection of all Class A and B streams	Input to the West Clayton NCP	On-going as development applications are received and further NCPs are completed
Culverts that allow for fish and wildlife passage where suitable	Revise 2004 Design Criteria Manual	On-going design review
Revise and review the transition between Class A and B streams	Needs to be completed.	
Preservation of riparian setback	Revise 2004 Design Criteria Manual. Input to the West Clayton NCP.	On-going implementation as development applications are received and further NCPs are completed.
Protect the Latimer Wetlands	Begin the discussion as part of the Lowlands Scheme.	Full implementation.
Controlling storm water run-off	Revise 2004 Design Criteria Manual. Input to the West Clayton NCP.	On-going implementation as development applications are received and further NCPs are completed.

7.15 2004 Design Criteria Review and Recommendations

We conducted a review of Sections 2.0 and 5.0 (including Appendix A) of the City of Surrey's, Engineering Department's Design Criteria Manual Version, May 2004 to determine if any changes should be made based on the recommendations resulting from this ISMP. The City may choose to implement the following recommendations as needed.

The City of Surrey's Engineering Department's Design Criteria Manual (2004) states that drainage systems must meet four basic criteria which form the fundamental aspects of the City's Drainage Policy:
(a) A minor system conveyance capacity up to the 1:5 year return period storm to minimize inconvenience of frequent surface runoff.
(b) A major system conveyance capacity up to the 1:100 year return period storm to provide safe conveyance of flows to minimize damage to life and property.
(c) Where erosion is a concern, to 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 5-year pre-development flow rate.

(d) Maintenance of a flood control and drainage system in the lowlands that meets provincial guidelines for agriculture in floodplains (ARDSA).

Recent research suggests that it is not simply the rate of flow that determines erosion levels but also the duration of critical flows. Therefore, we recommend that the City reconsider its design criteria to address runoff volumes as well as flows. Therefore detention is not sufficient and retention must also be considered. In addition, the Design Criteria do not address top-soil requirements which may be addressed elsewhere but have a significant impact on storm water run-off.

Detailed recommendations for changes to the City of Surrey's Engineering Department's Design Criteria Manual are listed in **Table 7.19**.

Table 7.19 Recommended Changes to Surrey's 2004 Storm Water Design Criteria

Page	Section	Item	Required Modification
8	2.0	Highway Dedication, Pavement Widths and Sidewalks	This same table is within Schedule A of the Subdivision Bylaw (8830) and should be changed accordingly.
2 and 6	5.2.	Drainage Servicing	References to Master Drainage Plans should be revised to include Integrated Storm water Management Plans
3	5.2.D	Servicing Objectives	Servicing Objectives should include reference to the fact that the duration of erosion flows needs to be controlled as well as the rate.
4	5.2.E	Typical Drainage Constraints	Table 5.2 (a) should note that retention and infiltration facilities can help mitigate an undersized minor system. In addition – controlling flow from upland areas may be an option for minimizing lowland flooding.
6 and 7	5.2.	Drainage Servicing	The storm water control plan as outlined on pages 6 and 7 should include measures for managing the quality of storm water run-off and for ensuring that stream base flows are maintained.
9-22	5.3.B	Rainfall Data	The City of Surrey may want to review their rainfall data in light of climate change and new findings in statistical analysis of rainfall as demonstrated by the City of Edmonton.
23	5.3.C	Rational Method	Table 5.3 (h) Runoff Coefficients - the City may want to consider higher imperviousness ratios for residential development and consider adding new ratios for development with BMP's.
27	5.3.D	Hydrograph Method	Does the City want to consider allowing the Water Balance Model as an approved hydrologic computer program? For presentation of modelling results the City should ask for duration of erosion causing flows as well as % of flow infiltrated for base flow considerations.
35	5.4	Minor Conveyance System Hydraulic Design	There are no design standards for or requirements for on-lot or on-street BMPs such as infiltration facilities.
37	5.4.G	Ditches	This section should consider swales and bio-swales.
37	5.4.H	Culverts	This section should be modified to consider fish and wildlife passage.
49	5.4.O	Catch Basin Inlets	This section should be modified to require infiltration trenches associated with catch basins.
61	5.6.D	Outflow Control Works	Rates of discharge may come out of the Neighbourhood Concept Plans or the ISMPs. These studies should not only address the rate of discharge but also the duration of discharge.
71-72	5.7	Figure 5.5 "Typical Major/Minor System"	This figure would need to be changed to show infiltration/retention areas.
72	5.7.B.b	Erosion and sediment impacts of urbanization	The second paragraph on Page 72 suggests that watercourses can adjust over time to accommodate greater flows from urbanization. Perhaps, greater emphasis should be placed on ensuring that the new flows are controlled in order to not impact watercourses.
73	5.7.B.e	Master Plans and Land Use Controls	The first paragraph should include ISMP as a type of study that designs must conform to.
75	5.7.C.c	Development Setbacks and Top-of-Bank Limits	The third paragraph states that "no development-related encroachments to the top-of-banks should be permitted ". It should also state the need for a riparian setback beyond the top-of-bank (i.e. min. 30 metres unless an environmental assessment can prove otherwise).
77	5.7.D.b	Overall Design Principles and Methodology	Should the needs of wildlife corridors be considered in the design of natural channels?
80-85	5.7.E	Natural Drainage Design Parameters	This section does not address the design of vegetation associated with natural channels in order to provide habitat and biofiltration.
A-2	A.4.1	Policy Summary	Master Drainage Plans should be changed to ISMP Should include methods to limit the volume of discharge to natural creeks.
A-4	A.4.4	Drainage Planning Process	Change Master Drainage Plan to Integrated Storm water Management Plans
A-5	A.4.4	Quantity of Flow Entering the Creeks	This should include limiting the volume of discharge as well as the peak rate

8. How Do We Stay On Target? (Adaptive Management)

8.1 Adapting For The Future

Planning for a 25, 50, or 100-year horizon is a challenge that all municipalities face. Due to economic, political, climatic, technological, and social changes as well as changes in our understanding of the watershed it is imperative that the ISMP adapt accordingly to ensure the watershed vision is met over time. As such, a key component to a successful ISMP is to develop a long-term adaptive management program that includes monitoring, operation, and maintenance strategies to verify that the vision and goals set out are met through the implementation plan.

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

8.2 Key ISMP Coordinator

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

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

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

8.3 BMP Operation & Maintenance Plan

Stage 3 proposed several BMPs such as enhanced topsoil, detention ponds, infiltration trenches, porous sidewalks, and pervious pavement that all require specific operation and maintenance requirements in order to function properly. As such, it will be necessary to perform regular inspections and upkeep on BMPs. **Table 8.1** summarizes the key BMPs identified in Stage 3 and the associated O & M plan for each.

Table 8.1 Operation and Maintenance Strategy for BMPs

BMP	Description	Maintenance Required When	Operation & Maintenance Plan	Timeline
Infiltration Trench	Gravel-filled excavations that temporarily store stormwater and allow it to drain into underlying soil	Standing water is visible in the observation well for more than 48 hours after a rain event.	Catchbasins and inlets to be inspected and cleaned.	Annually
		Insects and/or odor problems develop.	Ensure vehicles are not driven or parked on trench.	Construction Phase and on-going
		There is visible damage to the trench (eg. Sinkholes).	Avoid excessive compaction from equipment and mowers	Construction Phase and on-going
		Trash, leaves, and other debris have collected on the surface.	Remove debris from surface to maintain proper function.	Quarterly
		Runoff runs over or across the trench and not into the facility.	Repair any damages to trench.	As needed
			Provide temporary diversions and ensure trench is protected from sediments during construction phase.	Construction Phase
Pervious Pavers	Provide structure and stability while allowing runoff to infiltrate through to the ground's surface.	Significant amounts of sediment have accumulated between the pavers.	Surface sweeping to be completed with a commercial vacuum sweeping unit.	Bi-annually
		Puddling or ponding of water is visible on the surface 48 hours after a rain event.	Inspection to check surface conditions to determine if any remedial work is needed such as pothole repair, weeding, and paver replacement.	Annually
Porous Paving	Diverts runoff through a porous asphalt or concrete layer and into an underground gravel trench, gradually infiltrating into the subsoil.	Standing water is visible on the surface 48 hours after a rain event.	Avoid loading or placement of landscaping materials such as mulch, sand, or topsoil on porous paving, even temporarily.	On-going
		There is visible damage to the pavement (eg. Sinkholes)	Inspection of surface conditions to determine if there is uneven settling, water ponding, or potholes that require remedial work.	Bi-annually
		Dirt, debris, and vegetation is present on the surface.	Surface vacuuming with commercial vacuum sweeping unit or pressure washing of clogged surfaces.	Bi-annually
			Restrict use of de-icing chemicals and sand on porous paving	Winter periods
Enhanced Topsoil	Additional topsoil treats runoff through detention, exfiltration, and slows down flows.	Vegetation is wilting or dying.	Inspections to ensure required depths have been constructed throughout the construction phase.	Construction Phase
		Topsoil is exposed and/or being eroded.	Ensure areas of enhanced topsoil placement remain uncompacted during the construction phase.	Construction Phase
Detention Pond	Stormwater basins that include a permananent pool for water quality treatment and temporary runoff storage.	Vegetation is wilting or dying.	Inspect vegetation of pond to ensure healthy growth.	Quarterly
		Sediment accumulation is affecting hydraulic capacity.	Inspection of any erosion, flow channelization, bank stability, sediment/debris accumulation, and inlet/outlet issues.	Quarterly
		Undesirable species of plants or insects are present.	Pond to be drained and sediment be removed from forebay	Every 5 to 10 years

8.4 Water Quality and Flow Monitoring

Monitoring flows and pollutant concentration will be necessary in determining watershed health within the area covered by the Clayton ISMP. There is a requirement to establish baseline pre-development conditions and compare these with post-development conditions in order to properly analyze the effectiveness of the implementation plan and to provide concrete evidence to City staff and stakeholders. As such, we recommend a water quality monitoring program and a flow monitoring program as part of the adaptive management process of this ISMP.

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

- Flow and rainfall monitoring program;
- Benthic Index of Biotic Integrity (B-IBI) monitoring program;
- Ravine Erosion Assessment program;
- Water quality monitoring program;
- Species At Risk Assessment (SARA) program;
- Sensitive Habitat Inventory Mapping (SHIM); and
- Boundary Bay Ambient Monitoring Program (BBAMP).

Since monitoring and collecting data can be time consuming and extremely expensive, the programs listed above provide a plethora of information that should be reviewed prior to determining the need for new monitoring locations and equipment. It is essential that what types of data and the level of data detail required for the Clayton ISMP be established so that any new monitoring to be done can be focused and cost effective.

When the East Clayton NCP began, the City performed water quality monitoring of North Creek to look at changes in stream chemistry as development continued. Subsequently more monitoring locations were added to specific streets in East Clayton to see if BMPs implemented within the neighbourhood were performing properly and if infiltration goals were achieved. Water quality monitoring parameters included:

- Water Flow rates;
- Temperature;
- Conductivity;
- Turbidity;
- Dissolved oxygen;
- Rainfall;
- pH; and
- B-IBI data.

Results from this monitoring program allowed the City to complete an analysis of the performance of the BMPs and it was determined that infiltration volumes had been achieved in East Clayton. Downstream systems possessed longer base flows and lower peak flows than compared to pre-development conditions and the City had achieved 97% capture in the exfiltration systems implemented, which met their storm water volume reduction goal.

Existing flow monitoring locations within and adjacent to the Clayton ISMP study area are shown on **Figure 8.1** respectively. We recommend a new water monitoring station on 184th Street near 80th Ave. to first identify baseline conditions before further development occurs within the southwest portion of the ISMP study area. This portion of the ISMP study area is where development is expected to occur first and where the highest densities are expected. Data from this station could then be used to determine the effectiveness of the stormwater strategy as development progresses.

Stage 3 of this ISMP recommended the installation of a number of detention ponds that would also be designed to treat water quality. We recommend that a water quality monitoring program be implemented to determine the effectiveness of these detention ponds, once installed.

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

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

8.5 Benthic Index of Biotic Integrity Monitoring

Since 1999, the City of Surrey has conducted a yearly B-IBI monitoring program in the spring and fall seasons for many local streams. Monitoring of benthic invertebrates is considered a standard method of determining biodiversity and watercourse health since they live in the stream for most or all of their lives, they differ in tolerance as to the types of water quality and flows, and often live more than a year allowing for temporal patterns to be observed.

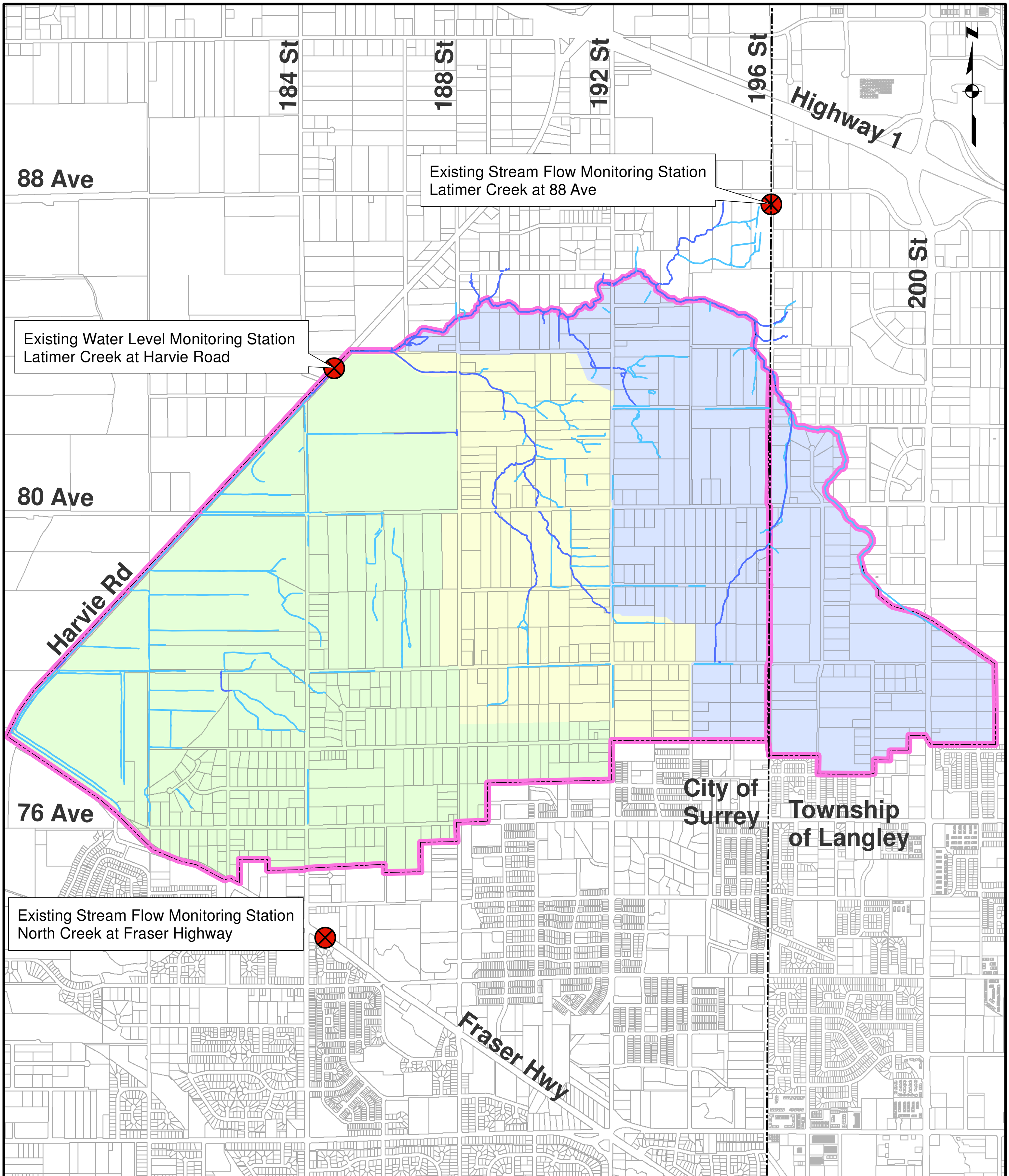
Currently, there are three (3) B-IBI monitoring stations located within the Clayton study area that should be continually monitored and assessed. Station L1 is located at the headwaters of Latimer Creek south arm near 192 Street and 78 Avenue. Station L2 is located on the north arm of Latimer Creek, downstream of 196 Street. The third station T1 is located at the intersection of 184 Street and 76 Avenue. These stations are shown on **Figure 8.2*.***

When interpreting B-IBI data, there must also be an assessment of the entire health of the stream and the overall composition of various invertebrates present. The City has expressed the need to look beyond the monitored B-IBI counts in determining the status of stream health. For example, looking at the change in B-IBI scoring from one year to the next may only be representative of short-term effects that the stream is experiencing. It will be necessary to look at the historical nature of that stream and compare it to other streams within the City to obtain an accurate understanding of its health condition.

8.6 Erosion and Ravine Stability Monitoring

The City has conducted regular ravine erosion assessments every two years to monitor the condition of creek erosion and bank stability. It is recommended that the City continue with this program to monitor erosion conditions, outfalls, and riparian areas for Class A and B streams and complete pre and post-development comparisons to see if erosion has been mitigated and riparian areas are being protected.

Specific areas within the Clayton watershed for long term monitoring include the 196th Avenue Creek ravine continuing into the Township of Langley, the 76th Avenue Creek ravine, and the creeks west of 184th Street. These areas are predicted to experience the greatest impact as development continues.



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Project No.	Date
60158414	December 2011

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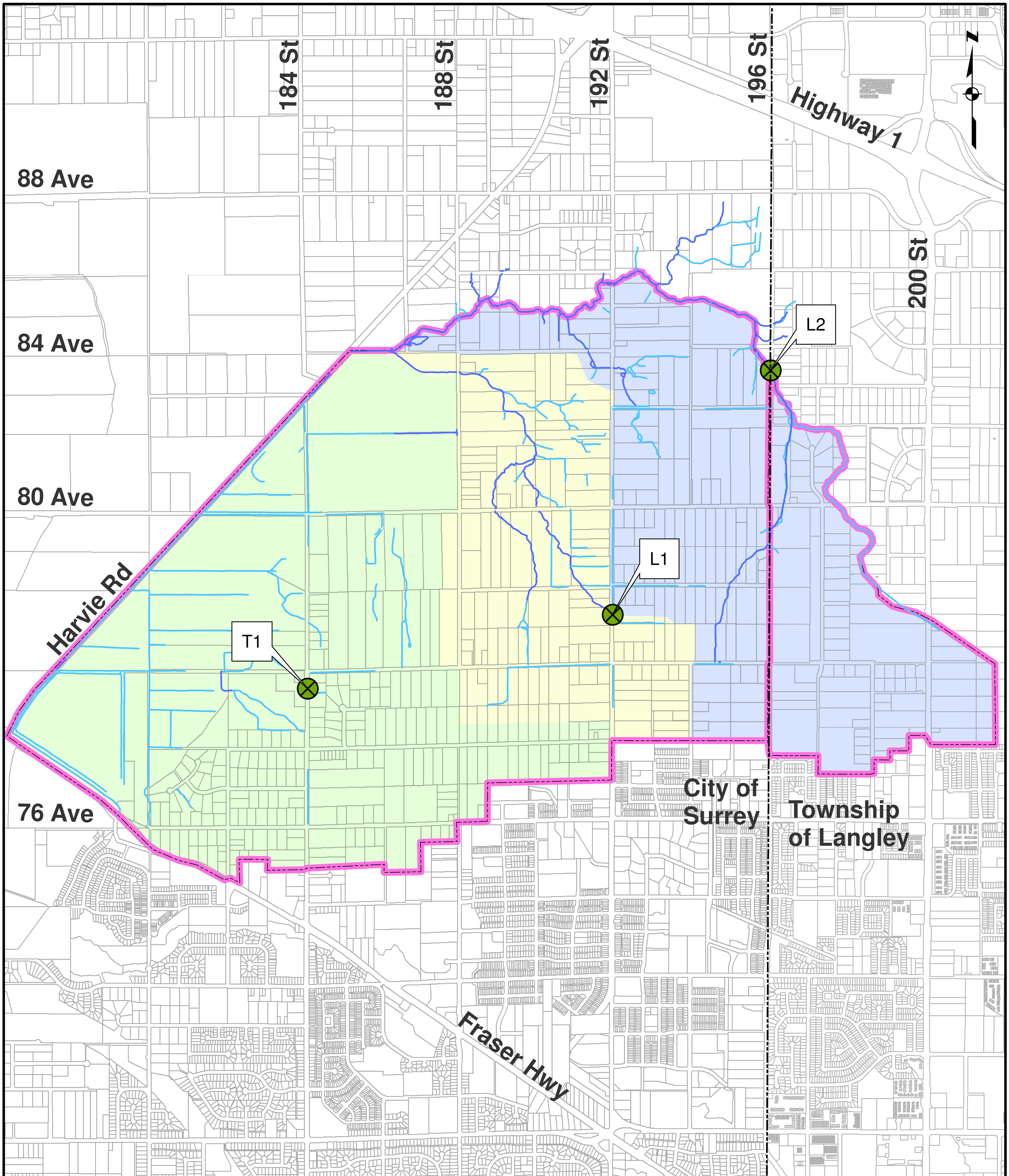
Flow Monitoring Locations

FIGURE 8.1



City of SURREY the future lives here.

Clayton ISMP

Project No. 60158414

Date December 2011

Legend

Study Area Boundaries

Watercourse

Major

Minor

Future ISMP Watersheds

Harvey Road East

Latimer Creek North Arm

Latimer Creek South Arm

BIBI Monitoring Station

AECOM

Meters 0 250 500

BIBI Monitoring Locations

FIGURE 8.2

8.7 Public Outreach Programs

Carrying out the long-term watershed vision must be a shared responsibility. Engaging communities, schools, and politicians to participate in the ISMP process is an important step that is at times under-emphasized or overlooked. The more education and awareness that is generated about the importance of maintaining watershed health, the more likely it will be for the City to establish funding, create capital works projects, and take a pro-active approach to future planning.

An example of successful outreach programs within the City is the Salmon Habitat Restoration Program (SHaRP), a student-based initiative that promotes watershed stewardship and habitat enhancement for fish species within the City. Students are involved in public education programs and perform creek restoration work while being provided with valuable youth work experience in environmental management. SHaRP students develop a strong stewardship mentality and gain a sense of ownership for the habitats they are involved with. Programs such as SHaRP are ways in which the City can gain support from communities to share in the responsibility of a watershed vision. **Figure 8.3** shows locations of public schools and recreation centres where outreach programs can be held within and near the area covered by the Clayton ISMP.

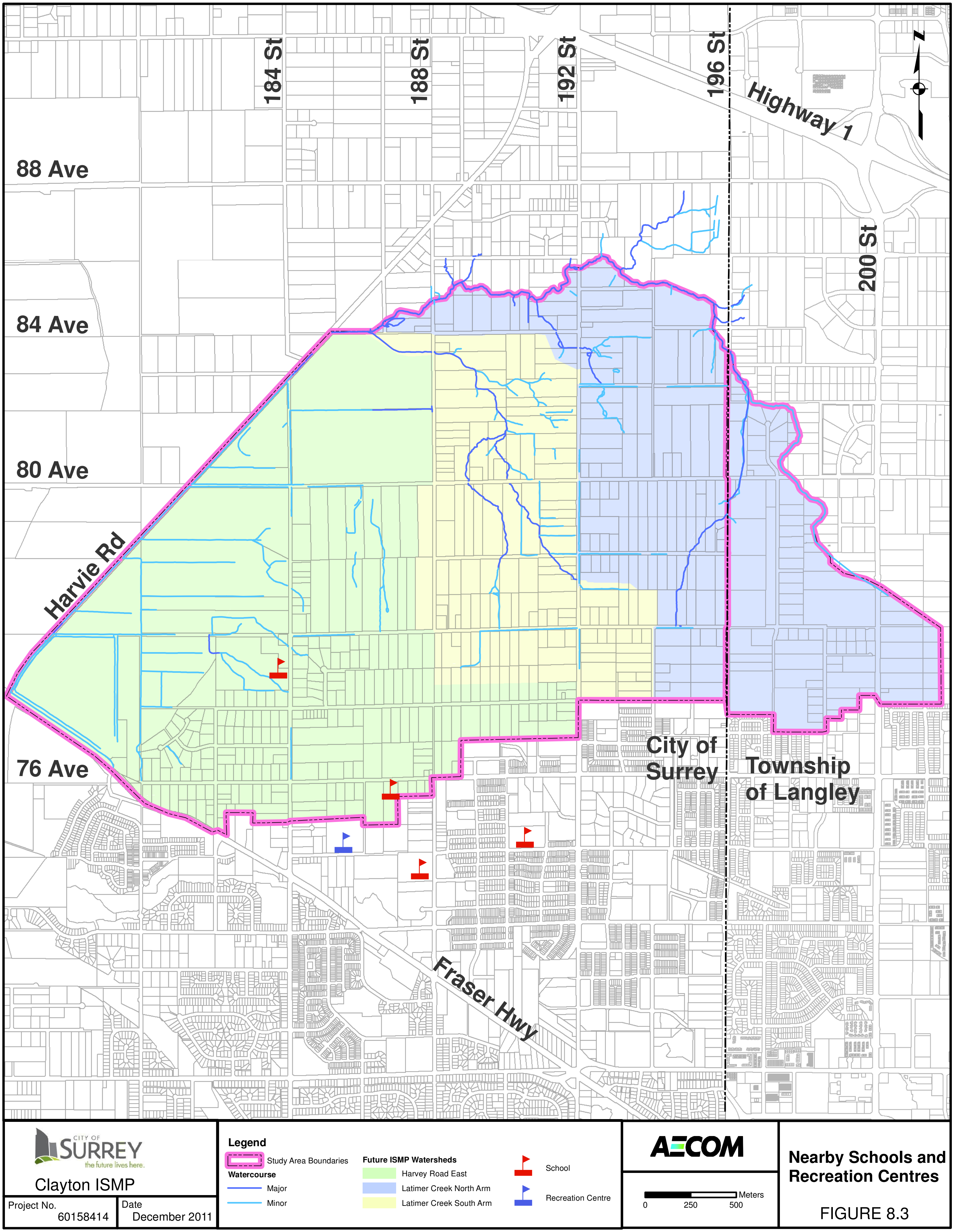
8.8 Review and Adapting the ISMP

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

Upon completing the construction of any new subdivisions or other significant developments in the watershed, post-development monitoring should be performed up to three years. This post-development review shall include analyzing the collected data with baseline conditions in order to determine if there is progress in achieving the watershed vision through the implementation plan, and what revisions are required to adapt the ISMP accordingly.

Metro Vancouver's Liquid Waste Management Plan template recommends that ISMPs be updated every 12 years. Due to the high development demand in the Clayton area (West Clayton NCP areas 1 and 2 are currently under way), the Clayton ISMP should be reviewed more frequently to adapt to ever-growing changes in the watershed. An update to the ISMP may be warranted if:

1) There is a revision to the OCP, zoning bylaw, or an NCP is amended with significant changes to future land uses;
2) Water quality and flow monitoring data show watercourses with less base flows and higher amounts of pollutants after implementing the ISMP recommendations;
3) Creek erosion is worsening and there is degradation in bank stability despite implementing the ISMP recommendations; or
4) Occurrences of flooding and damage to properties have increased.



CITY OF SURREY the future lives here.

Clayton ISMP

Project No.	Date
60158414	December 2011

AECOM

Nearby Schools and Recreation Centres

FIGURE 8.3

Appendix A Clayton Study Area Soil Infiltration Test Results

AECOM
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www.aecom.com

Memorandum

To	Nancy Hill	Page 1
CC	Rob Dickin; Ryan Mills; Bojan Vujicic	
Subject	Clayton Study Area Soil Infiltration Test Results	
From	Fikre Debela	
Date	August 29, 2011	Project Number 60158414

Introduction

The purpose of this memorandum is to report the findings of the on-site soil infiltration test conducted for the Clayton Study Area on August 24th and 25th, 2011. This memorandum provides a brief account of:

- Test locations and an assessment of existing site and soil conditions,
- Infiltration test methodology, and
- Test results and concluding remarks.

Test Locations and Existing Conditions

The Clayton Study Area is located in the Clayton Uplands/ Willoughby Heights area of Surrey and Langley and bordered by Harvie Road, Fraser Highway, East Clayton NCP and Latimer Creek (AECOM, 2010). Prior to the field testing, four study sites were identified as the potential locations for the soil infiltration testing within the study area. The test sites were chosen based on their accessibility for the required test (i.e., on city property or street ROW). The four proposed sites were:

- Site 1: End of 76th Ave, on street ROW towards 196th Street
- Site 2: End of 180th St, on street ROW north of Fraser Highway
- Site 3: Roadside of Clayton Elementary School at 76th Ave and 184th St
- Site 4: Roadside of Hazelgrove Annex Elementary School at 72nd Ave east of 184th St

All of the above identified potential study sites are located on or adjacent to street ROW. Therefore, disturbance to the native soil and the presence of anthropogenic fill materials was expected. An initial on-site soil assessment was conducted either by hand auguring or shallow backhoe excavation to determine the degree of disturbance to the native soil and site suitability for the intended infiltration testing.

From initial site assessment, Site 1 and Site 3 were deemed appropriate for the infiltration testing as originally proposed (as communicated to the client). A backhoe excavation to a depth of 1.8 m was conducted at these locations.

However, Sites 2 and 4 were moved to alternative sites as close as possible to the originally proposed sites for the following reasons:

- Site 2 – the proposed site was within a street ROW where the top 0.8 m of soil was composed of a highly compacted, very coarse, and gravely fill material. Such material is not suitable for the infiltration testing method used. Backhoe excavation deeper than 3 ft was not recommended by the excavation contractor at this location without knowing the exact locations of underlying utilities. The alternative test site was located immediately adjacent to the ROW by doing a soil auguring to 1 m depth to identify undisturbed native soil. However, due to the closeness of this identified alternative site to a fire hydrant, only manual digging to a depth of 0.8 m was conducted.

- Site 4 – was also moved off the street ROW to city owned sports ground adjacent to the Hazelgrove Annex Elementary School due to the closeness of the original site to utilities. However, the use of the school property was required to operate a backhoe excavator at the alternate location. As permission to use the school property was not obtained in time, only manual digging to the depth 0.8 m was conducted.

Soil Conditions

An initial review of a previous report on the soils of the study area indicated that the test sites are located within the Upland soil region which largely includes moderately well drained, and moderately fine textured glaciomarine soils (AECOM, 2010). Telluric seepage is reported for these soils which is an indicative of a fairly close watertable and/or a restrictive soil layer at depth.

Our field assessment revealed that the soils in the study area are either modified or highly disturbed as the result of fairly recent urban development activities in the area. The native soils at two of the test sites were found to be overlain by 0.5 to 1.3 m of fill material (Fig 1). The native soils at all locations are moderately to well developed similar to what would be expected under well established forest cover. This further confirms that the disturbance to the soils in the area is recent.

The native soils at all of the locations are found to be morphologically similar as they have developed from one kind of silty clay glaciomarine parent material (C horizon). These soils can be roughly described as imperfectly drained, medium textured, Gleyed Podzols. Glaciomarine deposits are sediments of glacial origin laid down in a marine environment in close proximity to glacier ice (Howes and Kenk, 1997). For the undisturbed native soils, the C horizon is found at about 0.7 m depth. At all test locations evidence of strong mottling was observed at the C horizon (Fig 1). This is an indication of a periodic/seasonal saturation of the native soils at depth.

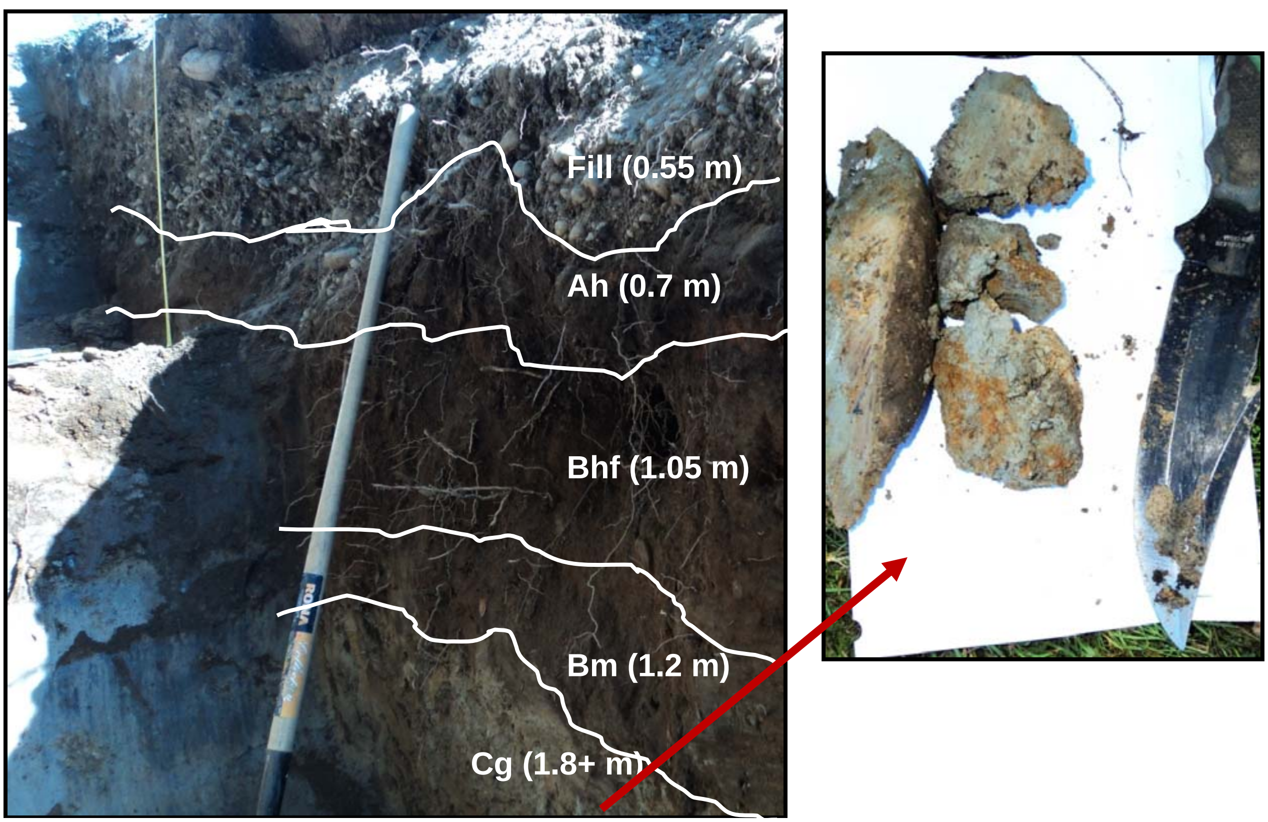

Fig 1. Typical soil profile in the study area. Test pit shown for Site 3 (roadside of Clayton Elementary school. Signs of strong mottling as shown by the inset indicates slower water movement and prolonged and periodic subsurface soil saturation in the study area.

Table 1. Summary of soil conditions at the four test sites.

	Anthropogenic (fill) material	Native Soil
Site1	- 1.3 m thick mixed fill material; - first 0.5 m very gravely sandy clay fill and lower portion mix of gleyed clay and clay loam material; - surface gravely layer highly compacted , not suitable for surface testing	- upper and mid soil sections, well developed, medium to fine textured (sandy loam to clay loam); - strongly mottled silty clay galciomarine parent material at 1.60 m depth; - seepage at 1.6 m depth - test conducted at 1.4 m mark to avoid saturated seepage layer below
Site 2	None	- upper soil well developed, and medium textured; strongly mottled glaciomarine deposit at 0.8 m depth; - no seepage noted to 1.0 m depth
Site 3	- 0.6 m deep, very gravely fill material; - surface layer very compacted, not suitable for surface testing	- upper soil horizon, well developed, well drained, medium textured (sandy loam to silt loam); - thick (~15 -20 cm) organic enriched native Ah horizon (surface soil); - middle soil layers, well developed, well drained, slightly coarser texture; - strongly mottled silty clay glaciomarine parent material at 1.2 m depth. - no seepage noted to 1.8 m depth
Site 4	None	- upper soil horizon, well developed, well drained, medium textured (sandy loam to silt loam); - 10 cm organic enriched native Ah horizon (surface soil); - middle soil layers, well developed, well drained, slightly coarser texture; - strongly mottled silty clay glaciomarine parent material at 0.7 m depth. - no seepage noted to 1.0 m depth

Infiltration Test Methodology

The soil infiltration rate is defined as the amount of water per surface area and time unit which penetrate the soils. A variety of test methods can be used to determine soil infiltration rates. One of the most commonly used and inexpensive way to determine infiltration rates is the use of a double-ring infiltrometer. This method is recognized in BC and is used in providing reliable data for subdivisions (VCH, 2011) and in stormwater management planning (GVSDD, 2005).

A double-ring infiltrometer consists of two concentric rings that are driven into the ground and filled with water (Fig 2). The water level in the inner ring is maintained at a constant head over a period of time. The volume of water used to maintain a steady constant head is used to calculate the infiltration rate. The purpose of the outer ring in this method is solely to restrict lateral flow of water from the inner ring.

Materials**:**

- spade and auger for soil surface preparation / test site checking
- a 15 and 30 cm diameter inner and outer PVC rings
- a flat wooden block for driving cylinders uniformly into the soil surface
- rubber mallet
- water supply
- ruler
- stopwatch

Procedure:

- level test surface was prepared at the desired depth using spade to remove vegetation cover or smeared soil surface from backhoe excavation
- outer and inner rings were driven to the prepared soil surface up to 4 and 2 inches deep, respectively
- both outer and inner ring were filled immediately one after the other using a ruler as a splash guard not to disturb the soil surface in the inner ring
- a constant head of 8-10 inches was maintained in the inner ring by filling up to the marked fixed reference point immediately after the ruler measurement is taken
- water level in the outer ring was maintained as close to the inner ring during the test. No measurement was taken from the outer ring
- volume of water used to maintain a constant head was calculated from the total inner ring readings at fixed time intervals of initially at 15 min and afterwards at 30 min
- measurement continued for a minimum of 2 hrs and thereafter until a steady state was obtained. A steady state in this case is defined as less than a 5 mm

difference in the inner ring reading between three consecutive readings over the same time interval

- for practical reasons, the accuracy of inner ring ruler readings for this test is assumed to be $\pm$ 1 mm. A default value of 0.99 mm is assumed for calculations of infiltration rate whenever an inner ring reading of less than 1mm is recorded at any time during the test.

Fig 2. Double-ring infiltrometer setup.

Results and Concluding Remarks

The results of the double-ring infiltration test conducted at the four locations is summarized in Table 2. The results clearly demonstrates that water infiltration rates within the study area are highly variable. Contributing factors for the variability include but are not limited to:

- test depth from surface
- degree of soil disturbance/ compaction
- soil texture, organic matter and coarse fragment content of the soil layer at which the test was conducted

The highest infiltration rate recorded was 338 mm/hr at Site 3. The lowest infiltration rate recorded was 2 mm/hr at two different locations (Site 2 and 3). A variable range of 10 -128 mm/hr rate was recorded from the remainder of the test sites (Table 2).

Table 2. Clayton Stud Area soil infiltration test results

Location	Infiltration Rate (mm/hr)	Remarks
Site 1		
surface	n/a	very gravely and compacted fill layer, not suitable for test
0.8 m	10	soil at this depth is fine clay and clay loam material, however there is abundant evidence this material is not native and has been brought from other sources during nearby construction activities
1.4 m	10	seepage at 1.6 m mark, test could not be conducted at the desired 1.8 m mark
Site 2		
surface	n/a	
0.8 m	2*	test on strongly mottled native parent material; highly compacted silty clay, very impervious
1.8 m	n/a	only shallow hand digging at this site
Site 3		
surface	n/a	very gravely and compacted fill layer, not suitable for test
0.8 m	338	test conducted on organic enriched native sub soil; medium textured (silt loam), less than 10% gravel content; abundant fibrous roots present
1.8 m	2*	test on strongly mottled native parent material; highly compacted silty clay, very impervious
Site 4		
surface	128	test conducted on organic enriched native surface soil; medium textured (silt loam) , less than 10% gravel content
0.8 m	88	test on strongly mottled native parent material; this layer is not as compacted as other sites, because of the presence of gravely coarse glacial outwash deposit on top of it
1.8 m	n/a	only shallow hand digging at this site

*constant less than 1 mm head fall was observed over more than 2 hr period at these sites. A default value of 0.99 mm reading was assumed for rate calculation.

The lowest rate of 2 mm/hr obtained at 0.8 m (Site 2), and 1.8 m (Site 3) depths are not unexpected as the native soil layer at these locations was strongly mottled suggesting periodic saturation. In fact, the rates at this site could be well below the reported 2 mm/hr rate as a mathematical assumption was considered to the rate calculation as described above. A longer period (usually a 24 hr) observation data would be required to exactly calculate infiltration rates on highly impervious soils like this.

Infiltration rates > 300 mm/hr is not uncommon for undisturbed native forest soils (e.g., Gregory *et al.*., 2006). The highest infiltration rate at Site 3 signifies that disturbance to the native soil particularly in terms of compaction was minimal. In addition, the observed presence of high organic matter accumulation and abundance of roots are considered to be the major contributing factors for the observed high infiltration rate at this location

In conclusion, the test results signifies that soils are inherently highly variable and other external factors such as disturbances from human activities can greatly influence their properties. The test results as reported here, therefore, could only be used as guidelines to estimate the infiltration rates of similar soils as described at each test condition within the study area.

Reference:

AECOM. 2010. Clayton ISMP – Stage 1 Report.

Howes, D.E., and E. Kenk. 1997. Terrain classification system for British Columbia. Ministry of Environment, Lands and Parks, Vitoria BC.

Gregory, J. M.D. Dukes, P.H. Jones, and G.L. Miller. 2006. Effect of urban soil compaction on infiltration rate. Journal of Soil and Water Conservation 61:117-124.

GVSDD (Greater Vancouver Sewerage and Drainage Disttrict). 2005. Stormwater Source Control Design Guidelines.

VCH (Vancouver Coastal Health). 2011. Subdivision Guidelines (http://www.vch.ca/your_environment/safe_&_healthy_environments/)

Appendix B Stakeholder Consultation Meeting Attendees

Organization	Representative	Dec 17	Jan 28
A.A.C Surrey	Mike Bose		X
AECOM	Nancy Hill	X	X
	Tina Atva	X	
	Jim Dumont	X	
	Dear Manityakul		X
	Rebecca Lee	X	X
BC Hydro	Gerry Gerwin		X
	Michael Zhang		X
BC Ministry of Agriculture	Kathleen Zimmerman		X
BFW Development:	John Turner		X
City of Surrey	Bhargav Parghi	X	X
	Stephen Godwin	X	
	Doug McLeod	X	
	Doug Merry	X	
	Don Luymes	X	
	Carrie Baron	X	
	David Hislop	X	X
Clayton Community Association	Donna Boerken		X
	Greg MacRae		X
EAC	Martin Harcourt		X
P,R&C Committee	Rick Benson		X
Phoenix Environmental	Ken Lambertsen		X
Surrey Environmental Partners	Deb Jack		X
Terasen Gas	Lorne Sandstrom		X
Township of Langley	Kevin Larsen		X
	Kristi McKay		X

Appendix C Stakeholder Consultation Meeting Minutes

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604 294 8597 fax

Minutes of Meeting

Date of Meeting	January 28, 2011
Start Time	10:30am
Project Number	60158414
Project Name	Clayton ISMP
Location	Surrey City Hall – Pondside Room
Regarding	Clayton ISMP Stage 2 – Stakeholder Consultation

Attendees		
	A.A.C Surrey:	Mike Bose
	AECOM:	Nancy Hill (NH)
		Dear Manityakul (DM)
		Rebecca Lee
	BC Hydro:	Gerry Gerwin
		Michael Zhang
	BC Ministry of Agriculture:	Kathleen Zimmerman
	BFW Development:	John Turner
	City of Surrey (COS):	Bhargav Parghi
		David Hislop (DH)
	Clayton Community Association:	Donna Boerken
		Greg MacRae
	EAC	Martin Harcourt
	P,R&C Committee:	Rick Benson
	Phoenix Environmental:	Ken Lambertsen (KL)
	Surrey Environmental Partners:	Deb Jack
	Terasen Gas:	Lorne Sandstrom
	Township of Langley (ToL):	Kevin Larsen
		Kristi McKay

Distribution	All Attendees
Minutes Prepared By	Rebecca Lee (AECOM)

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

	Action
Introduction	
• David Hislop (COS) and Nancy Hill (AECOM) introduced the project, provided an outline of the ISMP process, and shared highlights from Stage 1 (What do we have). Stage 1 report summary and figure to be posted to CoS website.	DH
Goal 1 – Protect Agriculture and Agricultural Activities	
• When asked if anyone was not in support of this goal, none of the attendees responded.	
• Agricultural activities to be considered should include those that may be conducted in the future as well those being conducted now.	
• It was noted that agricultural noise and smells can become magnified in upland areas that overlook farmland.	
• It was noted that topography can be a guide for ALR-Residential buffers. Existing developments adjacent to the ALR stop at the escarpment. Residents have chosen to live above the ALR despite the activities occurring here. The escarpment offers a natural boundary for geotechnical reasons.	
• A site-specific ALR buffer (rather than a set, standard distance) would better reflect the variable topography, development needs, agricultural needs, riparian areas, etc.	
• Increased density in pockets may better protect the buffers.	
• The ALR buffer is not greenspace. The existing policies allow it to be developed, but at low densities, and with a 15m vegetation buffer, and 37.5m to the nearest house.	
• If increasing the density and clustering next to the ALR, then perhaps the 37.5m setback should be increased. Other options include specifying double or triple glazed windows, and orienting the bedrooms away from the ALR. Potential agricultural – residential conflicts need to be minimized.	
• An example of good development adjacent to the ALR was highlighted at Turnberry by Polygon in Cloverdale. Restrictive covenants on buffering were used.	
Goals 2/3 – Preserve, Maintain, and Enhance Streams and Riparian Areas	
• Mechanisms for compensating property owners should be in place if watercourse riparian setbacks are increased over the standard distances (for example, if the setback is 30m from top of bank, and this distance is increased to 50m in one area as environmental compensation for reduced setback in another area)	
• A(O) setbacks in the ALR (shown on the discussion figure) are not enforceable under the ISMP.	
• Consider public access when planning riparian buffers	
• KL noted that in his experience, 30m setbacks for Class A streams and 15m setbacks for Class B streams, generally work. However setback requirements should consider the specifics of the stream and adjacent development.	
Goal 4 – Preserve, Maintain, and Enhance Latimer Wetlands	
• It should be noted that jurisdiction and enforcement mechanisms are different for those areas within the ALR and those outside of the ALR. Existing ALR policies allow farmers to drain wetlands within their properties.	NH

• One suggestion was to provide farmers with compensation in exchange for wetland preservation.	
Goal 5 – Preserve, Maintain, and Enhance Key Forest Habitats	
• Existing road rights-of-way cross through the identified forest habitat.	
• A large portion of Surrey's greenspace in located in the ALR (where the City has limited jurisdiction). The ALR is not truly greenspace as it is productive land. Retaining greenspace outside of the ALR which is within the City's jurisdiction and control is important.	
• BC Hydro noted that there is an incompatibility between trees and overhead power lines.	
• Wildlife/Urban interface with regards to safety requires education and awareness. Not a large resident population of large animals in these forest habitats (KL). Large animals here are typically solitary (KL).	
Goal 6 – Maintain Base Flow to Streams **Goal 7 – Maintain Stream Water Quality** **Goal 8 – Reduce the Likelihood that Increased Development Will Increase Lowland Flooding** **Goal 9 – Reduce the Likelihood that Increased Development Will Increase Stream Erosion**	
• Questions about the efficacy of the low-impact development techniques used at East Clayton. Ten years of monitoring data on North Creek has shown that they appear to be working	
• Any stormwater ponds in the Clayton area would likely be designed for water quality not for peak flow control. Wet ponds or bioswales may be an option for DFO habitat compensation as they have been shown to have greater productivity and diversity than the Class B Streams (ie Roadside ditches) that they replace (KL). However, they come at a cost.	
• A high flow bypass that discharges directly into the Serpentine River was suggested.	
• There is existing water quality monitoring on the Serpentine River and Latimer Creek.	
• The upper reaches of the Serpentine are known to get very dry and oxygen deficient in summer. Protecting baseflows is important.	
• If maintenance costs for low impact stormwater management infrastructure are higher and required more frequently than traditional infrastructure then the City needs to be on board to make this work.	NH/DH
Goal 10 – Increase Density in Areas of Lower Environmental Value	
• The Clayton General Land Use Plan (GLUP) shows a village hub at 188th Street at 72nd Avenue.	
• "Zero lot line" building footprint has no setback on one property line (ie duplex development). This could consolidate the greenspace area.	
• Land use planning should be consistent with the Surrey Environmental Management Study (EMS) to ensure that key corridors are preserved and that connectivity is maintained. It was noted that the ALR divides the City. East-west corridors are not established.	

Goal 11 – Improve and Maintain Wildlife Connectivity	
• Future ISMP documents should include available small scale mapping of environmental features under discussion so that connectivity across the City can be clearly seen.	NH
Goal 12 – Connecting Communities	
• 72nd Avenue should connect with Fraser Highway.	
• Consider future Hwy 1 planning (new interchanges etc.) when looking at future transportation networks in the ISMP area.	DM
• Harvie Road should not be an arterial. It is key to agricultural connectivity and access to it should be discouraged for non-agricultural traffic.	
• Intersection of 76th Avenue and 192nd Street disconnect the key interior forest habitats.	
• 80th Avenue and 72nd Avenue will remain key corridors in Langley.	
• BC Hydro has an existing agreement with the City that every 4 city blocks there is a right-of-way corridor for overhead lines.	
• ToL is considering limiting pedestrian crossings of 200th Street with lights at 72nd and 80th Avenues and possible overhead crossings at select locations.	
• Locating arterial roadways is a matter of choice. Should plan/locate them around protected areas.	
Other Items	
• BC Hydro does not upgrade facilities unless necessary. Generally spot loads can be incorporated but large-scale developments may require an area capacity assessment. The densities proposed in the Clayton area are higher than those of other Neighbourhood Community Plans (NCP). BC Hydro would like to work with the City to decide on future corridors and facilities required to serve the new developments.	
• The Surrey School Board should be included as a stakeholder.	NH
• The Latimer Creek Master Drainage Plan includes stormwater ponds being constructed in Surrey to control drainage largely sourced from Langley. Co-ordination on this should be considered with future neighbourhood planning.	
• ToL is currently conducting a district energy study.	
• Additional comments were welcomed through email and the stakeholder feedback forms.	

Appendix D City of Surrey Sustainability Charter and the Clayton ISMP

CITY OF SURREY SUSTAINABILITY CHARTER & THE CLAYTON ISMP

The City's ability to achieve its vision of sustainability requires the setting of targets, and the establishment of indicators with current baseline values to monitor progress toward meeting these goals. Several of the key actions outlined in the Sustainability Charter relevant to the Clayton ISMP are listed below.

1. Sustainable Infrastructure Maintenance and Replacement – The City will ensure long-term corporate sustainability related to infrastructure by:

    - Developing policies and programs to undertake full life-cycle cost analysis evaluation of new and retrofitted buildings and infrastructure;

    - Designing new infrastructure as green infrastructure and to have as long a service life and as low a long-term maintenance cost as practicable;

2. "Green" Infrastructure and Sustainability Grants – The City will maximize the utilization of available funding to support the development of green infrastructure in the city.

3. Support initiatives and projects that introduce agriculture into the urban and the industrial areas of the city through means such as community garden plots, green roofs with agricultural capacity, "vertical farming" and other initiatives.

4. Sustainable Engineering Standards and Practices – The City will take steps to minimize environmental impacts of development by re-creating the natural environment in drainage, landscaping, sewer and water projects. Demonstration projects can be implemented and monitored to refine best practices and the City can distribute lessons learned to the development industry and to other jurisdictions. The City will demonstrate best practices in sustainable civil engineering by:

    - Reviewing current practices and regulations and removing any unnecessary barriers to the provision of green infrastructure;

    - Implementing sustainable green infrastructure on public land, in public rights-of-way and in private developments;

5. Sustainable Land Use Planning and Development Practices - A fundamental responsibility of municipalities, and one of the most effective tools for achieving sustainability, is land use regulation and the control of land development practices. The location of the various types of land uses, transportation choices, density, and the mix of land uses, along with development practices, are key determinants in the ecological footprint of the City. The City will promote sustainable land use and development by:

    - Establishing sustainability guidelines and policies in the Official Community Plan and in the development of all new and updated Neighbourhood Concept Plans;

- Requiring land use densities and mixes of land use and activities that allow local access to goods and services and support high levels of walking, cycling and transit use for residents and employees;

- Formalizing site planning processes that avoid critical habitat and preserve, protect and enhance natural habitat and landscape features; and

6. Enhancement and Protection of Natural Areas, Fish Habitat and Wildlife Habitat – The City will support its natural areas by:

   - Showing environmental leadership in the management, conservation and/or development of City-owned lands;

   - Maintaining and increasing the area of fish habitat and wildlife habitat in the City, in both established and newly developed areas; and

   - Continuing to protect and remediate existing natural areas and to acquire additional new natural areas.

7. Enhancing the Public Realm – The City will support sustainability through the public realm by:

   - Implementing street widths and roadway design standards that minimize the negative impacts of transportation facilities on communities while providing appropriate infrastructure in support of the transportation needs of the City;

   - Establishing an attractive pedestrian environment with appropriate sidewalks or paths wherever walking is a viable option;

   - Expediting the completion of a continuous Greenway, bicycle and trail systems throughout the City;

   - Designing and programming active public spaces and streetscapes to increase public safety and a sense of ownership and community;

   - Implementing demonstration projects in the public realm that promote best practices in sustainability, such as natural drainage systems (e.g., permeable pavers) and improved lighting (e.g., energy efficient heads, white light and minimum spillover into adjacent buildings or the night sky).

8. Enhance Biodiversity

   - Technical and financial assistance for habitat protection, potentially in partnership with private organizations and the community;

   - Practical, effective and equitable approaches to protect fish habitat and wildlife habitat; and,

   - Environmental monitoring resources to identify and manage areas of environmental concern as they emerge.

Appendix E Environmental Assessment Report (Phoenix Environmental Services Ltd.)

ENVIRONMENTAL ASSESSMENT REPORT

Stage 1: Clayton Integrated Stormwater Management Plan

Surrey, B.C.

Prepared for:

AECOM and City of Surrey

Prepared by:

PHOENIX ENVIRONMENTAL SERVICES LTD.

September, 2010

TABLE OF CONTENTS

List of Appendices

EXECUTIVE SUMMARY

Phoenix Environmental Services Ltd. (Phoenix) has been retained by AECOM to provide the environmental components for the Clayton Integrated Stormwater Management Plan (ISMP) that AECOM has been retained to prepare for the City of Surrey Engineering Department. This report has been completed in support of Stage 1 of the formulation of the Clayton ISMP (the ISMP). The objective of Stage 1 is to provide an inventory and assessment of existing terrestrial (wildlife habitats and corridors) and aquatic habitats (watercourses, wetlands) within the Study Area using available information and limited "ground-truthing" site reconnaissance. The scope of work by Phoenix has included use of existing research and reports, as well as field verification where necessary. The priority areas for protection include the Class A and B streams and their riparian areas, the wetlands along Latimer Creek, and the interior forest areas, and the remaining forest stands of $\geq$ 1 hectare.

Latimer Creek and Latimer Creek South Arm are the primary fish habitat within the watershed, although there are several Class B tributaries that are contributing significantly to the downstream fish habitats (76th Av B Creek, Latimer Creek South - East Trib, 196th Street Creek, and 192nd Street Creek). There are existing records of Coho Salmon and Cutthroat Trout within the Latimer Creek network, as well as field observations of Coho at the 196th Street culvert during July 2010. Benthic macroinvertebrate sampling over the past 10 years does not show a trend of improvement or degradation. Sampling at Station L1 (193rd Street Creek) had the lowest percentage of pollution sensitive individuals, as represented by the Percent EPT metric (percentage of individuals collected belonging to the orders Ephemeroptera, Plecoptera, and Trichoptera). This may indicate a water quality issue, but requires additional investigation. All sampling results were better than those for McLellan Creek, which is within the highly urbanized watershed to the south of the Study Area.

The primary concerns for the aquatic habitats are 1) erosion that could result from future increases in peak flow volume and velocity, 2) flooding in the lowland channels, and 3) preservation of base flows for aquatic organisms. Erosion is most likely to occur in the steeper ravine stream reaches and could result in damage to existing high quality habitats as well as increases suspended sediments in the lowland channels. As the watershed develops, it is likely that stormwater runoff will be collected and diverted at some locations. It is essential that base flows continue to be delivered to the small headwaters streams so that aquatic habitat is not lost.

The Study Area land use is primarily low density residential and agricultural. There are unopened road right-of-ways, which have contributed to the conservation of significant interior forest habitats within the Study Area. Based on previous studies, existing data, and field verification, the key wildlife habitats in the Study Area include 1) the interior forest habitat in the area between 76th and 80th Avenues and 184th and 192nd Streets and 2) the interior forest habitat east of 194th Street and south of 76th Avenue.

A total of 21 potential wildlife crossings along various roads within the study area were identified during the field program. These crossings were part of potential wildlife corridors that may be used by at least 13 Federally or Provincially listed terrestrial wildlife and vegetation species. The crossings associated with the main stem of Latimer Creek were identified as having the highest wildlife values and provided high rated habitat for a number of listed wildlife species including Pacific water shrew (*Sorex benderii*), red-legged frog (*Rana aurora*) and beaverpond baskettail (*Epitheca canis*). This portion of Latimer Creek also provided important habitat for other wildlife including beaver (*Castor canadensis*), coyote (*Canis lantrans*), raccoon (*Procyon lotor*) as well as a number of bird, amphibian, reptile and invertebrate species. Some of the forested blocks within the study area also provided high rated habitat for the Federally listed Oregon forestsnail (*Allogona townsendiana*) and the Provincially listed Trowbridge's shrew (*Sorex trowbridgii*) and Pacific sideband snail (*Monadenia fidelis*).

No Provincially listed wildlife species were detected during the field program. The SARA listed Great Blue Heron was observed foraging near Harvie Road during the field investigations. Sign of coyote, raccoon, beaver, woodpecker and passerines were detected within the study area. One Red-tailed Hawk was foraging within the project area. Most of the treed portions within the study area provided potential breeding/roosting habitat for raptors, passerines, woodpeckers and a number of bat species.

The primary concern for terrestrial habitats is that encroachment and fragmentation will reduce or eliminate interior forest habitats and habitat corridors will be lost. There are many opportunities to increase the connectivity of the existing forest stands and wildlife corridors, which will contribute to the overall biodiversity potential of the Study Area and beyond.

1. INTRODUCTION

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

1.1 ISMP ENVIRONMENTAL OBJECTIVES

From our review of the Terms of Reference issued by the City for this Study, it is clear that the Study requires a balance of stormwater engineering and environmental assessment. The City is interested in a holistic approach whereby environmental friendly designs and protection and restoration of natural features would be an integral component. The objectives of Phoenix's contributions to the Study would be:

- to provide an inventory and assessment of existing terrestrial (wildlife habitats and corridors) and aquatic habitats (watercourses, wetlands) within the Study Area using available information and limited "ground-truthing" site reconnaissance,
- to work with AECON and with City of Surrey staff, DFO, and others (stakeholders) to identify environmental issues associated with existing and potential future stormwater infrastructure and development within the watershed,
- to work with AECON and stakeholders to identify mitigation, enhancement and restoration opportunities associated with options for new or retrofitted stormwater infrastructure,
- to contribute to development of design criteria that will help achieve the long-term watershed goals of protecting and enhancing watercourses and aquatic life as well as preventing pollution and maintaining water quality,
- to contribute to and participate in the public consultation process for the Study;
- to contribute to the establishment of a monitoring and assessment strategy for long-term assessment of watershed health,
- and to contribute to the Final Integrated Stormwater Management Plan report and maps.

This report addresses the first of the above objectives, with the other objectives to be addressed in the future stages of the ISMP preparation.

1.2 Methodology

The scope of work by Phoenix for Stage 1 of the ISMP has included use of existing research and reports, as well as field verification where necessary, to conduct an inventory and assessment of the wildlife and aquatic habitats within the ISMP Study Area.

The methodology for this Stage 1 ISMP Environmental Assessment (Stage 1 EA) has entailed:

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

2. WATERCOURSES

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

- Headwaters channels
- Latimer Creek and ravine streams
- and lowland channels

2.1 Headwaters

The headwaters of the watershed are primarily located on the upper plateau of Clayton Hill and consist of roadside ditches, yard swales, and small channels (see Appendix B, Site Photos). Many of these streams have been modified (straightened, culverted, etc.) and they often only convey seasonal flows. Site reconnaissance during July 2010 verified that a majority of the headwater ditches are dry for a portion of the year and they offer little direct habitat value. Roadside swales are generally mowed with limited riparian vegetation and the channels are homogenous. However, there were areas with existing pooled water or minor flows, and some wetland vegetation such as rushes and sedges were often present at these locations. The headwater channels with year-round water are important sources of groundwater and baseflows for the watershed during the summer.

The two key headwaters streams are:

- 192nd Street Creek - Class B watercourse east of 192nd Street between 82A and 84th Avenue
- 196th Street Creek - Class B watercourse west of 196th Street between 76th and 80th Avenue; this may be upgraded to a Class A watercourse if all existing and future culverts

remain passable. The Clayton Master Drainage Plan noted that this creek between 76th and 78th Avenues currently flows at full capacity during large storm events and could be negatively impacted by future development. Downstream of 78th Avenue, there is also the possibility of increasing erosion within the areas of steeper grades and within the ravine.

2.2 Ravine Streams and Latimer Creek

The ravine streams and Latimer Creek are characterized by cobble/gravel substrates, moderate gradients, forested riparian vegetation, and diverse in-stream habitat compared to the headwaters and lowland streams (see Appendix B, Site Photos). Due to the steeper gradient, the ravine stream channels are wider and deeper, often with riparian vegetation present to the top of ravine bank. Some of the key ravine streams include:

- Creek 274 – Class B watercourse west of 184th Street and south of 76th Avenue (north of Clayton Elementary School)
- Creek 283 – Class B watercourse west of 184th Street and north of 74th Avenue (south of Clayton Elementary School)
- The 76th Avenue B Creek – Class B watercourse that flows north from 76th Avenue to join the roadside ditches along 80th Avenue
- Latimer Creek South Arm – Class B watercourse that joins the 76th Avenue and 193rd Street Creeks southeast of the intersection of 188th Street and 84th Avenue (not inspected).
- 196th Street Creek – North of 80th Avenue, Class A continuing into Langley before joining Latimer Creek

Latimer Creek is similar to the ravine streams in that it still has much of its riparian vegetation remaining and has greater habitat complexity than either the upper headwaters or the lowland channels. Latimer Creek has a lower gradient than most of the ravine streams as it follows a longer path from Clayton Hill down to the Serpentine River agricultural areas. Latimer Creek has areas with high quality fish habitat, particularly where the riparian area is still intact.

2.3 Lowland Channels

The lower stream reaches of the watershed are within the wide, broad agricultural lands on the east side of the Serpentine River (see Appendix B, Site Photos). To maximize agricultural land uses, these channels have been straightened along roads, property lines, farm fields, and right-of-way corridors. The channels are very typical of the agricultural ditches throughout Surrey. There is very little natural vegetation except small patches of trees within some of the fields and in exceptionally wet areas and areas that are not under cultivation. Typical roadside channels are 0.5 - 1 meter deep and 1-2 meters wide with very homogenous channel dimensions and little habitat diversity.

2.4 Benthic Index of Biotic Integrity (B-IBI)

Three monitoring stations have been established within the study area by the City of Surrey to monitor the composition of the benthic macroinvertebrates. Station L1 is located on the headwaters of the south arm of Latimer Creek near the intersection of 192nd Street and 78th Avenue. This branch of the creek is also known as the 193rd Street Creek. Station L2 is located on the north arm of Latimer Creek, just downstream of 196th Street, which is the boundary between the Township of Langley and the City of Surrey. The third station, T1, is located on an unnamed tributary near the intersection of 184th Street and 76th Avenue. The creek at this location is near the transition point from headwaters channel to a ravine stream, as described above.

Data from each of the stations were provided from 1999 through 2008. At each sampling station, three benthic macroinvertebrate samples were collected at each station roughly twice per year (spring and fall). The graphs below show the average results of the three samples for each sampling event for the following metrics:

- The Benthic – Index of Biotic Integrity (B-IBI): B-IBI is a recognized standard method for determining the health of the aquatic ecosystem of a stream using analysis of the benthic macroinvertebrate population composition. The B-IBI is most useful in comparing streams with different watershed conditions or to track changes over time. Ten metrics are used, each with a possible score of 1, 3 , or 5 for a combined possible total of 50 points.

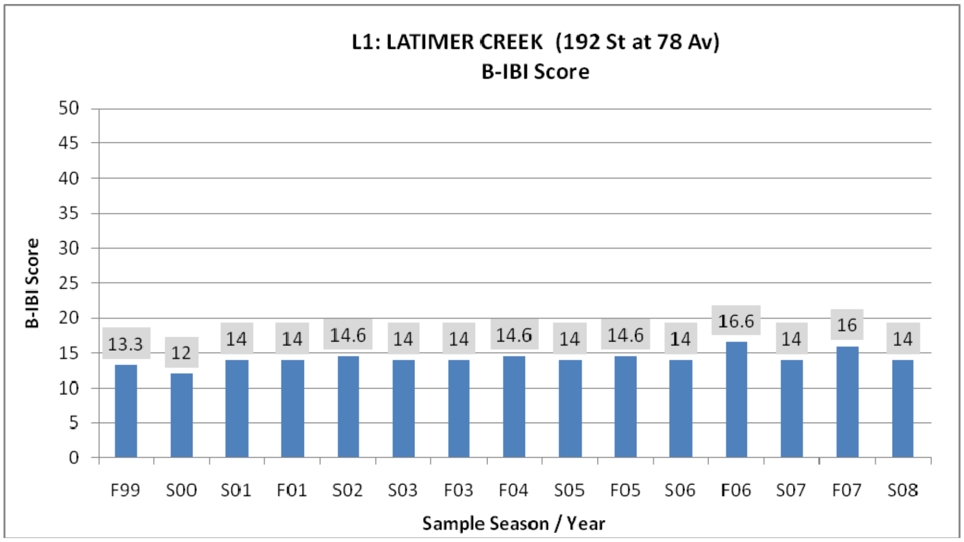
- Productivity – The total number of individuals collected for each sample generally indicates the ability of the aquatic environment to support benthic macroinvertebrate populations. As with B-IBI, this metric is best used to track changes over time from a baseline or as compared to a high quality reference stream.

- Biodiversity – The total number of different taxonomic groups found in the samples can be used to infer the ability of the aquatic ecosystem to support a wide variety of different types of macroinvertebrates. Different taxonomic groups often play different roles within the ecosystem such as predator, scrapers (eat plant material off of surfaces), shredders (break down organic materials such as leaves), filterers (filter food out of the water column), etc.

- Percent EPT – The taxonomic orders of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) are recognized as pollution sensitive, and therefore their presence and relative abundance may indicate whether there are water quality concerns. Greater scrutiny down to the species level and the pollution sensitivity and ecosystem roll of each species is sometimes used to determine what type of water quality impairment may exist. In general, Ephemeroptera are scrapers and collectors, Plecoptera are predators, and Trichoptera are scrapers, collectors, or shredders (Watershed Science Institute, Tech. Note #3). The EPT taxa richness, or the number of distinct taxa found, can also be compared. Greater EPT richness correlates with better water quality conditions.

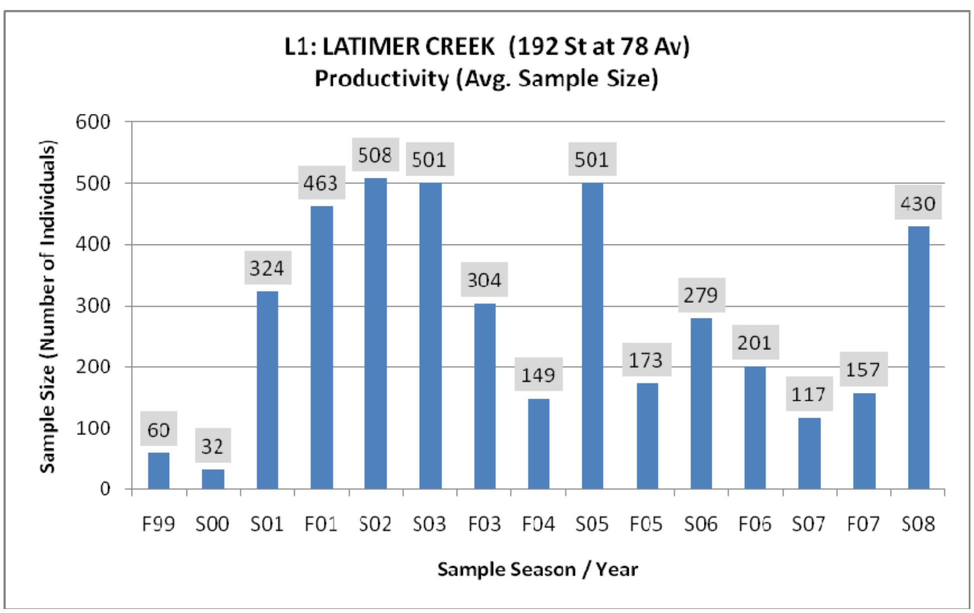
L1: Latimer Creek (193rd Street Branch)

Station L1 is located on the South Arm of Latimer Creek, within the segment that originates near 193rd Street (Class A). The samples for L1 were very consistent across the 10 years of data with B-IBI scores ranging from 12 to 16.6. These scores are within the bottom 33% of the B-IBI scale and are lower than the other two sampling station (scores from 14 to 20); however, there is no discernable trend of improvement or degradation.

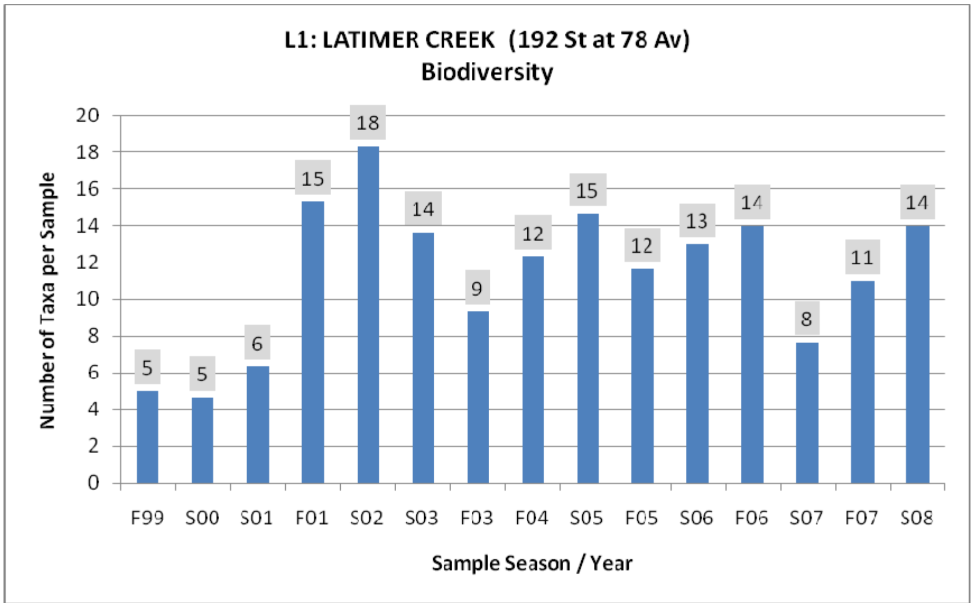


Note: S = Spring; F=Fall; Number refers to the year of sampling (ie. S01 = Spring 2001)

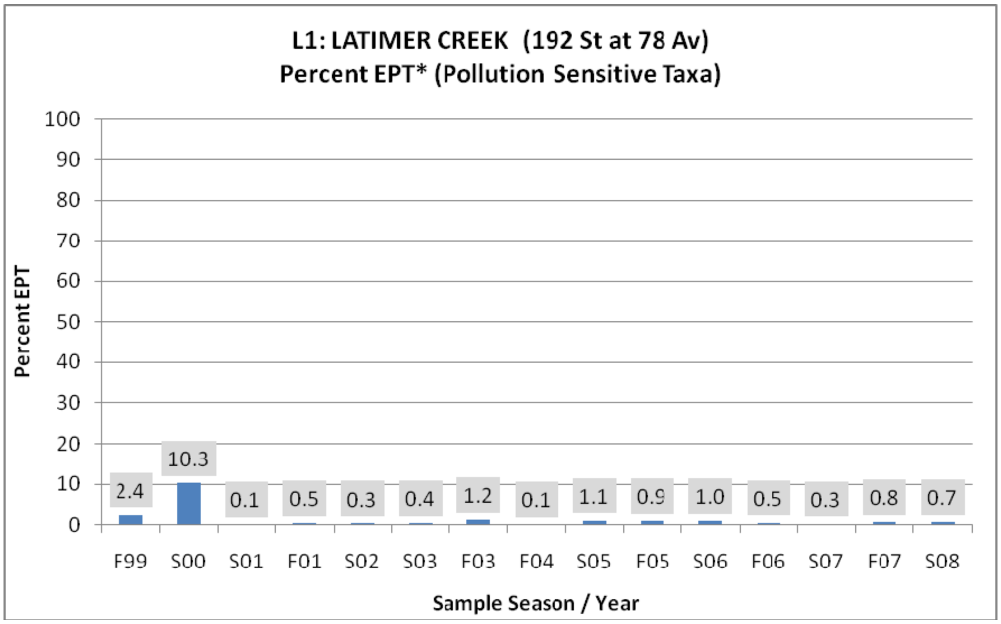
The productivity of the L1 sampling station varied greatly from 32 to 508 individuals, but there is no discernable trend of increasing or decreasing productivity. Productivity was generally lower in 2005-2007 than in the period from 2001 to 2003, and this pattern is repeated at all three sampling stations.



The biodiversity of the L1 samples varied from 5 to 18 taxonomic groups, but there was no discernable trend of improvement or degradation.

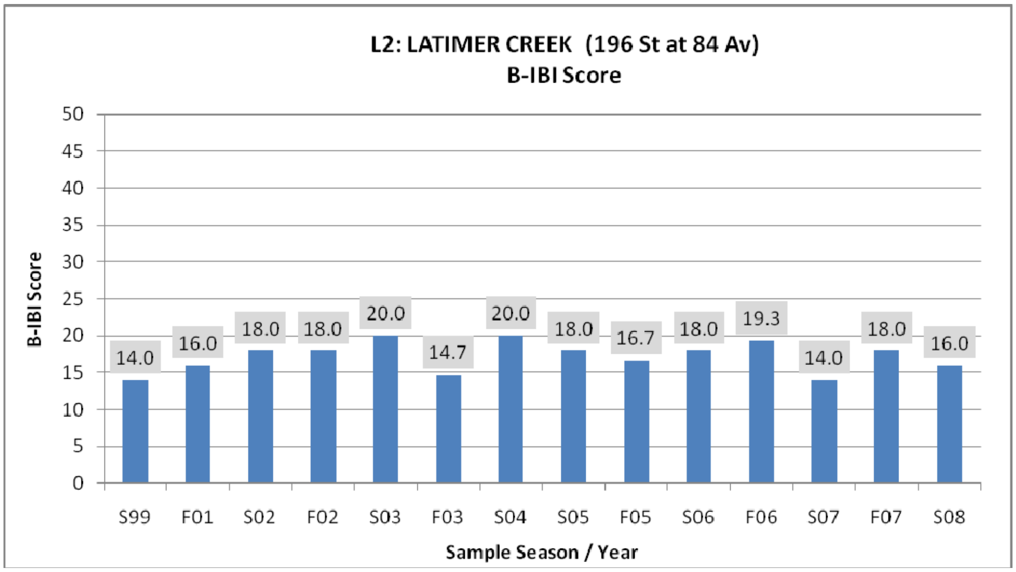


The percentage of EPT individuals found at the L1 sampling station was consistently low. Most samples included less than 1% EPT individuals, with the exception of the Fall 1999 and Spring 2000 samples. Compared with the other two sampling stations, the results are far lower than the other locations. This could be due to the difference in the aquatic habitat conditions, water quality, or another unknown factor. Further analysis of the sampling data shows that the EPT richness (the number of different taxa found within the EPT orders) was also very low (0-3 taxa per sample).

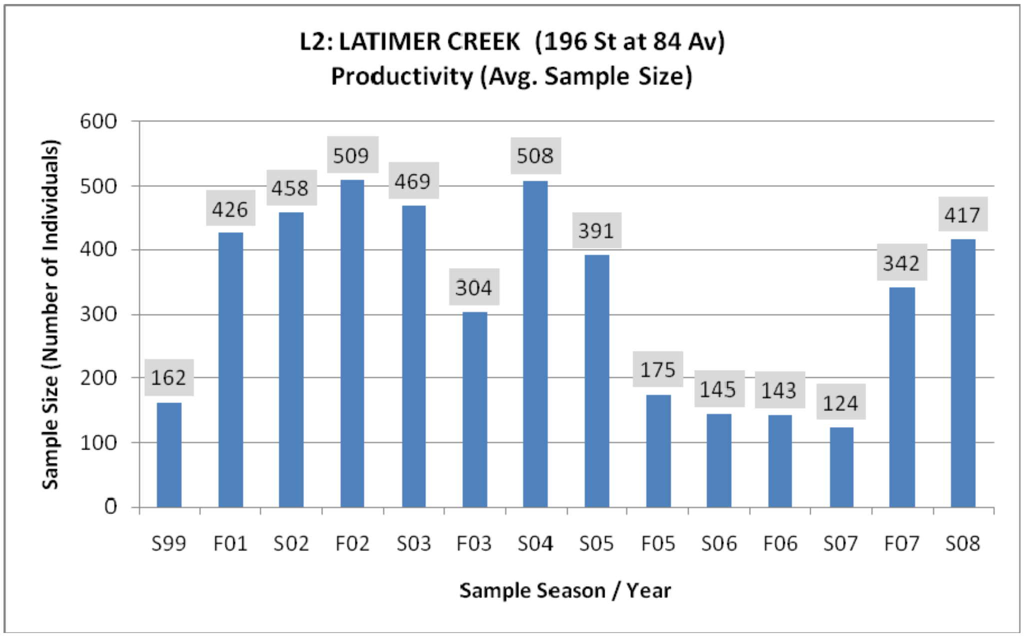


L2: Latimer Creek (South Arm)

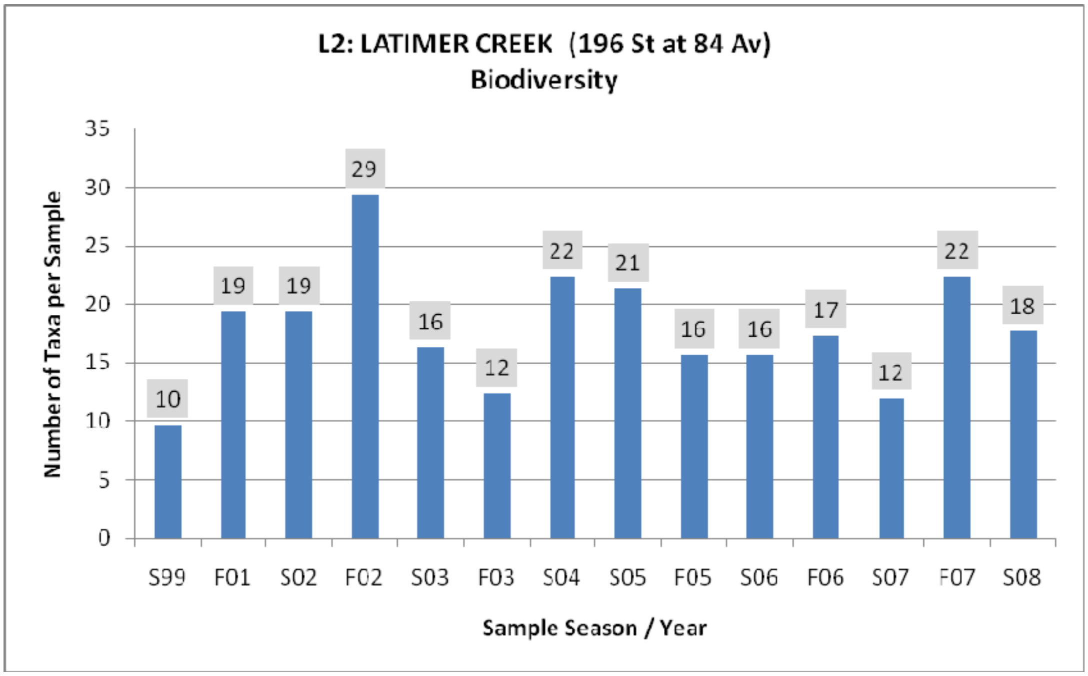
Station L2 is located downstream of 196th Street near 84th Avenue, within Latimer Creek (Class A). The B-IBI scores at the L2 station (14-20 out of 50) were generally higher than those for the L1 station. Part of this increase could be attributed to the greater diversity generally found in larger streams due to the variety of habitats and the larger watershed collection area. Water quality may also play a part.



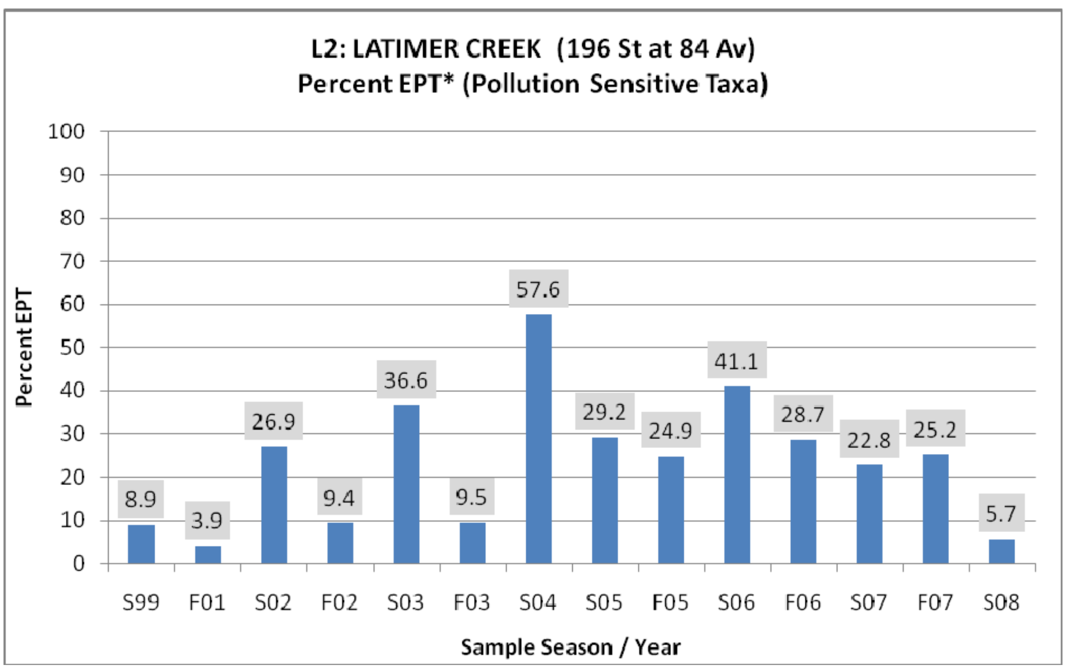
The productivity of the L2 sampling station ranged from 124 to 509 individuals, but there is no discernable trend of increasing or decreasing productivity. Similar to the L1 results, productivity was substantially lower in 2005-2007 than in the period from 2001 to 2004.



The biodiversity of the L2 samples varied from 10 to 29 taxonomic groups, but there was no discernable trend.

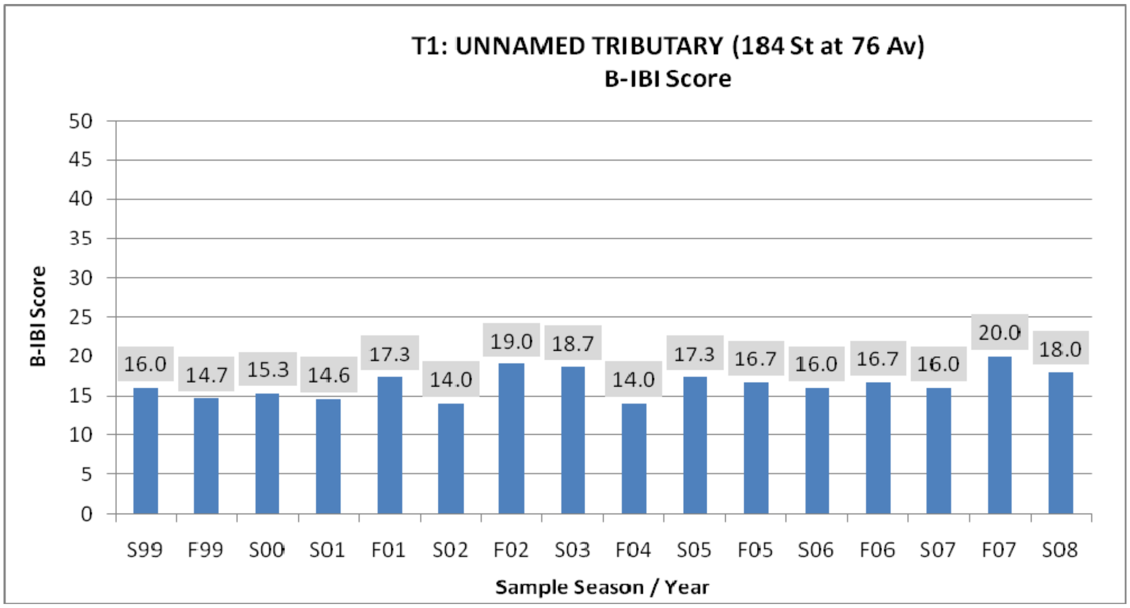


The percentage of EPT individuals found at the L2 sampling station varied widely from only 4% to 58%. Five of the samples were under 10%, while the remaining 9 were all greater than 23%. Compared with the other two sampling stations, the results are higher than L1 and approximately equivalent to those at station T1.

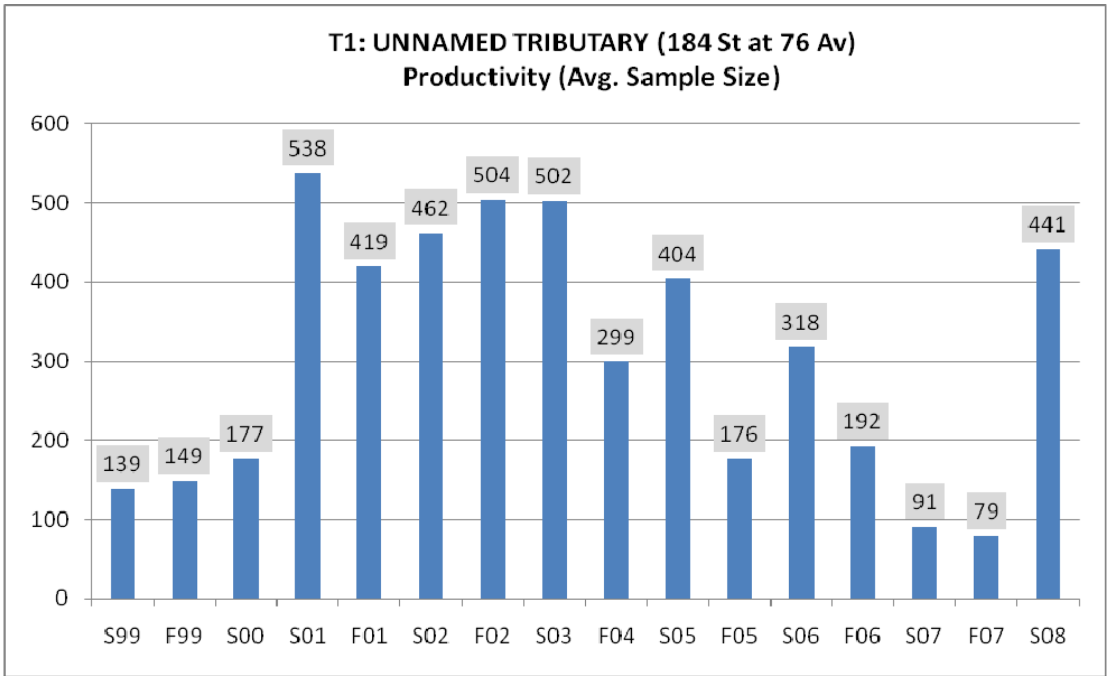


T1: Unnamed Tributary (184th Street at 76th Avenue)

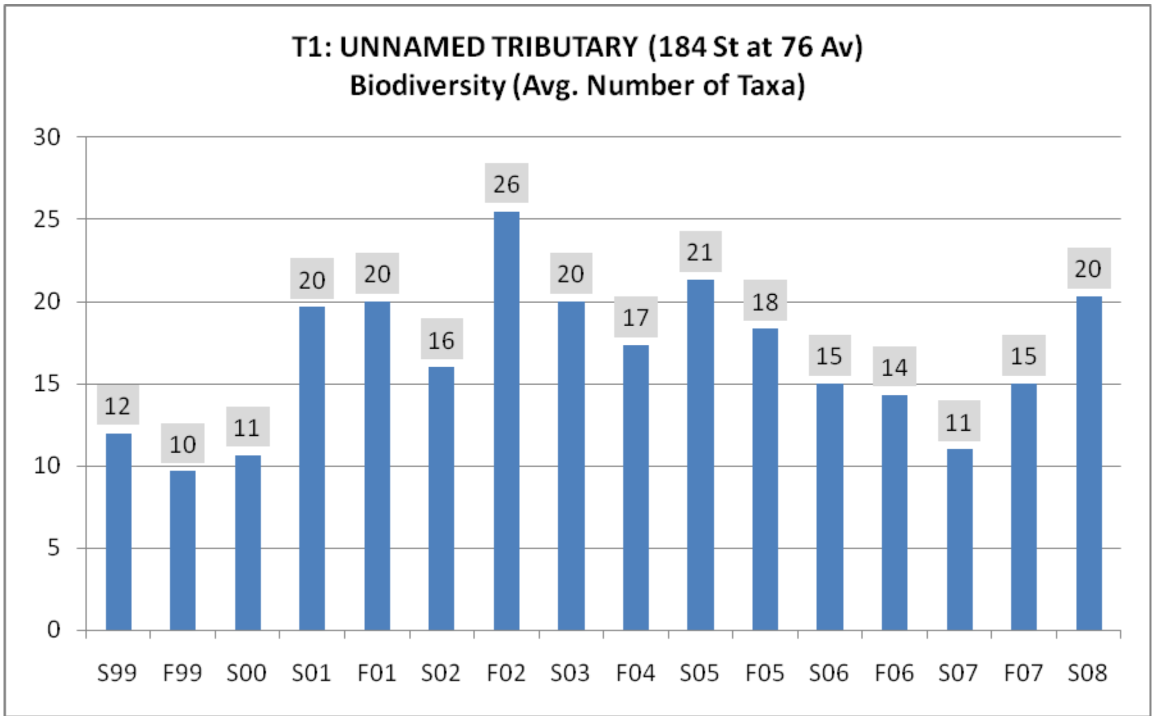
Station T1 is on a Class B watercourse that flows through a ravine from 184th Street down to the agricultural lands along the Serpentine River to the west. The B-IBI scores at the T1 station (14-20 out of 50) were generally higher than those for station L1, but were in the same range as station L2; both are second order streams primarily fed by roadside ditches and swales.



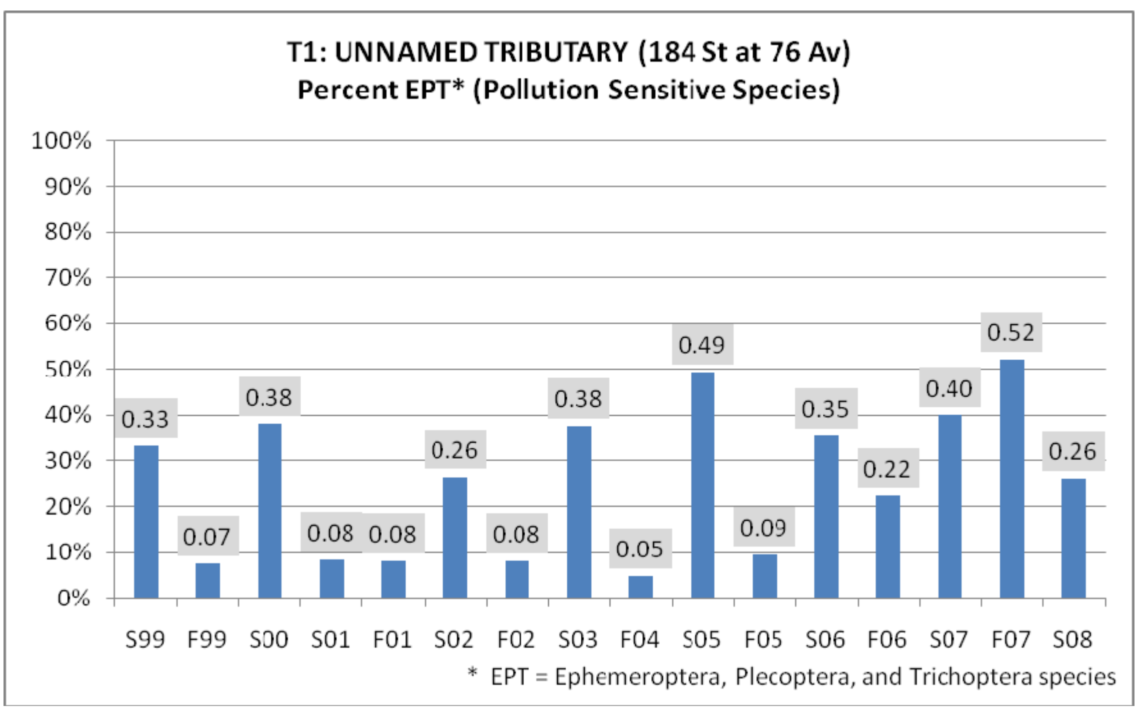
The productivity of the T1 sampling station ranged from 124 to 509 individuals. Productivity was generally lower in 2005-2007 than in the period from 2001 to 2003, but there is no discernable trend of increasing or decreasing productivity.



The biodiversity of the T1 samples varied from 10 to 26 taxonomic groups, but there was no discernable trend.



The percentage of EPT individuals found at the T1 sampling station varied widely from only 5% to 52%. Compared with the other two sampling stations, the results are higher than L1 and approximately equivalent to those at station L2.



2.5 Watercourse Classifications

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

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

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

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

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

Based on the background data, airphotos, and limited ground truthing, a majority of the streams in the watershed have been classified correctly, as shown on the City of Surrey GIS mapping. Verification in the field consisted primarily of locating the reach breaks between Class A and Class B designations to see if fish barriers or flow restrictions were consistent with the classifications. In a few cases, however, the break between Class A and Class B watercourses should be revised to reflect current and potential conditions. No fish sampling was done, but fish were observed at some locations during the field reconnaissance. The following revisions should be considered:

1. 192nd Street Creek: Extend Class A designation upstream (east) of 192nd Street at least to 82A Avenue. There appear to be ponds and possibly other modifications to the stream within the property at the corner of 192nd Street and 82A Avenue, but the culvert at 192nd Street is passable.

2. 196th Street Creek: Class A designation may extend upstream beyond 80th Avenue if culvert crossing is confirmed to be passable.

3. Latimer Creek Tributaries: Two Class B tributaries connect to Latimer Creek just north of the 196th Street culvert. No fish barriers were observed, and there was flow in both creeks during the site visit in July 2010.

3. TERRESTRIAL HABITATS

A majority of the Study Area is covered by large lot residential and agricultural lands. Several road right-of-ways have not been opened, resulting in the preservation of some large forest tracts on properties with no road access. Many of the rear yards of the large residential lots are also forested, creating habitat corridors relatively free of road crossings. A majority of the road network comprises two lane roads most with gravel shoulders, no sidewalks, and drainage swales.

The Ecosystem Management Study currently underway describes the Cloverdale area (Clayton is a subarea of Cloverdale) as 10% forest, 1.4% interior forest, 1.8% freshwater wetlands, and 8.6% old field habitat. The Clayton subarea contains a majority of the forests, wetlands, and old field habitats ascribed to Cloverdale in the Ecosystem Management Study (EMS).

The Study Area has been plotted on four of the most relevant maps from the EMS including the Sensitive Species Occurrences, Green Infrastructure Opportunities, Habitat Hubs, and Habitat Corridors (see Appendix A, Figures 3-6). These maps highlight opportunities to plan for preservation and enhancement of some of the high quality habitat hubs and corridors during the redevelopment and densification of the Study Area.

3.1 TREES AND WOODED AREAS

The Ecosystem Management Study identifies that most forests in Surrey are deciduous, followed by mixed deciduous-coniferous, and a small percentage of forested area is dominated by coniferous species. Based on a qualitative assessment, this was observed to be consistent with the forests within the Study Area. A majority of the forests have young to mature trees and include a mix of deciduous and coniferous species such as red alder, paper birch (*Betula papifera*), big leaf maple (*Acer macrophyllum*), black cottonwood (*Populus balsamifera ssp. trichocarpa*), western redcedar (*Thuja plicata*), western hemlock (*Tsuga heterophylla*), Douglas fir (*Pseudotsuga menziesii*), and Sitka spruce (*Picea sitchensis*).

Forest stands of $\geq$ 1 hectare were identified by orthophoto (see Appendix A, *Figure 2: Sensitive Environmental Areas*). Many of these areas are along the interior property boundaries of the large residential lots (i.e. not along the roads) and along unopened road right-of-ways. The forest stands are essential for providing refuge for birds and small mammals, protecting water quality and aquatic habitat, and enabling wildlife movement between habitat hubs.

The largest forest within the Study Area is west of 192nd Street between 76th and 80th Avenues (roughly 42 hectares). The right-of-way for 78th Avenue has not been opened within this block, and as a result the interior of the block is predominantly forested and has nearly 6 hectares of forest that could potentially support interior bird species (species who require greater than 100 meter forest buffers). The forest block also includes portions of the South Arm of Latimer Creek (193rd Street Creek and 76th Avenue Creek). Creating forested corridor connections between this large forest block and nearby, smaller habitat fragments would greatly enhance the robustness of the habitat network within the Study Area (see Appendix A, *Figure 4: Habitat Restoration and Corridors*).

A second large forest block located west of 196th Street between 74th and 76th Avenues. Similarly, the right-of-way for 196th Street and 74th Avenue have not been opened at this location. There is approximately 1.6 hectares of interior forest habitat within the forest block. This interior habitat would be reduced at least to 1.2 hectares if both roads were opened, and would likely be further reduced with development along the new road frontages.

3.2 OLD FIELDS

A large portion of the Study Area is within the Agricultural Land Reserve. Some of these lots are not currently under cultivation and provide very high quality foraging habitat for wildlife such as raptors and small mammals. These areas are not currently threatened by development and have not been highlighted as Sensitive Environmental Areas. One old field located at the intersection of Fraser Highway and Harvie Road has been identified as an SEA because it includes seasonally flooded areas (wetlands) that connect to Class A(O) fish habitat.

3.3 WILDLIFE TREES

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

Most of the trees observed in the study area were identified as Class 1 wildlife trees. Class 1 wildlife trees are described as live healthy trees with no decay. Many of the decayed trees identified were Class 2 to 4 wildlife trees. Class 2 wildlife trees are live/unhealthy trees with internal decay or growth deformities (including insect damage, broken tops); a dying tree. Class 3 wildlife trees are dead trees with hard heartwood; needles and twigs present and stable roots. Class 4 wildlife trees are dead trees with hard heartwood; no needles/twigs; 50% of branches lost; loose bark; top usually broken and stable roots.

A Red-tailed Hawk was observed foraging within the study area during the field survey. At least five Red-tailed Hawk nests were detected during the field investigations for the CANCPER (Dillon and Strix 1997). Potential nest cavities were detected within many of the wildlife trees observed. Most of the wildlife tree observations were recorded along the Latimer Creek main stem. Pileated Woodpecker (*Dryocopus pileatus*) foraging sign was observed on three of the wildlife trees. One Hairy Woodpecker (*Picoides villosus*) and one Northern Flicker (*Colaptes auratus*) were observed foraging throughout portions of Latimer Creek during the field assessment. These trees also provided habitat for many bird and mammal species including songbirds, squirrels and bats.

3.4 COARSE WOODY DEBRIS

CWD is typically described as woody debris greater than 0.3 m in diameter. CWD provides critical foraging, nesting, and cover components in the forested ecosystem for small mammals, amphibians, reptiles and invertebrates (Anonymous 1991). Many insectivorous small mammals, birds, and black bears feed on insects found in decomposing woody material. CWD provides a safe, moist environment in which species such as salamanders and shrews can forage and seek shelter.

Limited CWD cover (<0.1%) was recorded within most of the study area. Moderate to heavy CWD cover (5-10%) was recorded within many of the forested blocks and along portions of Latimer Creek and its tributaries. No CWD cover was recorded within the residential and agricultural areas.

4. WILDLIFE INVENTORY AND HABITAT

Prior to the field assessment, a literature search was conducted covering the Clayton ISMP study area of Surrey, including British Columbia Conservation Data Centre (BCCDC) searches, Wildlife Tree Stewardship Program (WiTS) and local knowledge. Past reports of the study area including the *Clayton Area Neighbourhood Concept Plan Environmental Report* (CANCPER) were also reviewed. The BCCDC website was searched for all species listed under SARA, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), Provincial Identified Wildlife and the Provincial *Wildlife Act* that are suspected to occur within habitats identified within the study area. In addition, species listed as Red and Blue-listed by the BCCDC but not specifically covered under legislation were also included. BCCDC Data within 10 km of the study area was also reviewed. Aerial photographs of the study area were examined and all potential habitats and wildlife corridors were stratified.

Each water crossing along the various roads within the study area were assessed for wildlife and vegetation values during the field survey. Sample sites were restricted to these locations as most of the study area is situated on privately owned lands. Vegetation species within each site were identified and recorded. In addition, the presence of coarse woody debris (CWD), wildlife trees, dens, burrows and other habitat features were also recorded. All wildlife trees were classified according to methodologies identified by Backhouse (1993) and Fenger et al. (2006).

Pacific water shrew habitat was assessed following methodologies described by Craig and Vennesland 2008. Potential raptor/heron nest trees were scanned visually with binoculars. All wildlife and wildlife sign encountered was recorded.

4.1 FEDERALLY AND PROVINCIALLY LISTED SPECIES OF CONCERN

Fifteen Federally and/or Provincially listed species may occur within the Clayton ISMP study area. These species are listed in Table 1.

Table 1: Federally and/or Provincially listed species that occur or may occur in the study area (SARA 2010; BCCDC 2010[1]).

Species	**Federal/Provincial Status**		**Legislation**			**Site Occurrence**
Common/Scientific Name	**COSEWIC/SARA Status**	**BCCDC Status***	**SARA**	**Provincial Identified Wildlife**	**Provincial Wildlife Act**	**Expected Onsite Habitat Use**
Vegetation:						
California-tea (*Rupertia physodes*)	-	Blue	-	-	-	**Suitable** – Undisturbed portions of the forested blocks within the study area may provide habitat for this species.
False-pimpernel (*Lindernia dubia* var. *anagallidea*)	-	Blue	-	-	-	**Suitable** – The banks and shores of the wetlands and streams within the study area may provide habitat for this species.
Slender-spiked Mannagrass (*Glyceria leptostachya*)	-	Blue	-	-	-	**Suitable** – The ditches and watercourses within the study area may provide habitat for this species.
Vancouver Island Beggarticks *(Bidens amplissima)*	Special Concern (November 2001)	Blue	X	-	-	**Suitable** – the wetland areas along Harvie Road within the study area may provide habitat for this species.
Vertebrates:						
Barn Owl (*Tyto alba*)	Special Concern (November 2001)	Blue	X		X	**Suitable** – Suitable habitat occurs within the agricultural habitats of the study area. Incidental observations reported in CANCPER.
Great Blue Heron (*Ardea herodias fannini*)	Special Concern (November 2008)	Blue	X	X	X	**Suitable** – Observed foraging in ditches along Harvie Road. Suitable habitat occurs within the wetlands west of Harvie Road. Incidental observations reported in CANCPER.

Table 1 (concluded): Federally and/or Provincially listed species that occur or may occur in the study area (SARA 2010; BCCDC 2010[1]).

Species	Federal/Provincial Status		Legislation			Site Occurrence
Common/Scientific Name	COSEWIC/SARA Status	BCCDC Status*	SARA	Provincial Identified Wildlife	Provincial Wildlife Act	Expected Onsite Habitat Use
Vertebrates: (continued):						
Green Heron (*Butorides striatus*)	-	Blue	-	-	X	**Suitable** – Suitable habitat occurs within the wetlands west of Harvie Road.
Red-legged Frog (*Rana aurora*)	Special Concern (Nov 2004)	Blue	X	X	X	**Suitable** – Possible breeding habitat (ponds) within the study area. Rearing habitat occurs along most riparian areas. Unconfirmed sighting in a pond during the field assessment.
Pacific Water Shrew (*Sorex bendirii*)	Endangered (Apr 2006)	Red	X	X	X	**Suitable** – Moderate-high rated habitat detected along portions of Latimer Creek and its tributaries.
Short-eared Owl (*Asio flammeus*)	Special Concern (November 2008)	Blue	X	-	X	**Suitable** – Potential habitat occurs within the wetlands west of Harvie Road.
Snowshoe Hare (*Lepus americanus washingtonii*)	-	Red	-	-	X	**Suitable** – Potential habitat detected within forested blocks of the study area.
Trowbridge's Shrew (*Sorex trowbridgii*)	-	Blue	-	-	X	**Suitable** – Potential habitat detected within forested portions of the study area.
Invertebrates:						
Beaverpond Baskettail (*Epitheca canis*)	-	Blue	-	-	-	**Suitable** – Potential habitat within the Latimer Creek Wetland (East of 192nd Street).
Oregon Forestsnail (*Allogona townsendiana*)	Endangered (Nov 2002)	Red	X	-	-	**Suitable** – Suitable habitat occurred within the Forested Block located west of 19024 84 Avenue.
Pacific Sideband (*Monadenia fidelis*)	-	Blue	-	-	-	**Suitable** – Suitable habitat occurred within the Forested Blocks.

*Red= Extirpated, Endangered or Threatened *Blue= Special Concern

4.2 Potential Vegetation Species and Ecological Communities with Special Federal/Provincial Status that May Occur in the Study Area

4.2.1 California-tea

California-tea usually inhabits mesic open forests in portions of the lowland zones of the Coastal Douglas-fir (CDF) and CWH biogeoclimatic zones. It is considered rare on southern Vancouver Island and the lower Fraser River Valley. Outside of B.C. it is found south to California (Douglas et al. 2002).

This species was not detected during the field survey. One BCCDC record for this species occurred within 10 km of the study area (Appendix C; Figure 3). This species was recorded in the Brookswood area of Langley (1975) and occurred on gravelly soil in a small second growth Douglas-fir stand with scrubby salal (*Gaultheria shallon*)(BCCDC 2010). Undisturbed portions of the forest blocks within the study area may provide habitat for this species.

4.2.2 False-pimpernel

The Provincially Blue-listed false-pimpernel occurs on wet, sandy or muddy banks and shores in the drier lowland and steppe subzones of the Bunch Grass (BG), CWH and Interior Douglas-fir (IDF) biogeoclimatic zones within B.C. It is considered rare in south-central B.C. and the lower Fraser Valley. Disjunct populations also occur east to Ontario and south to New Hampshire, New York, South Carolina, Florida, Missouri, Texas, Utah, Arizona, California, Mexico and South America (Douglas et al. 2002).

False-pimpernel was not observed during the field survey. One BCCDC record for this species occurred within 10 km of the study area near Latimer Pond (Appendix C; Figure 3). The plants were situated in wet sandy gravel in an old gravel pit (BCCDC 2010). The banks and shores of the wetlands and streams within the study area may provide habitat for this Blue-listed species.

4.2.3 Slender-spiked Mannagrass

Slender-spiked mannagrass usually occurs in brackish tidal marshes, swamps, lakeshores, streamsides and wet meadows in the lowland subzones of the CDF and CWH. It is considered rare in coastal B.C. It also found north to southeast Alaska and south to California (Douglas et al. 2002).

Slender-spiked mannagrass was not observed during the field survey. One BCCDC record for this species occurred within 10 km of the study area near 104 Ave and 176 Street (Appendix C; Figure 3). The record is of one large plant growing in shallow ditch, in moist dredged sand, near railway tracks (BCCDC 2010). The ditches and watercourses within the study area may provide habitat for this Blue-listed species.

4.2.4 Vancouver Island Beggarticks

The Vancouver Island beggarticks is listed under Schedule 1 (part 4) of SARA. Except for a single historical location on a research station in Brandon, Manitoba, the entire global range of the species occurs in the Pacific Northwest of North America. In Canada, it has been found in the Lower Fraser Valley and on Southern Vancouver Island, with one additional record on the mainland coast of British Columbia just north of Vancouver Island. The Vancouver Island beggarticks is a wetland species found occasionally in successional wetlands, but is generally limited to a very narrow band of habitat around pond, lake and stream margins, areas where annual and seasonal water level fluctuations are prevalent. It tends to occur in sites where waterfowl are common and shows a distinct preference for silty alluvial soils (EC 2009[1]).

Two BCCDC records for this species occurred within 10 km of the study area (Appendix C; Figure 3). One record occurred along the tidal portion of Douglas Island within the Fraser River and a historical record (1954) for this species occurred near Fleetwood (BCCDC 2010).

Although not detected during the field survey the wetland areas along Harvie Road within the study area may provide habitat for Vancouver Island beggarticks.

4.3 Ecological Communities

The BCCDC defines listed ecological communities as ecosystems identified in a Sensitive Ecosystems Inventory. These sites are generally old growth stands that are generally 500 m^2 or greater. These ecosystems are often the remnants of the natural ecosystems that once occupied a much larger area. Typically, mature and old growth upland ecological communities are of concern to the BCCDC. In addition, all listed riparian, wetland and estuarine communities at any growth stage are also of concern to the BCCDC (K.A. McIntosh pers. comm.). The listed ecological communities are classified using methodologies and nomenclature developed by Green and Klinka (1994).

The forested portions within the study area were second to third growth stands. These stands were at seral states that are not of concern to the BCCDC.

4.4 General Wildlife Observations

Wildlife sign and activity was recorded throughout the study area. Songbirds were observed flying and feeding in vegetation throughout the site. Sign of beaver, raccoon and coyote were observed along Latimer Creek. The Federally and Provinically listed Great Blue Heron was observed feeding along the ditches of Harvie Road. All animal species detected are listed in Attachment 5.

4.5 Wildlife Habitat Assessment

Habitats were assessed for the eleven wildlife species listed in Table 1. The following are the results of the habitat assessment for each of the eleven species.

Barn Owl

The Barn Owl is listed in Schedule 1 (Part 4) of SARA and has been Blue-listed by the Province of British Columbia (BCCDC 2010). This species is considered an uncommon resident throughout the Fraser Lowlands to Hope. Barn Owls are solitary nesters who prefer agricultural areas. Nests are usually situated in man-made structures including barns and old buildings (Campbell et. al, 1990).

This species was not detected during the survey, and no BCCDC records for this species occur within 10 km of the study area. As mentioned in the CANCPER local residents have observed this species within the study area. The agricultural lands within and adjacent to the site provided suitable habitat for this species.

Great Blue Heron

In addition to being listed on Schedule 3 (Part 4) of SARA the Great Blue Heron *fannini* subspecies is also listed on the Provincial Blue List (BCCDC 2010). In British Columbia Great Blue Heron populations have been decreasing resulting in the listing of this species (MELP 1999). Population decreases are believed to be the result of human disturbance (EC 2010[2]). Great Blue Herons nest in a wide variety of tree species. Foraging habitat does not appear to be limiting factor for this subspecies as not all available habitat is used by herons each year. Critical nesting habitat includes both an established colony and a suite of alternative sites to retreat to should disturbance occur.

No Great Blue Heron nests were detected during the field survey. One BCCDC record for this species occurs within 10 km of the study area (Appendix C; Figure 3). The CANCPER identified the wetlands west of Harvie Road as providing suitable foraging habitat for this subspecies.

Green Heron

The Green Heron is listed on the Provincial Blue List (BCCDC 2010). In British Columbia, the small population size and the risk of habitat loss to urbanization has resulted in the listing of this species (Harper *et al*. 1994). Green Herons use a variety of habitats, including sloughs, rivers, lakes, ponds, reservoirs, estuaries and beaches in British Columbia. Important habitat components for Green Herons include: slow-moving or shallow water for foraging and nearby dense trees or tall shrubs for nesting (Fraser 1996).

No green heron nests were detected during the field survey and no BCCDC records for this species occurs within 10 km of the study area. The CANCPER (1997) identified the wetlands west of Harvie Road as providing suitable habitat for this species.

Red-legged Frog

In addition to being listed on Schedule 1 (Part 4) of SARA, the red-legged frog is also listed on the Provincial Blue List (BCCDC 2010[1]). Red-legged frogs in B.C. are found in moist forests and in forested wetlands (Corkran and Thoms 1996). Adults will often wander far from standing water to forage on small insects or forest invertebrates (Nussbaum et al. 1983 in Ovaska and Sopuck 2004). Generally, they breed in cool, shaded temporary ponds where they attach their eggs to submerged woody debris or vegetation (Corkran and Thoms 1996). Critical habitats for the red-legged frog would include all temporary and permanent breeding ponds. CWD would also be considered a critical habitat element for cover and foraging.

One frog was observed in a small pond along the north side of 84th Avenue, west of 192nd Street. Although the species of this frog could not be confirmed the habitat within this area was suitable for red-legged frogs. Breeding habitats (ponds) were detected within the study area and the riparian areas of Latimer Creek and its tributaries provided suitable rearing habitat for red-legged frog and many other amphibian species.

Pacific Water Shrew

Pacific water shrews are usually associated with riparian areas (Nagorsen 1996; Craig 2003). Past studies have reported that the majority of water shrews were captured within 25 m of streams, however in moist forests, Pacific water shrews can be found up to 1 km from water (Pattie 1973 in Craig 2003). The home range of the Pacific water shrew is suspected to be 400 m along a waterbody (Craig 2003).

In BC, capture sites appear to be primarily associated with coniferous or deciduous forest with capture sites located very close to water. Habitat components usually found at Pacific water shrew sites include the presence of red alder, bigleaf maple, western hemlock or western redcedar that border streams and skunk cabbage (*Lysichiton americanus*) marshes (Nagorsen 1996). In addition, Pacific water shrews have also been captured in more open habitat, with dense marsh vegetation. These include reed canarygrass (*Phalaris arundinacea*) vegetated roadside ditches and water bodies within highway medians (C. Schmidt, pers. comm.). CWD also seems to be an important habitat component. The presence of moist habitat appears to be more important than forest age (Craig 2003).

No Pacific water shrews were detected during the field survey. Two BCCDC records for this species occurred within 10 km of the study area (Appendix C; Figure 3). Records occur for the Fraser Heights area of Surrey and an additional record occurs near Trinity Western University. The forested portions of Latimer Creek and its tributaries provided moderate rated habitat for this species based on the presence of preferred vegetation and habitat features. High rated Pacific water shrew habitat was observed near creek crossings 8 and 9 at 192nd Street and 88th Avenue, and crossings 13 and 14 along 196 Street, north of 84th Avenue and the large wetland complex located east of crossing 8 near the 8500 block of 192nd Street (Appendix C; Figure 2: Appendix C; Photographs 4, 5 and 6).

Short-eared Owl

The Federally and Provincially listed Short-eared Owl can be found in a wide variety of open habitats, including arctic tundra, grasslands, peat bogs, marshes, sand-sage concentrations and old pastures. It also occasionally breeds in agricultural fields (EC 2010[3]). This ground-nesting owl species preferred nesting sites are dense grasslands, as well as tundra with areas of small willows. While the Short-eared Owl has a marked preference for open spaces, the main factor influencing the choice of its local habitat is believed to be the abundance of food, in both summer and winter. Suitable breeding, migration and wintering habitat has declined significantly throughout the 20th century, resulting in a reduction in the number of owls(EC 2010[3]).

The agricultural fields along Harvie Road may provide limited habitat for this species.

Snowshoe Hare

The Red-listed Lower Mainland subspecies of the snowshoe hare has been found in undeveloped areas of the Lower Mainland and Fraser Valley. It is considered critically imperiled since almost the entire native habitat for this species in the Lower Mainland has been developed. This primarily nocturnal species favours moist semi-open forests with clearings and thickets (McTaggart-Cowan and Guiguet 1965).

This subspecies has been recorded (approximately six years ago) north of the Fraser River near Burnaby Lake. In addition, one specimen was collected approximately nine years ago near Mission, (D. Nagorsen, pers. comm.).

Potential habitat for this species occurred in the forested portions of the study area.

Trowbridge's Shrew

The Trowbridge's shrew is Blue-listed by the Province of British Columbia (BCCDC 2010[1]). Trowbridge's shrew use both riparian and non riparian forest (Zuleta and Galindo-Leal 1994). In non riparian forests, the Trowbridge's shrew has shown a preference for areas with a high moisture regime (Nagorsen 1996).

Critical habitat elements for this species include rich soils and abundant decaying CWD and leaf litter on the forest floor (Nagorsen 1996). Ground litter, woody debris and shrub cover provides a secure environment for tunnelling and nesting.

One BCCDC record for this species occurred within 10 km of the study area (Appendix C; Figure 3). The forested portions of Latimer Creek and its tributaries provided moderate to high rated habitat for this species based on the presence of preferred vegetation and habitat features.

Beaverpond Baskettail

This Provincially Blue-listed dragonfly species is considered a rare inhabitant of marshy lake shores, boggy ponds and backwaters of slow moving streams (Cannings 2002). In B.C. this dragonfly species is found in the spring and early summer and ranges from the south coast to the Peace River drainage with no records occurring in the dry southern valleys of the interior (Cannings 2002).

This species was not detected during the field program. One record for this dragonfly species occurred within 10 km of the study area at Surrey Bend Regional Park (BCCDC 2010). This observation occurred along a pathside ditch. The wetlands west of Harvie Road and the large wetland of Latimer Creek located east of 192nd Street, near the 8500 block (Appendix C; Photograph 5), provided potential habitat for this species.

Oregon Forestsnail

The Oregon forestsnail has been listed as endangered by SARA (Schedule 1; Part 2) and is on the Provincial Red List.

The Oregon forestsnail is found in the western part of Oregon and Washington states, north into extreme southwestern British Columbia. Provincial records are mainly from Chilliwack and Fraser River valleys from near Hope to Mission (Forsyth 2004). Two additional locations are from Langley and southern Vancouver Island, and are considered outside the core region (EC 2010[4]).

The Oregon forestsnail occupies older mixed wood and deciduous lowland forests, typically dominated by bigleaf maple. This species appears to require sites that include some CWD, heavy leaf litter, and both living and dying vegetation (EC 2010[4]). It is suspected that these conditions aid in preventing the loss of moisture and extreme fluctuations in temperature that are thought to be particularly detrimental to hibernating snails (EC 2010[4]).

No Oregon forestsnails or their shells were detected within the study area. One BCCDC record for this species occurred within 10 km of the study area, near Trinity Western University (Appendix C; Figure 3). The maple dominated forested block situated west of 19024 84 Avenue provided potential habitat for this species (Appendix C; Photograph 7).

Pacific Sideband

The Pacific sideband snail is Blue-listed by the Province of British Columbia (BCCDC 2010). This large snail species is found from Alaska to California; west of the Coast and Cascade Mountains. Pacific sidebands live in deciduous, coniferous or mixed forests as well as in open forests and grassy areas (Forsyth 2004).

No Pacific sideband snails were detected within the study area. The undisturbed portions of the forested blocks within the study area provided potential habitat for this species.

4.6 WILDLIFE CORRIDORS

Moderately used wildlife trails, attributed to coyotes, were detected within the study area. Evidence of use by raccoon and beaver were also observed. These animals appeared to travel mainly along the riparian corridors. In addition to coyotes, raccoon and beaver these corridors may also be used by species such as Columbia black-tailed deer (*Odocoileus hemionus columbianus*) and Virginia opossum (*Virginia Opossum*) as well as many species of small mammals , birds, amphibians and reptiles.

5. SENSITIVE ENVIRONMENTAL AREAS

5.1 WATERCOURSES AND RIPARIAN HABITATS

The priority areas for protection include the Class A and B streams and their riparian areas, the wetlands along Latimer Creek, and the interior forest areas, and the remaining forest stands of ≥ 1 hectare. These areas are shown on *Figure 2: Sensitive Environmental Areas* in Appendix A.

Watercourses and their riparian areas are currently protected by the Land Development Guidelines for the Protection of Aquatic Habitat. Under this regulation, setbacks for streams range from 15-30 meters from the high water mark or from the top of ravine (if slopes steeper than 3:1 exist) depending on the density of development at a site. If a riparian area is to also function as a wildlife movement corridor, a 30 meter or greater vegetated setback would be preferred.

5.2 INTERIOR FOREST HABITAT

Interior forests have special habitat conditions that enable them to support different wildlife species than forest edge habitats. Interior forest habitats are relatively uncommon in the City of Surrey. The ISMP Study Area to the south (Cloverdale – McLellan), for example, does not contain any interior forest habitat. The Clayton ISMP Study area contains two areas of interior forest. These areas have also been the location of wildlife sightings including Great Horned Owls and Red Tailed Hawks.

6. CONCLUSIONS

6.1 KEY AREAS OF CONCERN

The Study Area is currently low density residential and agricultural land, but future development is expected, particularly along the southern edge which is closest to existing urban densities. Increasing development densities result in greater impervious surface cover, which is usually accompanied by an increase in peak flow volumes and velocities and decreases in water quality. Best management practices such as preservation and restoration of riparian forests, onsite infiltration, biofiltration, stormwater detention facilities, and other innovative stormwater management facilities are essential to preventing the degradation of the existing aquatic and riparian habitats. Specific to the Study Area, there are a few areas of particular concern that will be most affected by changes to the hydrologic regime.

6.1.1 Erosion of Ravine Streams

If future development results in increases of flow volumes, duration, and velocity, it is likely to result in erosion of the banks and downcutting of the channels with the steepest gradients. Stream segments such as the 196th Avenue Creek ravine that continues into Langley, the 76th Avenue Creek ravine, and the creeks west of 184th Street may incur the greatest impacts. Excessive peak flows can also undermine channel restoration activities by scouring out bank protection and vegetation.

6.1.2 Flooding in Lowland Channels

Many of the agricultural and roadside ditches in the western portion of the Study Area are already subject to flooding during large storm events under the low density development conditions in the watershed. Residents along 80th Avenue, for example, noted increases in flooding after the road was regraded. Increased development in the upper watershed may result in increased flow volumes, duration, and velocity, and the biggest impact will be on the low gradient streams. Sediments carried down the steeper gradient stream channels may accumulate in these channels as well.

6.1.3 Loss of habitat (forests, streams, etc.) and habitat fragmentation

The Study Area currently has substantial forest, riparian, and old field habitats due to the low density of development and the remaining unopened road right-of-ways. If development proceeds in the usual fashion, the hubs and patches of habitat are likely to become fragmented or lost. Future road and storm sewer improvements should include consideration of box culverts with shelves for small mammal movement, fencing to funnel wildlife to appropriate culverts, and connection of these wildlife tunnels to greenways or other appropriate movement corridors. Remaining interior forests and forest stands of $\geq$ 1 hectare should be protected to the greatest extent possible to provide a robust network of habitat patches.

6.2 VEGETATION AND ECOLOGICAL COMMUNITIES

No SARA listed vegetation species were detected during the field program. The site may provide habitat for the Provincially Blue-listed California-tea, false-pimpernel and sender-spiked mannagrass. In addition the site may provide habitat for the Federally and Provincially listed Vancouver Island beggarticks

BCCDC records for California-tea, false-pimpernel and sender-spiked mannagrass occur within 10 km of the study area. California-tea may occur within mesic portions of undisturbed, forested blocks and habitat for false-pimpernel and sender-spiked mannagrass may occur along the edges of watercourses within the study area. No Best Management Practices (BMPs) currently exist for these three species.

Two BCCDC records for Vancouver Island beggarticks do occur within 10 km of the study area. Habitat for this species may occur along the banks of Latimer Creek and its tributaries. This species typically flowers between mid-August to mid-September. The Vancouver Island beggarticks is a species of Special Concern under SARA, and is Provincially Blue-listed. According to the latest BMP available modifications to features that affect Vancouver Island beggarticks habitat may require authorization under the Water Act and/or The Federal Fisheries Act (FFA)**.** Activities such as, changes in site hydrology or soil composition, water level fluctuations, site disturbances, pollution from toxic chemicals, and dumping of garden waste and shade as well as encroachment of urban development could all potentially damage or destroy a Vancouver Island beggarticks population (MoE 2006).

No Ecological Communities as identified by the BCCDC occurred within the study area.

6.3 WILDLIFE ASSESSMENT

No Provincially listed wildlife species were detected during the field program. The SARA listed Great Blue Heron was observed foraging near Harvie Road during the field investigations. Sign of coyote, raccoon, beaver, woodpecker and passerines were detected within the study area. One Red-tailed Hawk was foraging within the project area. Most of the treed portions within the study area provided potential breeding/roosting habitat for raptors, passerines, woodpeckers and a number of bat species.

6.3.1 Mammals

Moderate to high rated habitat for the SARA listed Pacific water shrew and Provincially listed Trowbridge's shrew occurred within the forested portions of Latimer Creek and its tributaries. Two BCCDC record for Pacific water shrew occurred within 10 km of the study. The forested blocks within the study area also provided suitable habitat for the Provincially listed Trowbridge's shrew and snowshoe hare.

6.3.2 Birds

The Agricultural habitat association has been identified as suitable habitat for Barn Owl and Short-eared Owl. The wetlands west of Harvie Road and large wetland of Latimer Creek, east of 192nd Street, was identified as suitable Great Blue Heron and Green Heron habitat.

6.3.3 Amphibians

Breeding habitat for the SARA listed red-legged frog was detected within the study area. Potential rearing habitat for this species occurred within the forested portions of all habitat associations identified. This species would benefit from the enhancement of existing ponds and the creation of additional breeding ponds. The creation of breeding ponds would also benefit other amphibian species as well as other wildlife.

6.3.4 Invertebrates

One Forested Block provided high rated habitat for the Oregon forestsnail and Pacific sideband. BCCDC records for Oregon forestsnail occur within 10 km of the study area. The Latimer wetlands east 192nd Street and wetlands west of Harvie Road provided suitable habitat for the beaverpond baskettail dragonfly.

6.3.5 Wildlife Corridors

Moderately used wildlife corridors were observed along the forested portions of the banks of Latimer Creek and its tributaries during the field survey. Installing culverts and bridges suitable for wildlife passage at all road crossings of Latimer Creek and its tributaries within the study area would improve habitat connectivity to the existing forested areas for all wildlife, including Pacific water shrew and Trowbridge’s shrew. This habitat enhancement would also provide a secure wildlife corridor for all wildlife species.

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APPENDIX A

Figures 1-6

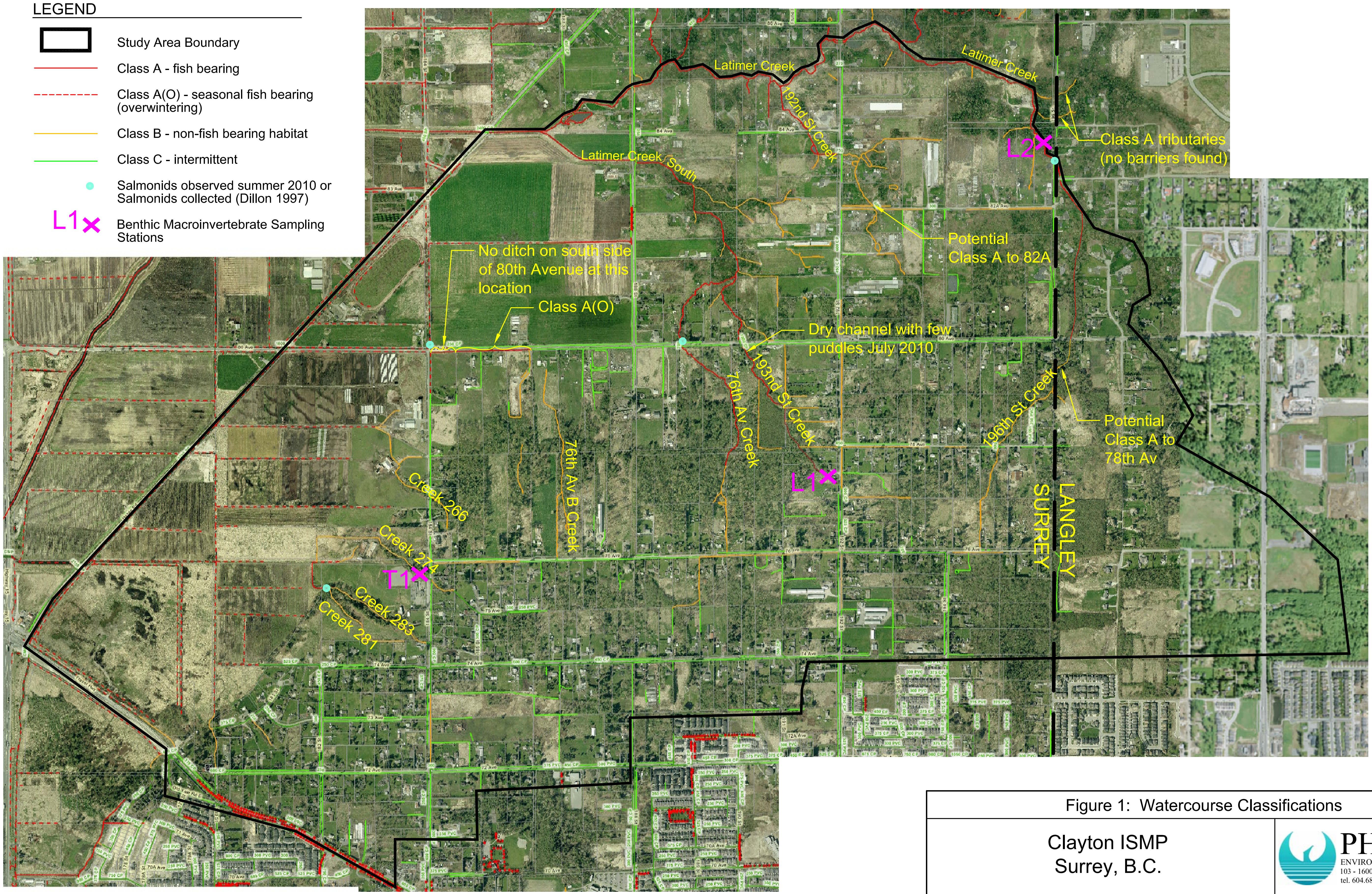


Figure 1: Watercourse Classifications

Clayton ISMP
Surrey, B.C.

PHOENIX
ENVIRONMENTAL SERVICES LTD.
103 - 1600 West 6th Av. Vancouver V6J 1R3
tel. 604.689.3888 fax. 604.689.3880

DATE: Aug 2010	DRAWN BY: MBT	SCALE: N.T.S.	DWG: ClaytonISMP_Maps.dwg

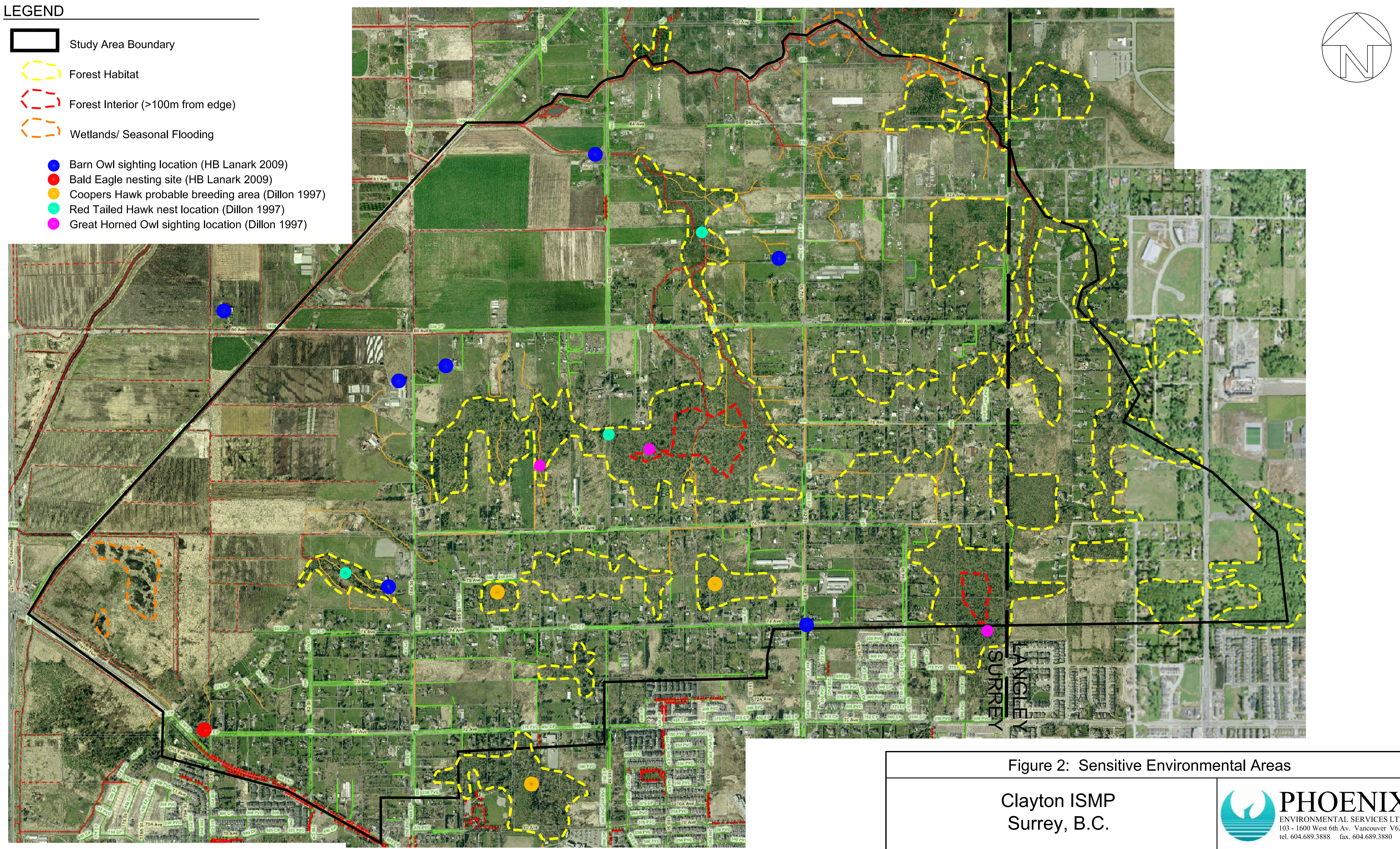


Figure 2: Sensitive Environmental Areas

Clayton ISMP
Surrey, B.C.

PHOENIX
ENVIRONMENTAL SERVICES LTD.
103 - 1600 West 6th Av. Vancouver V6J 1R3
tel. 604.689.3888 fax. 604.689.3880

DATE: Aug 2010	DRAWN BY: MBT	SCALE: N.T.S.	DWG: ClaytonISMP_Maps.dwg

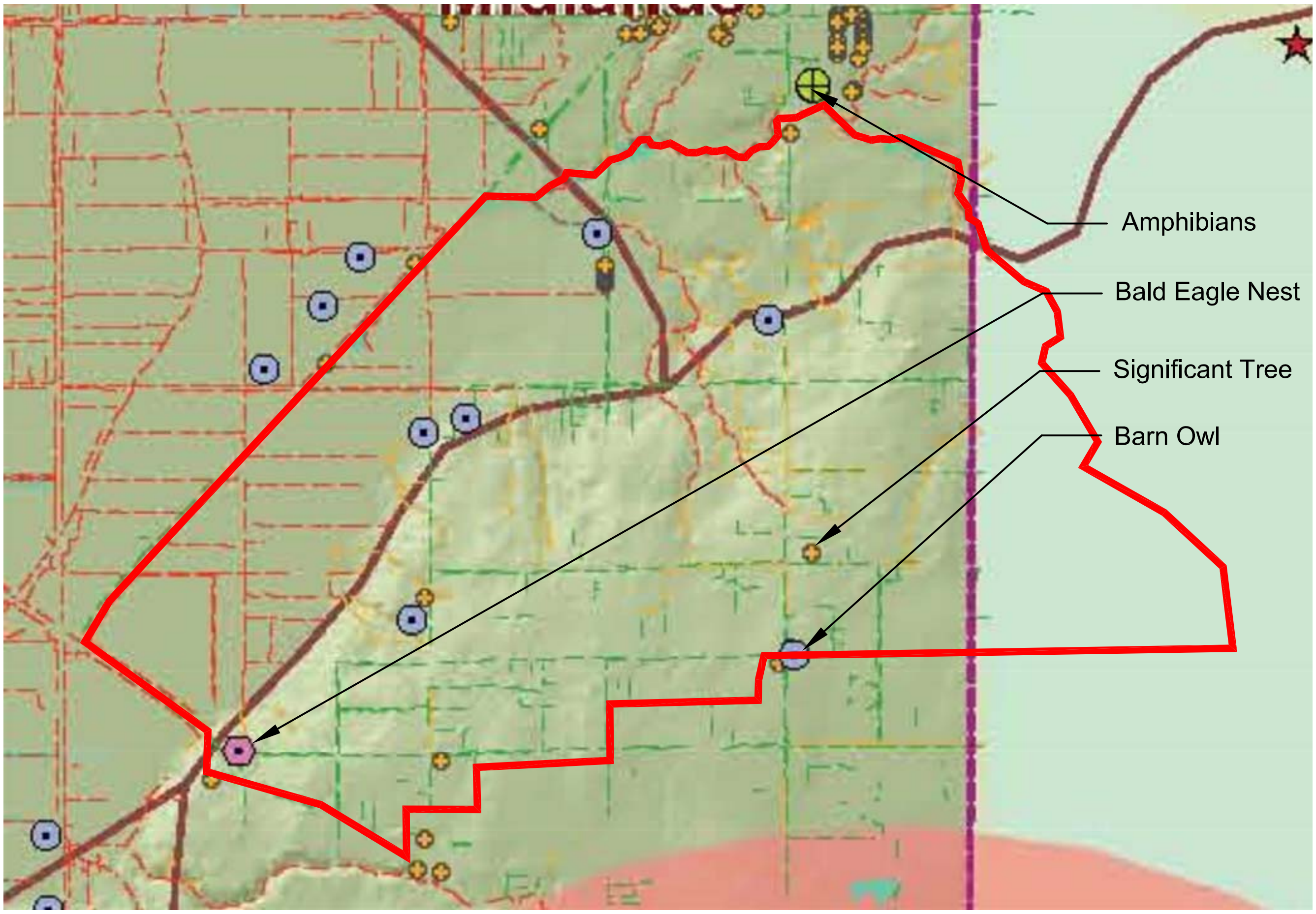


Figure 3: Sensitive Species Occurrences and Habitat (Source: Surrey Ecosystem Management Study)

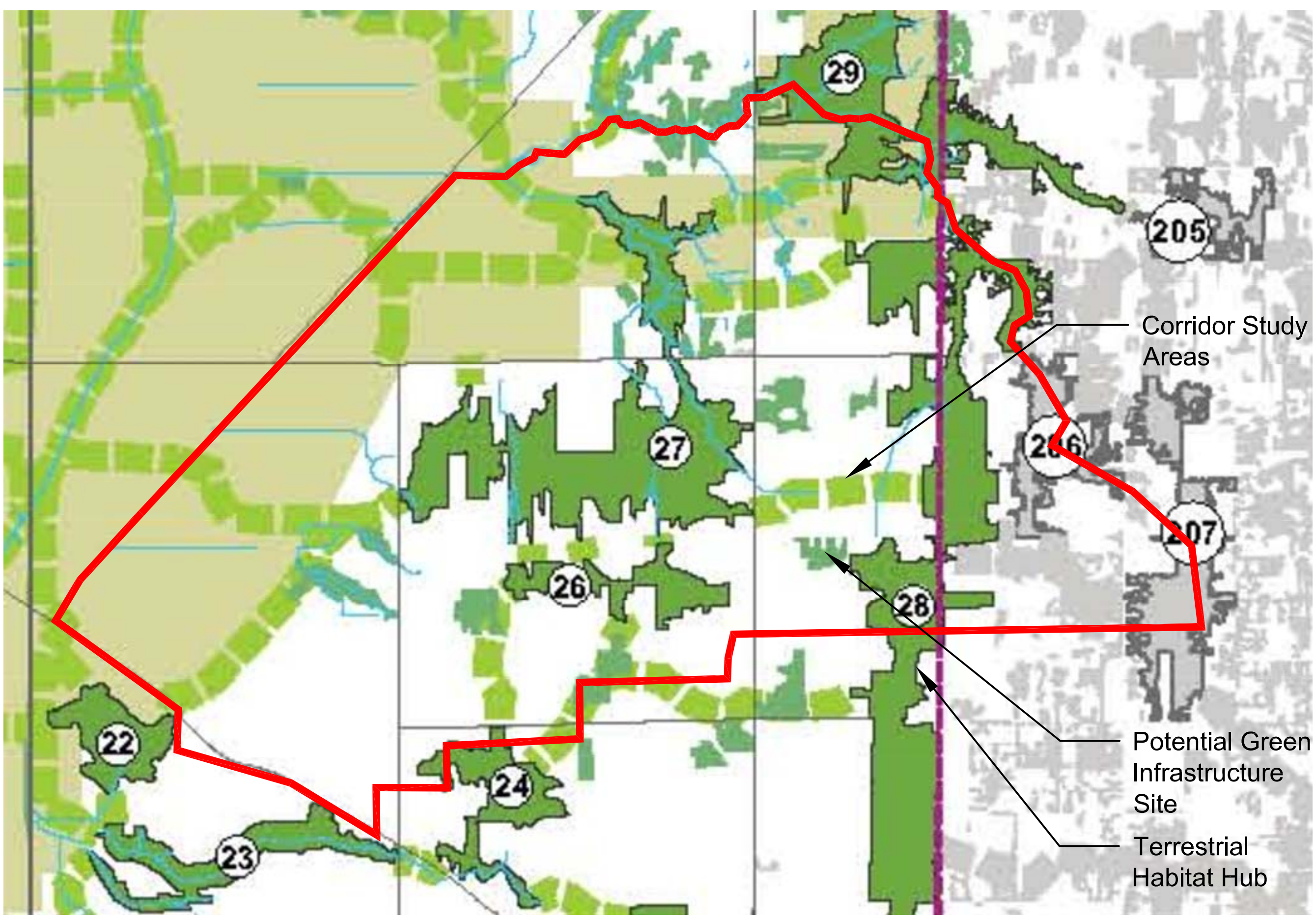


Figure 4: Green Infrastructure Opportunities (Source: Surrey Ecosystem Management Study)

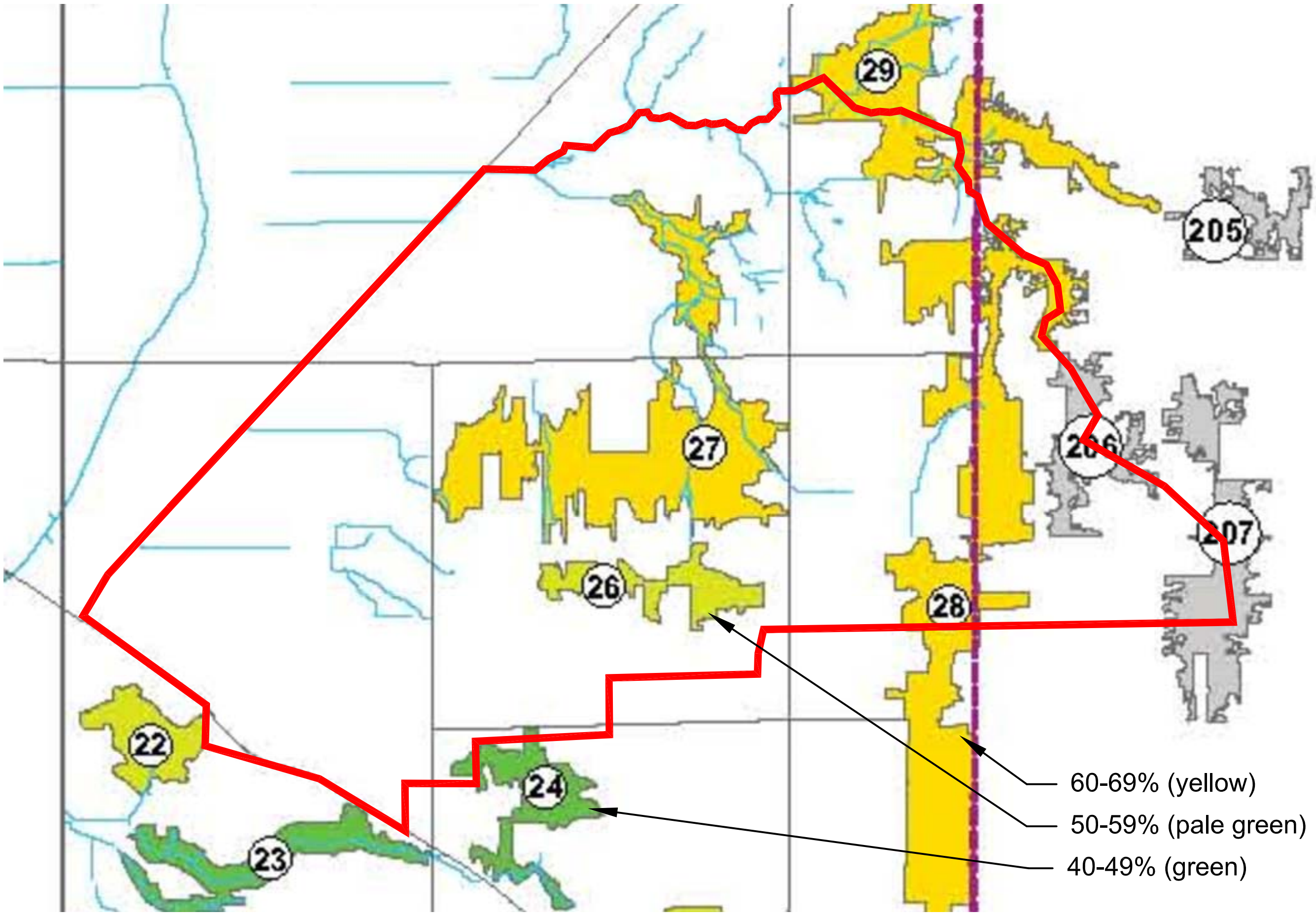


Figure 5: Habitat Hubs & Percent Ecological Significance (Source: Surrey Ecosystem Management Study)

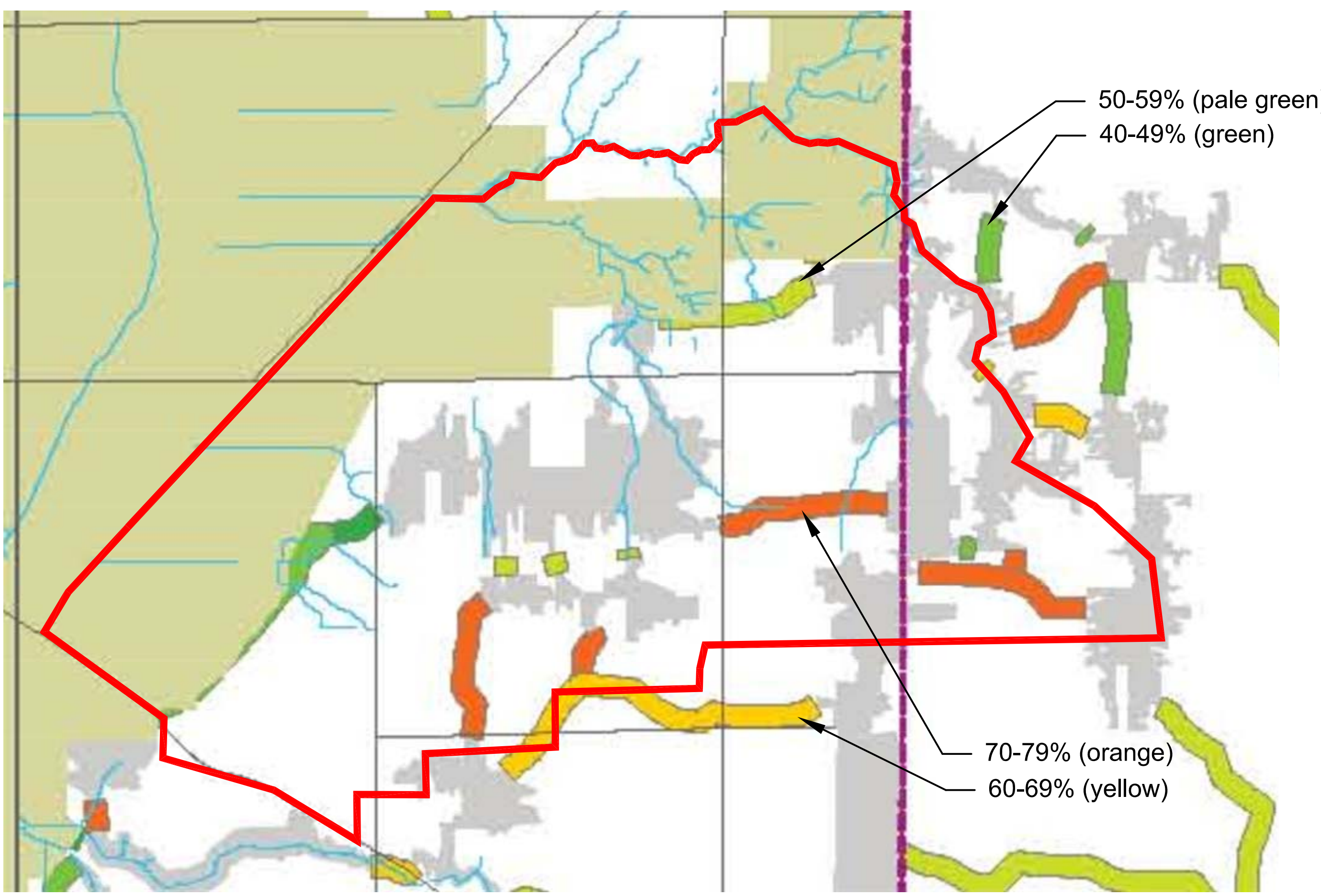


Figure 6: Habitat Corridors & Ecological Significance (Source: Surrey Ecosystem Management Study)

APPENDIX B

Site Photographs

196th Street Creek at 76th Avenue (view north/downstream)

196th Street Creek at 78th Avenue (view north/downstream)

Latimer Creek east of 196th Street, north of 82A Ave (view south/upstream)

Latimer Creek west of 196th Street, north of 82A Avenue (view west/downstream)

Wetland east of 192nd Street on Latimer Creek (view east/upstream)

Latimer Creek downstream (west) of 192nd Street

192nd Street Creek at 82A Avenue (view upstream, ponding on south side of road)

193rd Street Creek at 80th Avenue (view upstream, grade control and trash rack)

76th Avenue Creek (view of upstream culvert headwall at 80th Avenue)

Creek 274 at 184th Street, ravine condition adjacent to road (view east)

Typical lowland ditch along 80th Avenue, east of 184th Street (view east/upstream)

Typical lowland ditch perpendicular to 80th Avenue at 184th Street (view north/downstream)

APPENDIX C

Wildlife Maps and Photos

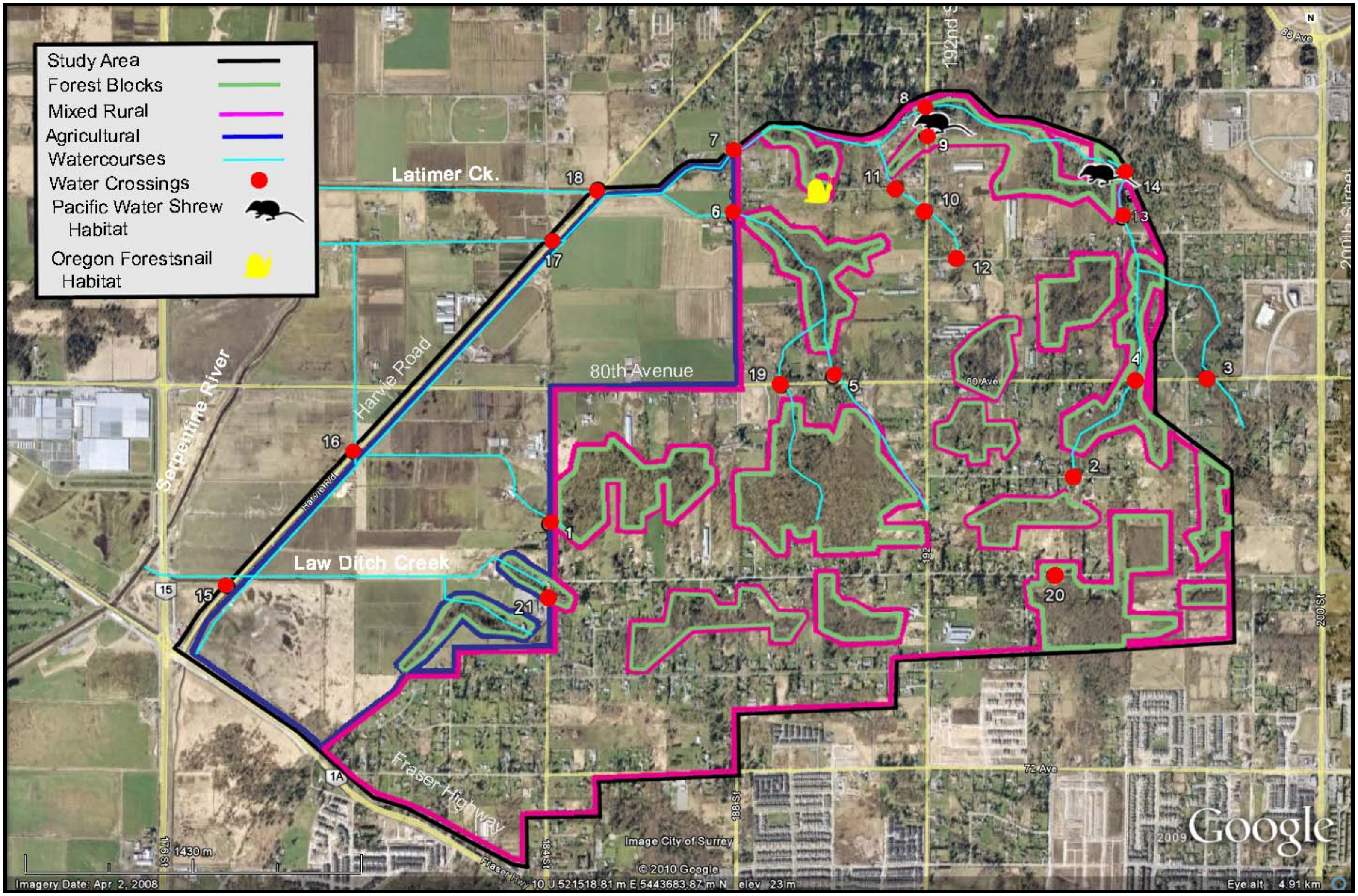


Figure 2. Modified graphic showing Forested Blocks, Mixed Rural and Agricultural habitat associations, high rated Pacific water shrew and Oregon forestsnail sites, and assessed water crossings within the Clayton study area (Google Earth 2010).

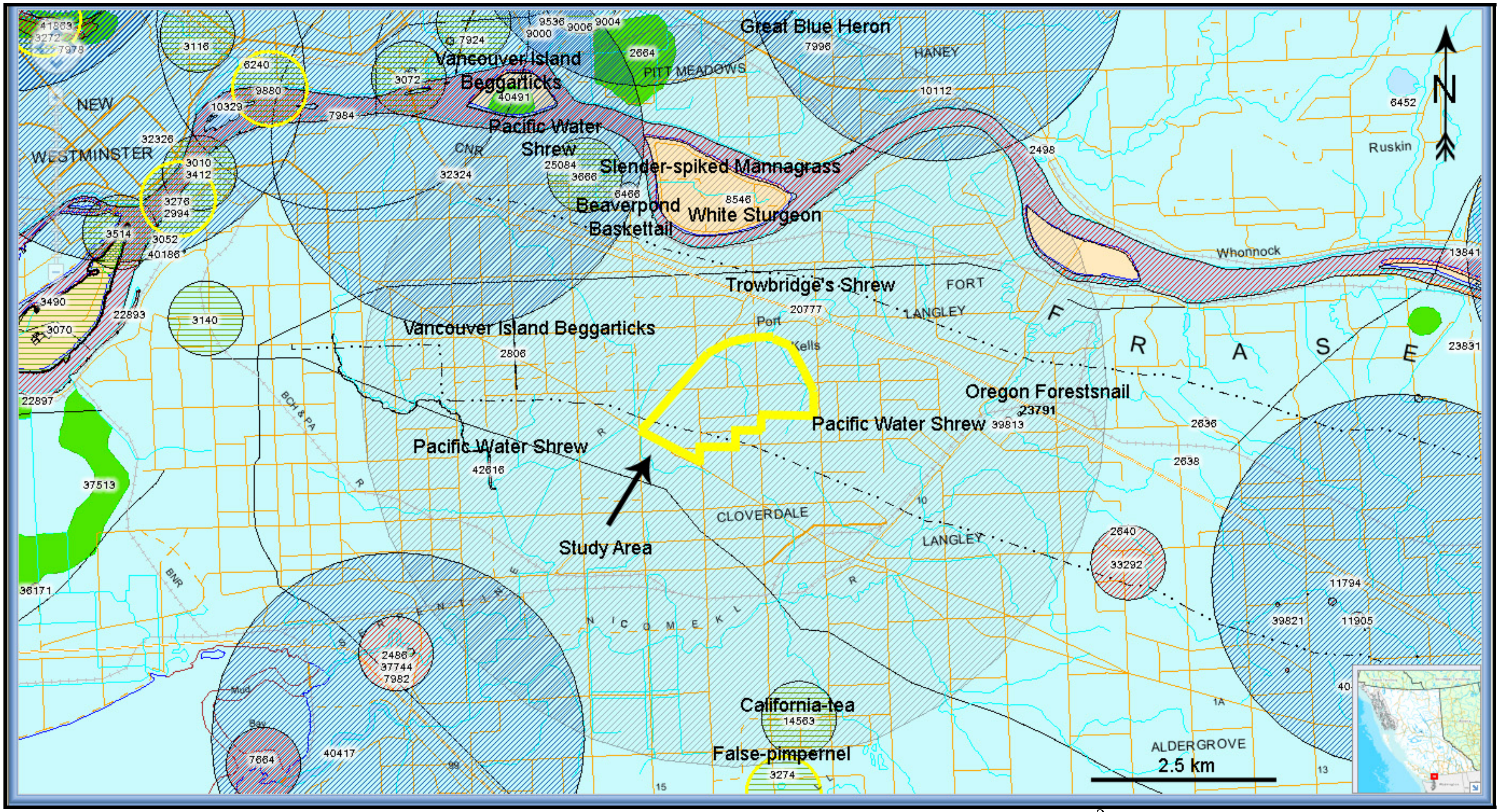


Figure 3. BCCDC map showing occurrence records within 10 km of the study area (BCCDC 2010[2]).

Photograph 1. An example of the Forested Blocks habitat association situated behind an acreage home within the study area (July 16, 2010).

Photograph 2. An example of a hobby farm within the Mixed Rural habitat association within the study area (July 16, 2010).

Photograph 3. An example of a corn and hay field within the Agricultural habitat association within the study area (July 16, 2010).

Photograph 4. High rated Pacific water shrew habitat of Latimer Creek at crossing 8 along 192nd Street near 88th Avenue (July 16, 2010).

Photograph 5. High rated Pacific water shrew and red-legged frog habitat of the Latimer Creek wetland situated east of crossing 8 along 192nd Street near 88th Avenue (July 16, 2010).

Photograph 6. High rated Pacific water shrew habitat of the Latimer Creek at crossing 14 along 196th Street near 85th Avenue (July 16, 2010).

Photograph 7.   High rated Oregon forestsnail habitat near 196th Street adjacent to 19024 84 Avenue (July 16, 2010).

Vegetation species detected within the study area (July 16, 2010).

Species	Scientific Name*	Forested Blocks Habitat Association	Mixed/Rural Habitat Association	Agricultural Habitat Association
Tree Layer[1]:				
Bigleaf Maple	*Acer macrophyllum*	X	X	
Black Cottonwood	*Populus balsamifera*	X	X	X
Douglas-fir	*Pseudotsuga menziesii*	X	X	
Grand Fir	*Abies grandis*	X		
Pacific Crab Apple	*Malus fusca*	X	X	
Paper Birch	*Betula papyrifera*	X	X	
Red Alder	*Alnus rubra*	X	X	X
Western Hemlock	*Tsuga heterophylla*	X	X	
Western Redcedar	*Thuja plicata*	X	X	X
Shrub Layer[2]:				
Black Cottonwood	*Populus balsamifera*	X		
Douglas-fir	*Pseudotsuga menziesii*	X		
English Holly	*Ilex aquifolium*		X	
Evergreen Blackberry	*Rubus laciniatus*	X	X	X
Himalayan Blackberry	*Rubus discolor*	X	X	X
Hardhack	*Spiraea douglasii*			X
Indian-plum	*Oemleria cerasiformis*	X		
Paper Birch	*Betula papyrifera*	X	X	
Red Alder	*Alnus rubra*	X	X	
Red Elderberry	*Sambucus racemosa*	X		
Red-osier Dogwood	*Cornus stolonifera*	X		
Salmonberry	*Rubus spectabilis*	X	X	
Scotch Broom	*Cytisus scoparius*		X	
Snowberry	*Symphoricarpos albus*	X		
Thimbleberry	*Rubus parviflorus*	X		
Trailing Blackberry	*Rubus ursinus*	X		
Vine Maple	*Acer circinatum*	X		
Western Redcedar	*Thuja plicata*	X	X	
Herb Layer:				
Bleeding Heart	*Dicentra formosa*	X		
Bluegrass	*Poa* spp.			X
Bull Thistle	*Cirsium vulgare*		X	X
Braken Fern	*Pteridium aquilinum*	X		
Canada Thistle	*Cirsium arvense*		X	X
Common Dandelion	*Taraxacum officinale*		X	X
Common Horsetail	*Equisetum arvense*	X	X	X
Common Plantain	*Plantago major*		X	X
Common Rush	*Juncus effusus*		X	X
Creeping Buttercup	*Ranunculus acris*	X	X	X
Curled Dock	*Rumex crispus*		X	X

Species	Scientific Name*	Forested Blocks Habitat Association	Mixed/Rural Habitat Association	Agricultural Habitat Association
False Lily-of-the-valley	*Maianthemum dilatatum*	X		
Few-seeded Bitter-cress	*Cardamine oligosperma*		X	X
Fireweed	*Epilobium angustifolium*	X		
Grasses	*Graminoid* spp.	X	X	X
Ground-ivy	*Glecoma hederacea*	X	X	
Hairy Cat's-ear	*Hypochoeris radicata*		X	X
Herb-robert	*Geranium robertianum*	X		
Japanese Knotweed	*Polygonum cuspidatum*		X	
Large-leaved Avens	*Geum macrophyllum*	X		
Large-leaved Lupine	*Lupinus sp.*		X	
Licorice Fern	*Polypodium glycyrrhiza*	X		
Mouse-ear Chickweed	*Cerastium fontanum*		X	X
Pineapple Weed	*Matricaria discoidea*		X	X
Policeman's Helmut	*Impatiens glandulifera*	X	X	
Red Clover	*Trifolium* spp.		X	X
Reed Canarygrass	*Phalaris arundinacea*	X	X	X
Ribwort	*Plantago lanceolata*		X	X
Sheep Sorrel	*Rumex acetosella*		X	X
Siberian Miner`s - lettuce	*Claytonia sibirica*	X		
Skunk Cabbage	*Lysichiton americanus*	X		
Spiny Wood Fern	*Dryopteris expansa*	X		
Stinging Nettle	*Urtica dioica*	X		
Swamp Horsetail	*Equisetum fluviatile*	X		
Sword Fern	*Polystichum munitum*	X		
Western Dock	*Rumex occidentalis*		X	X
Youth-on-age	*Tolmiea menziesii*	X		
Mosses:				
Haircap Moss	*Polytrichum* spp.	X		
Lanky Moss	*Rhytidiadelphus loreus*	X		
Pipecleaner Moss	*Rhytidiopsis robusta*	X		
Rock Moss	*Racomitrium* spp.	X		
Sphagnum Moss	*Sphagnum* spp.	X		

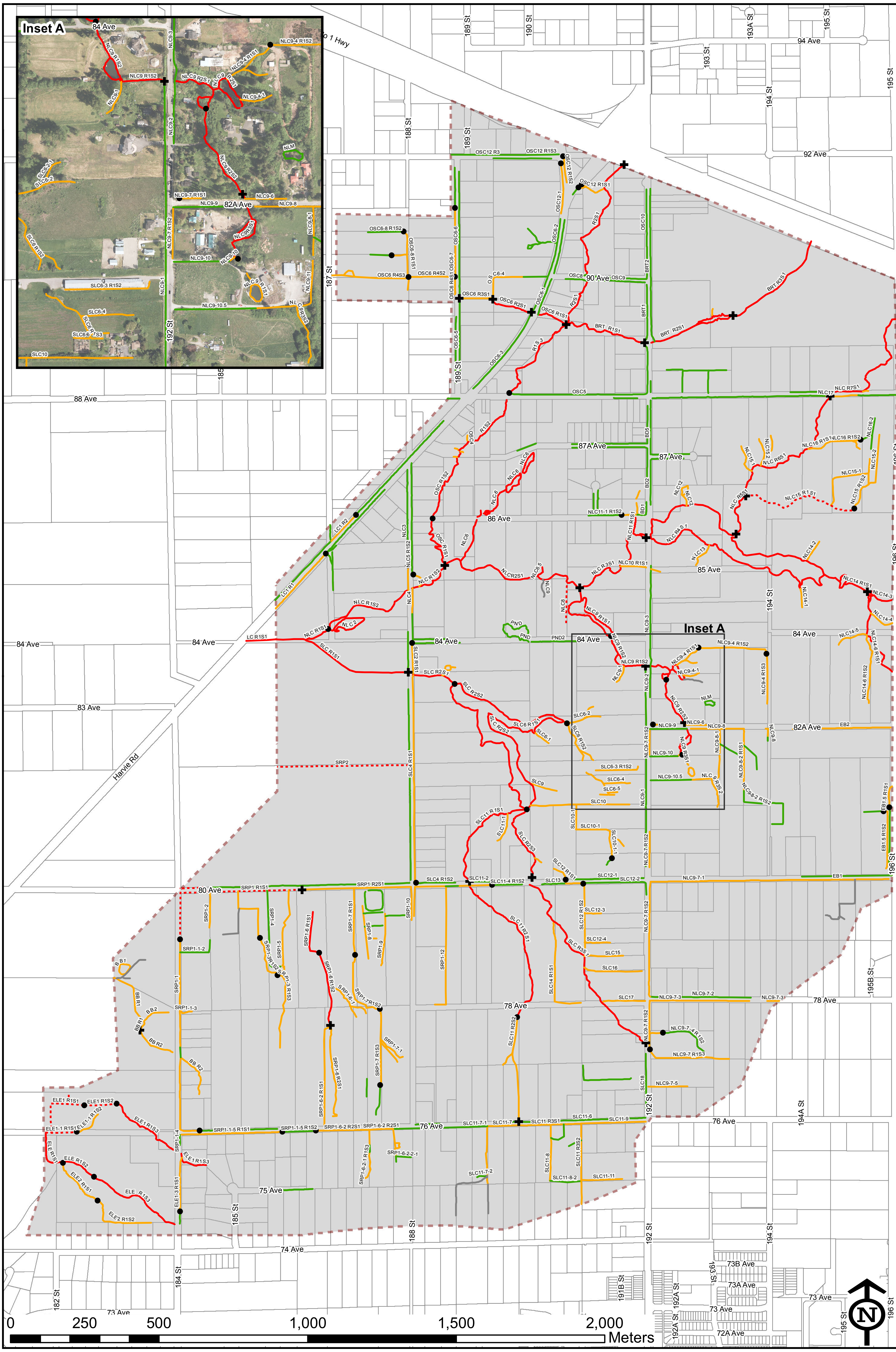
[1] Tree Layer: Woody plants >2m in height
[2] Shrub Layer: Woody plants 0-2m in height
*Scientific and common names from Klinkenberg 2006 (E-Flora BC)

Wildlife species detected within the study area (July 16, 2010).

Species	Scientific Name	Forested Blocks Habitat Association	Mixed/Rural Habitat Association	Agricultural Habitat Association
Birds:				
American Robin[1, 2]	*Turdus migratorius*	X	X	X
Bewick's Wren[1, 2]	*Thryomanes bewickii*	X		
Black-capped Chickadee[1, 2]	*Poecile atricapillus*	X	X	
Brown Creeper[1]	*Certhia americana*	X		
Dark-eyed Junco[1, 2]	*Junco hyemalis*	X	X	
Great Blue Heron[2]	*Ardea herodias fannini*			X
Hairy Woodpecker[1, 2]	*Picoides villosus*	X		
House Finch[1, 2]	*Carpodacus mexicanus*		X	
Mallard[2]	*Anas platyrhynchos*		X	X
Northern Flicker[1, 2]	*Colaptes auratus*		X	
Northwestern Crow[1, 2]	*Corvus caurinus*		X	X
Pileated Woodpecker[3]	*Dryocopus pileatus*	X		
Red-tailed Hawk[12]	*Buteo jamaicensis*			X
Song Sparrow[1, 2]	*Melospiza melodia*		X	
Mammals:				
Coast Mole[4]	*Scapanus orarius*		X	
Coyote[5, 6]	*Canis lantrans*	X		
Eastern Cottontail[2]	*Sylvilagus floridanus*		X	
Eastern Grey Squirrel[1,2]	*Sciurus carolinensis*	X	X	
Amphibians:				
Red-legged Frog[?]	*Rana araura*		X	
Invertebrates:				
Banana Slug[2]	*Ariolimax columbianus*	X		
Chocolate Arion[2]	*Arion rufus*	X	X	

[1]Heard [2]Seen [3]Forage Sign [4]Mounds [5]Tracks [6]Scats [?]Not verified – animal observed at a distance

Appendix F Latimer Creek SHIM Study Maps (Enkon Environmental Ltd.)



Legend

ENKON watercourse classification

- Class A
- Class A(O)
- Class B
- Class C
- No visible channel
- Study area boundary
- Property boundary
- Reach break
- Segment break

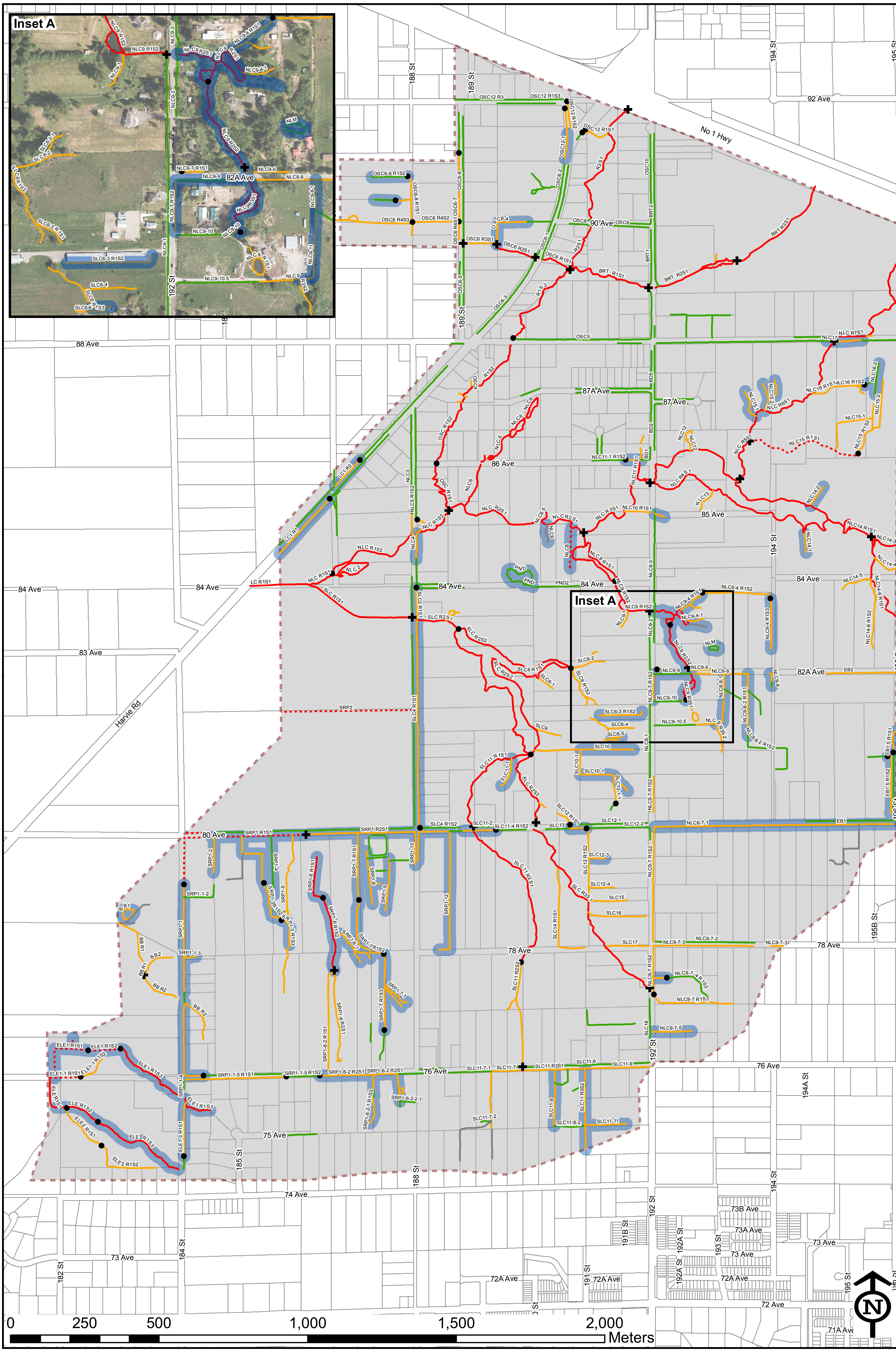
Prepared by:
ENKON
Environmental Ltd.

Map Created February 15, 2012
by: M. Tutsch
NAD 83, Zone 10N

Latimer Creek SHIM Study Area

Figure 1

City of Surrey



Legend

ENKON watercourse classification

- Class A
- Class A(O)
- Class B
- Class C
- No visible channel
- New, moved, or reclasified
- Study area boundary
- Property boundary
- Reach break
- Segment break

Prepared by: ENKON Environmental Ltd.

Map Created February 15, 2012
by: M. Tutsch
NAD 83, Zone 10N

New, Moved, or Reclassified Watercourses

Figure 2

City of Surrey

Statement of Qualifications and Limitations

The attached Report (the "Report") has been prepared by AECOM Canada Ltd. ("Consultant") for the benefit of the client ("Client") in accordance with the agreement between Consultant and Client, including the scope of work detailed therein (the "Agreement").

The information, data, recommendations and conclusions contained in the Report (collectively, the "Information"):

- is subject to the scope, schedule, and other constraints and limitations in the Agreement and the qualifications contained in the Report (the "Limitations")
- represents Consultant's professional judgement in light of the Limitations and industry standards for the preparation of similar reports
- may be based on information provided to Consultant which has not been independently verified
- has not been updated since the date of issuance of the Report and its accuracy is limited to the time period and circumstances in which it was collected, processed, made or issued
- must be read as a whole and sections thereof should not be read out of such context
- was prepared for the specific purposes described in the Report and the Agreement
- in the case of subsurface, environmental or geotechnical conditions, may be based on limited testing and on the assumption that such conditions are uniform and not variable either geographically or over time

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- as required by law
- for use by governmental reviewing agencies

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