TETRA TECH EBA

OQM | Organizational Quality Management Program

OCEAN BLUFF – CHANTRELL CREEK INTEGRATED STORMWATER MANAGEMENT PLAN (ISMP)

PRESENTED TO

City of Surrey

MAY 2015
ISSUED FOR USE
FILE: 704-V13203008-01

CONSULTING ENGINEERS & SCIENTISTS · www.eba.ca

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EXECUTIVE SUMMARY

This report presents the Integrated Stormwater Management Plan (ISMP) for the Ocean Bluff and Chantrell Creek watershed areas (the Study Area), which comprises approximately 1600 hectares and it is located between 122 Street and 152 Street and 13 Avenue to 40 Avenue in southern Surrey. It drains north into the Nicomekl River, and Mud Bay; west into Boundary Bay; and south into Semiahmoo Bay (partly through White Rock storm systems). The boundaries of the Study Area are shown in Figure R1.

The main objective of the ISMP is to provide a strategy to balance urban development and watershed health. In general, there are no major plans to develop or re-develop these areas. As re-development occurs, it would be prudent to introduce sustainability concepts regarding stormwater management, for the protection and enhancement of receiving water bodies.

This study summarizes the current conditions of the stormwater drainage system, land use, geomorphology of creeks, aquatic habitat, terrestrial habitat, and water quality. In general, the conveyance capacity of the stormwater drainage system was found acceptable according to City requirements, with a few exceptions where upgrades were recommended. Land use is expected to change little within the study area in the foreseeable future, based on the city's official community plan (OCP). As a result, the imperviousness level in the area will not change significantly in the future.

Climate change is an important aspect that needs to be considered as part of the ISMP. The City of Surrey has outlined a Climate Adaptation Strategy (Surrey, 2013) where it is recognized that changes to the current precipitation patterns are expected, such as increases in the frequency and intensity of moderate and heavy precipitation events. Again, the drainage system was assessed under extreme precipitation events through hydrologic and hydraulic modelling and it was found to perform adequately under such conditions, as required by the City in their Design Manual.

Another relevant effect of climate change relates to sea level rise (SLR). To this effect the City commissioned two separate studies, one to develop an adaptive management plan for the Crescent Beach area (Urban Systems, 2009) and the second to assess flood levels under various climate change scenarios along the Nicomekl and Serpentine River (NHC, 2012). Recommendations about how to deal with sea level rise on the Crescent Beach area were accepted by the City and some of the recommendations are already being implemented. On the other hand, the NHC study provided various water surface elevations for flood scenarios including climate change. These values were adopted and mapping of the Study Area was developed to illustrate which areas are under the expected Flood Control Levels provided by NHC. In summary, some areas along Crescent Road are shown to be potentially at risk from flooding due to SLRand protection is needed. The recommendation is to upgrade the dikes in order to provide flood protection.

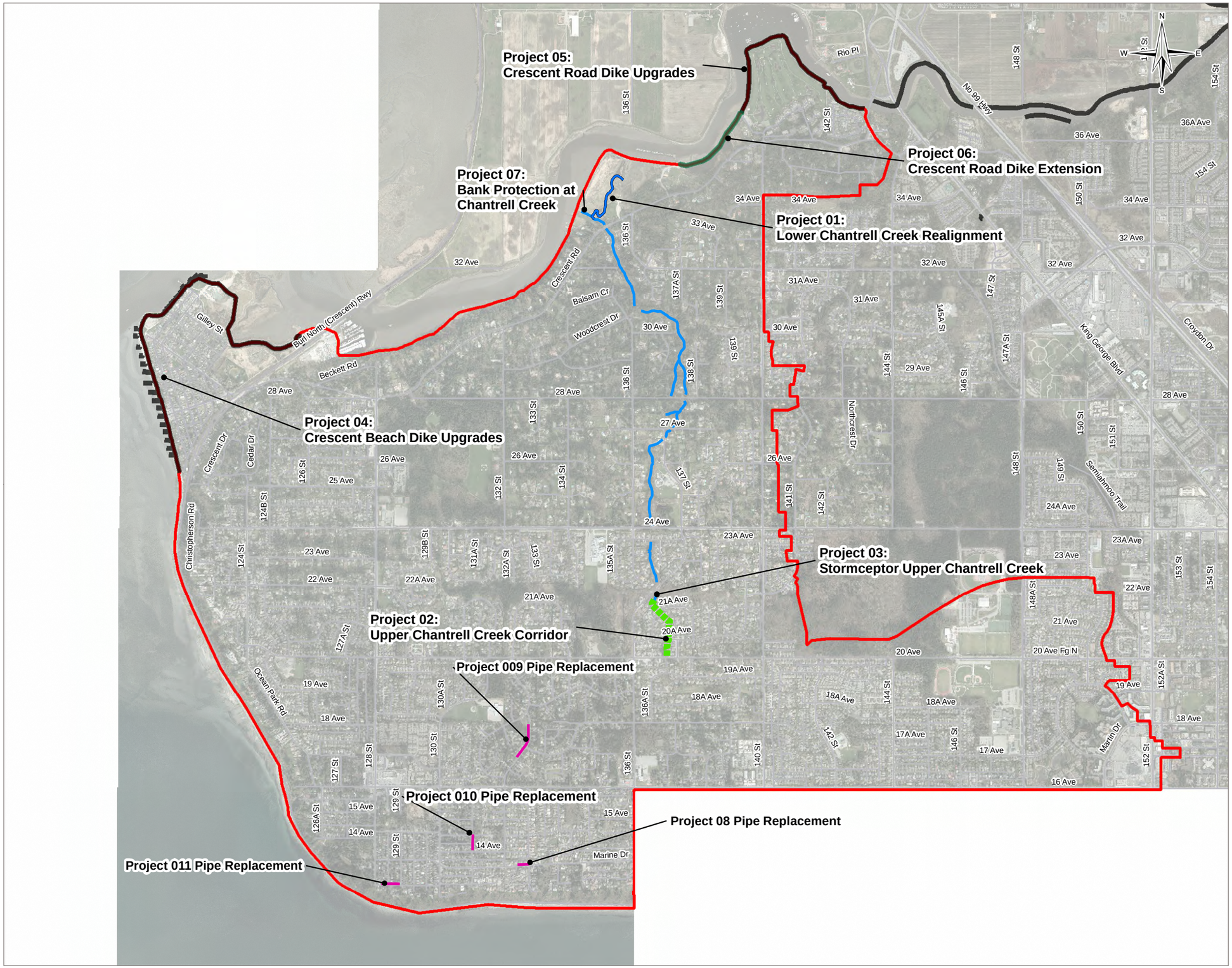
In terms of water quality, it was found that there are some parameters which exceed the guidelines, Arsenic being the most significant one. A hypothesis is that groundwater extractions, used for flow augmentation in Chantrell Creek may be the source of Arsenic. In addition, an analysis of Benthic Invertebrates data collected by the City shows that the creek has been impacted, likely by stormwater runoff discharges. To address this issue a strategy is outlined to convert the area into a "greener" community, where green infrastructure concepts with stormwater management functionality will be introduced opportunistically. Part of the strategy is to take advantage of current green spaces such as parks and green corridors where low impact development (LID) strategies can be implemented. This "greening" strategy is proposed to enhance groundwater recharge, promote controlled discharges, reducing the flashiness of runoff discharges, and improve water quality. To this effect, an opportunity was identified in the upper Chantrell Creek to convert an existing path into a green corridor with stormwater management capabilities.

Another component of the ISMP relates to aquatic, geomorphology and terrestrial habitat conditions. Following a review of available material and a site inspection of Chantrell Creek and other streams in the Study Area, it was concluded that the overall aquatic habitat conditions are currently acceptable, although some recommendations have been made regarding fish barriers and erosion sites. The most significant recommendation is the realignment of the lower part of Chantrell Creek. Currently, the last stretch of this creek, downstream of Crescent Road ends with a long culvert which is a less than desirable fish passage. The recommendation is to divert the creek away from this culvert and allow it to drain as an open channel into the Nicomekl River following a more historical course of the stream.

Stormwater management for a greener community requires on site mitigation of flows through the use of onsite landscape, and other low impact strategies. The objective of this is to control, in average, 90% of the total annual precipitation by providing:

- 420 m^3/ha of detention /infiltration capacity.
- A target release of 2 l/s/ha to the City storm system.

A summary of the proposed projects for the Ocean Bluff and Chantrell Creek ISMP are shown in Figure R1. Table R1 lists the proposed projects, including Class D cost estimates.



LEGEND

- StudyArea
- Storm Drainage Main Pipe
- Upper Chantrell Creek Green Corridor
- Dike
- Proposed Dike Extemnsion
- Chantrell Creek
- Chantrell Creek Proposed Realignment

NOTES
Base data source: All imagery and base data provided by the City of Surrey, 2012-2013.

STATUS
ISSUED FOR REVIEW

OCEAN BLUFF ISMP

Recommendations: Ocean Bluff and Chantrell Creek ISMP

PROJECTION: UTM Zone 10	DATUM: NAD83	CLIENT: CITY OF SURREY			
Scale: 1:23,585 (400 200 0 400 Meters)		TETRA TECH EBA			
FILE NO.: Report_Figures-FigR1_Lower_Chantrell.mxd					
PROJECT NO.: V13203008-01	DWN: YL	CKD: AMF	APVD: MH	REV: 0	Figure R1
OFFICE: Tt EBA-VANC	DATE: May, 2015				

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Table R1: Summary of Recommended Projects. Ocean Bluff and Chantrell Creek ISMP

Project #	Project Name/ Project Location	Class D Cost Estimate
01	**Lower Chantrell Creek Realignment** Lower part of Chantrell Creek, downstream of Crescent Road. See 4.2.1.	$1,400,000
02	**Upper Chantrell Creek Green Corridor** It starts northbound at the green corridor (gravel path) from 13741 20th Avenue; then crossing 20A Avenue, continuing north through the paved path that starts at 13729 20A Avenue until and through 21 Avenue, then turning northwest along 21 Avenue along the City's right of way, then crossing 21A Avenue and continuing through the asphalt path that leads to Chantrell Park, finally turning northeast through the park before reaching the upper end of Chantrell Creek. See 4.1.3.	$300,000
03	**Stormceptor Upper Chantrell** Manhole 1365502121, located northwest of the 21 Ave. and 21A Ave. intersection. See 4.1.4.	$50,000
04	**Crescent Beach Dike Upgrades** Raise 2.5 km of existing dike (+1.0m approx.) along Crescent Beach Shoreline. See 4.3. 11	$12,000,000
05	**Crescent Road Dyke Upgrades** Raise 1.4 km of existing dike (+0.5m approx.) along Nico-Wynd Golf Course. See 4.3.2.	$2,500,000
06	**Crescent Road Dike Extension** Construct approximately 500 m of new dike (H=3.5m) along shoreline from 35 Avenue to 13954 Crescent Road. See 4.3.2.	$4,000,000
07	**Bank protection at Chantrell Creek** Downstream of Crescent Road, adjacent to 13499 Crescent Road (See Table 15, Site 68-31)	$30,000
08	**Pipe Replacement** Marine Dr. and 132B St. (Figure 27), approx. 80 m length (pipe ID 1000755509). See 4.4.	$120,000
09	**Pipe Replacement** Amble Green Blvd and Amble Wood R. (Figure 28), approx. 230 m length (pipe ID 1000736515; 1000736534). See 4.4.	$350,000
10	**Pipe Replacement** 131 St and 14 Ave (Figure 29), approx. 95 m length (pipe ID 1000756215, 1000756133, u/s MH 1310001413)	$120,000
11	**Pipe Replacement (pipe ID 1001166915; 1001166965)** 13 Ave. and 128A St. (Figure 30), approx. 115 m length (pipe ID 1001166942; 1001166965) . See 4.4.	$150,000

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LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of City of Surrey and their agents. Tetra Tech EBA Inc. (Tetra Tech EBA) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than City of Surrey, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in Tetra Tech EBA's Services Agreement.

1.0 INTRODUCTION

Background

The City of Surrey (the City) retained Tetra Tech EBA Inc. (EBA) to develop an Integrated Stormwater Management Plan for the Ocean Bluff Chantrell Creek area (the "Study Area"). This report presents results of the current state of the study area, and the proposed plan, including an implementation strategy and a monitoring and surveillance program. The main objective of the ISMP is to provide guidance to the City to maintain or enhance the overall health of the watershed while allowing for future development or redevelopment.

Overview of the Study Area

The overall Study Area, shown in Figure 1, comprises an area of approximately 1600 ha. The Study Area is located between 122 Street and 152 Street and 13 Avenue to 40 Avenue. It drains north into the Nicomekl River, and Mud Bay; west into Boundary Bay; and south into Semiahmoo Bay (partly through the White Rock storm drainage system). Figure 2 shows the drainage basins. Most of the area is developed with suburban and urban and residential areas, and no major development or re-development is anticipated. The main stream in the Study Area is Chantrell Creek which discharges into the Nicomekl River. The soils in the watershed are predominantly silt and clay with some sand, gravel and till lenses, as shown in Figure 3.

LEGEND

- Study Area
- Storm Pipes

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NOTES
Base data source:
Orthophotos, stream networks, contours, property lines and road network supplied by the City of Surrey.

STATUS
ISSUED FOR REVIEW

OCEAN BLUFF ISMP

STUDY AREA

PROJECTION UTM Zone 10	**DATUM** NAD83	**CLIENT** CITY OF SURREY	
Scale: 1:22,000 (400 200 0 400 Meters)			
FILE NO. 20130321 Figure 1 - Study Area.mxd		eba A TETRA TECH COMPANY	
PROJECT NO. V13203008	**DWN** AMF / **CKD** AM / **APVD** MH / **REV** 0		**Figure 1**
OFFICE EBA-VANC	**DATE** March 21 2013		

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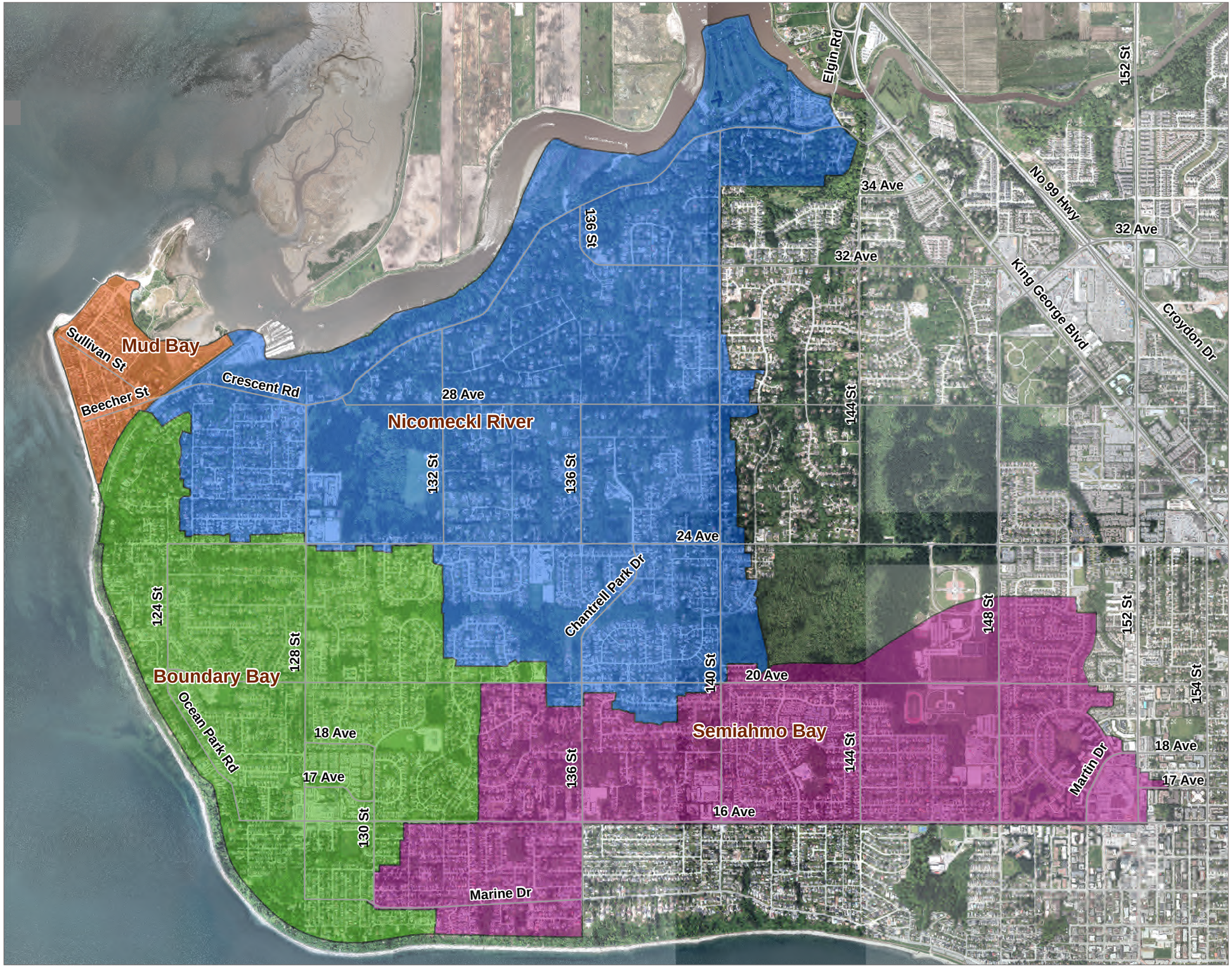

LEGEND

DrainageBasins

- Boundary Bay
- Mud Bay
- Nicomeckl River
- Semiahmoo Bay

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NOTES
Base data source:
Orthophotos, stream networks, contours, property lines and road network supplied by the City of Surrey.

STATUS
ISSUED FOR REVIEW

OCEAN BLUFF ISMP

DRAINAGE BASINS

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	CITY OF SURREY

Scale: 1:22,000
400 200 0 400
Meters

FILE NO.
20130321 Figure 2 - Drainage Basins.mxd

PROJECT NO.	DWN	CKD	APVD	REV
V13203008	AMF	AM	MH	0

OFFICE	DATE
EBA-VANC	March 21 2013

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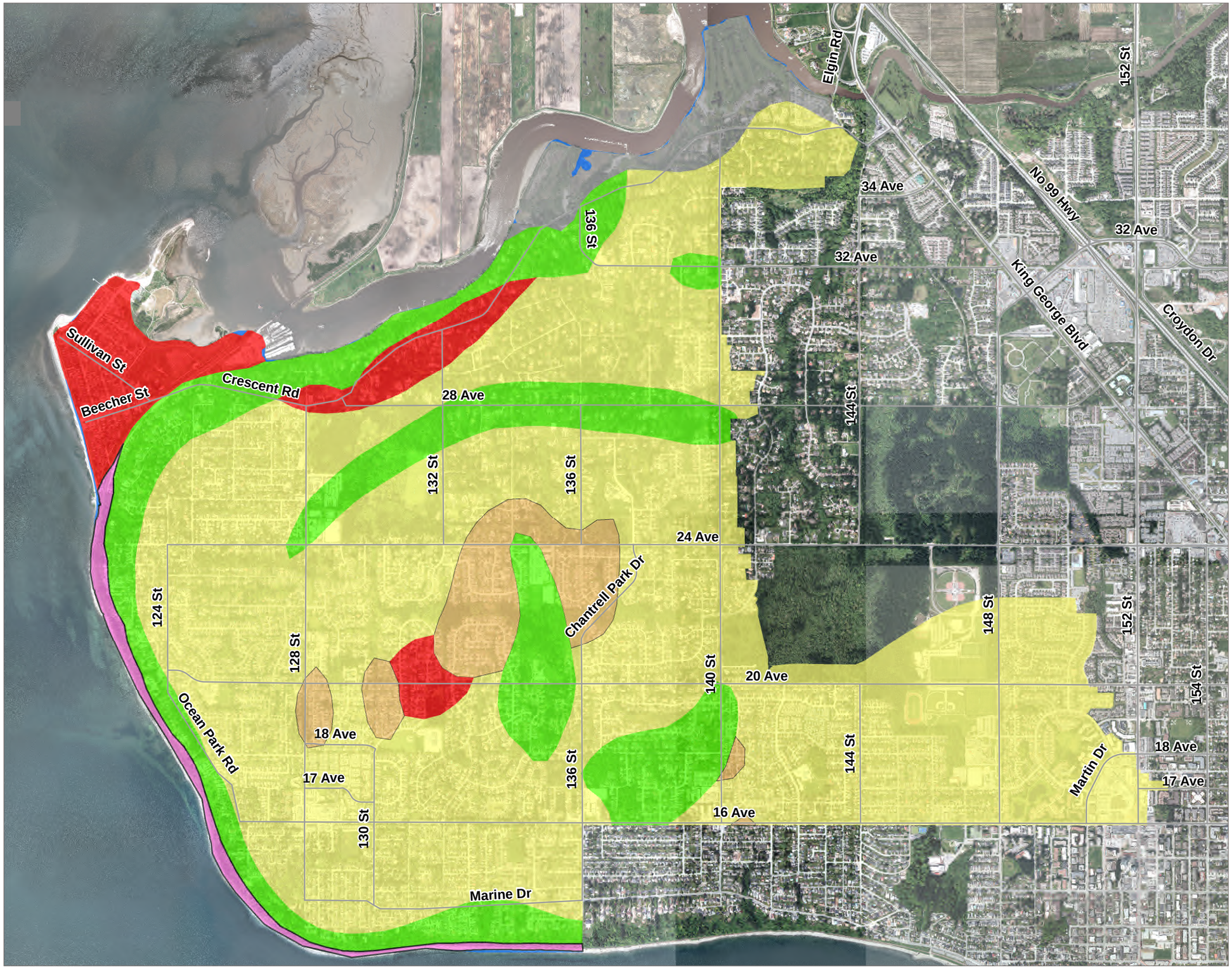
Figure 2

Q:\Vancouver\Engineering\V132\Projects\V13203008 Ocean Bluff ISMP\SPBGIS\20130321 Figure 2 - Drainage Basins.mxd modified 6/9/2014 by mauricio.herrera



LEGEND

Soils

- peat
- silt and clay
- sand
- gravel and sand
- till
- steepland sediments
- water

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NOTES
Base data source:
Orthophotos, stream networks, contours, property lines and road network supplied by the City of Surrey.

STATUS
ISSUED FOR REVIEW

OCEAN BLUFF ISMP

SOILS MAP

PROJECTION	DATUM
UTM Zone 10	NAD83

Scale: 1:22,000
400 200 0 400
Meters

FILE NO.
20130321 Figure 3 - Soils Map.mxd

PROJECT NO.	DWN	CKD	APVD	REV
V13203008	AMF	AM	MH	0

OFFICE	DATE
EBA-VANC	March 21 2013

CLIENT
CITY OF SURREY

eba
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Figure 3

Q:\Vancouver\Engineering\V132\Projects\V13203008 Ocean Bluff ISMP\SPB\GIS\20130321 Figure 3 - Soils Map.mxd modified 6/9/2014 by mauricio.herrera

2.0 RECONNAISSANCE

An important step in the ISMP is to conduct a reconnaissance of the current conditions of the study area in order to understand what issues need to be addressed in order to restore, maintain and improve the overall watershed health.

2.1 Land Use in the Study Area

2.1.1 Land Use and Stormwater Management

Traditionally, land use planning and watershed management have been two separate processes. However, changes in land use, such as intensive development and removal of trees and vegetation have a measurable impact on the ability of a watershed to function in terms of both water quality and quantity. Changes in land use can create or exacerbate stormwater and drainage related problems or present opportunities to restore stream health and improve water quality.

The relationship between land use and stormwater (or rainwater) is simple. Porous or permeable surfaces allow rainwater to infiltrate the soil and be retained in the ground, be absorbed by vegetation, evaporate or recharge groundwater. Impermeable or impervious surfaces such as roads, sidewalks and buildings prevent water from reaching the soil causing it to “runoff” these surfaces and into stormwater infrastructure including pipes and drainage basins. Runoff from roads and other surfaces can bring with it contaminants and in most cases, these contaminants are collected by a system of pipes before being released back into the natural water system.

2.1.2 Study Area Land Use

2.1.2.1 Summary

The City of Surrey is one of the fastest growing municipalities in the lower mainland. Over the next 20 years, the City as whole is anticipating a population increase of approximately 172,000 new residents and will require 57,800 new residential units to accommodate this increase. Despite the rapid growth of the City, the Study Area has remained relatively stable with only modest population growth and minimal development pressure.

Within the Study Area, the Suburban and Urban Official Community Plan (OCP) designations cover 86% of the land. The northern and central residential areas of the Study Area are assigned as Suburban. The remaining residential areas have urban zoning and are mainly in the eastern, southern and western parts of the Study Area. The Suburban designation accommodates large lot single family residential development as a transition between rural and urban areas to accommodate a diversity of lifestyles. The Urban designation allows a broader range of ground oriented residential uses including single family, semi-detached and townhouse development. The Urban designation is intended to accommodate future growth of the City. However, most of this growth will take place elsewhere in Surrey particularly in the City Centre and other Town Centres. Land areas designated Conservation comprises the largest non-residential or commercial use of land within the Study Area and consists of large, undeveloped areas of land. The lands designated as Conservation are protected and are anticipated to remain free of development in the long term. Likewise, the small proportion of land in the Study Area designated Agricultural is relatively free of development and no change in use is anticipated.

The areas with the most potential for change in intensity of land use comprise the smallest portions of the Study Area, namely the Town Centre and Commercial designations. While redevelopment in these areas is anticipated, it is likely to occur incrementally over the long term.

The existing zoning of the Study Area summarized in Table 1 generally aligns with the OCP land use designations with predominantly ground oriented single family use.

Table 1: Summary of Existing Zoning in Study Area

Zone Title	Area (Acres)	Area (Hectares)	Proportion of Study Area
Ground Oriented Residential Zones	3552.8	1437.7	87.64%
Comprehensive Development Zones	195.6	79.1	4.83%
Public Zones	109.9	44.5	2.69%
Multiple Family Residential Zones	105.3	42.6	2.59%
Agricultural Zones	54.3	22.0	1.34%
Commercial Zones	35.5	14.4	0.88%
Total Study Area	**4053.2**	**1640.3**	**100.00%**

Based on the existing zoning, the predominance of low density residential land use is evident. The Suburban and Urban OCP designations support the continuation of this land use pattern into the future. The Study Area is well established and not anticipated to accommodate the majority of the influx of new residents to the City and so is likely to see little or no land use changes over the long term.

In addition, the predominance of single family residential use suggests changes in stormwater management at the individual property level holds the most potential to effect change in the Study Area. Management changes may be used to decrease stormwater flows, increase water quality and foster habitat enhancement.

2.1.2.2 Potential Land Use Changes

The demographic analysis of the Study Area indicates it is stable in terms of land use and does not face significant pressure for redevelopment. Some small areas of higher density development are anticipated, specifically around the Semiahmoo Town Centre in the southeast corner of the Study Area.

Incremental land use changes are likely to take place over the long term in the Study Area on a small scale. Typically, this would occur through rezoning to a higher density with no change in the OCP designation or through a minor OCP change at the edge of existing designations. This has occurred in previous years but at low rates and on a minor scale. An alternative approach for development would be through the revision of existing zones or the creation of new zones to address perceived needs in the Study Area. This could allow accommodation of alternative housing forms on existing properties such as coach or laneway houses and secondary suites. The Crescent Beach Land Use Plan anticipates some accommodation of future population growth in the form of additional units including coach houses on existing single family lots.

A driving factor for adding alternative housing forms to existing single family neighbourhoods is the aging demographic of the City's population. As the residential demographic ages, many will want to remain in or near their existing neighbourhoods. Housing options that accommodate aging in place, reduced or no yard maintenance, support services, and intergenerational accommodation will all offer appeal.

2.1.3 Existing Land Use

Increased development typically increases rainwater runoff, volumes, peak flows and contaminant loads. Higher volumes and faster flows often lead to surface flooding and ponding as traditional piped stormwater systems are overloaded. As a result, significant investment is required to expand the stormwater systems regularly, specifically larger pipes and a more expansive drainage system.

There are, however, alternatives to this traditional means of design. Rainwater may be dealt with at the source, maximizing ground infiltration and slowing or diverting it entirely from the man-made stormwater system. This can be achieved through source controls at the property or building level and natural infrastructure such as creeks and streams. Rainwater management can start at the property level and be incorporated into every type of land use through development policy.

Land use within the Surrey portion of the Study Area (which directly impacts the management of stormwater) is regulated by the City of Surrey Official Community Plan (OCP) and the Surrey Zoning Bylaw 12000. While the OCP designations are intended to indicate the preferred future land uses, Table 2 provides a detailed land use breakdown based on existing zoning.

Table 2: Breakdown of Study Area Zoning

Zone Title (Abbreviation)	Max Lot Coverage	Paved Surface Coverage	Area (Acres)	Area (Hectares)	Proportion of Study Area
Single Family Residential Zone (RF)	40%	*	1398.7	566.0	34.51%
One Acre Residential Zone (RA)	20%	*	1105.9	447.5	27.28%
Half-Acre Residential Gross Density Zone (RH-G)	25%	*	693.1	280.5	17.10%
Comprehensive Development Zone (CD)			195.6	79.1	4.83%
Acreage Residential Gross Density Zone (RA-G)	20%	*	182.6	73.9	4.50%
Half Acre Residential Zone (RH)	25%	*	140.4	56.8	3.46%
Multiple Residential 15 Zone (RM-15)	45%	*	74.3	30.1	1.83%
General Agricultural Zone (A-1)	N/A	N/A	54.3	22.0	1.34%
Golf Course Zone (CPG)	10%	N/A	47.6	19.3	1.17%
Assembly Hall 1 Zone (PA-1)	35%	*	40.6	16.4	1.00%
Community Commercial Zone (C-8)	50%	*	23.3	9.4	0.58%
Multiple Residential 45 Zone (RM-45)	45%	*	23.2	9.4	0.57%
Duplex Residential Zone (RM-D)	33%	*	21.1	8.5	0.52%
Marina Zone (CPM)	40%	N/A	11.4	4.6	0.28%
Assembly Hall 2 Zone (PA-2)	40%	*	7.9	3.2	0.19%
Single Family Residential Oceanfront Zone (RF-O)	25%	*	7.8	3.2	0.19%
Neighborhood Commercial Zone (C-5)	50%	*	6.9	2.8	0.17%
Multiple Residential 30 Zone (RM-30)	45%	*	5.7	2.3	0.14%
Single Family Residential (9) Zone (RF-9)	52-60%	30%	2.8	1.1	0.07%
Special Care Housing 2 Zone (C-5)	45%	*	2.2	0.9	0.05%
Combined Service Gasoline Station Zone (CG-2)	30%	*	2.1	0.9	0.05%
Multiple Residential 10 Zone (RM-10)	40%	*	2.1	0.8	0.05%
Local Commercial Zone (C-4)	40%	*	1.7	0.7	0.04%
Highway Commercial Industrial Zone (CHI)	50%	*	1.5	0.6	0.04%
Single Family Residential (12) Zone (RF-12)	50%	30%	0.4	0.2	0.01%
Child Care Zone (CCR)	40%	*	0.2	0.1	0.00%
Total Study Area			4053.2	1640.3	100.00%

* Requires that all developed portions of the lot not covered by buildings, structures or paved areas shall be landscaped including the retention of mature trees. This landscaping shall be maintained.

Low density residential use in the form of large lot, single family development comprises over 87% of the existing land use in the Study Area. Single Family Residential zoning makes up the highest proportion with almost 35% of the land area designation for this use. One Acre Residential and Half Acre Residential Gross Density zoning are the next largest proportions of land use with 27% and 17%, respectively. The maximum lot coverage, or the maximum lot area covered by buildings and other impermeable (impermeable) in each of these three zones is 20 to 40%.

Generally, the residential zones do not have a requirement for maximum paved surface coverage. The exceptions are the Single Family Residential 9 and 12 zones, which have a maximum of 30% of paved coverage. While these zones allow the highest maximum lot coverage of any of the zones in the Study Area, they also comprise a negligible part of the total Study Area (<0.1%).

The Crescent Beach area which has its own Land Use Plan, has some of the smallest properties in the Study Area. These average 1/8 of an acre, or approximately, 500 sq. meters. This area also has a significant concentration of buildings on the City's Heritage Register which limits the desirability and potential for redevelopment.

2.1.4 Future Land Use

The Surrey OCP is intended to guide land use and development in the City over the next 5 to 20 years and was last updated in 2010. Table 3 provides a summary of the different land use designations as specified in the OCP for the Study Area. Figure 4 shows the OCP designations of the Study Area.

Table 3: Breakdown of Study Area Existing Land Use by OCP Designation

OCP Designation[1]	Area (Acres)	Area (Hectares)	Proportion of Study Area
Suburban[2]	1,876	759	46.3%
Urban	1,607	650	39.7%
Conservation	325	131	8.0%
Multiple Residential	95	39	2.4%
Agricultural	91	37	2.2%
Town Centre	30	12	0.7%
Town Centre	30	12	0.7%
Commercial	25	10	0.6%
Total Study Area	4,048	1,638	100.0%

The Suburban designation applies to approximately 759 hectares and makes up the largest proportion of land use within the Study Area (46.3%). This designation is intended to support semi-rural and suburban lifestyle and is characterized by a range of larger sized lots for single family use with a half-acre gross density or larger. The OCP states that for Suburban designated areas with full services, the minimum lot area may be reduced to 0.2 hectare (1/2 acre), including gross density subdivision, if allowed in a Neighbourhood Concept Plan (NCP).

The Urban designation encompasses some 650 hectares and represents the second largest proportion of the Study Area (40%). This designation is intended to provide for the development of self-contained urban communities. Zoning uses permitted under this designation include ground oriented housing in a wide range of urban densities as well as semi-detached and townhouse residences. The Urban designation also allows local

[1] Road designation included in overall designations within Surrey.
[2] Suburban designation within Surrey includes areas for Parks and Open Space.

commercial uses and public amenities such as elementary schools and parks. The Suburban and Urban designations combined apply to a total of 86% of the Study Area.

Blackie Spit, Crescent Park, Kwomais Point Park and a portion of Sunnyside Acres Urban Forest make up the Conservation designation in the Study Area. This designation provides for major parks, open spaces and environmentally sensitive areas in their natural state, including appropriate indoor and outdoor recreation activities and facilities. This designation applies to 131 hectares or 8% of the land within the Study Area.

Of the residential land use designations, Multiple Residential is the smallest proportion, with only 2.4% of the land area or 39 hectares designated as such. This designation is intended for areas around Town and Neighbourhood Centres, other centres including colleges and along the major transit corridor where higher residential density is appropriate. Within the Study Area, there are four locations where the Multiple Residential designation applies. The first of these is located immediately adjacent to the Nico Wynd Golf Course and is part of the same development; the second is located adjacent to the western boundary of Crescent Park; the third surrounds the Ocean Park commercial area; and the fourth is part of the Semiahmoo Town Centre in the northeast (in Surrey).

The small proportion of the Study Area designated Agricultural (2.2%) is within the Agricultural Land Reserve (ALR) and located in the northern portion of the Study Area abutting the Nicomekl River. This designation is intended to protect areas suitable for agriculture. The use of this land consists of the Nico Wynd Golf Course and Elgin Heritage Park, home to the historic Stewart Farm.

The Town Centre designation which comprises only 12 hectares of the Study Area is part of the Semiahmoo Town Centre. This designation is intended for the development of a single dominant, mixed use and moderate density centre. This area, including the Multiple Family Residential designation discussed above, is subject to the Semiahmoo Town Centre Plan which is currently being updated.

The Commercial designation within the Study Area applies to only two areas totalling 10 hectares, Crescent Beach along Beecher Street and the Ocean Park commercial area located at 128 Street and 16th Ave. The Commercial designation is intended for commercial developments which include the form of small-scale mixed use centres such as Neighbourhood Centres.

No lands within the Study Area are designated for Industrial use.

2.1.5 Population Growth Estimates

Generally, pressures such as population growth lead to an increase in development and density. This in turn can fundamentally affect the function of a watershed and the ability to manage stormwater through an increase in impermeable surface area. A demographic analysis of the City of Surrey in general and the Study Area specifically identified the following (Table 4):

- Between the 2006 and 2011 census, the population of the City of Surrey increased from 394,976 to 468,251, an increase of nearly 19%.
- While the increase in the overall population of the City of Surrey has been significant, the number of people living in the Study Area increased by only 216 people for a total of 25,772 between the 2006 and 2011 census This represents a 0.85% increase.
- The Study Area population in 2011 represents 5.5% of the total in the City of Surrey. This proportion represents a decline from 6.5% in 2006 and is expected to continue to decline in the future as growth continues outside the Study Area.

- An increase in population is typically accompanied by an increase in the number of private dwellings. Census data for the Study Area indicates the modest population change was accommodated mostly in single detached dwellings which increased by 200 units between the 2006 and 2011 census years.
- Growth is projected to take place in Grandview Heights, North Grandview Heights, Rosemary Heights, Douglas and Semiahmoo Town Centre for South Surrey over the next 10 to 20 years. It is estimated these areas have the potential capacity for 30,000 residents. With the exception of a small portion of the Semiahmoo Town Centre, these areas are all outside the Study Area.
- With the exception of the Semiahmoo Town Centre none of the areas anticipated to accommodate Surrey's rapid population growth are within the Study Area.

The City population projections estimate a total population of 581,780 by the year 2021 and 667,200 by the year 2031, pf which, South Surrey will contribute 97,570 and 114,180 respectively. The OCP anticipates the majority of Surrey's future growth will be located within the OCP Urban land designation (which makes up almost 40% of the Study Area) and will include infill development of vacant lands through subdivision, the establishment of neighbourhood concept plans (NCPs) to increase density and redevelopment of older housing stock in established urban areas. The majority of residential growth over the next 10-15 years will be located within the City's NCP areas. The urban infill development capacity of South Surrey is estimated at 81 hectares (200 acres). However, it is important to note there are currently no NCPs planned or in progress within the Study Area nor is there any rapid transit, existing or proposed. Given this information, the Study Area is considered to have limited capacity to accommodate the projected population growth. Only some small urban infill areas are identified within the Study Area.

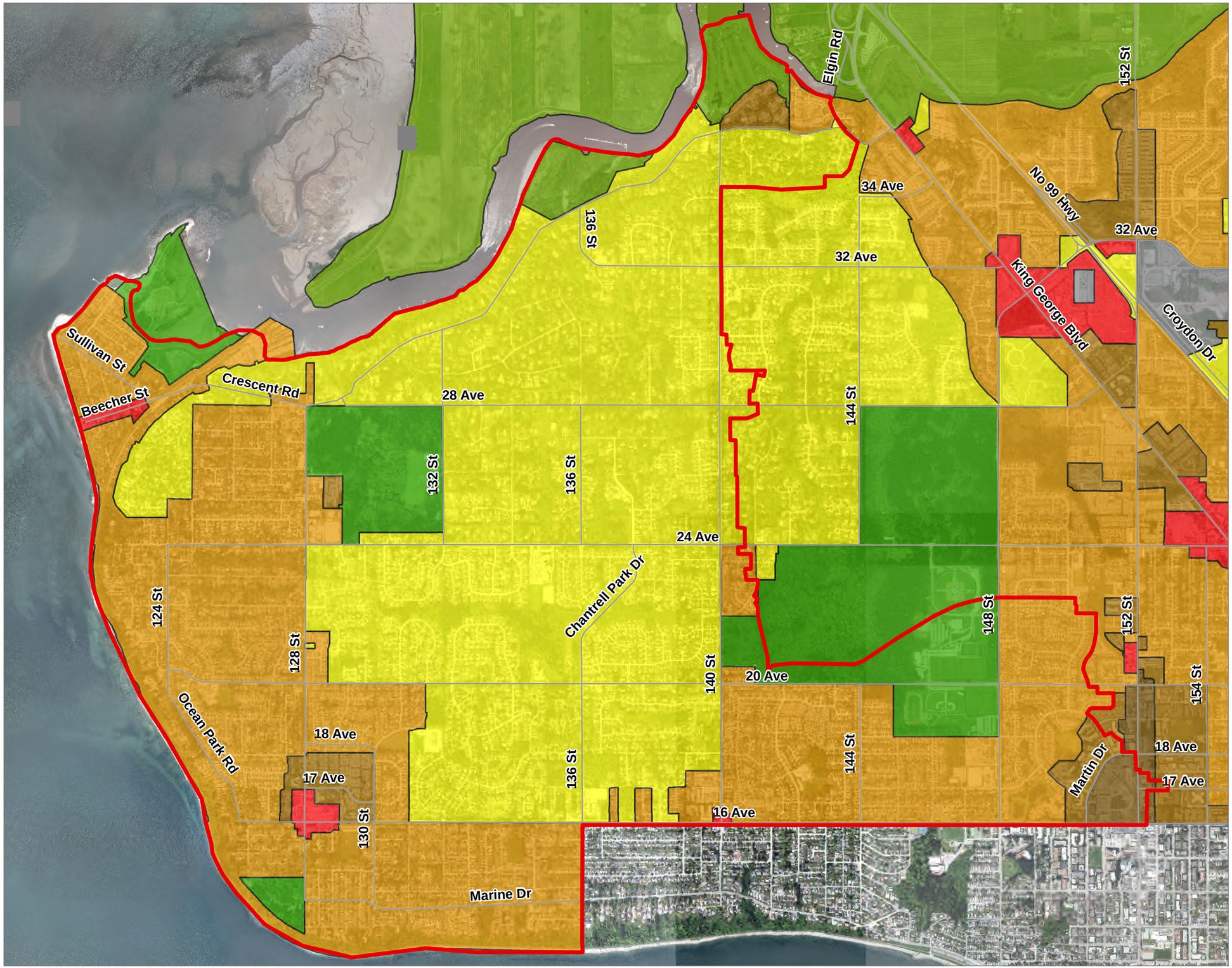
The Suburban designation which makes up over 46% of the land use in the Study Area provides some reserve for future development but limited dwelling capacity. Although the dwelling capacity of the Suburban designation is difficult to estimate, the OCP anticipates that about 2,000 new single family dwellings could be constructed within the Suburban designation for the entire City over the next 20 years. It is likely only a very small proportion of this will be located in the Study Area.

Table 4: Population and Residential Land Use Summary

Indicator	2006 Census	2011 Census	Change
City of Surrey Total Population	394,976	468,251	19%
Study Area Population[3]	25,556	25,772	0.85%
Study Area Total Private Dwellings	9,905	10,120	+215 units[4]
▪ Single Detached House	6,925	7,125	+200 units
▪ Apartment, fewer than 5 stories	1,745	1,785	+40 units
▪ Rowhouse	415	430	+15 units
▪ Semi-detached House	390	390	N/C
▪ Apartment, Duplex	410	380	-30 units
▪ Other Single-attached House	10	5	-5 units
▪ Movable Dwelling	0	5	+5 units
▪ Apartment, more than 5 stories	5	0	-5 units

[3] Approximate based on Census Tract boundaries
[4] Total unit numbers do not add up due to census rounding.

The minimal population growth of the Study Area in comparison to the rest of Surrey reflects the exceptional stability of the area within a City that is growing rapidly. A major factor in this stability is the location, as the area is surrounded by water or agricultural land on three sides. Another important factor is its physical isolation from the more urban areas of Surrey. The historic development pattern and the strong desire to retain its distinctive assets is also a critical guiding element.



LEGEND

OfficialCommunityPlan

- City Centre
- Town Centre
- Commercial
- Business
- Industrial
- Multiple Residential
- Urban Residential
- Suburban Residential
- Rural
- Agricultural
- Conservation
- Indian Reserve
- StudyArea

N W E S

NOTES
Base data source:
Orthophotos, stream networks, contours, property lines and road network supplied by the City of Surrey.

STATUS
ISSUED FOR REVIEW

OCEAN BLUFF ISMP

OFFICIAL COMMUNITY PLAN

PROJECTION UTM Zone 10				**DATUM** NAD83	**CLIENT** CITY OF SURREY
Scale: 1:22,000 400 200 0 400 Meters					
FILE NO. 20130321 Figure 4 - Official Community Plan.mxd					eba A TETRA TECH COMPANY
PROJECT NO. V13203008	**DWN** AMF	**CKD** AM	**APVD** MH	**REV** 0	**Figure 4**
OFFICE EBA-VANC	**DATE** March 21 2013				

Q:\Vancouver\Engineering\V132\Projects\V13203008 Ocean Bluff ISMP\SPB\GIS\20130321 Figure 4 - Official Community Plan.mxd modified 6/9/2014 by mauricio.herrera

2.2 Inventory of the Drainage System

The Study Area is serviced with municipal storm pipes, ditches, swales and natural streams. There is a pump station (Maple Drainage Pump Station) and a floodbox at the outlet of the tidally influenced Dunsmuir Channel located in the Crescent Beach area. The total length of storm pipes within the Study Area is approximately 156 km with diameters ranging from 100 mm to 2.4 m. About 62% of the total length of pipes lies between 250 mm to 450 mm in diameter. There are 30 stormwater detention facilities within the Study Area including ponds, underground tanks and storage pipes. Figure 5 shows a map of the drainage infrastructure in the Study Area, including manholes, storage units, storm mains, and the drainage subcatchments from the City's GIS system.

The existing streams can be summarized as follows:

1. Chantrell Creek: Originates north of 21A Avenue at the Chantrell Park, spanning a total length of approximately 2.38 km with an average gradient of 3.4% before discharging into the Nicomekl River. The only flow monitoring station within the Study Area is installed in this creek at 32 Avenue.

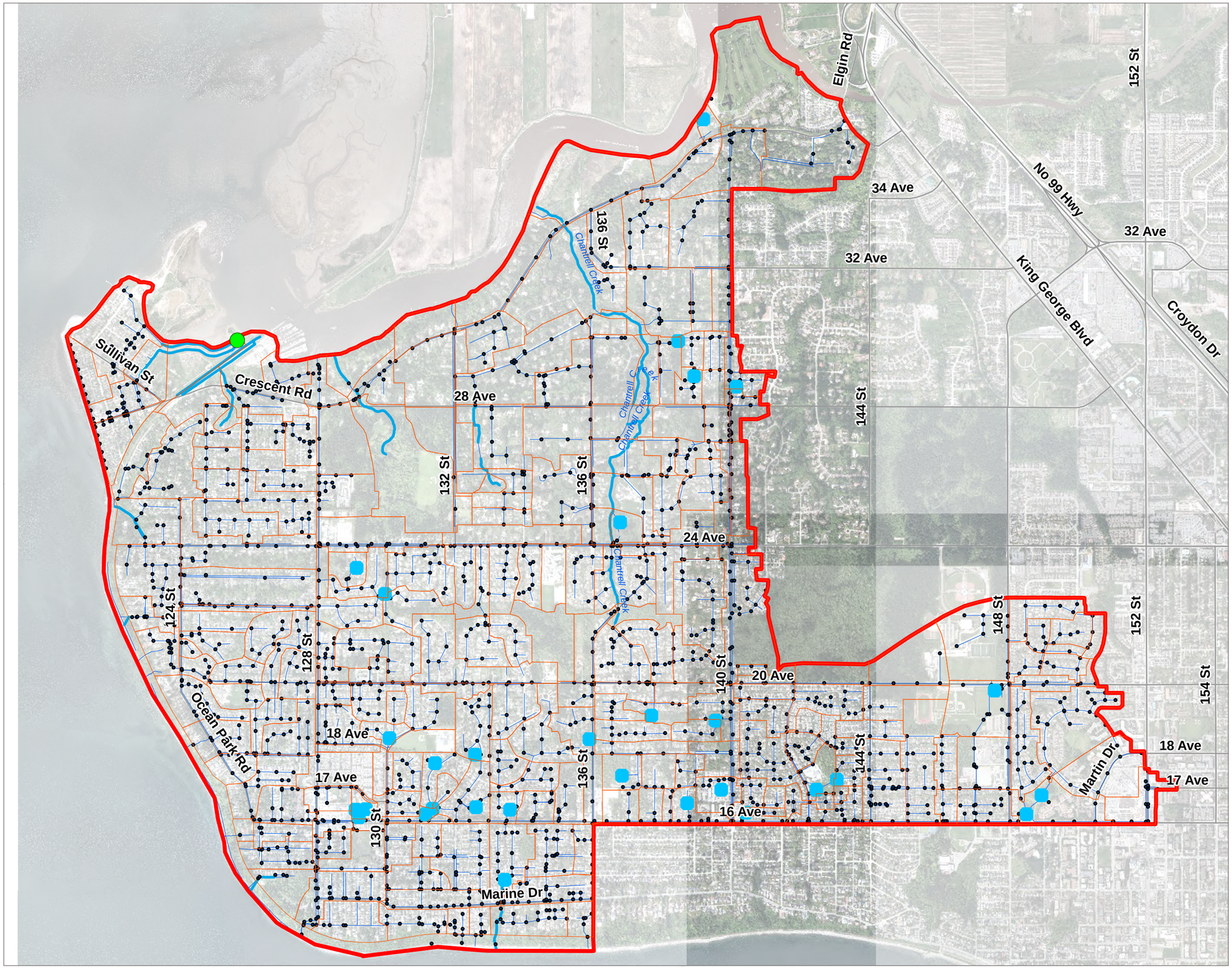
2. Dunsmuir Channel: Located in the Crescent Beach area, it is tidally influenced and with a length of approximatly 700 m and an average gradient of 0.014%. It discharges to Mud Bay via a floodbox and the Maple Drainage Pump Station, which is provided with an ultrasound water level sensor.

3. Crescent Park Watercourse: Originates in Crescent Park and discharges into the Nicomekl River. Spans a total length of approximately 700 m and has an average gradient of 10%.

4. Knudson Creek: Originates south of 14A Avenue, between 132B Street and 134 Street. It drains south towards Semiahmo Bay, spanning a total length of 320 m with an average gradient of 20%.

5. Various unnamed Watercourses: There are several minor watercourses in the Study Area which are described to some extent in the environmental inventory (Section 5.1).

As noted in the review of background reports, there have been significant improvements to the drainage infrastructure in the last few years, and more works are also underway in the Crescent Beach area. According to City staff, there are no major drainage issues currently in the Study Area.



LEGEND

- Pump Station & Floodbox
- Subcatchments
- Stormwater Detention Facilities
- Streams
- Manholes
- Storm Mains
- StudyArea

N
W E
S

NOTES
Base data source:
Orthophotos, stream networks, contours, property lines and road network supplied by the City of Surrey.

STATUS
ISSUED FOR REVIEW

OCEAN BLUFF ISMP

DRAINAGE INFRASTRUCTURE

PROJECTION	DATUM
UTM Zone 10	NAD83

Scale: 1:22,102
400 200 0 400
Meters

FILE NO.
20130321 Figure 5 - Drainage Infrastructure.mxd

PROJECT NO.	DWN	CKD	APVD	REV
V13203008	AMF	AM	MH	0

OFFICE	DATE
EBA-VANC	March 21 2013

CLIENT
CITY OF SURREY

eba
A TETRA TECH COMPANY

Figure 5

Q:\Vancouver\Engineering\V132\Projects\V13203008 Ocean Bluff ISMP\SPB\GIS\20130321 Figure 5 - Drainage Infrastructure.mxd modified 6/10/2014 by mauricio.herrera

2.3 Existing Geomorphological Conditions

Fieldwork on the Chantrell Creek / Ocean Bluff watershed was carried out by Mr. Jamie Stirling, M.Sc., P.Geo. on September 19 and October 24, 2012. The focus on this site visit was to identify and evaluate current conditions in the watershed from a creek stability and slope stability perspective. The 2011 Ravine Stability Assessment Data Sheets by Web Engineering Ltd. were used as a guideline for the assessment. The intent was to visit each of the sites identified in the Web report and document if changes to the sites have occurred since the 2011 report and to identify any new sites of instability or other features that would be of interest to the City.

The results of the stability assessment for the watershed are summarized in Appendix A, including location maps of the sites (Figure A1 to Figure A25). A general map showing overall vicinity of the sites is also included in Appendix A. Existing sites are referenced by their previous identification number (e.g., 72-15). In Table A, existing sites are referenced to photo numbers with a description of site conditions. New sites are labelled “new” and referenced to their photo number with a description of site conditions. On the figures, new sites are referenced by their corresponding photo number. All of the sites (existing and new) are categorized into one of four creeks in the watershed (Chantrell Creek, 132 Street Creek, 128 Street Creek and Knudson Creek) or the Ocean Bluffs area. Photos of each existing and new site that were identified during the field investigation are provided on the CD attached to this report. For visual comparison and wherever practical, the 2012 photos of existing sites were taken from the same position as the 2009 and 2011 photos in the Web report.

In general, the previously identified sites in the 2009 and 2011 assessments were found to be unchanged in this 2012 assessment. Some erosion sites had been fortified with bank protection in the form of riprap or gabion baskets. Some of the minor bank erosion and/or slope failure sites reported by Web Engineering Ltd. were not detectible during the 2012 assessment. This could be due to the small scale of the site, vegetative growth or the inaccuracy of coordinates recorded with the handheld GPS device.

Chantrell Creek, 132 Street Creek, 128 Street Creek and Knudson Creek were walked in their entirety between the previously identified points, with the exception of a few small sections where the creek was inaccessible or too small to justify ground truthing. Chantrell Creek was walked for a significant distance upstream of the most upstream point as shown in Figure A5 to Figure A7. The field investigation consisted of a visual inspection of the creeks, ravine slopes and bluff slopes. The inspection occurred from the creek and ravine valley bottom to the toe of the bluffs. Detailed inspections of the slopes, including their crests, were not carried out as the visual inspection was limited to what could be seen from the toe of the slopes. Ideally, such detailed inspections would occur during the winter months when the vegetation provides minimal visual obstruction.

Several new sites were identified in the creeks and on the bluff. However, these sites were not limited to eroding banks and slope instabilities. This investigation also included features such as bank protection, fish ladders, culverts, and bridges. It was assumed that these features would be of interest to the City and will be included in the inventory database. It is also important that these structures be properly documented, as they can represent potential hazards should they become blocked, damaged or collapse. None of the new creek sites documented represent a high hazard and therefore no immediate mitigation or further detailed study is required.

Assessing the slope failures on Ocean Bluffs was also challenging, as many of the sites were located part way up the slope, near the crest, or on private property. These sites were difficult to view from the beach due to the forest canopy. A detailed study is recommended to determine if these slope instabilities have changed since the previous assessment. This would involve accessing the right of way on the railway, and private residential properties as well as and traversing the steep and densely vegetated bluff slopes at each site.

The field investigation and the subsequent mapping of the newly identified sites in Figure A1 to Figure A25 demonstrate that the creek alignments provided in the City of Surrey base mapping is not always accurate.

For example, the location of 128 Street Creek, as confirmed the field, is quite different from that provided by the City mapping database. To avoid confusion on the figures, Tetra Tech EBA did not adjust the creek alignments to reflect the actual creek position. Therefore, there are many instances where the location of the 2012 site photo or existing site number in the creek does not actually line up with the creek alignment shown on the figures.

2.4 Environmental inventory

Tetra Tech EBA biologists reviewed relevant background documents as part of the assessment of aquatic habitats, water quality sampling, vegetation and terrestrial habitats, and riparian corridors. Background information obtained allowed the biophysical reconnaissance to focus on areas of known or anticipated areas of high, moderate or low values.

Subsequently, field reconnaissance of the Study Area was undertaken to verify information gathered from existing sources.

2.4.1 Aquatic Habitat Reconnaissance

Information on potential fish and fish habitat was obtained through a thorough review of available ancillary information, including GIS data from the City of Surrey's Mapping Online System COSMOS (Appendix B), the Ministry of Environment's (MOE) HabitatWizard (Appendix C), Fisheries Information Summary System FISS (Appendix D), the Conservation Data Centre's (CDC) internet mapping service, iMap, (Appendix E) and Species and Ecosystems Explorer database (Appendix F); and the Species at Risk Act (SARA) Registry.

The City classifies watercourses according to the following criteria:

- Class A – red coded are fish-bearing watercourses year round.
- Class AO – red-dashed coded are fish-bearing during the overwintering period.
- Class B – orange coded are non-fish-bearing, but provide water, food and nutrients to Class A or AO watercourses.
- Class C – green coded are not fish-bearing and are not considered fish habitat.
- Blue coded are unclassified watercourses.

Chantrell Creek is Class A watercourse from the confluence with the Nicomekl River upstream as far as 22 Avenue. Other Class A watercourses include the Dunsmuir Channel at Blackie Spit Park and four unnamed tributaries to the Nicomekl River between 132 Street and 32 Avenue, all occurring north of Crescent Road on a steep north-facing slope. A number of unnamed Class B watercourses were identified, including one originating at a pond in Crescent Park which flows into the Nicomekl River, and another downstream of 14 Avenue and between 132B Street and 133A Street, crossing Marine Drive down a steep south-facing slope at the south end. Several others are mapped along the south and west facing slopes and discharging directly into the marine environment.

A search of the CDC iMap system did not produce any known occurrences of fish species at risk. However, the BC Species and Ecosystems Explorer identified three fish species at risk. As only the blue-listed coastal cutthroat trout's habitat requirements could be met near or within the Study Area, it is therefore the only expected fish species at risk.

Tetra Tech EBA conducted aquatic habitat reconnaissance on September 27 and October 24, 2012. The purpose of this reconnaissance was to update previous stream habitat and fish presence information through identification of potential barriers to fish migration, areas of spawning or rearing, non-fish-bearing locations, and areas where

mitigation and/or enhancement opportunities exist. Reconnaissance efforts were primarily focused on Chantrell Creek, the unnamed Class B watercourse in Crescent Park and Dunsmuir Channel, as these were deemed to have the highest fisheries values and/or potential for mitigation and enhancement opportunities. It is noted that during the reconnaissance, incidental fish observations occurred at various locations within Chantrell Creek and within the Crescent Park Pond.

2.4.1.1 Chantrell Creek

Chantrell Creek is a first order stream approximately 2.38 km in length. The headwaters originate approximately at 22 Avenue and 136A Street and the creek outlets into the Nicomekl River north of Crescent Road in Surrey, BC (MOE Habitat Wizard Stream Report). The MOE's databases identify only Chantrell Creek (WC: 900-004300-06800) within the Study Area. No other watercourses have had a watershed code established. Coho salmon (*Oncorhynchus kisutch*), steelhead (*O. mykiss*) and cutthroat trout (*O. clarki*) were identified by HabitatWizard Stream Report and FISS as inhabiting Chantrell Creek. The coastal species of cutthroat trout (*O. clarki clarki*) found locally within the Lower Mainland is currently blue-listed within the province of BC.

No fish sampling was conducted, and therefore fish observations were cursory and none were identified.

Considerable work has been undertaken within the creek in order to allow and restore fish migration potential into upper reaches. This was completed using numerous concrete fish ladders. Nine ladders were observed between Crescent Road and 28th Avenue. The ladder immediately downstream of 28th Avenue consisted of 5 steps, each approximately 1.40 m long by 0.70 m wide. The first two and last two steps were higher than the middle step. During low water conditions, inadequate flow cascaded down the steps. It is therefore unlikely that they are passable under low water conditions due to the height of each step and lack of sufficient water. Evidence of fish presence upstream was observed, including eggs within the gravels between the fish ladder and culvert outlet at 28th Avenue and fish observation (approximately 10 cm length) immediately downstream of the culvert outlet from 27th Avenue.

Chantrell Creek has been impacted predominantly as a result of past development of the neighbourhoods through which the creek flows and which likely limit the productive capacity of fish. At the confluence with the Nicomekl River, Chantrell Creek is buried in a culvert under private property for approximately 75 m., offering less than desirable conditions to upstream migration of anadromous fish.

Potential migration barriers are present within Chantrell Creek and are identified in Figures A1 to A7. Potential barriers include falls of 30 to 50 cm in height caused predominantly by debris jams (at point 68-6 on Figure A5, downstream of Chantrell 2 on Figure A3 and 68-19 on Figure A2). These barriers appeared sufficient in size that even under high water conditions may preclude upstream fish migration. Fish presence was recorded above all four potential migration barriers and therefore, likely represent local populations of non-migratory fish species.

As the creek exists within many private properties, fourteen footbridge crossings, a wooden staircase and platform, and a partly submerged wire fence perpendicular to the channel were observed. The wire fence did not obstruct flow or prevent upstream migration at present. However, debris was observed trapped on the fence and could eventually become an obstruction.

Chantrell Creek occurs within a well-defined channel. Flow was observed during the low water period in all areas. Riparian vegetation was mostly intact; however, ground cover on the channel banks was heavily impacted, particularly along private properties and creek crossings, where dumping of yard wastes have introduced many non-native species including yellow archangel (*Lamiastrum galeobdolon*), English ivy (*Hedera helix*), and Himalayan blackberry (*Rubus armeniacus*).

As a result of the urban setting, the overall channel morphology was diverse but was predominantly represented by a step-pool morphology due to the north-sloping grade of the watershed, combined with the numerous culvert crossings, fish ladders and occasional debris jams. Areas of short riffles were observed where flow was unimpeded by crossings or other obstacles, as were glides, although these occur infrequently. The average wetted width was approximately 1.3 m except at culvert inlets and outlets where channel widths tended to narrow (< 1 m) to ravine-like (> 30 m). Pools at culvert outlets, ladder outlets or cascades through debris jams were wider than average wetted widths and averaged approximately 0.34 m deep.

Substrates were generally comprised of a high percentage of gravels, followed by fines and cobbles; while boulders were less frequent. Considerable rip-rap was present in the channel, particularly near man-made structures such as roads and culverts.

Left and right banks varied from vertical to very gently sloping and were composed of a wide range of particle sizes from fines (silts, clays) to cobbles and boulders in steep areas. In some areas, the banks were artificially built up with gabion baskets or stone walls (between 27 and 28 Avenue) either to protect private property from erosion or for aesthetic value. In other areas, the banks were undercut, providing suitable cover for fish.

The channel has accumulated considerable large and small woody debris piles, mostly clumped in areas of erosion or at debris jams. For the most part, vegetation provided a high percentage of cover and canopy to regulate water temperature and provide debris, insect- and litter-fall.

Fish were observed at various locations within Chantrell Creek. Abundant salmonid fry were observed at the mouth of the creek within the Nicomekl River. Unidentified fish were observed immediately downstream of the Crescent Road culvert outlet near point 68-38 (Figure A1). A fish was observed just upstream of water sampling station Chantrell 2 amongst clumped SWD (Figure A3) and a fish was observed downstream of the 27 Avenue culvert outlet (Figure A5).

Chantrell Creek appears to provide moderate to good fish habitat. Suitable spawning and rearing habitats were observed. Migratory habitat/access issues, encroachment from non-native vegetation species and low water levels during summer periods were considered to be the largest concerns to overcome.

2.4.1.2 Dunsmuir Channel

No data was available from the HabitatWizard database on the Dunsmuir Channel; therefore, a Stream Report could not be generated to describe potential fish presence or stream statistics. The City's Mapping system COSMOS identifies the channel as a Class A (O) watercourse, providing overwintering habitat to salmonids. The channel is approximately 680 m long and terminates at the fish friendly Maple Drainage Pump Station and floodbox. This pump station was upgraded in 2013 and it allows gravity fed discharge through the floodbox to Mud Bay at low tide and is required to pump drainage during high tide.

Environmental assessments of the area have identified the following species within Blackie Spit Park and within or near Dunsmuir Channel (Catherine Berris Associates 1999):

- Large schools of unidentified fish, including several salmonid species at Mud Bay.
- Six amphibians including the blue-listed Northern red-legged frog (Rana aurora).
- Twelve mammal species, including Muskrat, but no rare species.
- Greater than 190 species of birds counted, including the Bald Eagle and Great Blue Heron.

- Various invertebrate species such as the Dungeness Crab (Cancer magister).

During the site reconnaissance, it was noted that the Dunsmuir Channel lacked a canopy and had little natural vegetation cover on the banks at the Dunsmuir sampling station. Bank vegetation consisted of a very high percentage of non-native species along the dike and walkway. The banks and substrates were dominated by fines due to the lack of flow. Beaver activity was noted, as the sampling station was adjacent to a beaver lodge.

The channel appeared to have very little flow at the time of the field surveys, but it is expected that during high intensity or prolonged rainfall during the rainy season, drainage from the Crescent Beach community provides higher inputs and flows.

2.4.1.3 Crescent Park Class B Watercourse

The Class B watercourse originating at the pond in Crescent Park was dry during the initial reconnaissance in September but did have a low flow during the October reconnaissance (Figure A10 to Figure A12). Fish (likely three-spine stickleback) were observed in the pond (Figure A22). Downstream of the pond water is conveyed through an approximately 100 m long culvert and re-emergences near the park parking lot (Figure A11). Downstream of Crescent Road, this watercourse has a steep channel grade, which likely prohibits upstream fish migration (Figure A10).

In general, the fish classification appears to be appropriate given the steep grades from the Nicomekl River.

2.4.1.4 Unnamed Class A Watercourses (Nicomekl Bluffs)

The City's mapping system COSMOS identifies four Class A watercourses along the Nicomekl Bluffs between 132 Street and 32 Avenue. The bluffs are steeply sloped to the north. Using contour lines and the measuring tool provided by COSMOS, each slope is estimated at a 20% slope or greater, suggesting that they are unlikely to be fish bearing. These sites were not ground-truthed due to lack of access onto private property.

2.4.1.5 Unnamed Class B Watercourses

Numerous unnamed Class B watercourses exist within the Study Area, and not all were observed during either of the site visits. Those that were are described below:

1. Class B upstream and Class A downstream of Crescent road immediately west of Tulloch Road. This watercourse channel exists within a deep ravine with steeply sloped banks. No water was observed within the channel and appears appropriately coded as a Class B.

Class B northwest of 24 Avenue and Harbourgreen Dr. (Figure A23). A large tidally influenced pool was observed downstream (beachside) of the culvert outlet. Fish were observed within the pool, which was isolated from the sea due to low tide but is likely accessible to fish at high tide. Fish were not identified.

Numerous Class B drainages along the Ocean Park Bluffs (Figure A13 to Figure A23). The majority of these Class B watercourses were not ground-truthed due to lack of access through private property. All Ocean Park Bluff watercourses are sloped steeply to the south and southwest at grades that preclude fish presence (> 20%). One Class B watercourse (Knudson Creek, Figure A13) however; has a very long (approximately 50 m) fish ladder constructed at the downstream end near the railway, along with several notched log structures to encourage upstream fish migration. Fish access would have to occur through a large culvert under the railway. This watercourse was not identified through provincial databases and no information regarding fish presence was found.

2.4.2 Water Quality Sampling and Analyses

Urban stormwater runoff can be a significant source of pollutants to natural drainages. Water quality analysis was undertaken to determine the types of existing pollutants, their potential sources and the quantities of the pollutants of concern. Two replicates of three water quality samples were taken. Two samples within the Chantrell Creek watershed and one at the Dunsmuir Channel. Sampling was conducted September 27, 2012 during a prolonged dry period representing low flow conditions, and again on October 24, 2012 following significant rainfall representing the first fall flush in the watershed. Between the two sampling periods a total of 126.4 mm of rain was recorded by a City of Surrey rain gauge located at Chantrell Creek Elementary from October 12 through 24 (City of Surrey Flowworks, 2012). During that time accumulations of 14 mm or more in 24 hours occurred four times, three of which were significant rainfall events of 27.4 mm, 33.0 mm and 28.2 mm respectively, accounted for 70% of rainfall accumulation between sampling periods. These rainfall statistics suggest significant flushing occurred, and higher water levels were observed in all locations.

Field sampling was undertaken using a YSI 550A Dissolved Oxygen meter, a Hanna Instruments Combo pH/EC/TDS/Conductivity meter (HI 98129) and a LaMotte 2020we Turbidity Meter, each calibrated according to manufacturer's specifications.

Sampling station Chantrell1 (Figure A7) is at the outlet of the stormwater detention pond between 136 and 137A Streets and north of 24 Avenue. Samples were collected just upstream from a large outlet structure where the pond is allowed to drain back into Chantrell Creek by way of side-channel. Sampling station Chantrell 2 (Figure A3) is within a ravine between 136 and 137A Streets and north of 30 Avenue. Sampling station Dunsmuir (Figure A25) is located adjacent to the corner of Dunsmuir Road and Gilley Street immediately downstream of a beaver lodge on the north bank of the channel. Table 5 provides the locations of each sample station and results of field sampling measurements.

Table 5: Field Water Quality Results September to October 2012

Parameter	Date	Location		
		Chantrell 1 511446E 5432683N	Chantrell 2 511858E 5433787N	Dunsmuir 508781E 5433685N
Dissolved Oxygen (%)	September 27	22.7	90.7	48.3
	October 24	34.7	58.4	37.8
pH	September 27	6.65	7.08	7.07
	October 24	8.20	7.92	7.40
Conductivity (µS)	September 27	297	228	2540
	October 24	200	206	895
Temperature (°C)	September 27	12.2	12.6	-
	October 24	8.8	9.9	11.0
Turbidity (NTU)	October 24	2.72	2.78	14.0

The minimum dissolved oxygen saturation measured was less than 82% (approximately 8 to 10 mg/L), below the optimum dissolved oxygen saturation levels for salmonids which should be higher than 90% (Chilibeck et al. 1993).

Laboratory analysis of the following parameters was conducted: dissolved and total metals, suspended and dissolved solids (TSS/TDS), alkalinity, ammonia, biochemical oxygen demand (BOD), chloride, fecal coliforms, fluoride, nitrate plus nitrite, and total oil and grease. Results are presented in table format in Appendix 7. As all samples were surface water, results were compared to the BC Water Quality Guidelines (BCWQG) for the Protection of Aquatic Life for freshwater (MOE 2006).

Samples obtained during the low water period (Sept 2012) had exceedances as follows:

- Chantrell 1 exceeded BCWQG for total arsenic (11.4 µg/L), total iron (1570 µg/L), and dissolved zinc (43.6 µg/L).
- Chantrell 2 exceeded BCWQG for dissolved iron (364 µg/L).
- Dunsmuir exceeded BCWQG for total iron (2240 µg/L) and chloride (610 mg/L).

A possible source of Arsenic is from groundwater pumping for flow augmentation in Chantrell Creek. Notably, observations of orange discolouration and staining of substrates and culverts within the watercourses were frequent, suggesting high levels of iron. In some cases, such as immediately upstream of 28 Avenue, small accumulations of iron bacterial mats were observed during the September reconnaissance. These naturally occurring bacterial mats result from the bacterial metabolization of iron in the water column and are typical of slow moving or stagnant waters low in oxygen.

While the sampling at Dunsmuir resulted in higher concentrations of chloride than allowable under the BCWQG, it is noted that this water body is tidally influenced and therefore mixed with sea water as indicated by the field measurement for conductivity (Appendix G).

Total coliform counts in the collected water samples were high (1600 CFU/100 mL) at Dunsmuir. There are no BCWQG for the Protection of Aquatic Life for total or fecal coliform (unless shellfish harvesting is occurring). However, for the sake of comparison, CCME Agricultural Irrigation Guidelines (2005) are 1,000 CFU/100 mL for total coliforms and 100 CFU/100 mL for fecal coliforms. In general, a large number of fecal coliform bacteria (>200 colonies/100 mL of water sample) can indicate that possible pathogenic (disease or illness causing) organisms are present in the water. This result may have been influenced by the high number of waterfowl present and that the samples were taken very near a (presumably) active beaver lodge within a relatively slow moving watercourse. Another possible source is the Nicomekl River that drains a larger watershed with urban and agricultural land uses.

Coliforms are a group of bacteria that live in soil, water, and the intestinal tracts of cold and warm blooded animals. Fecal coliforms, including Escherichia coli (*E.coli*) are specific to mammals, including humans. The presence of *E. coli* and other fecal coliforms indicates contamination with fecal matter. In a predominantly urban setting the most obvious sources of coliforms in stream water are dog feces and cross-connection with the sanitary system.

2.4.3 Vegetation and Terrestrial Habitat Reconnaissance

A vegetation and terrestrial survey was conducted to verify information provided in the City of Surrey Ecosystem Management Study (EMS). The scope of the EMS was far broader, encompassing the entire City, whereas the information in this report is specific to only the Study Area.

The City undertook the EMS as a science-based study to identify and map their Green Infrastructure Network (GIN) (City of Surrey, 2012). Its purpose was to strategically manage ecosystems within the City and to identify management guidelines and strategies to maximize the health and benefits of the City's green infrastructure through a Biodiversity Conservation Strategy (HB Lanarc and Raincoast 2011). The study focused on four main elements of the City's landscape: Hubs – large areas of complex ecological processes; Sites – smaller sites of less complex ecological activity; Corridors – pathways that offer species and ecological process connection between hubs; and The Matrix – other land base with varying ecological values. This was accomplished through the collection and review of existing GIS data; mapping of natural and semi-natural vegetation communities; delineation of the Green

Infrastructure Network; and an evaluation of the relative ecological significance of hubs and corridors (HB Lanarc and Raincoast 2011).

Tetra Tech EBA's field survey consisted of spot checks at various locations (Hubs, Sites, Corridors) within the Chantrell Creek Watershed to verify vegetation communities, wildlife habitat and corridors, and to identify species of wildlife, including rare or species of concern, that have potential to inhabit the watershed. It is noted that at the time of this draft report, additional spot checks are required prior to report finalization.

In addition, information on potential vegetation and wildlife habitat within the Study Area was obtained by a thorough review of available ancillary information, which included GIS data from the City of Surrey's Mapping Online System COSMOS (Appendix B), the Conservation Data Centre's internet mapping service iMap (Appendix E) and Species and Ecosystems Explorer database (Appendix F); and the SARA Registry.

2.4.3.1 Vegetation

The Study Area exists within the Coastal Douglas-Fir moist maritime (CDFmm) biogeoclimatic zone. The CDFmm occurs along a narrow strip of the southern coast mainland and at low elevations (<150 m) (Meidinger & Pojar, 1991). The area has relatively dry summers and moist, mild winters with limited snowfall. The mean annual temperature ranges from 9.2 to 10.5°C, while mean annual precipitation ranges from 647 to 1263 mm, only 5% of which falls as snow. The CDF forests are mainly second growth following logging in the early 1900's and are dominated by coastal Douglas-Fir (*Pseudotsuga menziesii var. menziesii*). The forests also commonly include western redcedar (*Thuja plicata*), grand fir (*Abies grandis*), arbutus (*Arbutus menziesii*), Garry oak (*Quercus garryana*) and red alder (*Alnus rubra*) (Meidinger & Pojar, 1991).

As a result of the work completed for the EMS, COSMOS includes mapping layers which identify ecosystem hubs, sites and corridors, several of which occur within the Study Area (Appendix B). Study Area hubs include:

- Elgin Heritage Park.
- Chantrell Creek.
- Nicomekl Bluffs.
- Blackie Spit.
- Crescent Park.
- Dogwood Park.
- Ocean Park Bluffs.

These seven hubs are connected through a series of sites and corridors (Appendix B). As reported in the EMS, no hub, site or corridor in the South Surrey region registered within the top 5 in each category of ecological significance (HB Lanarc, 2011).

The CDC Internet Mapping Service was queried for known occurrence records of at-risk plants and communities (Appendix E). A total of four plant species occur within a 5 km radius of the Study Area (Appendix E). Two species in particular, Vancouver Island beggarticks (*Bidens amplissima*) and needle-leaved navarretia (*Navarretia intertexta*) were identified within the Study Area. A known occurrence of Vancouver Island beggarticks exists near the confluence of the Nicomekl River and Chantrell Creek adjacent to the boardwalk in Elgin Heritage Park, while the needle-leaved navarretia occurrence exists west of White Rock along the BNSF Railway line. The other two species occur at low level sites within riparian margins. The small spike-rush (*Eleocharis parvula*)

occurrence exists east of the Study Area along the Serpentine River, while the field dodder (*Cuscuta campestris*) is known to exist at the mouth of the Little Campbell River slightly south east of the Study Area.

A search of the CDC BC Species and Ecosystems Explorer database for plant species and ecological communities of conservation interest within the CDFmm (within which the Study Area exists) identified 33 potential rare plant species and 30 potential communities (Appendix F). Of the 33 rare plant species, 9 are provincially red-listed and 24 are blue-listed. Three species are also recognized by COSEWIC and are listed under Schedule 1 of SARA:

- Vancouver Island beggarticks (*Bidens amplissima*) – blue listed, Special Concern (2001), Schedule 1 Special Concern (2003), known occurrence within Elgin Heritage Park boardwalk (Appendix 6 & 7) at the confluence of Chantrell Creek and Nicomekl River.
- Streambank lupine (*Lupinus rivularis*) – red-listed, Endangered (2002), Schedule 1 Endangered (2005), no nearby occurrences noted, but may occur.
- Phantom orchid (*Cephalanthera austiniae*) – red-listed, Threatened (2000), Schedule 1 Threatened (2003), all known occurrences in Fraser Valley, not likely to occur.

None of these species were observed during the field surveys conducted. However, this does not suggest their absence, only that they were not detected. The timing of the surveys was not conducive to observation of rare vegetation species and more surveys should be undertaken in spring or early summer.

Approximately 50 rare species are known to occur only within the CDF, and are at the northern extent of their distribution occupying seaside, aquatic, rock outcrops and forested habitats (Meidinger & Pojar, 1991).

Vegetation species observed during the habitat reconnaissance completed to date reflect the various vegetation types described in the EMS and depicted on Map 1 shown in the EMS report (HB Lanarc, 2011). Large areas of evergreen and mixed forest exist within the Study Area comprised of Douglas-fir, western red cedar, big-leaf maple (*Acer macrophyllum*), western hemlock (*Tsuga heterophylla*) and red alder with an understory of salmonberry (*Rubus spectabilis*), vine maple (*Acer circinatum*), sword fern (*Polystichum munitum*), and beaked hazelnut (*Corylus cornuta*). Several non-native species were observed including Himalayan blackberry, yellow archangel, English ivy, and Japanese knotweed (*Polygonum cuspidatum*). Where found, non-native species were often in large patches of monocultures forming a uniform ground-cover and the result of dumping of garden wastes.

2.4.3.2 Terrestrial Habitat and Corridors

In order to assess the potential for wildlife and wildlife habitat to occur within or adjacent to the Study Area, Tetra Tech EBA conducted a review of available ancillary information which included the CDC Internet Mapping Service (Appendix E), Species and Ecosystems Explorer database (Appendix F), and SARA Registry. Prior to conducting the site visit, a list of wildlife species at risk with potential to be present within the Study Area was created in order to prepare a species focal list for use during the assessment.

The field survey identified wildlife habitat and migration corridors and assessed the types of wildlife that may inhabit the Study Area. Evaluations of wildlife corridors have been based on the following criteria: habitat connectivity, canopy regeneration, physical disturbance, size and shape of natural areas, habitat maturity, proportion of natural communities, plant species, ecologically significant plants, animals and wildlife habitats. The surveys were focused on ecosystems hubs, sites and corridors according to the EMS. Significant hubs are identified above. The Study Area includes numerous sites and corridors (Appendix B).

The City's EMS report includes a map of sensitive occurrences (sightings) and habitat (Map 2, HB Lanarc, 2011). The map includes identification of a blue-listed animal at Blackie Spit Park, a Barn Owl (*Tyto alba*) nesting structure,

also observed by Tetra Tech EBA at Elgin Heritage Park, six bald eagle (*Haliaeetus leucocephalus*) nesting sites, two amphibian sites (Crescent Park pond and Elgin Heritage Park), and numerous important tree locations within the Study Area.

According to the CDC Internet Mapping Service database, there are three known occurrences of wildlife species at risk within or near the Study Area. The Green Heron (*Butorides virescens*), is provincially blue-listed and has occurred in the past (last observed in 1987) within the Study Area at Blackie Spit Park (Appendix E). The other two wildlife species occurrences are both from the Serpentine Fen, which is just over 1 km north of the Study Area. In addition, there is one masked (confidential) occurrence of wildlife species at risk, masked ID 7982 which encompasses the Study Area (Appendix B).

A search of the CDC BC Species and Ecosystems Explorer database for wildlife species (excluding fish) of conservation interest within the CDFmm identified 16 rare species with potential to exist (Appendix F). These are rare species which have potential to occur within habitats that are present within the Study Area and may therefore exist. Based on the general habitat types observed or expected to be present, the wildlife species of conservation interest was reduced to a focal list of 12 species. Four species unlikely to occur within the Study Area include:

- Townsend's Big-eared Bat (*Corynorhinus townsendii*) – blue-listed.
- Keen's Myotis (*Myotis keenii*) – red-listed, SARA Schedule 3.
- Audouin's Night-stalking Tiger Beetle – red-listed, Candidate (short-list for upcoming assessment) 2011.
- Western Pine Elfin (*Callophyrs eryphon sheltonensis*) – blue-listed.

Habitat requirements for important life history stages for each of these species appear to be lacking within and each is therefore unlikely to occur in the Study Area.

The extent and quality of ecosystem corridors within the Study Area has yet to be assessed in sufficient detail at the time of this report. Additional work is required to evaluate existing corridor areas to determine potential for wildlife and wildlife habitat in its present state.

2.5 Benthic Invertebrate Bioassessment

Benthic invertebrates are an important part of the food chain. While they feed on algae, bacteria, leaves and other organic matter; when they die they leave behind nutrients which can be reused by plants and animals, especially fish. Furthermore, biological communities in urban streams respond to pollutants and alterations of watershed hydrology; especially effects resulting from storm events. Often, the variety of pollutants and delivery mechanisms are difficult to separate for effects on the biological community. Multiple pollutant types, or stressors, influence response in the biological community so that the additive or synergistic effects from toxics and habitat alterations explain results from biological assessments.

Benthic macroinvertebrate (BMI) data was collected from a single site in the Chantrell Creek watershed. Other samples were collected in streams throughout the City. These were used to evaluate biological health of stream reaches. Following taxonomic analysis of the data, biometrics were used to further evaluate how attributes of the biological community were responding to known land use setting characteristics and to a limited set of in-stream water quality data and physical habitat assessment information. The procedure used to analyze biological information from each of the sites is as follows:

- Classify biological index scores and individual biometrics based on land use, to determine relative biological condition at each stream reach.

- Identify correlation(s) between biometric condition and physicochemical characteristics.
- Determine indicator expressions (e.g., biometrics or individual species) that respond to stormwater stressors and that can be used to evaluate effectiveness of pollution abatement.

All data, including the single Chantrell Creek site was combined to determine how physical habitat influenced biological response. The additional streams outside of the Study Area were used to construct a biological condition gradient (i.e., how biological communities respond to individual physical and chemical parameters) along each of the environmental indicator gradients. Biological information collected from the multiple sites throughout the City of Surrey was used to identify existing relationships between physical habitat and biological communities.

The goal for this analysis was to identify stressor groups related to biological condition, the causes for pollutant introduction to stream reaches, and what additional monitoring information would be useful for diagnosing causes of biological impairments in future programs.

2.5.1 Biometric Relationships to Physical Parameters

Sites were divided by major land use categories (e.g., High-Density Residential, Medium-Density Residential, Low-Density Residential, and Commercial/Industrial) as determined by a qualitative assessment of satellite imagery of land development intensity. The single Chantrell Creek watershed site was categorized as a low density residential area. More detailed and descriptive land use categories for each site are shown below in Table 6. Relationships between physical habitat and water quality conditions (e.g., Percent Fines and Small Gravel, Percent Cobble, and Specific Conductivity) and biological metrics were developed. Descriptions of each biological metric used for determining strength of correlations with physicochemical parameters can be found in Table 7.

Table 6: Land Use Categories in the Chantrell Creek Watershed and Dominant Types at a Stream Reach

Site Name	Land Use Area Category
	High Density Residential Land Use Area
Logan Creek	high density residential/ commercial
Cougar Creek	high density residential
North Creek 2	high density residential
Robson Ravine	high density residential
Bolivar Creek	high density residential
Delta Creek 1	high density residential
Fergus Creek 1	high density residential/ by major highway/ low density on other side of highway
Old Logging Ditch	forested/ high density residential/ golf course
	Medium Density Residential Land Use Area
Hyland Creek 2	forested/ medium density residential
Delta Creek 2	med to high density residential/ railroad
Elgin Creek	med density residential/ forest
King Creek	forested/ medium density residential
Archibald Creek	med density residential/ forested
Enver Creek	med to high density residential
	Low Density Residential Land Use Area
Latimer Creek 1	low density residential and open space- farmland
Fergus Creek 2	low to med density residential/ open space/ forested
Latimer Creek 3	low density residential and open space- farmland
North Creek 1	low to medium density residential
McLellan Creek 1	residential and open space
Latimer Creek 2	low density residential and open space- farmland
Little Campbell River 1	low density residential and open space- farmland
Little Campbell River 2	low density residential and open space- farmland
Unnamed Tributary	open space/ low density residential
Chantrell Creek	Low density residential
	Commercial/ Industrial Land Use Area
Bear Creek	forested/ commercial
McLellan Creek 2	railroad/ industrial
Quibble Creek	forested/ commercial
Hyland Creek 1	industrial
	Open Space Land Use Area
Anderson Creek	Open Space
Erickson Ditch	Open Space
Burrows Ditch	Open Space

Table 7: Definitions of Biometrics and Expected Response from Pollutants

Biometric	Definition	Predicted Response to Impairment
Taxa Richness	A measure of the number of different kinds of organisms (taxa) in a collection.	Decrease—portions of the community taxa list will be absent in the presence of stormwater impacts.
Percent (%) Pollution Tolerant taxa	Organisms that are tolerant of pollutants and are not affected as readily as other taxa.	Maintains or Increases—number of pollution-tolerant taxa usually increase in the presence of increasing pollution.
Clinger Richness	Number of taxa constructing fixed retreats or adaptations for attachment to surfaces in flowing water.	Decrease—substrate instability resulting from *flashy* flow patterns will destabilize substrate preferred by *clingers*.
Ephemeroptera	Number of Mayfly taxa.	Decrease—a pollution-sensitive order of taxa with exception of the family Baetidae.
Trichoptera	Number of Caddisfly taxa.	Decrease—a generally pollution-sensitive order of taxa with exception of the family Limnephilidae.
Percent Predator	Proportion of the *predator* functional feeding group represented in a sample.	Decrease—*predator* taxa representation generally declines in the presence of change to physical habitat; also sensitive to chemical pollutants.
% Dominant Taxa	Measures the dominance of the single most abundant taxon. Can be calculated as dominant 2, 3, 4, or 5 taxa.	Increase—pollution-tolerant taxa increase in the presence of stormwater pollution, individual taxa outcompete more sensitive taxa in the presence of physicochemical stressors.

The single Chantrell Creek bioassessment site was located in a forested reach downstream of Crescent Road. Surrounding land use included both a forested riparian area upstream of the site and adjacent open space within 25 m of the stream channel. The stream channel is dominated by finer substrate particles including unconsolidated coarse gravel, sand, and muck/silt/clay (Figure 6). Channel braiding is evident in the site photographs indicating a gradient break (e.g., transition from a higher gradient above the reach to a low gradient represented by the reach) where suspended sediment settles from the water column and is deposited at this location. A culvert is located upstream of the reach downstream of Crescent Road. Physical habitat and water quality factors were identified by using information from other sites within the area in order to identify patterns that would explain stormwater impacts to this stream reach.

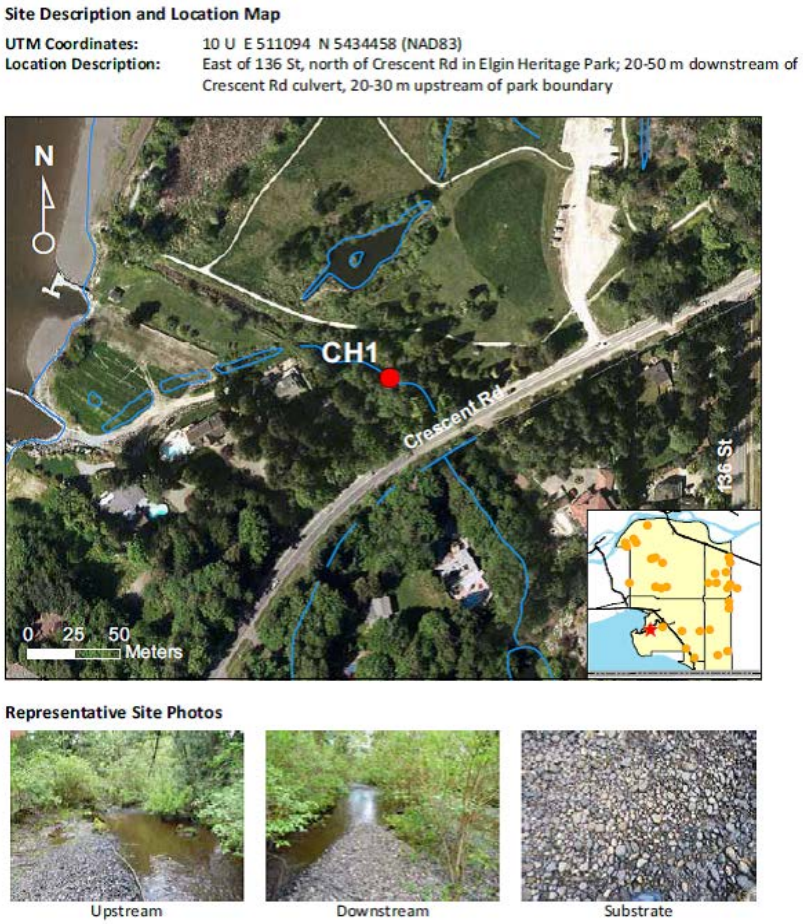


Figure 6 - Aerial image for location of Chantrell Creek bioassessment site and images of the stream reach at time of sampling (May 3, 2011) - Source: Lilley and Page (2012).

The generated physical habitat, water quality and biological metric relationships were then used to define central themes for response by biological communities and determine the relative sensitivity of each metric to changes in the aquatic environment. Once relationships between biological condition and environmental measurement were established, it was determined the likelihood that each negative impact on biological response was related to past stormwater input.

Table 8: Summary of Biometrics and Physical Habitat Range Values per Land Uses

Biometric/Land Use	High Density	Medium Density	Low Density	Commercial	Open Areas	Chantrell Creek
Trichoptera	0-1.6	0-3	0-3.6	0	0.7-1.3	1.3
Pollution Tolerance	0-16	0-0.9	0-11	0-1.8	0-1.3	1
Ephemeroptera	1-2	1-3	0.6-4.6	0.7-1	1-3	2
Taxa Richness	6-17	5-16	10-21	6-14	7-17	12
% Dominance	60-95	70-95	50-100	95-98	70-95	70
Clinger Richness	0-3.5	0-6	1-11	0-0.32	2.6-3.6	3.4
Predator %	0-15	0-2	0-25	0.1-2.5	0.6-4.6	0.5
Physical Habitat/ Land Use	**High Density**	**Medium Density**	**Low Density**	**Commercial**	**Open Areas**	**Chantrell Creek**
Sp. Cond.	150-300	125-250	75-250	200-275	140-180	140
% Fines and Smal Gravel	25-75	10-50	10-70	35-45	40-80	40
% Cobble	0-50	0-15	0-20	0-15	0-10	10

2.5.1.1 High Density Residential Land Use Area

High density residential land use areas are characterized by large amounts of impervious surfaces, high occupant density, and well-developed infrastructure. Runoff from roads during stormwater events is routed toward or directly input to existing channels and ditches. Pipes and culverts route water under and beside roads. This exposes the water to pollutants from surrounding impervious areas and transports the pollutants into channels and other conveyance systems.

High density residential land use area sites have specific typical characteristics. Substrate in the creek is composed mainly of small gravel and fines due to flashy stormwater events, which break up and transport larger substrate. Trails may run parallel to the creek, indicating that the stream is accessed by local residents with little or no natural barrier to stream access. These settings are typical of high-density residential land use where the lack of a natural vegetation barrier allows the input of surface flow and any pollutants carried within this discharge into the creek.

It is expected that pollution-sensitive species such as Ephemeroptera (mayflies) and Trichoptera (Caddisflies) are absent in high-density residential environments due to limitations in availability of larger substrate sizes such as percent Cobble. The sensitive species groups like Trichoptera (caddisflies) and Ephemeroptera (mayflies) are not well-represented in these streams, indicating that chronic impacts like presence of toxics and habitat instability are present. It is also expected that pollution tolerant and dominant organisms presence increases with increasing percentages of small gravel and fine substrate. Stream channels with dominance of fine substrates and located within high-density or highly developed landscapes are an indication that storm events impact biological condition. High specific conductivity would correlate with increases in %Dominant taxa and decreases in Trichoptera richness and Ephemeroptera richness. High conductivity is an indication that there could be high metals concentrations sequestered in sediments with periodic releases. In addition, stormwater mixed with wastewater could explain high conductivity observations (e.g., Fergus Creek1).

2.5.1.2 Medium Density Residential Land Use Area

Medium density residential land use areas are characterized by moderate amounts of impervious surfaces, population density, and impervious surfaces. Runoff from roads are the main source of stormwater runoff into

surrounding water bodies; however the number of pipes and culverts for stormwater conveyance and leading to open surface waters is known to be less numerous than in high density residential land use areas.

There are specific characteristics associated with streams assessed in medium density residential land use areas. Substrate sizes in stream reaches sampled were dominated by fines and small gravel and are assumed to have accumulated from flashy stormwater events. Some of this material may have been introduced into upstream locations from the assessed reaches and deposited downstream. The stream reaches surveyed in this land use type were surrounded by an increased density of vegetation (in contrast to the high density residential land use areas), but had adjacent roadways. The type of vegetation was thin and did not present a barrier to access by local residents or by pollutant runoff.

It is expected that pollutant sensitive species such as Ephemeroptera and Trichoptera would be more prevalent in medium density residential land use sites than in high density residential stream reach sites. It also expected that pollution tolerant organisms would increase with increasing percentages of small gravel and fine substrate at these streams, as the result of the type of stormwater delivery during individual events. High Specific Conductivity can be correlated with increased %Dominant species and %Predators, while Pollutant sensitive species abundance would decline.

2.5.1.3 Low Density Residential Land Use Area

Low density residential land use areas were characterized by low to moderate amounts of impervious surfaces, low population density along and upstream of the assessed stream reaches, and minimal impervious surfaces. The more dense vegetation growth adjacent these streams reaches moderates the flashiness of storm events and limits their effects on the main stream channel. Water delivery to the stream during storm events is slower compared to moderate- or high density residential land use areas.

There are typical characeristics for a low density residential land use stream reach. Distribution of substrate sizes in stream reaches are broader and include larger sizes like cobble and boulder. The stream reaches have dense vegetative cover along the riparian margins and fewer signs of human access to the channel.

It is expected that pollutant sensitive species such as Ephemeroptera and Trichoptera would be identified in greater numbers in low density as compared to the more populated residential areas; with the differentiating factor being abundant large substrate sizes. It is also expected that pollution tolerant organisms and clingers would increase with increasing percentages of small gravel and fine substrate; this pattern of substrate size dominance can be linked with cumulative effects from stormwater events. High specific conductivity observations can be correlated with %Dominant species at most of the sites.

2.5.1.4 Commercial and Industrial Land Use Area

Commercial and industrial land use areas are characterized by large infrastructure (e.g., buildings, parking lots, and machine operation) and high impervious surface cover. Biological impairments to surface water channels in these land use areas materialize as low numbers of benthic macroinvertebrate species. Some of the explanations for the low species diversity are based on: increased metals concentrations in sediments and surface water, solvents transported with stormwater through runoff, acid rain in urban environments (e.g., caused by NOx/SOx automobile emissions), and other air pollutants from industrial manufacturing and processing.

Stream reaches located in the commercial and industrial land use areas demonstrated specific characteristics. Adjacent riparian vegetative cover is prevalent, but impervious surfaces and an industrial park are dominant. A variety of pollutants is input to stream reaches during storm events and include both airborne and surface water particulates. The substrate in the assessed reaches is dominated by fines and small gravel. Cloudiness in the water

will have high conductive properties as indicated by specific conductance observations. This water quality condition indicates continuous input of storm conveyance water as well as other types of off-site drainage that increased dissolved conductive materials like metals.

In commercial settings, it is expected that pollution sensitive species such as Ephemeroptera and Trichoptera would be completely absent at all commercial/industrial site settings. The sensitive species groups are usually found where larger substrate sizes dominate in contrast to the dominant fines and small gravel where pollution tolerant species and clingers are able to survive.

2.5.1.5 Open Space Land Use Area

Forested land use areas have heavy vegetative cover providing some in-stream structure for biological communities. Nevertheless, stormwater runoff does occur in this landscape setting and can cause minor erosion and sediment transport to the stream channel in areas with high-sloping forest banks. Sediment particles transported into the stream may result in higher surface water conductivity.

Open space land use areas have little to no impervious surface cover or infrastructure. This land use type is also applicable to agricultural land and may contribute nutrients to stream reaches in the surrounding watersheds. Typically, vegetative cover surrounding the creek is dense; however, high, unstable banks can periodically result in failure during the storm season and transport pollutants that may be sequestered along the margins into the receiving water. The substrate typically varies in size with a prevalence of cobble size range that supports pollution-sensitive species.

Pollution-sensitive species such as Ephemeroptera and Trichoptera prefer larger substrate sizes, such as cobble, as this structure provides a more diverse stream-bottom habitat. Smaller substrate sizes are populated by a greater number of pollution tolerant organisms and predators. Increased conductivity in a stream reach results in a large presence of single species groups (e.g., measured as %Dominant species).

2.5.2 Results of Bioassessment

The results of the biological assessments indicate that biometrics across the City are at the low end of the spectrum when compared to more pristine environments. Such comparison, however, may not be appropriate as urban streams have undergone transformational processes since their pre-development state. It is important to note that the physical reconnaissance of the aquatic habitat conditions on Chantrell Creek suggest that this creek provides moderate to good fish habitat conditions (Section 2.4.1.1). It is then necessary to establish how healthy the watershed using a holistic approach rather than a single metric.

Data obtained through the benthic invertebrate monitoring process provides an insight into the likely mechanisms of processes that have impacted a watershed through the various stages of urban development. It also offers baseline conditions to determine whether improvements have been achieved after the implementation of various management strategies.

Physical habitat characteristics such as substrate size and its susceptibility to transport by storm events have the strongest correlation with attributes (i.e., biometrics) of the BMI community in the City of Surrey area. Pollution-sensitive taxa such as Ephemeroptera and Trichoptera were more abundant in most low density residential and open space sites where stormwater influences were assumed to be less low than in more densely urbanized areas. There is a tendency for substrate size class to be dominated by larger particles in these land use types along with lower conductivity observations. However, these are general trends as the land use classification was not rigorous and some sites with lower urban densities do not support this conclusion. Pollution tolerant taxa, clingers and predators were, in general, more prevalent in stream reaches associated with higher impacts due to stormwater

and were identified by dominance of smaller substrate particles and higher conductivity observations. These conditions appeared more frequently in stream reaches in high density residential areas and commercial/ industrial land use types.

2.5.2.1 Multi-Metric Index Scores

Biological conditions for sites were calculated using a multi-metric index (B-IBI) and partitioned into land use setting categories (Table 9). The range of multi-metric index scores was generally low across the board, with some of the larger numbers associated to low density residential areas. Biological condition scores have a maximum score of 50 and these assessment scores indicate that severe impairment to biological communities has occurred. The historic evolution of land uses and the delivery mechanisms of stormwater runoff and pollutants to the streams needs to be assessed in order to develop a better understanding of the causes of the low multi-metric index scores. However, the limited amount of physicochemical data available for analysis and diagnosis of impairments indicate that stormwater runoff and physical habitat alteration are major factors for explaining current conditions.

Table 9: B-IBI Scores for Each Site and Corresponding Condition Category

Site Name	B-IBI Score
High Density Residential Land Use Area	
Logan Creek	14.7
Cougar Creek	14
North Creek 2	14.7
Delta Creek 1	21.3
Fergus Creek 1	14
Old Logging Ditch	16
Medium Density Residential Land Use Area	
Hyland Creek 2	14
Delta Creek 2	14
King Creek	14
Archibald Creek	16
Enver Creek	14
Low Density Residential Land Use Area	
Chantrell Creek	16
Fergus Creek 2	14
Latimer Creek 3	14
North Creek 1	17.3
McLellan Creek 1	14
Latimer Creek 2	20
Little Campbell River 1	18.7
Little Campbell River 2	26.7
Commercial/ Industrial Land Use Area	
Bear Creek	14
McLellan Creek 2	14
Quibble Creek	14

Table 9: B-IBI Scores for Each Site and Corresponding Condition Category

Site Name	B-IBI Score
Hyland Creek 1	14
Open Space Land Use Area	
Anderson Creek	21.3
Erickson Ditch	14
Burrows Ditch	16.7

2.5.2.2 Chantrell Creek Biological Condition and Impairments

Biological conditions from replicate assessment of the Chantrell Creek reach were consistently low. The interpretation of the B-IBI scores (Benthic Index of Biological Integrity) assessed this site as in "poor" biological condition. As mentioned above, this index is compared to pristine conditions which would be very difficult to achieve in an urban environment.

Biometrics associated with available physical habitat data (e.g., substrate size distribution) and water quality (e.g., specific conductance) indicate that sheetflow and/or water from storm pipes originating during storm events could explain current instream habitat conditions. The high specific conductance associated with the increased percentage of pollutant-tolerant taxa in Chantrell Creek is likely associated with stormwater inputs. Low B-IBI scores for each of the biometrics and substrate size classes has indicated that volume of water and delivery to the stream channel results in "pulses" that moves the small particle sizes. Other factors that may influence the results in Chantrell Creek is the periodical entrance of waters from the Nicomekl River during high tide events. Also, water quality analysis conducted on this study revealed metal concentrations exceeding BCWQG guidelines. This may also be associated with the low B-IBI numbers found in Chantrell Creek.

It is likely that multiple sources of pollutants are depressing the biological community in Chantrell Creek that require management action. It is important that both volumes and quality of water entering streams is addressed. In this case, the volume is the water "pulsed" into the stream during storms and quality treatment would include treatment of storm pipe outlet water for removal of metals and other pollutants identified through sampling. The installation of appropriate Best Management Practices (BMPs) that reduce water velocity and encourage the settlement of particulates with adsorbed pollutants is recommended.

2.6 Assessment of the Drainage System

2.6.1 Hydrologic and Hydraulic Modelling

A stormwater model of the drainage system was built using PCSWMM 2012 Professional, which runs the EPA SWMM 5 engine, version 5.0.022. The model was built using GIS data and as-built drawings obtained from the City's website.

2.6.2 Hydraulic Network

The hydraulic network was imported from the City's GIS data. The model was built with pipe diameters 375 mm and greater. Nodes (manholes and junctions), links (pipes and channels), and detention units (ponds) were imported and connected in the model. All relevant attributes were readily available in the GIS database, but in some instances geometrical attributes of model elements were obtained from as-built drawings. Likewise, rim elevations were extracted from the Digital Terrain Model (DTM) also obtained from the City's GIS system. Cross sections for natural streams were obtained where available from geomorphology assessment data sheets provided by the City.

Hydraulic model parameters such as conduit roughness and inlet and exit losses were defined according to industry standards, consistent with the City's Design Manual recommendations. Roughness values were selected based on pipe materials and open channel surface. Exit losses were set to 0.1 for straight pipe alignments, to 0.4 for pipe angles between 10 and 75°, and 1 for 90° angles.

Boundary conditions were set as free outflow for all outfalls in the model, except for the Chantrell Creek outfall, which was defined as a tidal boundary. The reason for not including tidal conditions in most of the model outfalls is twofold:

1. The tidally influenced Crescent Beach area was subject of a detailed hydraulic study conducted by Urban Systems (2009) for the City of Surrey. The methods used in this study took into consideration the effect of tidal fluctuations in both the drainage system and the groundwater. Recommendations were provided in terms of drainage infrastructure required to mitigate the effects of climate change in Crescent Beach.

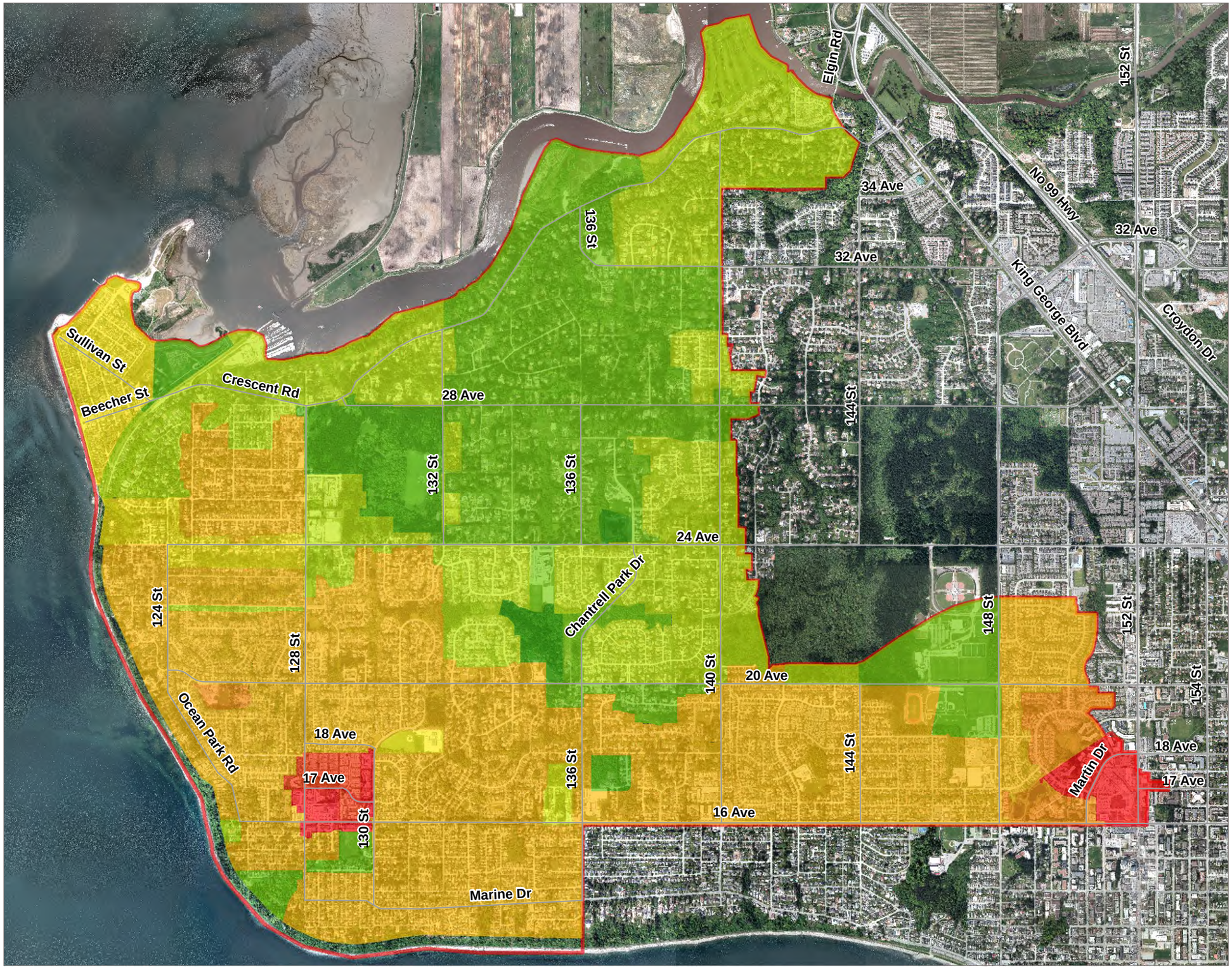
2. Other outfalls that discharge to the Nicomekl and the ocean are also tidally influenced, however the tidal influence is very limited (except for the lower Chantrell Creek) and there is no influence to the upstream drainage system, thus the tidal effect was not deemed necessary.

2.6.3 Hydrologic Parameters

Subcatchments obtained from the City's GIS were imported into the model and further divided to better represent the runoff distribution throughout the drainage network. Infiltration parameters were assigned to the various soil types available in the Study Area (see Table 10) as shown in Figure 3. There parameters were then assigned to the model subcatchments through an area-weighted average process using PCSWMM tools. Subcatchment imperviousness was assigned initially based on the land use coverage, and then finalized through detailed inspection of the aerial orthophotography (see Figure 7). Figure 8 shows the model elements, including nodes, links, and subcatchments.

Table 10: Infiltration Parameters: Ocean Bluff Chantrell Creek ISMP

Soil Type	Suction Head (mm)	Hydraulic Conductivity (mm/hr)	Initial Deficit (ratio)
Peat	300	5	0.5
Silt and clay	292.2	1	0.346
Till	166.8	5	0.171
Gravel and sand	40	250	0.4
Steepland sediments	292.2	1	0.092
Sand	49.5	235.6	0.346



LEGEND

Imperviousness

- < 2
- 2.1 - 5.0
- 5.1 - 12.0
- 12.1 - 16.0
- 16.1 - 20.0
- 20.1 - 25.0
- 25.1 - 30.0
- 30.1 - 35.0
- 35.1 - 40.0
- 40.1 - 55.0
- 55.1 - 70.0
- 70.1 - 75.0

N W E S

NOTES
Base data source:
Orthophotos, stream networks, contours, property lines and road network supplied by the City of Surrey.

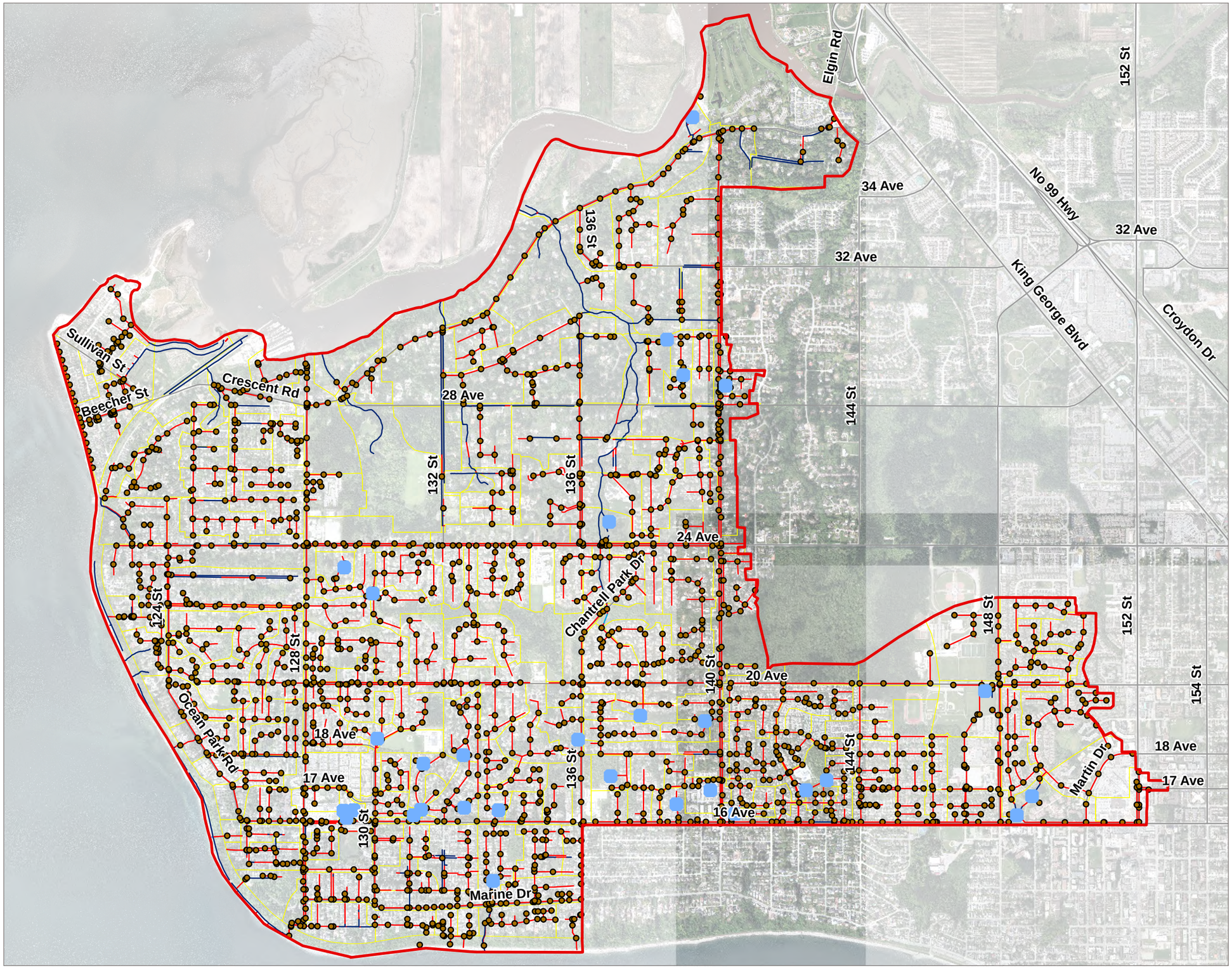
STATUS
ISSUED FOR REVIEW

OCEAN BLUFF ISMP

IMPERVIOUSNESS

PROJECTION UTM Zone 10		**DATUM** NAD83			**CLIENT** CITY OF SURREY
Scale: 1:22,000 (400 200 0 400 Meters)					eba A TETRA TECH COMPANY
FILE NO. 20130321 Figure 7 - Imperviousness.mxd					
PROJECT NO. V13203008	**DWN** AMF	**CKD** AM	**APVD** MH	**REV** 0	**Figure 7**
OFFICE EBA-VANC	**DATE** March 21 2013				

Q:\Vancouver\Engineering\V132\Projects\V13203008 Ocean Bluff ISMP\SPBGIS\20130321 Figure 7 - Imperviousness.mxd modified 3/7/2014 by mauricio.herrera



LEGEND

- Storage Nodes
- Model Nodes
- Subcatchments
- <all other values>

Model Conduits (Cross Section)

- ARCH
- CIRCULAR
- IRREGULAR
- RECTANGULAR CLOSED
- RECTANGULAR OPEN
- TRAPEZOIDAL
- TRIANGULAR

N W E S

NOTES
Base data source:
Orthophotos, stream networks, contours, property lines and road network supplied by the City of Surrey.

STATUS
ISSUED FOR REVIEW

OCEAN BLUFF ISMP

STORMWATER MODEL

PROJECTION UTM Zone 10	**DATUM** NAD83	**CLIENT** CITY OF SURREY	
Scale: 1:22,000 (400 200 0 400 Meters)			
FILE NO. 20130321 Figure 8 - Stormwater Model.mxd		eba A TETRA TECH COMPANY	
PROJECT NO. V13203008	**DWN** AMF / **CKD** AM / **APVD** MH / **REV** 0		**Figure 8**
OFFICE EBA-VANC	**DATE** March 21 2013		

Q:\Vancouver\Engineering\V132\Projects\V13203008 Ocean Bluff ISMP\SPB\GIS\20130321 Figure 8 - Stormwater Model.mxd modified 6/10/2014 by mauricio.herrera

2.6.4 Model Calibration

Model results were compared to the observed flows in Chantrell Creek at the station in 32 Avenue. Infiltration parameters, groundwater parameters, subcatchment width and percent imperviousness were used as the calibration parameters. The model was calibrated and verified using long term (several months) periods from the multi-year rainfall and flow record available for Chantrell Creek. In general, the model compares well with the observed flows. An example of the model calibration comparing the computed versus observed flows is available in Figure 9 which shows the event of January 16th to 23rd of 2005. The model provides a reasonable response in terms of hydrograph shape and peak flows, in the long term the model produces a fair result in term of mean and total flows. Figure 10 shows a comparison between computed vs. observed peak flows for several storm events and Figure 11 shows a comparison for total flows. For the purpose of this project, at this stage, the model calibration is considered appropriate for the evaluation of the storm drainage system of the Study Area. Although the calibration was also performed for the Chantrell Creek watershed, calibration parameters, primarily groundwater parameters were also transferred to the rest of the subcatchments in the Study Area.

2.7 Stormwater and Drainage Criteria

The City of Surrey has a number of guidelines, bylaws, policies and documents which address stormwater management issues, including:

- City of Surrey Design Criteria Manual.
- Integrated Stormwater Management Plans.
- Surrey Stormwater Drainage Regulation and Charges Bylaw.
- Surrey Erosion and Sediment Control Bylaw.
- Surrey Soil Conservation and Protection Bylaw.
- Floodplain Policy.
- Neighbourhood Concept Plans.
- Ecological Management Assessment.
- Parks Strategic Plan.
- Natural Areas Management Plan.
- Sustainability Charter.

Section 5 of the Design Criteria Manual outlines guidelines for Storm Drainage Systems. It includes criteria for assessing the adequacy of existing drainage infrastructure which is a key objective of this study. Some of the important items from this section include:

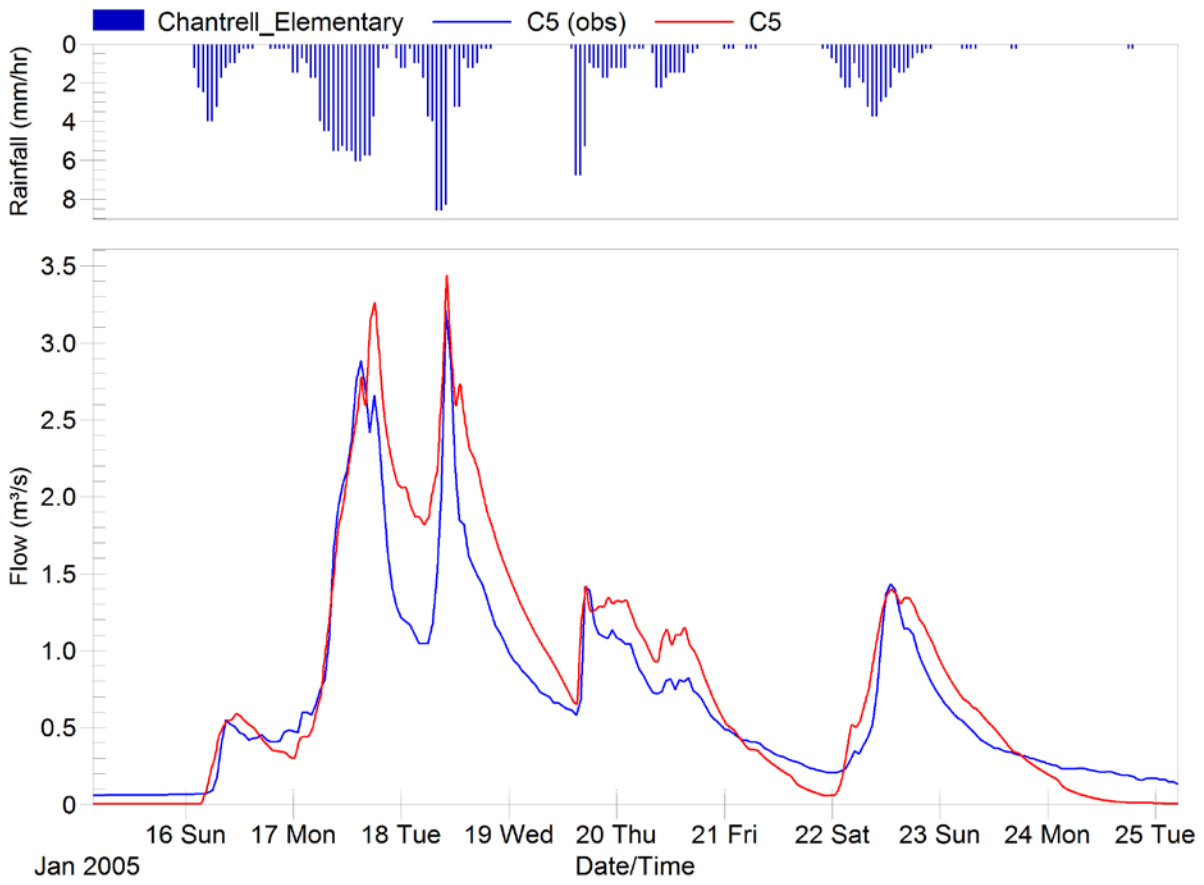
Section 5.2 C. Servicing Objectives:

- A minor system conveyance capacity up to the 1:5 year return period storm.
- A major system conveyance capacity of up to the 1:100 year return period storm.

- Control of discharges to natural upland watercourses and creeks to pre-development rates for 1:2 year to 1:5 year return period storms or to 50% of the post-development 1:2 year.

2.8 Hydraulic Performance of the Drainage System

The drainage system of the Study Area was assessed under various hydrologic conditions, including recorded storm events using data from the Chantrell Elementary rain-gauge station, and design storm events provided in the City of Surrey Design Manual for South Surrey. Figure 12 to Figure 15 illustrate the results of the drainage system assessment using the 1:5-year 2hr, 1:100-year 2hr, 1:5-year 24hr design storms as well as the monitored rainfall event of January 16th to 23rd, 2005. The colour coded maps illustrate show the pipes that exceeded 85% of total capacity during these events. For both the 2 hour and 24 hour 1:5-year storm events, the drainage system of the Study Area performs well, with some exceptions. For the simulated 100-year event, as well as for the observed storm event of 2005, the number of pipes under capacity is increased being more severe in the latter. The model indicates surcharging and limited flooding during these events. However, anecdotal information suggests that during the January 2005 storm event, the system performed adequately and no major flooding was registered.



LEGEND

NOTES

STATUS
ISSUED FOR USE

CLIENT

CITY OF SURREY

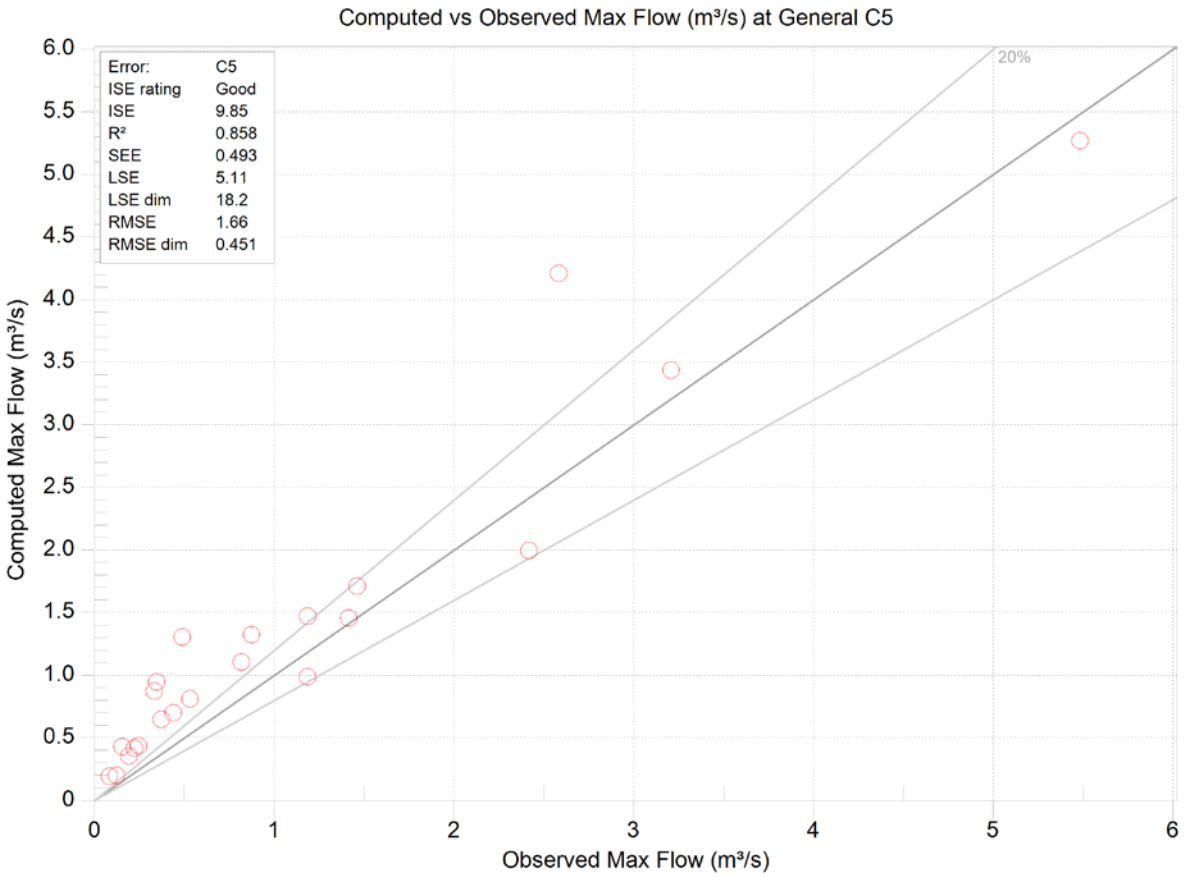
A TETRA TECH COMPANY

Model Calibration Results Computed vs Observed Flows at 32Ave at Chantrell Creek (Model Link C5)

PROJECT NO.	DWN	CKD	APVD	REV
V13203008				MH

OFFICE	DATE
EBA-VANC	November 21, 2012

Figure 9



LEGEND

NOTES

STATUS
ISSUED FOR USE

CLIENT

CITY OF SURREY

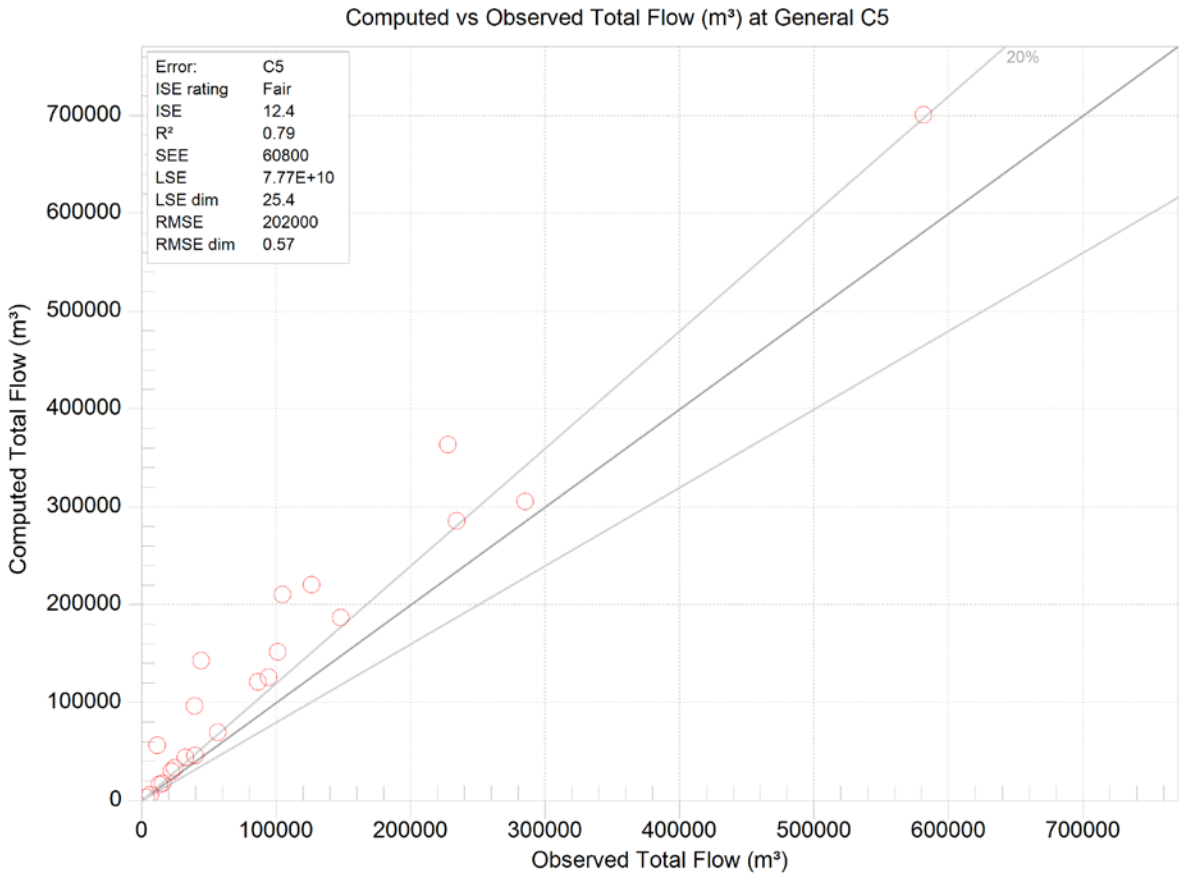
A TETRA TECH COMPANY

Model Calibration Results
Computed vs Observed Peak Flows at 32Ave at Chantrell Creek (Model Link C5)

PROJECT NO.	DWN	CKD	APVD	REV
V13203008				MH

OFFICE	DATE
EBA-VANC	November 21, 2012

Figure 10



LEGEND

NOTES

STATUS
ISSUED FOR USE

CLIENT

CITY OF SURREY

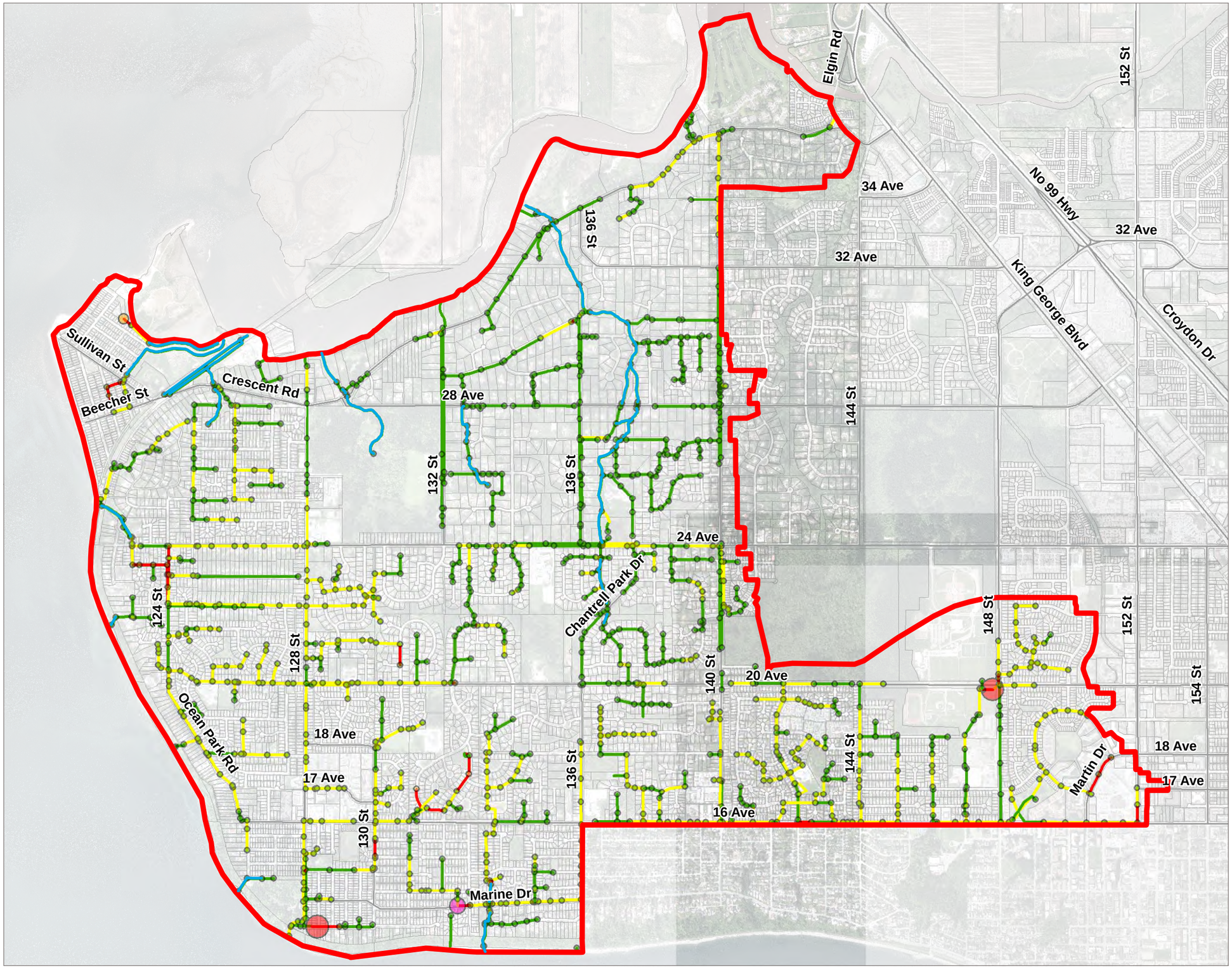
A TETRA TECH COMPANY

Model Calibration Results
Computed vs Observed Total Flows at 32Ave at Chantrell Creek (Model Link C5)

PROJECT NO.	DWN	CKD	APVD	REV
V13203008				MH

OFFICE	DATE
EBA-VANC	November 21, 2012

Figure 11



LEGEND

Streams

Flooding Duration (hrs)

- 0
- 0 - 0.010
- 0.01 - 0.16
- 0.16 - 0.28
- 0.28 - 1

N W E S

Pile Capacity (Max Depth/Conduit Height)

- 0.00 - 0.30
- 0.31 - 0.79
- > 0.80

NOTES
Base data source:
Orthophotos, stream networks, contours, property lines and road network supplied by the City of Surrey.

STATUS
ISSUED FOR REVIEW

OCEAN BLUFF ISMP

DRAINAGE SYSTEM CAPACITY 5 YR - 2 HR STORM EVENT

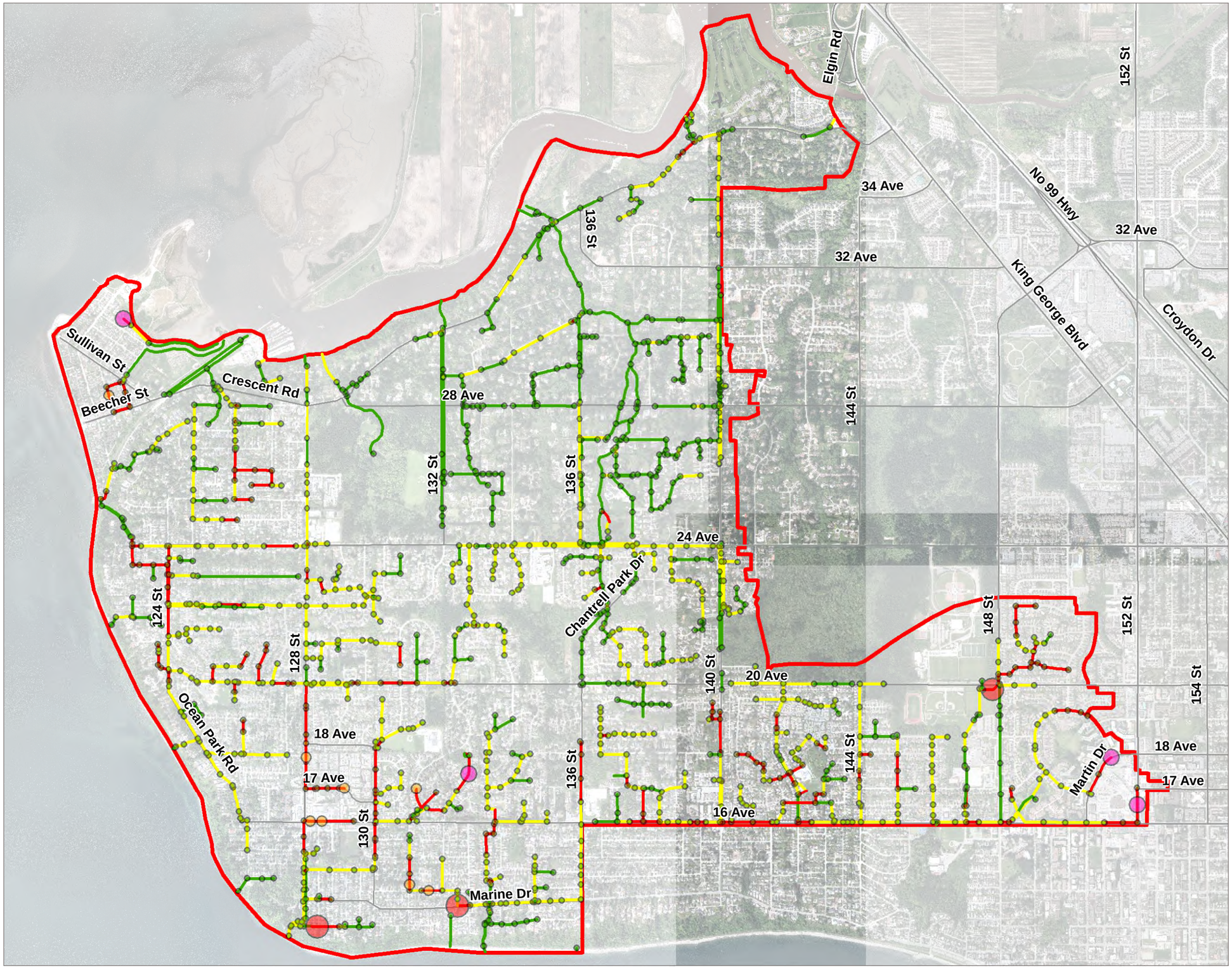
PROJECTION UTM Zone 10	**DATUM** NAD83			
Scale: 1:22,000 (400 200 0 400 Meters)				
FILE NO. 20130321 Figure 12 - Drainage System Capacity - 5yr2hr.mxd				
PROJECT NO. V13203008	**DWN** AMF	**CKD** AM	**APVD** MH	**REV** 0
OFFICE EBA-VANC	**DATE** March 21 2013			

CLIENT CITY OF SURREY

eba A TETRA TECH COMPANY

Figure 12

Q:\Vancouver\Engineering\V132\Projects\V13203008 Ocean Bluff ISMP\SPB\GIS\20130321 Figure 12 - Drainage System Capacity - 5yr2hr.mxd modified 6/10/2014 by mauricio.herrera



LEGEND

Flooding Duration (hrs)

- 0 - 0.03
- 0.03 - 0.33
- 0.33 - 0.81
- 0.81 - 1.61
- 1.61 - 2.12

N W E S

Pile Capacity (Max Depth/Conduit Height)

- 0.00 - 0.30
- 0.31 - 0.79
- > 0.80

NOTES

Base data source:
Orthophotos, stream networks, contours, property lines and road network supplied by the City of Surrey.

STATUS
ISSUED FOR REVIEW

OCEAN BLUFF ISMP

DRAINAGE SYSTEM CAPACITY 100 YR - 2 HR STORM EVENT

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	CITY OF SURREY

Scale: 1:22,000
400 200 0 400
Meters

FILE NO.
20130321 Figure 13 - Drainage System Capacity - 100yr2hr.mxd

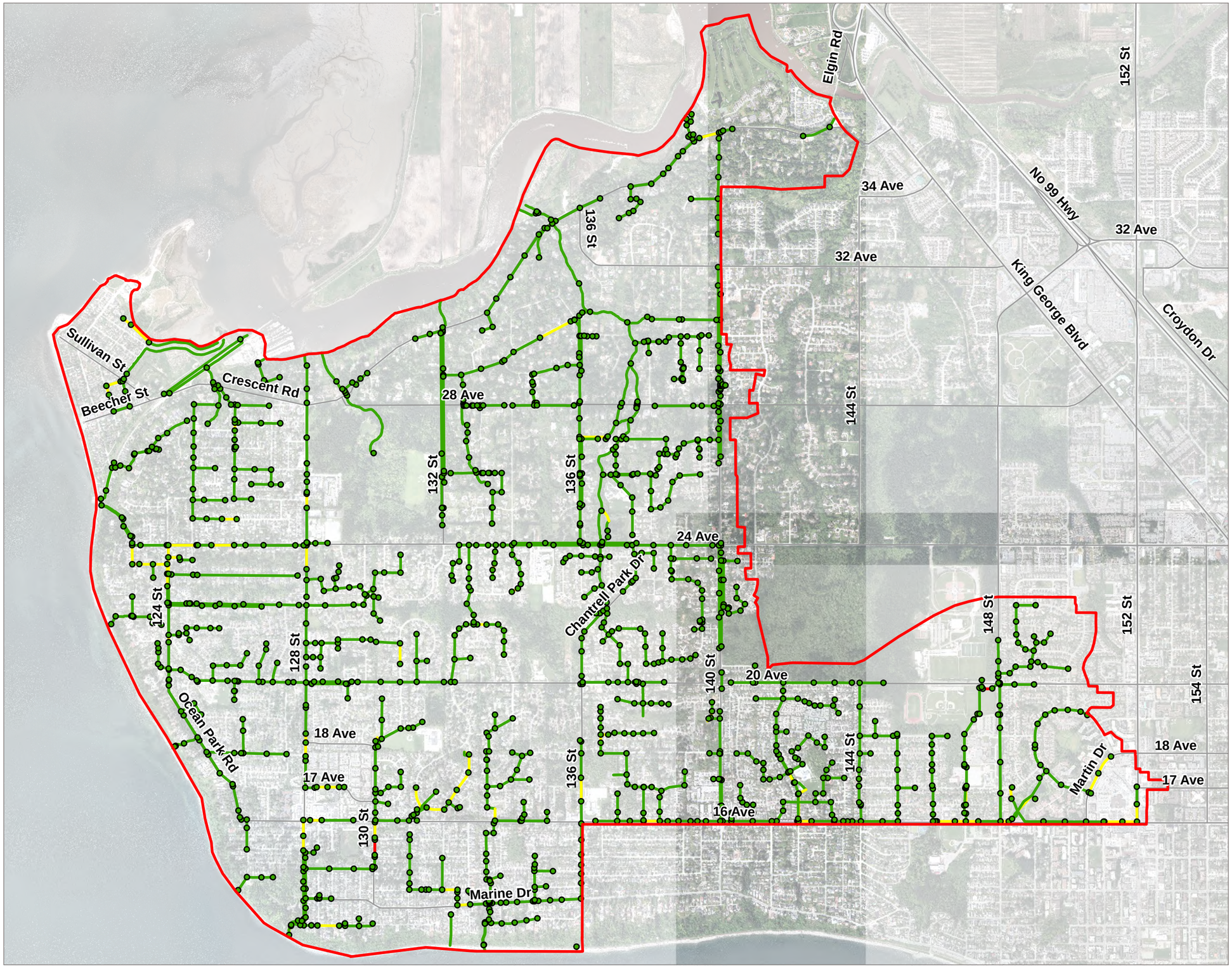
PROJECT NO.	DWN	CKD	APVD	REV
V13203008	AMF	AM	MH	0

OFFICE	DATE
EBA-VANC	March 21 2013

eba A TETRA TECH COMPANY

Figure 13

Q:\Vancouver\Engineering\V132\Projects\V13203008 Ocean Bluff ISMP\SPB\GIS\20130321 Figure 13 - Drainage System Capacity - 100yr2hr.mxd modified 6/10/2014 by mauricio.herrera



LEGEND

Flooding Duration (hrs)

- 0

Pile Capacity (Max Depth/Conduit Height)

- 0.00 - 0.30
- 0.31 - 0.79
- > 0.80

N W E S

NOTES
Base data source:
Orthophotos, stream networks, contours, property lines and road network supplied by the City of Surrey.

STATUS
ISSUED FOR REVIEW

OCEAN BLUFF ISMP

DRAINAGE SYSTEM CAPACITY 5 YR - 24 HR STORM EVENT

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	CITY OF SURREY

Scale: 1:22,000
400 200 0 400
Meters

FILE NO.
20130321 Figure 14 - Drainage System Capacity - 5yr24hr.mxd

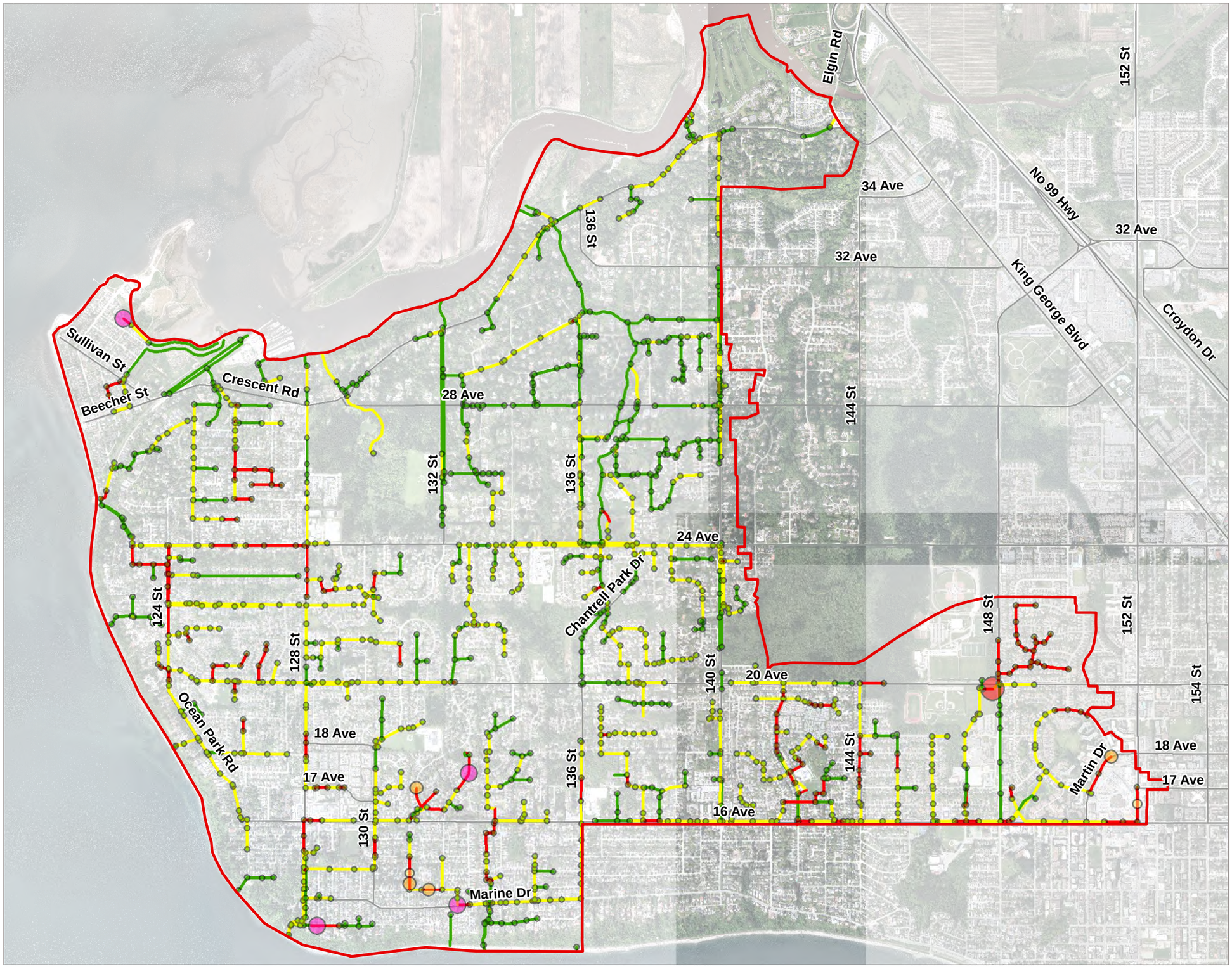
PROJECT NO.	DWN	CKD	APVD	REV
V13203008	AMF	AM	MH	0

OFFICE	DATE
EBA-VANC	March 21 2013

eba A TETRA TECH COMPANY

Figure 14

Q:\Vancouver\Engineering\V13\Projects\V13203008 Ocean Bluff ISMP\SPB\GIS\20130321 Figure 14 - Drainage System Capacity - 5yr24hr.mxd modified 6/10/2014 by mauricio.herrera



LEGEND

Flooding Duration (hrs)

- 0 - 0.16
- 0.16 - 1
- 1 - 2.39
- 2.39 - 9
- 9 - 25.8

N W E S

Pile Capacity (Max Depth/Conduit Height)

- 0.00 - 0.30
- 0.31 - 0.79
- > 0.80

NOTES
Base data source:
Orthophotos, stream networks, contours, property lines and road network supplied by the City of Surrey.

STATUS
ISSUED FOR REVIEW

OCEAN BLUFF ISMP

DRAINAGE SYSTEM CAPACITY RAINFALL EVENT JANUARY 16 - 23, 2005

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	CITY OF SURREY

Scale: 1:22,000
400 200 0 400
Meters

FILE NO.
20130321 Figure 16 - Drainage System Capacity - Observed Event.mxd

PROJECT NO.	DWN	CKD	APVD	REV
V13203008	AMF	AM	MH	0

OFFICE	DATE
EBA-VANC	March 21 2013

eba A TETRA TECH COMPANY

Figure 15

Q:\Vancouver\Engineering\V132\Projects\V13203008 Ocean Bluff ISMP\SPB\GIS\20130321 Figure 16 - Drainage System Capacity - Observed Event.mxd modified 6/11/2014 by mauricio.herrera

2.9 Climate Change Issues

Although most of the Ocean Bluff and Chantrell Creek drainage areas are in high elevation, there are some low-lying areas, vulnerable to the effects of climate change, such as sea level rise, storm surge, and rainfall increases. These areas are identified and a summary of vulnerable infrastructure is presented, along with a discussion on the adequacy of existing flood protection infrastructure, including dikes and drainage works.

2.9.1 Climate Change Projections

To provide context as to what changes are expected in the Metro Vancouver area, as summarized in Surrey (2013), by 2050 the Metro Vancouver area is expected to experience the following changes in precipitation patterns:

- **Winter precipitation** change is expected to range from -4% to +15%; with the median scenario expected to **increase** by 6%.
- **Summer precipitation** change is expected to range from -25% to +3%, with the median scenario expected to **decrease** by 15%.
- **Precipitation during very wet events** (95th percentile) is expected to **increase** by 21%, from the 2010 value of 28mm.
- **Precipitation during extremely wet days** (99th percentile) is expected to **increase** by 28%, from the 2010 value of 44 mm.
- **Extreme events with 3 hour duration** that in the past occurred every 10 years **are projected to occur on average three times as often**.

In terms of **sea level rise**, the BC Ministry of Environment recommends planning for a **1 meter increase**, projected by 2100, and for 2 meters increase by 2200. Based on these regulations, and considering subsidence in the City of Surrey at a rate of 0.225 mm/year, a net SLR by 2100 is expected at **1.195 from the 2010 base**. Because these values are based on a coarse analysis, the City of Surrey retained NHC to conduct a climate change floodplain review for both Serpentine and Nicomekl Rivers (NHC, 2012) in order to obtain more realistic estimates of SLR considering local conditions.

Using a joint probability analysis, NHC (2012) provided flood levels along the Nicomekl River, Mud Bay and Boundary Bay under extreme conditions considering climate change. Based on this report, there are three water levels of relevance:

- DFL (designated flood level): Flood elevation with no allowance for freeboard and serve as a base level (i.e. minimum).
- FCL (flood control level): Elevation required by the City for residences to be built to in an area.
- DCE (dike crest elevation): Elevation required by City where dikes have to be built to protect from waves and wave run-up.

For the purposes of the ISMP, both the FCL and the DCE are the values of interest. The FCL is the minimum elevation at which properties and infrastructure should be built in order to be protected from flooding. The projected FCL values for the year 2100 are used to establish areas floodplain limits and flood construction elevations, as recommended by NHC (2012). On the other hand, the DCE is used to assess whether the existing dikes in the Study Area are high enough to prevent flooding considering waves and wave run-up. Recommended dike elevations for the year 2100 were provided by NHC (2012) and summarized in Table 11.

Table 11: Summary of FCL and DCE Projections for the year 2100 from NHC (2012)

Location	Flood Control Level (FCL)	Dike Crest Elevation (DCE)
Crescent Beach	5.0m (4.97 north beach and 5.05 south beach)	5.7m (5.63 north & 5.8 south)
Crescent Road	4.6m	4.7m

2.9.2 Areas Vulnerable to Inundation

LiDAR data obtained from the City of Surrey's online GIS system (COSMOS), and flood elevation values reported by NHC (2012), were used to determine vulnerable areas to inundation for the year 2010, according to the joint probability analysis for the 200-year return period water levels; and for the year 2100 according to the joint probability analysis. Figure 16 and Figure 17 show the areas vulnerable to flooding for the projected condition in the years 2010, and 2100 respectively. Table 12 presents a summary of vulnerable areas and assets.

Both dike systems in the Study Area, one along the edge of the Crescent Beach area and the other along the edge of the Nico-Wynd golf course are below the projected DCE for years 2010 and 2100.

Crescent Beach is below the projected FCL, and the dikes that protect this area are below the projected DCE making this area vulnerable to inundation for both the 200-year return period water levels, and for the effects of climate change in the year 2100. Similarly, there are other areas along Crescent Road below the projected FCL thus vulnerable to inundation. The dike system along the edge of the Nico-Wynd golf course is below the projected DCE for both conditions as well.

Table 12: Vulnerable Areas to Inundation due to Climate Change Impact

Map Id	Area	Vulnerable Assets
A	Crescent Beach	All properties (~580 mostly residential and some commercial buildings with an approximate value of $400M), 9 Km. of municipal roads, utilities and other assets inside this area
B	Property on Crescent Road	Private property on lot 13499 Crescent Road
C	Wards Marina on Elgin Heritage Park	Marina, Yacht club
D	Crescent Road	400 meters of Crescent Road (from Crescent Road and 35 Avenue to 13954 Crescent Road); residential buildings on lots 13890, 13909, 13937, 13954 Crescent Road
E	Golf Course and residential area	Golf course, 1.2 Km of municipal roads, 77 residential buildings, utilities and other assets inside this area

N
W
E
S

Sheltered Section of Mud Bay Dike

Existing DCE: 2.98m
2010 DCE: 3.51m

Sheltered Section of Crescent Beach East

Existing DCE: 2.88m
2010 DCE: 3.75m

Crescent Beach North Beach Dike

Existing DCE: 2.90m
2010 DCE: 3.95m

Crescent Beach South Dike

Existing DCE: 3.30m
2010 DCE: 4.16m

A
B
C
D
E

GILLEY LS
SULLIVAN LS
Maple Drainage
CRESCENT BEACH LS (Metro Van)
STEWART FARM LS
Nico Wynd
SOUTHPORT LS
Decommissioned - Harbour Greene

Chantrell Creek
Crescent Stream
Dunsmuir Channel 2
Dunsmuir Channel

Burl North (Crescent) Rwy

136 St
Rio Pl
King George Blvd
Elgin Rd
142 St
36A Ave
Greencrest Dr
143A St
35 Ave
34 Ave
33B Ave
33 Ave
32A Ave
32 Ave
32B Ave
31A Ave
31 Ave
30A Ave
30 Ave
29A Ave
29 Ave
28A Ave
28 Ave
27A Ave
27 Ave
26A Ave
26 Ave
25A Ave
25 Ave
24A Ave
24 Ave
23A Ave
23 Ave
22B Ave
22A Ave
22 Ave
21A Ave
21 Ave
20A Ave
20 Ave
136 St
137 St
137A St
138 St
138A St
139 St
139A St
140 St
140A St
141 St
142 St
143 St
144 St
Balsam Cr
Woodcrest Dr
Woodcrest Pl
Vine Maple Dr
Chantrell Pl
Chantrell Park Dr
Northcrest Dr
McBride Ave
Sullivan St
Adams Lane
Beecher St
Bayview St
Crescent Dr
Crescent Rd
Maple St
Cedar Dr
Seacrest Dr
Indian Fort Dr
Ocean Cliff Dr
Oceana Terrace
124 St
124B St
125 St
125A St
126 St
126A St
127 St
127A St
127B St
128 St
128A St
129 St
129A St
129B St
130 St
130 St
131 St
131A St
131B St
132 St
132A St
133 St
133A St
134 St
134A St
135A St
136A St
138A St
139A St
140 St Fig E
140A St

LEGEND

- StudyArea
- Vulnerable Areas - 2010
- 2010 FCL
- Watercourse
- Dike
- Pump Station
- Flood Box
- Cadastral Property Boundary
- Building Footprint
- Road

Sheltered Section of Mud Bay Dike
Existing DCE: 2.98m
2010 DCE: 3.51m

Existing Dyke Crest Elevation (m)

DCE for 2010 scenario using joint probability approach

Source: NHC, 2012

A - Vulnerable Areas (Refer to Table 12)

NOTES
Base data source: All imagery and base data provided by the City of Surrey, 2012-2013.

STATUS
ISSUED FOR REVIEW

OCEAN BLUFF ISMP

Areas Vulnerable to Inundation due to Climate Change. Condition 2010.

PROJECTION UTM Zone 10	**DATUM** NAD83	**CLIENT** CITY OF SURREY	
Scale: 1:15,000 (250 125 0 250 Meters)		TETRA TECH EBA	
FILE NO. Report_Figure-Fig16_Vulnerability_2010.mxd			
PROJECT NO. V13203008-01	**DWN** YL / **CKD** AMF / **APVD** MH / **REV** 0		**Figure 16**
OFFICE Tt EBA-VANC	**DATE** April, 2015		

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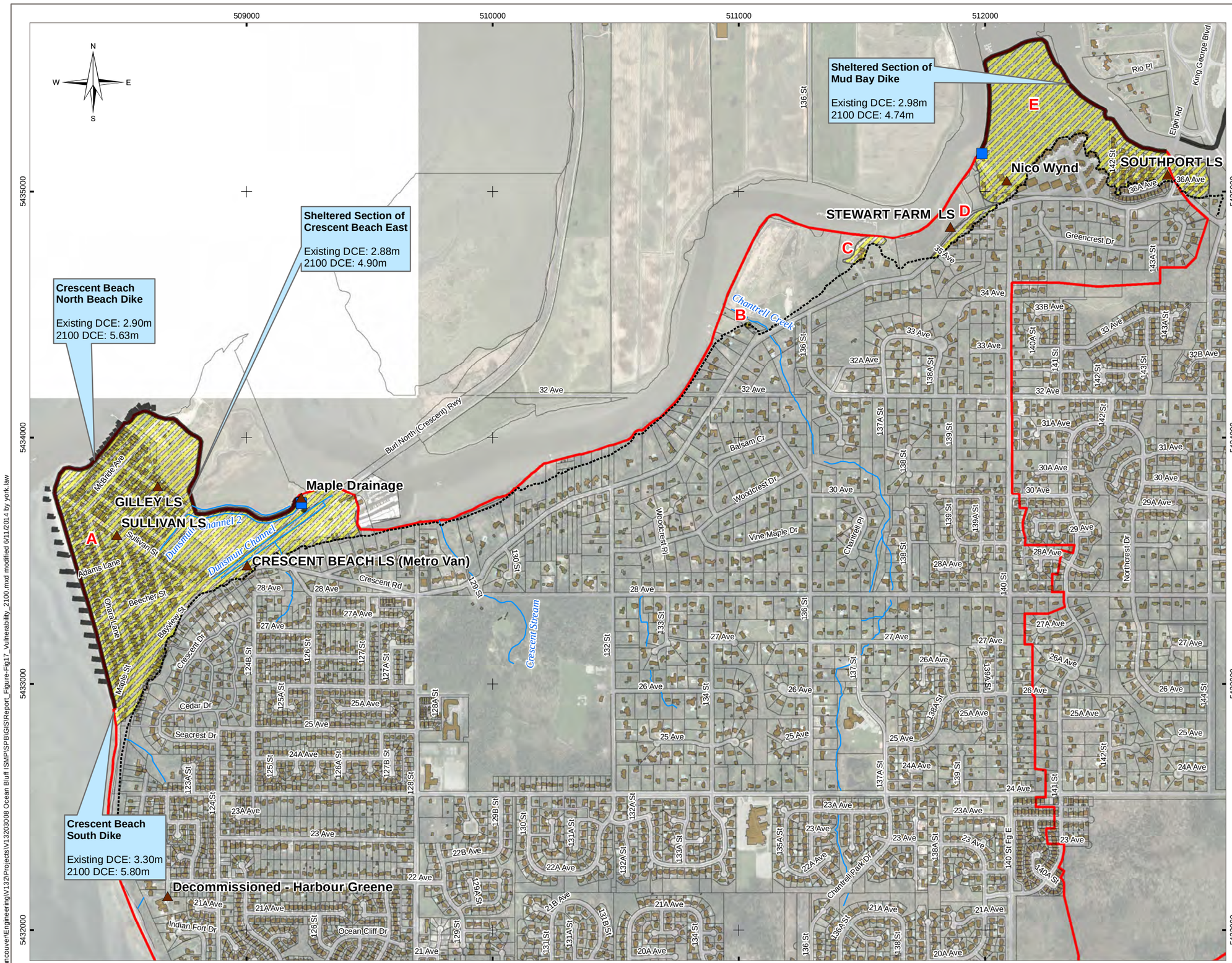

NOTES
Base data source: All imagery and base data provided by the City of Surrey, 2012-2013.

STATUS
ISSUED FOR REVIEW

OCEAN BLUFF ISMP

Areas Vulnerable to Inundation due to Climate Change. Condition 2100.

PROJECTION: UTM Zone 10	DATUM: NAD83	CLIENT: City of Surrey		
Scale: 1:15,000 (250 125 0 250 Meters)				
FILE NO.: Report_Figure-Fig17_Vulnerability_2100.mxd		Tt TETRA TECH EBA		
PROJECT NO.: V13203008-01	DWN: YL	CKD: AMF	APVD: MH	REV: 0
OFFICE: Tt EBA-VANC	DATE: May 22, 2014			Figure 17

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2.9.3 Drainage Issues: Crescent Beach

This low-lying area is protected from high tides and storm surge with a system of dikes and drainage works, including the recently upgraded Maple Drainage pump station. Nevertheless, there are a number of issues that still prevent an efficient drainage of this area, and that can be exacerbated due to climate change effects, including:

- High groundwater table.
- Groundwater fluctuations in connection with tides.
- Stormwater drainage infrastructure below groundwater table.

Urban Systems (2009) prepared a report titled “Crescent Beach Climate Change Adaptation Study” in which a thorough assessment of the drainage system was conducted under existing and future climate change conditions.

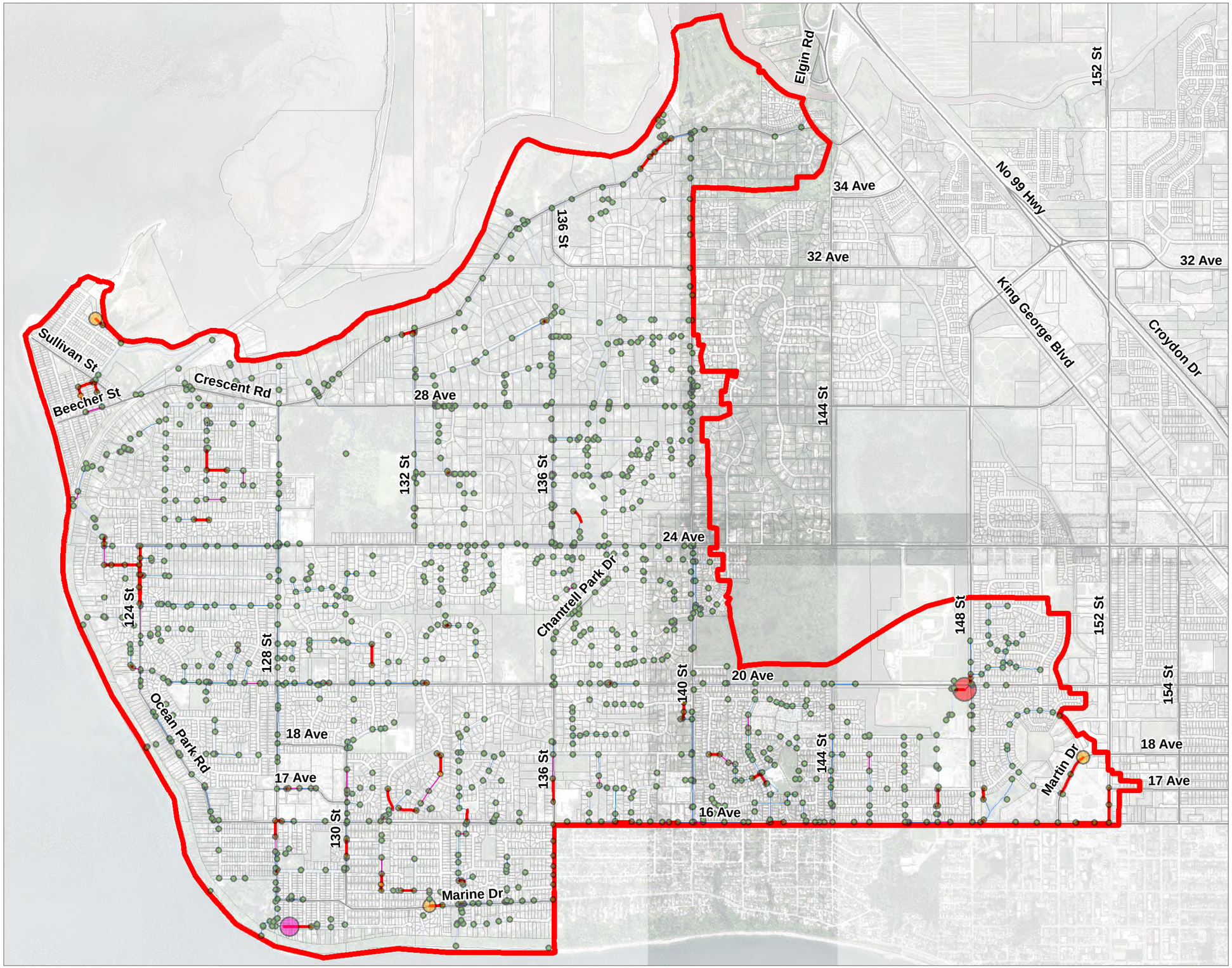
2.9.4 Drainage Issues: Ocean Bluff and Chantrell Creek Drainage Areas (excluding Crescent Beach)

The drainage system of the Study Area was assessed through the use of a stormwater model, as described in Section 2.8. As discussed, the system functions adequately according to City’s criteria (e.g. convey the 5 year storm event through storm pipes without flooding). The system was also assessed under climate change conditions. According to the Surrey (2013) by 2050 the Metro Vancouver area is expected to experience an increase in 28% of very wet storm events. Accordingly, the 5year-2 hr. storm event was increased by this amount and used to assess the system via hydraulic modelling. Results can be observed in Figure 18. Compared to the 5-year 2hr storm events, a few more pipes experience surcharge and only very few manholes are overtopped.

2.9.5 Environmental Concerns Due to Climate Change

As reported by Surrey (2013), Metro Vancouver is expected to have warmer and dryer summers. Extreme hot days, which historically have occurred every 10 years (exceeding 35C) are projected to occur over twice as often by the 2050s. As noted before, summer rainfall is expected to decrease in 15% by the 2050s.

These changes may result in environmental impacts, such as reduced summer baseflows, and warmer stream water temperatures, which in turn will impact aquatic habitat. In term of reduced baseflows, an additional concern is that it can be expected that larger groundwater volumes may be extracted in Chantrell Creek for flow augmentation. As noted before, there are water quality concerns, particularly high Arsenic concentrations coming from the groundwater. Also, thermal enrichment, or the warming of impervious areas will lead to warm runoff and increased stream temperatures.



LEGEND

Flooding Duration (hrs)

- 0 - 0.04
- 0.04 - 0.34
- 0.34 - 1.24
- 1.24 - 1.83
- 1.83 - 4.92

N W E S

Pipe Capacity (Max. Depth/Conduit

- 0 - 0.5
- 0.5 - 0.75
- 0.75 - 0.85
- > 0.85

NOTES
Base data source:
Orthophotos, stream networks, contours, property lines and road network supplied by the City of Surrey.

STATUS
ISSUED FOR REVIEW

OCEAN BLUFF ISMP

STORM SYSTEM CAPACITY CLIMATE CHANGE SCENARIO 5YR-2HR EVENT - INCREASED 28%

PROJECTION UTM Zone 10	**DATUM** NAD83	**CLIENT** CITY OF SURREY
Scale: 1:22,000 (400 200 0 400 Meters)		
FILE NO. 20130321 Figure 18 - Drainage System Capacity - Climate Change 5yr2hr.mxd		eba A TETRATECH COMPANY
PROJECT NO. V13203008	**DWN** AMF / **CKD** AM / **APVD** MH / **REV** 0	**Figure 18**
OFFICE EBA-VANC	**DATE** March 21 2013	

Q:\Vancouver\Engineering\V132\Projects\V13203008 Ocean Bluff ISMP\SPB\GIS\20130321 Figure 18 - Drainage System Capacity - Climate Change 5yr2hr.mxd modified 6/11/2014 by mauricio.herrera

3.0 VISION

A vision for the Ocean Bluff and Chantrell Creek drainage areas was established in consultation with the City departments of planning, environment and engineering, and in agreement with the City of Surrey's Climate Adaptation Strategy. Although there are no major development or re-development plans, the mainly residential character of this area, its favorable micro-climate within the Lower Mainland, and its proximity to the ocean, makes it a desirable place to live. Yet, to improve the interaction between the urban settings and the natural environment, and also its resilience to climate change, a vision has been established whereby:

"The City of Surrey, the residing community and the main stakeholders in the Ocean Bluff and Chantrell Creek drainage areas will strive to ensure that this area will continue to promote a healthy balance between natural ecosystems and human activity, in the face of a changing climate".

This vision involves three main components:

- Becoming a "Greener" community.
- Enhancing the environmental value of receiving water bodies.
- Climate Change Adaptation: In alignment with Surrey's Vision.

3.1 Becoming a "Greener" Community

The overall vision from the ISMP is that the Ocean Bluff and Chantrell Creek drainage areas will become "greener" over time. This means that green infrastructure features, with a stormwater control function, will be progressively incorporated into the study area. There are opportunities to do so by adding low impact development (LIDs) concepts on parks and opportunistically on capital projects in the area, and on any development or re-development that may occur. Focus will be on public lands for easy access and maintenance; however the same principles will be applied to private lands.

The main objective of this strategy is to slowly increase the capture of a target rainwater volume, which will be filtered through cleansing materials, infiltrated into the soil to replenish groundwater, and released at a controlled rate and with a lower temperature into the drainage system. This action will achieve a reduction of the pollutant load associated to urban runoff, and will also help to regulate the discharges of stormwater runoff into the receiving water bodies. As noted in Section 2.5.1, stormwater discharges are likely related to impacts to the low biometrics of benthic macro-invertebrates in Chantrell Creek. These impacts are associated with degradation of the water quality and changes in the hydraulic regime, mainly associated with increased "flushes" or "pulses" from the urban runoff.

3.2 Enhancing the Environmental Value of Receiving Water Bodies

An important part of the vision is to improve the conditions of receiving water bodies in the Study Area. This will be achieved through a combination of water quality management, stormwater management and localized projects to enhance fish habitat conditions. The most relevant stream enhancement project is the re-alignment of the lower part of Chantrell Creek, which currently discharges to the Nicomekl through a culvert structure.

3.3 Climate Change Adaptation: In Alignment with Surrey's Vision

As outlined in the City of Surrey's Climate Adaptation Strategy (Surrey, 2013): "the City of Surrey will be resilient in the face of a changing climate", and will also: "…take timely action to reduce the risks of climate change and thereby minimize social, environmental, and economic costs in the future".

As noted by Surrey (2013): “There is a high risk of increase in frequency and duration of flooding within low lying floodplains due to reduced system drainage resulting from sea level rise (SLR) and more intensive precipitation events”.

In order to increase resiliency in the Study Area, the City will upgrade the existing dikes along Crescent Beach and the Nicomeckl River and will provide any other protection means necessary to mitigate the risk of flooding.

4.0 MANAGEMENT MODEL

The vision developed for the Study Area will be achieved through a number of actions and strategies that can be classified on five main categories:

- Rainwater management.
- Aquatic habitat enhancement.
- Geomorphological enhancements.
- Educational outreach.
- Climate change adaptation.

4.1 Steps to Become a “Greener” Community

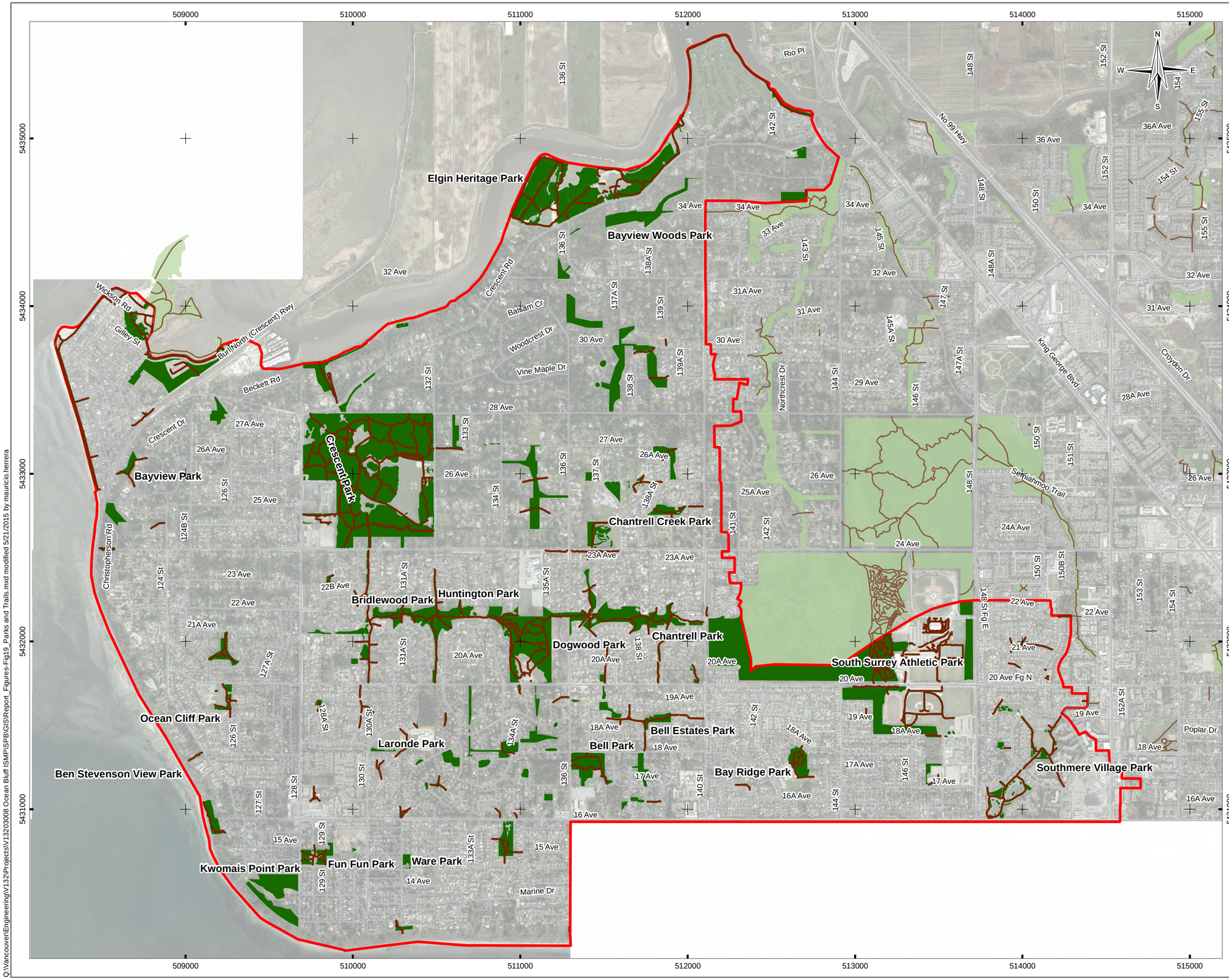
The Ocean Bluff and Chantrell Creek areas have a total of 132 ha of park or green spaces, and a total of 46 Km of paths and trails distributed throughout the Study Area, as shown in Figure 19. Table 13 presents a summary of all parks and their respective areas. Parks not only are a refuge from paved areas, they also serve (or can serve) other functions, including stormwater management, air cleansing, habitat and corridors for wildlife, and carbon emission traps which contribute to global warming. Although existing parks in the Study Area provide these functions to some extent, there is still room for improvement in order to convert these green areas into high performance parks, a concept used in the City of New York as part of their climate change adaptation strategy. Yet, not only parks can be developed into high performance parks, other often neglected areas such as roadway medians, rooftops, abandoned railway tracks and former industrial areas can be converted as well. Paths and trails also offer opportunities to enhance the benefits of green areas as they act as connecting green corridors between parks. Similarly, capital works such as road and utility upgrades also provide an opportunity to include green infrastructure components, which can be integrated into nearby green areas or corridors. Development and re-development will also provide opportunities to introduce green infrastructure concepts. ISMP focuses on how to enhance the stormwater management function of green areas or parks, paths or trails, capital works, and development and re-development. With this in mind, rainwater capture and release targets are defined for the study area.

Table 13: Summary of Parks within Study Area

Park Name	Area within Study Area (ha)
Ben Stevenson View Park	0.010
Bayview Woods Park	0.02
Elgin Heritage Park	0.03
Chantrell Park	0.04
Blackie Spit	0.08

Table 13: Summary of Parks within Study Area

Ocean Park Terrace - 121B	0.14
Laronde Park	0.15
Christopherson Steps	0.16
Crescent Park School Grounds	0.16
Bayview Woods Park	0.23
South Surrey/White Rock Pool	0.28
Ware Park	0.29
Elgin Community Hall Grounds	0.38
Ocean Cliff Park	0.41
Bayview Park	0.59
Southmere Village Park	1.1
Bell Estates Park	1.2
Fun Park	1.2
Chantrell Creek Park	1.2
Blackie Spit	1.4
Bay Ridge Park	1.5
Blackie Spit	1.5
Bayview Woods Park	2.6
Bell Park	2.7
South Surrey Athletic Park	3.3
Huntington Park	3.6
Bridlewood Park	4.1
Kwomais Point Park	4.1
Blackie Spit	5.0
Chantrell Park	6.1
Dogwood Park	7.6
Elgin Heritage Park	7.8
Elgin Heritage Park	8.6
Sunnyside Acres Urban Forest	23.1
Crescent Park	41.1
Total Park Area (ha)	**132.0**



LEGEND

- StudyArea
- Parks within Study Area
- Parks Outside Study Area
- Park Paths and Trails Within Study Area
- Park Paths and Trails Outside Study Area
- Road

NOTES

Base data source: All imagery and base data provided by the City of Surrey, 2012-2013.

STATUS

ISSUED FOR REVIEW

OCEAN BLUFF ISMP

Green Spaces: Parks and Corridors in the Ocean Bluff and Chantrell Creek Area

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	CITY OF SURREY

Scale: 1:22,000

400 200 0 400

Meters

TETRA TECH EBA

FILE NO. Report_Figures-Fig19_Parks and Trails.mxd

PROJECT NO.	DWN	CKD	APVD	REV
V13203008-01	YL	AMF	MH	0

OFFICE	DATE
Tt EBA-VANC	May 29, 2014

Figure 19

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4.1.1 Rainwater Management: Capture and Release Targets

The small and frequent storm events account for most of the annual runoff volume which finds its way into the drainage system. In turn, this runoff is responsible for washing off most of the pollutants that build up during dry weather conditions on the watershed surface. As such, capturing these events using LIDs (Low Impact Development) will allow the removal of pollutants and the recharge of the groundwater, improving water quality and reducing the flashiness of the stormwater discharges into the creeks.

Rainfall events which account for up to 90% of the total annual precipitation were selected as the target to be captured and released at a controlled rate. The target was determined using local hourly rainfall data from 2000 to 2012. Data was obtained from the City operated raingauge located in Chantrell Creek Elementary School. A multi-year frequency analysis was conducted to determine that the size of this event is 42 mm per 24hr (or 420 m^3 of storage required, for one impervious hectare, in a 24 hour period), as shown in Figure 20. To put this target in context, according to the City of Surrey's Design Criteria Manual 92004), for the White Rock STP raingauge station, the 24hr storm event volume for various return periods are shown in Table 14.

Table 14: White Rock STP Raingauge Station. 24 hr Storm Events

Return Period (years)	Rainfall Volume (mm)
2	50.6
5	62.5
10	70.5
25	80.4
50	87.9
100	95.2

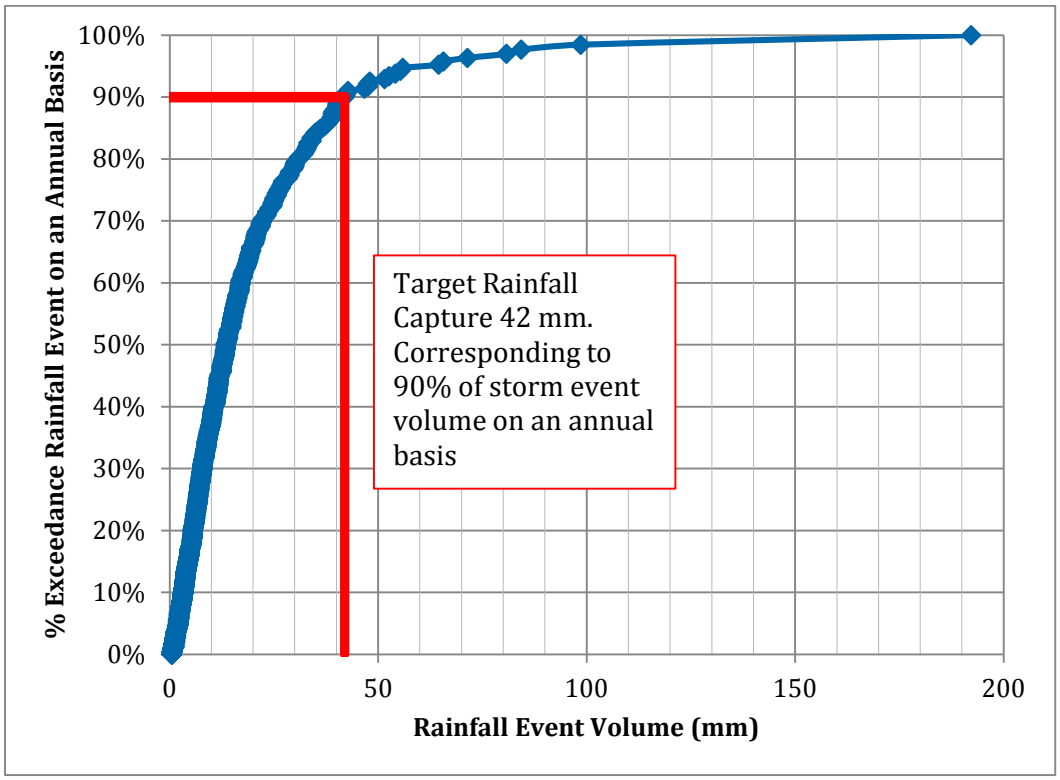


Figure 20 - Stormwater Capture Target: Ocean Bluff and Chantrell Creek ISMP

The objective is to use onsite Low Impact Development (LID) strategies such as raingardens, bioswales, infiltration trenches, vegetated swales, and permeable pavement among other technologies to capture and infiltrate this rainfall volume. In addition a flow release target is also required for hydrologic conditions in which full infiltration of the captured volume is not possible.

Findings from the Stoney Creek ISMP in Burnaby Mountain, suggested that during pre-development conditions, where most of the precipitation is detained by the canopy, surface and infiltrated into the ground, the average observed flows in the creek were in the order of 2 L/s/ha. Given that pre-development flows for the Chantrell Creek watershed are not available, the suggested rate of 2 L/s/ha was adopted as the release rate target.

Furthermore, infiltration rates in the Chantrell Creek watershed were assessed using the long term rainfall and flow data available. This was determined by conducting a volumetric analysis of observed flows and rainfall. The rainfall volume that was not accounted as downstream flows in the creek was assumed to be the 'infiltration' volume. Using data from all storm events and flows available, it was determined that the "infiltration" rates varied between .5 and 8 L/s/ha during the 12 year period. The lower end of this range is related to storm events where most of the precipitation events made it into the creek. On the other hand, the higher end of the range is related to events where the watershed "absorbed" a higher ratio of the rainfall volume. By conducting a frequency analysis of this data, it was determined that a value of 1.5 L/s/ha is the most frequent "infiltration" rate in the watershed system, as shown in Figure 21. These findings are important because they show that selected release rate falls within the natural range of groundwater recharge.

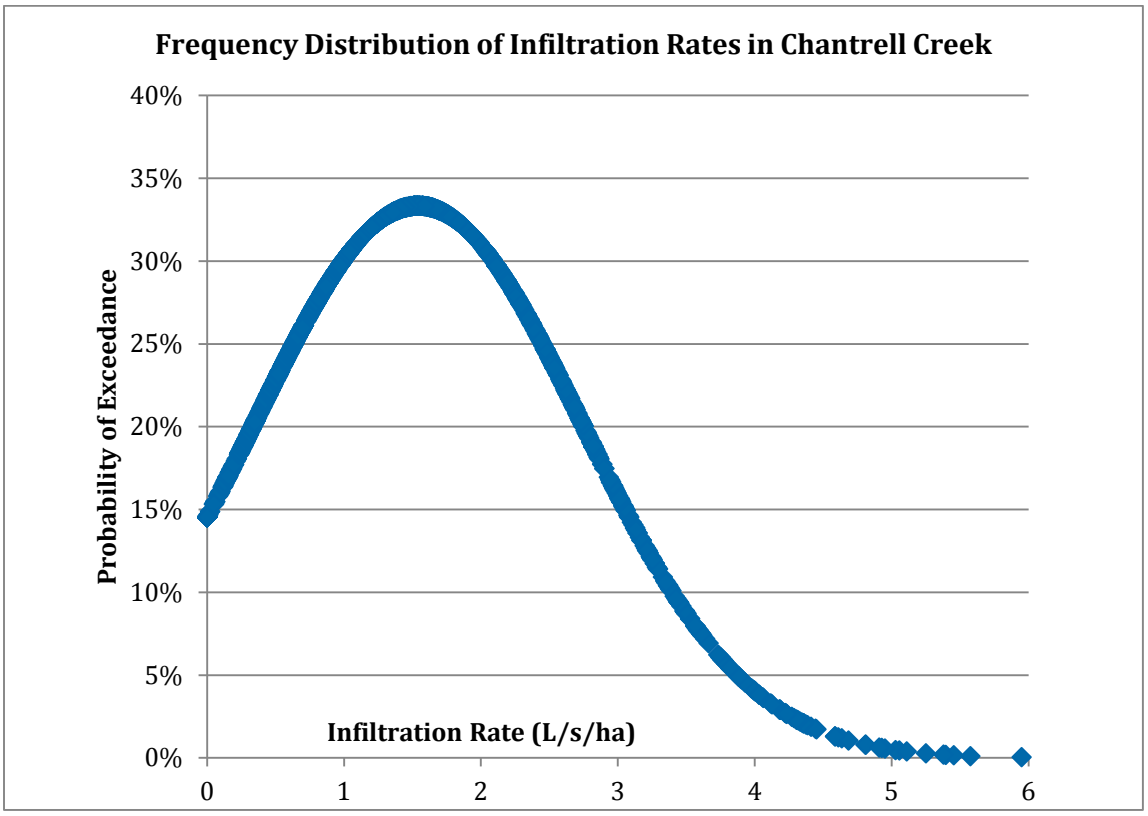


Figure 21 - Probability of Exceedance of Infiltration Rates in Chantrell Creek

4.1.2 Green Infrastructure Design Application

A number of Low Impact Development (LID) alternatives are available to achieve the above described rainwater capture and release targets, depending on the specific setting and site constraints. Selection of an appropriate LID option and final configuration will be defined on a project by project basis. These projects offer an opportunity to introduce green infrastructure concepts for stormwater management. To better understand this concept, a design example is presented below:

DESIGN EXAMPLE

Assuming that a road segment will be upgraded, an onsite stormwater feature (i.e. an infiltration trench) will to be added in order capture the first 42 mm of rainfall in a 24hr period. Assuming that segment is 100 meters long and 10 meters wide (area = 0.1 ha), then the required storage capacity would be 42 m^3 (42 mm X 0.1 ha). Furthermore, the release rate would be 2 L/s/ha X 0.1 = 0.2 L/s.

The implementation of green infrastructure in the Study Area will be accomplished progressively and opportunistically. The ISMP provides the general requirements on the level of rainfall capture that needs to be achieved by the LIDs, and the maximum release rate to be permitted off the LIDs. Although there are no significant plans for development and redevelopment in the area, a project was identified, and discussed next, to develop a green corridor with rainwater management features.

4.1.3 Upper Chantrell Green Corridor

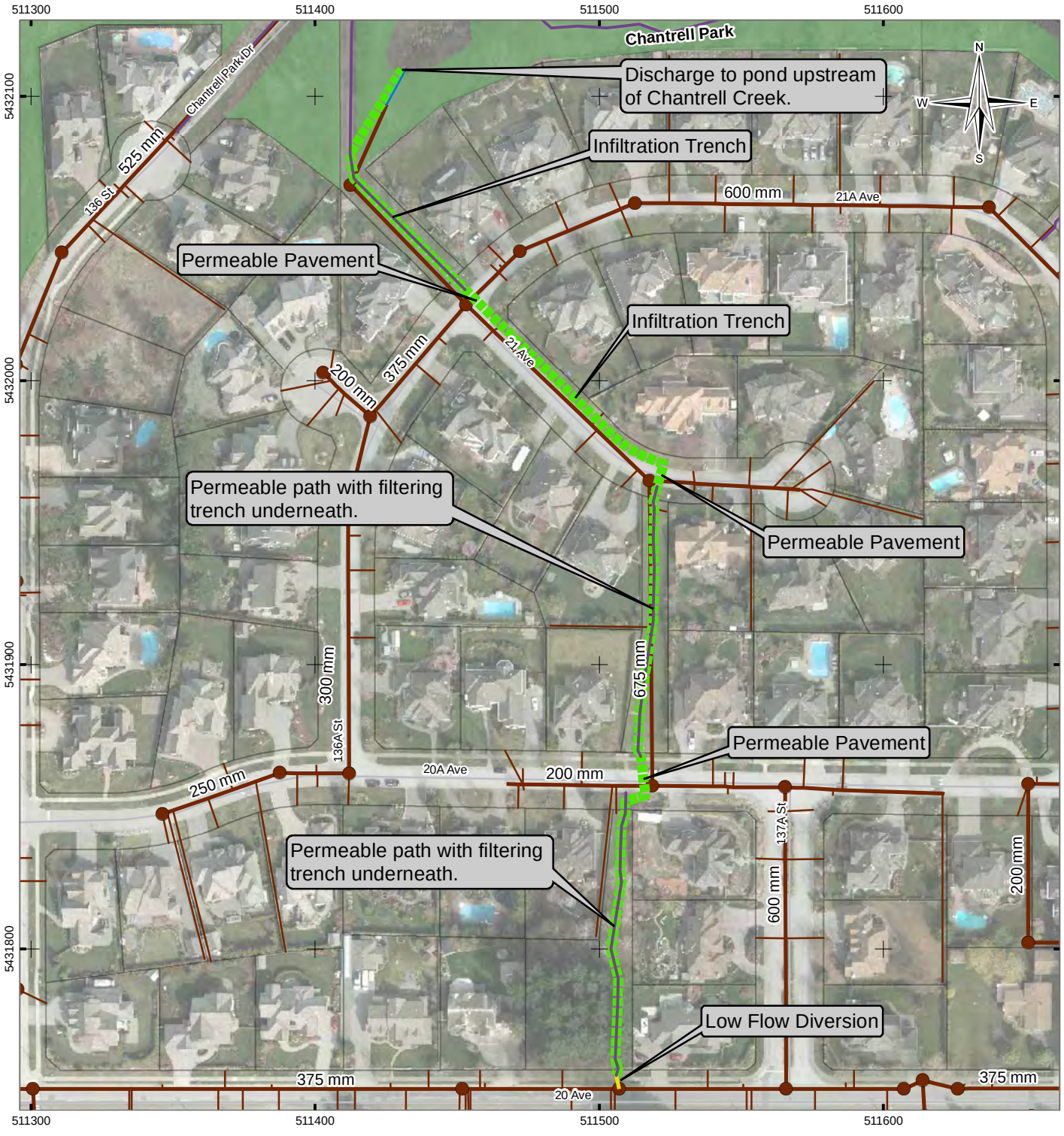
An opportunity is identified in the upper Chantrell Creek watershed by converting an existing path into a green corridor with rainwater management functions. The selected path is shown in Figure 22. It starts northbound at the green corridor (gravel path) from 13741 20 Avenue; then crossing 20A Avenue, continuing north through the paved path that starts at 13729 20A Avenue until and through 21 Avenue, then turning northwest along 21 Avenue along the City's right of way, then crossing 21A Avenue and continuing through the asphalt path that leads to Chantrell Park, finally turning northeast through the park before reaching the upper end of Chantrell Creek.

This project will provide a number of benefits to the Chantrell Creek watershed, including:

- Cleaner and cooler runoff water.
- Groundwater recharge.
- System redundancy.
- Climate change adaptation.

The proposed green corridor shown in Figure 22 will collect runoff from a total area of approximately 4.5 ha. The project has the following components:

- A low flow diversion at the manhole at 2011 20 Avenue, just south of the Green Corridor. This will connect manhole 1370201963 with the green corridor. The approximate flow to be diverted is calculated using the release target of 2L/s/ha, which results in a flow of 2 x 4.5 = 9 L/s.
- An infiltration trench, going south to north from 20 Avenue to 20A Avenue, underneath the gravel path on the Green Corridor.
- A permeable pavement section at 20A Avenue to cross from the gravel path onto the Green Belt.
- An infiltration trench, underneath the path on the Green Belt, from 20A Avenue to 21 Avenue.
- A permeable pavement section at 21 Avenue.
- An infiltration trench along the road right of way, on the north side of 21 Avenue.
- A permeable pavement section along 21A Avenue.
- An infiltration trench along the path that leads to Chantrell Park.
- An outfall onto Chantrell Creek.



LEGEND

Type

- Upper Chantrell Creek Green Corridor
- Low Flow Diversion
- Park Paths and Trails
- Storm Drainage Main Pipe
- Storm Drainage Lateral Pipe
- Storm Drainage Manhole

NOTES
Base data source: All imagery and base data provided by the City of Surrey, 2012-2013.

STATUS
ISSUED FOR REVIEW

OCEAN BLUFF ISMP

Upper Chantrell Creek Green Corridor

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	CITY OF SURREY

Scale: 1:2,000
40 20 0 40
Metres

FILE NO. Report_Figures-Fig22_Green_Corridor.mxd

PROJECT NO.	DWN	CKD	APVD	REV
V13203008-01	YL	AMF	MH	0

OFFICE Tt EBA-VANC
DATE June 4, 2014

TETRA TECH EBA

Figure 22

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4.1.4 Runoff Water Quality Treatment at Upper Chantrell Creek

To supplement the Upper Chantrell Green Corridor, a Stormceptor is proposed to be installed at the upper end of Chantrell Creek, at manhole 1365502121, located northwest of the 21 Avenue. and 21A Avenue. intersection as shown in Figure 23. This water quality treatment unit will receive runoff from 35 ha residential area, with a percentage of imperviousness of approximately 15%.

Figure 23 - Proposed Stormceptor – Upper Chantrell Creek

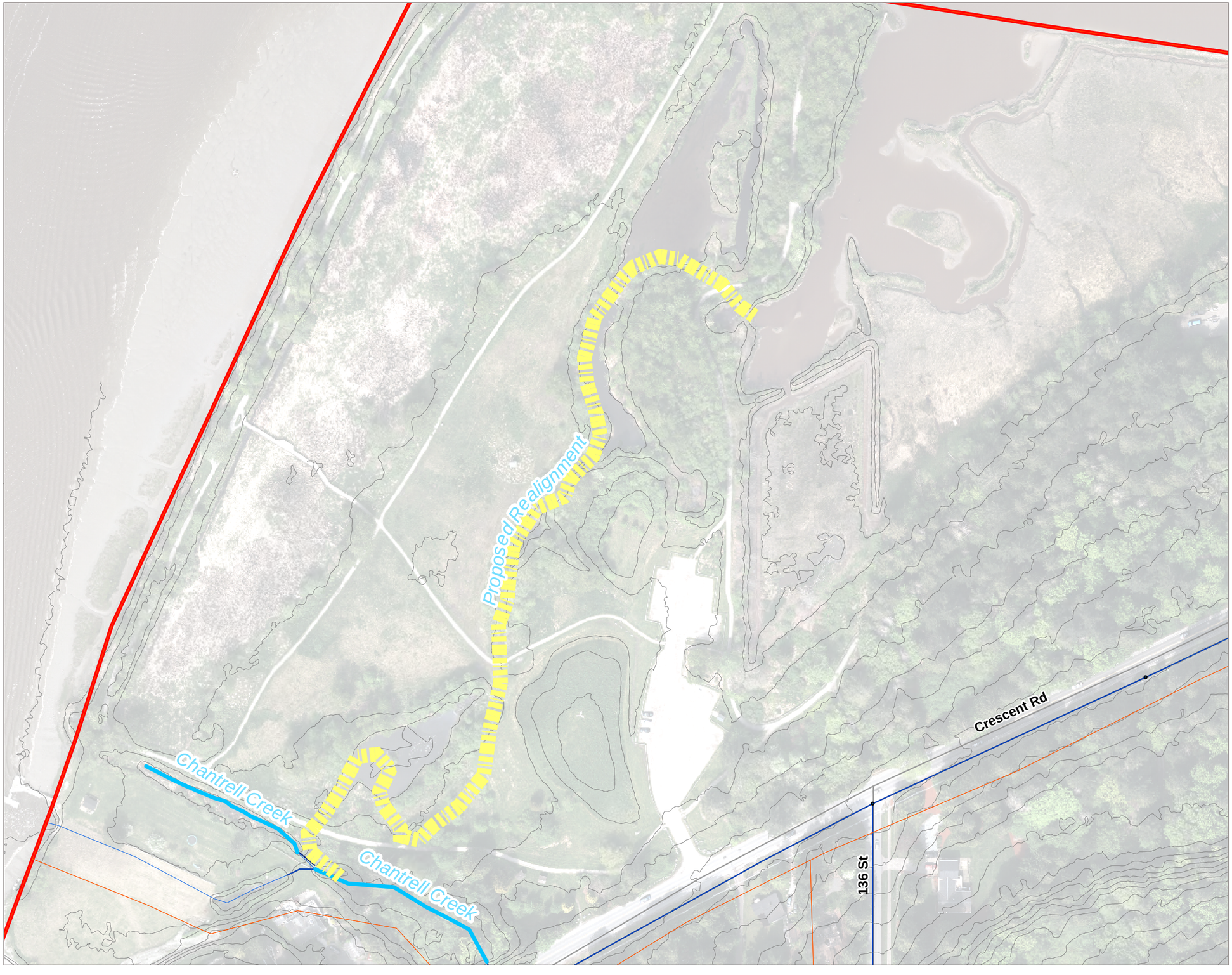
4.2 Aquatic Habitat Enhancements

4.2.1 Lower Chantrell Creek Re-Alignment

Chantrell Creek discharges to the Nicomekl River through a 75 meter culvert, which constitutes a less than ideal passage for fish. This setting is a modification of the natural creek alignment which used to meander through Elgin Park before joining the Nicomekl. There has been a desire from the City and the community to restore the creek's original alignment. This would help to re-establish fish habitat conditions, suitable for upstream fish migration, and would also provide a more natural setting for the enjoyment of the community.

A re-alignment project of the lower Chantrell Creek was proposed a number of years ago, and carried up to the conceptual design level. The proposed alignment, shown in Figure 24 and preliminary channel design is deemed appropriate at the conceptual level and will be used as the starting point moving into detailed design. A preliminary cost estimate for this project is also included in Appendix H. Funding and project management for this project will be provided by the Drainage Department of the City of Surrey. There are several benefits that will stem from the implementation of this project, including:

- Protection of fisheries.
- Restitution of the historical stream.
- Water quality improvements.
- It will encourage community interface with a natural stream.
- It will result in environmental credits for the City.
- It will address existing bank instability problems.



LEGEND

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NOTES
Base data source:
Orthophotos, stream networks, contours, property lines and road network supplied by the City of Surrey.

STATUS
ISSUED FOR REVIEW

OCEAN BLUFF ISMP

PROPOSED LOWER CHANTRELL CREEK REALIGNMENT

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	CITY OF SURREY
Scale: 1:1,640		eba A TETRA TECH COMPANY
FILE NO. 20130321 Figure 24 - Lower Chantrell Realignment.mxd		

PROJECT NO.	DWN	CKD	APVD	REV
V13203008	AMF	AM	MH	0

OFFICE	DATE
EBA-VANC	March 21 2013

Figure 24

Q:\Vancouver\Engineering\V13\2\Projects\V13203008 Ocean Bluff ISMP\SPB\GIS\20130321 Figure 24 - Lower Chantrell Realignment.mxd modified 6/10/2014 by mauricio.herrera

4.2.2 Geomorphology Enhancements and Culvert Maintenance

A geomorphology assessment was conducted and erosion sites were identified. The erosion sites were classified as low, medium, and high consistent with past Surrey ravine stability assessments. Table 15 presents a summary of the recommendations. Table 16 presents a summary of culvert recommendations.

Most sites are natural erosion sites in the creek; however, at one of the sites, 68-7, there is weir installed by the City, downstream of 28 Avenue, where the water is not flowing over. There are two concerns with the weir, first, it appears it is not serving its purpose to allow fish migration, and second, there are concerns that flows going around the weir could potentially cause bank erosion.

Table 15: Summary of Geomorphological Recommendations

Site	Location	Photo	Priority Ranking	Description/Recommendation
68-31	Chantrell Creek -Downstream of Crescent Road, adjacent to 13499 Crescent Road (See Figure A1)	P002	Medium	**Bank protection is recommended** due to proximity of shed at the top of the bank. Further investigation is recommended to determine the type and extent of bank protection. Mitigation should consider potential re-alignment of Lower Chantrell Creek. This site was also identified to be at risk under climate change conditions for the year 2100. Bank protection works should take this into consideration.
68-29	Chantrell Creek – back of 13548 Crescent Road. (See Figure A1)	P008	Low	Shed near top of bank. Continue surveillance to determine rate of erosion progression.
68-25 68-16	Chantrell Creek – back of 3133 136 St. (See Figures A2 and A3)	P041, P042, P043, P044, P045, P046, P047, P049	Low Low	It is recommended that the effectiveness of the energy dissipation structure at storm pipe outlet (GIS pipe ID: 1000738588; photo P049) is assessed given that downstream sites show signs of erosion.
68-27	Chantrell Cr (See Figure A3)	P048,	Medium	Shed near top of bank. Continue surveillance to determine rate of erosion progression. Recommended to investigate conditions at top of bank.
68-32	Chantrell Cr (See Figure A3)	P053	Low	200 mm storm pipe discharge has created a gully on the slope. Because erosion continues to evolve from previous assessments, **corrective measures are recommended:** **Check to see if pipe is approved, work with resident to fix situation.** **Extend pipe along the slope to discharge at the toe.**
68-14	Chantrell Creek – at the back of 13685 30 Avenue (See Figure A3)	P058	Medium	Left bank slope failure with chainlink fence along crest. No changes from previous assessment. Further investigation of conditions at top of bank should be conducted.

Table 15: Summary of Geomorphological Recommendations

68-8	Chantrell Creek – At the back of 2817 138 St. (See Figure A4)	P073	Medium	Upstream end of fish ladder. Right bank erosion. Recent riprap installed. **It is recommended to review that installed riprap is appropriate.**
68-7	Chantrell Creek - At the back of 2817 138 St. (See Figure A4)	P075	Low	Riprap installed. **It is recommended to review that installed riprap is appropriate.**
New – P089	Chantrell Creek – At west lower corner of 13739 27 Avenue (See Figure A5)	P089	Low	Wooden fence across stream with wire mesh fencing down to the creek bed, creating partial flow obstruction. **Recommended to speak with home owner about removing wire mesh across channel.**

Table 16: Summary of Culvert Recommendations

Site	Location	Photo	Description	Recommendation
New (u/s of 68-18)	Chantrell Cr. (See Figure A2)	P031 (see CD attached to report)	600 mm Culvert outlet. This culvert is not in the GIS database.	Verify status of culvert. If in service, add to GIS database, and maintenance is required. Clear sediment accumulation at culvert outlet.

4.3 Climate Change Adaptation

4.3.1 Inundation Control

4.3.1.1 Crescent Beach

Urban Systems (2009) provided a number of recommendations to address climate change in the Crescent Beach area. The results of the study indicate that a number of actions have to be completed in order to alleviate the drainage issues, including:

- Drainage upgrades:
  - Perforated storm sewer.
  - New closed storm sewer system, pump station and flood box.
- Surface grading and inlet improvements.
- Land filling and lot coverage restrictions.
- Drainage improvements on private property.
- Minimum basement elevation (MBE) and flood proofing for new development.
- Dike upgrades: Approximately 2,500 meters of dike need to be upgraded the proposed dike crest elevations (DCE) shown in Figure 25, based on NHC (2012) for 2010.

- Dike upgrades for year 2100 should be confirmed after the 2010 upgrades have been implemented. Climate change science keeps evolving these numbers will likely need to be adjusted.

4.3.2 Crescent Road

As noted in Section 2.9, there are areas vulnerable to inundation along Crescent Road, including roads, private homes and the Nico-Wynd golf course. The dike that protects the golf course is below the DCE for both the 2010 and 2100 conditions as shown in Figure 16 and Figure 17. Proposed management strategies include:

- Existing dike upgrade: Increase DCE from 2.98 m (current) to 3.51m (2010 – 200 year return water level condition) for approximately 1,380 meters of dike (Figure 26). Dike upgrades for year 2100 should be confirmed after the 2010 upgrades have been implemented. Climate change science keeps evolving these numbers will likely need to be adjusted.

- Dike extension: As shown in Figure 26, a 534 meter extension of the current dike is proposed in order to protect the segment of Crescent Road from 35 Avenue to 13954 Crescent Road, and to protect properties on lots 13890, 13909, 13937, 13954 on Crescent Road.

4.4 Hydraulic Capacity Enhancement

The capacity of the minor system was assessed using the historical 5 year storm event and the 5 year storm increased by 28% based on climate change projections. In general, the system performs adequately with a few exceptions where manholes are surcharged and flooding occurs. Table 17 presents a summary of recommendations for each of these pipes, which are shown in Figures 27 to 31. The identified pipe upgrades are based on the model results, and any upgrades should review the actual performance in light of future climate change and the desired performance.

Table 17: Recommended Stormwater Pipe Replacements

Pipe ID	Pipe Location	Current Pipe Internal Diameter (mm)	Pipe Material	Year of Installation	Length (m)	Proposed Pipe Internal Diameter (mm)
1000755509	Marine Dr. and 132B St. (Figure 27)	375	CP	1977	74.2	450
1000736515	Amble Green Blvd and Amble Wood R. (Figure 28)	375	PVC	1980	105.6	450
1000736534	Amble Green Blvd and Amble Wood R. (Figure 28)	375	PVC	1980	122	450
1000756215	131 St and 14 Ave (Figure 29)	300	PVC	1979	64	375
1000756133	131 St and 14 Ave (Figure 29)	250	CP	1979	35	375
1001166942	13 Ave. and 128A St. (Figure 30)	300	CP	N/A	79.9	375
1001166965	13 Ave. and 128A St. (Figure 30)	250	CP	N/A	35	375

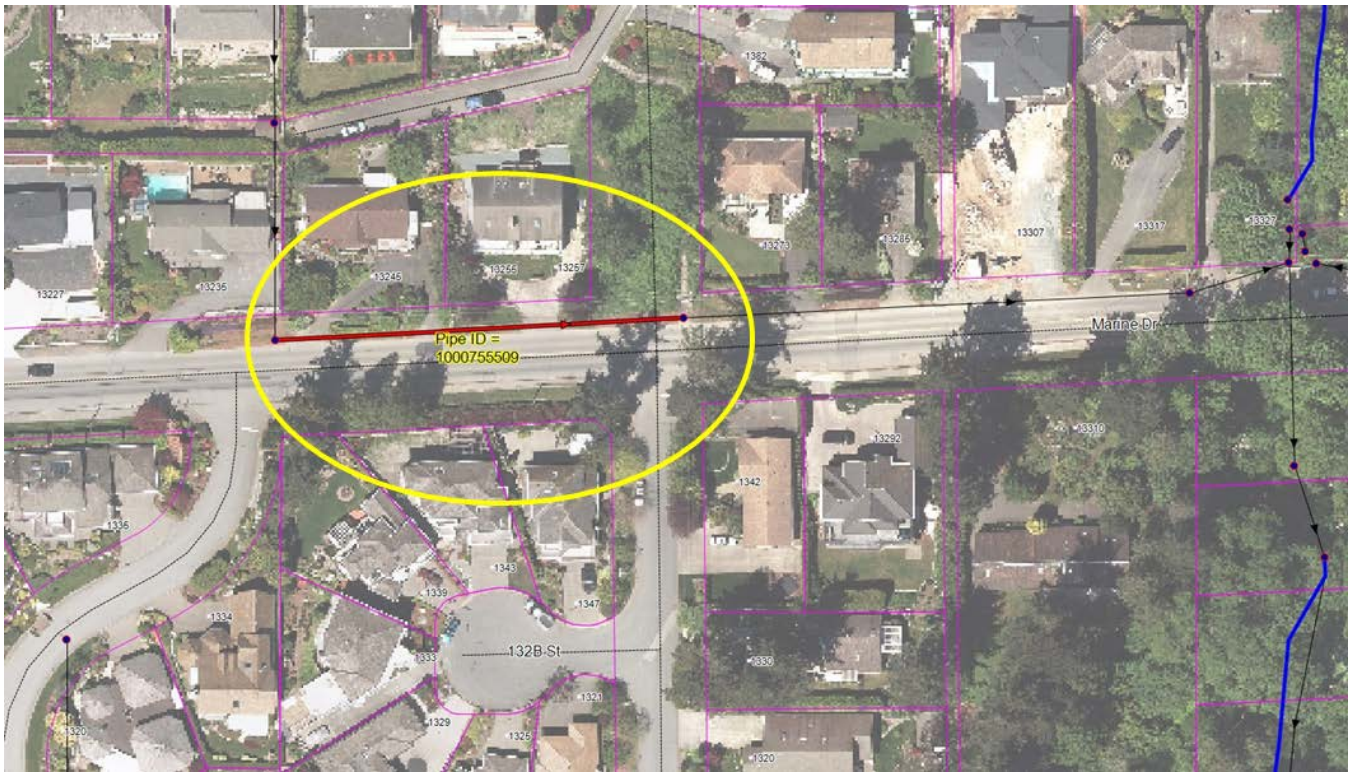

Figure 27 - Recommended Storm Pipe Replacement at Marine Dr. and 132B St

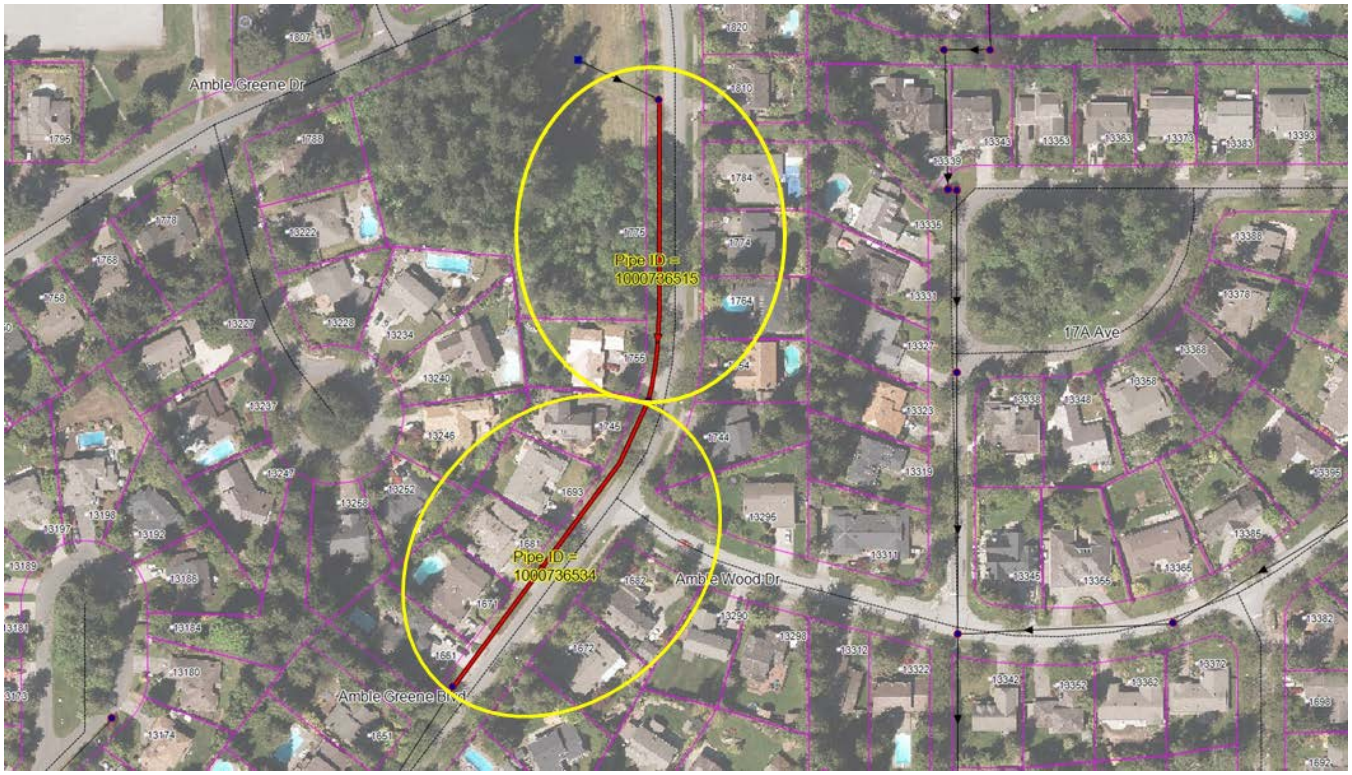

Figure 28 - Recommended Storm Pipe Replacements at Amble Green Blvd and Amble Wood Dr.

Figure 29 – Recommended Storm Pipe Replacements at 131 St and 14 Ave

Figure 30 - Recommended Storm Pipe Replacements AT 13 Ave. and 128A St.

4.5 Educational Outreach

An educational campaign is proposed to be conducted and aligned with existing City programs, primarily with SHARP. The main objective of the educational outreach program will be to educate neighbours on a number of key points:

- Removal of fish barriers. During the course of the field investigation, a number of small fish barriers were encountered along Chantrell Creek. Most of them are log jams that create a barrier that could prevent upstream fish migration. Given the size of these barriers, it is recommended that the removal of these barriers is combined with educational programs with stream keeper groups, nearby residents and also with the SHARP program with the City of Surrey.
- Riparian habitat protection. Particularly with neighbours living adjacent to a natural stream.
- Rainwater management. Understanding the relevance of onsite rainwater management is extremely important as it will open the doors to the installation of low impact development strategies (e.g. rainbarrels, raingardens, etc) within private lots.
- Additional programs such as campaigns through the local schools to stop littering, and promote proper disposal of pet waste.

5.0 MONITORING AND ADAPTIVE MANAGEMENT

The proposed monitoring and adaptive management strategy follows the guidance provided by Metro Vancouver in their “Draft Monitoring and Adaptive Management Framework” released in 2013.

5.1 System Classification

The Study Area can be divided in two main areas, Chantrell Creek watershed which can be classified as a High Gradient system, and the remaining area, which can be classified as a Piped System. Although there are some minor streams in the piped area, as described in previous sections, this area is predominantly drained by pipes.

5.2 Monitoring Plan

According to Metro Vancouver’s monitoring guidelines, for the High Gradient area it is required to monitor water quality, flows, and benthic invertebrates. For the Piped System, only water quality monitoring is required. In addition to these requirements, a geomorphology surveillance plan is also outlined for Chantrell Creek as well as for the minor streams in the Study Area.

5.3 Chantrell Creek

5.3.1 Water Quality Monitoring

It is recommended that two water quality monitoring locations (stations Chantrell 1 and 2, see Section 2.4.2) on Chantrell Creek used on this project continue to be used in the long term for assessing water quality conditions in Chantrell Creek. Monitoring will be conducted at least every five years and the parameters to measure are:

Dissolved oxygen, temperature, turbidity, pH, conductivity, nitrate, e.coli, fecal colifors, total iron, total copper, total lead, total zinc, and total cadmium.

In addition to the two monitoring stations, it is recommended that an automatic water quality sampler, provided with a YSI sonde for continuous monitoring, be installed at the location shown in Figure 31. The objective of this additional monitoring effort is to gain a better understanding of the actual pollutant loads from urban runoff which are being discharged to Boundary Bay. The selected location is upstream of the railway crossing and discharges to a tidal pool with known fish presence. It is recommended that the equipment is installed in the late summer/early fall in order for it to capture several first flush events. The sampler is not to be installed permanently. Following confirmation that at least three first flush events were captured, the equipment can be removed. The same water quality parameters listed above will be analyzed for each first flush event.

5.3.2 Flow Monitoring

The City of Surrey has a continuous flow monitoring station at Chantrell Creek and 32 Avenue. The City has no plans to decommission this station. Data from this station will be used to assess the effectiveness of any Green Infrastructure for stormwater control to be in installed in the Chantrell Creek watershed.

5.3.3 Monitoring of Benthic Invertebrates

The City of Surrey has a monitoring location in Chantrell Creek as shown in Figure 6. It is recommended that this monitoring station is relocated further upstream to eliminate influences of the Nicomekl River on water quality and flow regime. The new site should be located along Chantrell Creek, downstream of the Balsam Cr. and Woodcrest Dr. stormwater discharge point. This location will enable an assessment of the effectiveness of the proposed Upper Chantrell Green Corridor and Stormceptor.

Some suggestions are made for future benthic invertebrate assessments include the following:

- Expanded physical habitat assessments at each site.
- A broader range of surface water analyses associated with stormwater pollution.
- Sediment sampling.
- Coordination of results identifying causal factors for biological impairments with recommendations for the types of best management practices prescribed throughout the watershed.

5.4 Piped System

The remaining of the Study area is considered a Piped System for the purposed of monitoring. The only requirement from the Metro Vancouver guidelines is for water quality monitoring. According to the guideline, the following parameters will be monitored:

Dissolved oxygen, temperature, turbidity, pH, conductivity, nitrate, E. Coli, fecal coliforms, total iron, total copper, total lead, total zinc and total cadmium.

The above parameters will be monitored during two periods of the year – in the wet season (between November and December) and in the dry season (between July and August). Each of the seasonal monitoring will collect 5 samples over a 30 day period, on a weekly basis. The monitoring location, shown in the Figure 31, is located upstream of the railway tracks, south of Bayview St, and with coordinates X =508502.679, and Y = 5432777.548 [5]. This site was selected as it receives drainage from a tributary area of 127 ha with an average imperviousness of 40%.

[5] Coordinate System: NAD83 UTM Zone 10

Figure 31 - Proposed Water Quality Monitoring Location

6.0 REFERENCES

Chilibeck, B., G. Chislett and G. Norris. (1992). Land Development Guidelines for the Protection of Aquatic Habitat. Editor. B. Chilibeck. Habitat Management Division, Department of Fisheries and Oceans. Co-Authors. G. Chislett and G. Norris. Integrated Management Branch, Ministry of Environment Lands and Parks. Canada's Green Plan. ISBN 0-7726-1582-9.

City of Surrey (2013). “Climate Adaptation Strategy”

City of Surrey. Engineering Department (2004). “City of Surrey Design Criteria Manual”.

HB Lanarc (2011). “City of Surrey Ecosystem Management Study”. Book 1. Main Report.

Lilley, P., Page, N. (2012). “2011 City of Surrey Benthic Invertebrate Sampling Program: Methods and Results”.Draft Report, July 2012.

Meidinger, D.V; Pojar, J. (1991). Ecosystems of British Columbia. BC Ministry of Forests. ISSN 0843-6452.

NHC (2012). “Serpentine, Nicomekl & Campbell Rivers – Climate Change Flood Plan Review”. Report submitted to the City of Surrey.

Urban Systems (2009). “Crescent Beach. Climate Change Adaptation Study”. Report submitted to the City of Surrey.

7.0 CLOSURE

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

Sincerely,
Tetra Tech EBA Inc.

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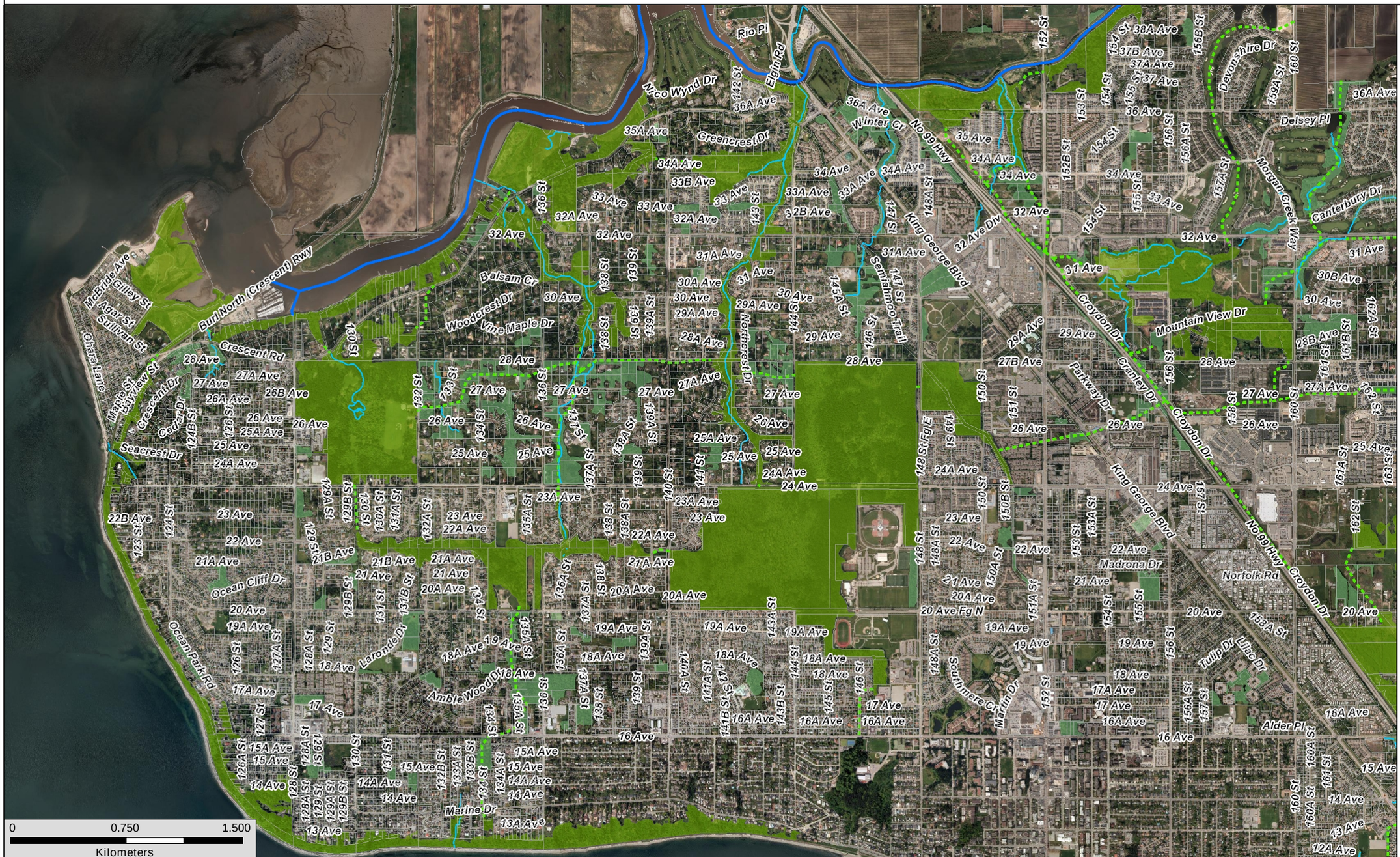
MH/MF/ml

PHOTOGRAPHS

Attached CD

APPENDIX A
SUMMARY OF THE GEOMORPHOLOGIC ASSESSMENT

Ocean Bluff Chantrell Creek ISMP



Legend

- Lots (Outline)
- Road Names4000_25000
- Water Courses
  - Creek
  - River
- Ecosystem Corridors
- Ecosystem Sites
- Aerial Photo April/May 2011
  - Red: Band_1
  - Green: Band_2
  - Blue: Band_3
- Lots
  - BC Gas
  - BC Hydro
  - BC Rail Standard Lot
  - BN Rail Standard Lot
  - CN Rail
  - City Land Standard Lot
  - City Land Strata
  - FRPA Foreshore Tenure
  - Federal Standard Lot
  - GVRD Standard Lot
  - Harbour Board Standard Lot
  - Park - City Dedicated
  - Park - City Purchased
  - Park - Provincial
  - Park - Regional
  - Private Standard
  - Private Strata
  - Provincial Standard
  - Road
  - School Standard Lot
  - Transit Standard Lot

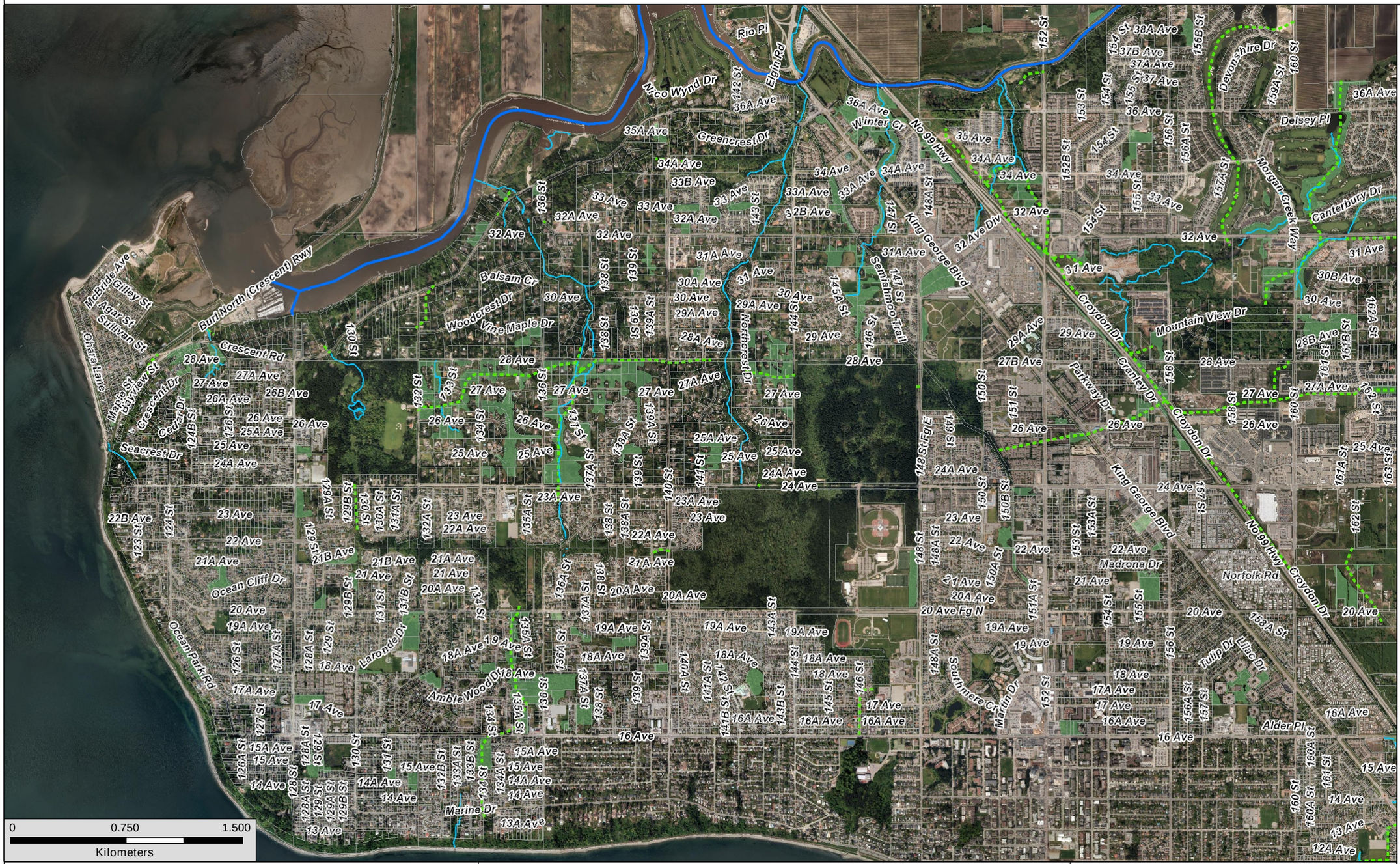
The data provided is compiled from various sources and is NOT warranted as to its accuracy or sufficiency by the City of Surrey. This information is provided for information and convenience purposes only. Lot sizes, legal descriptions and encumberances must be confirmed at the Land Title Office. Use and distribution of this map is subject to all copyright and disclaimer notices at cosmos.surrey.ca.

Ecosystem Corridors, Sites and Hubs

Scale: 1: 25,000

Map created on: September-06-12

Ocean Bluff Chantrell Creek ISMP



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- Lots (Outline)
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  - Red: Band_1
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  - BC Hydro
  - BC Rail Standard Lot
  - BN Rail Standard Lot
  - CN Rail
  - City Land Standard Lot
  - City Land Strata
  - FRPA Foreshore Tenure
  - Federal Standard Lot
  - GVRD Standard Lot
  - Harbour Board Standard Lot
  - Park - City Dedicated
  - Park - City Purchased
  - Park - Provincial
  - Park - Regional
  - Private Standard
  - Private Strata
  - Provincial Standard
  - Road
  - School Standard Lot
  - Transit Standard Lot

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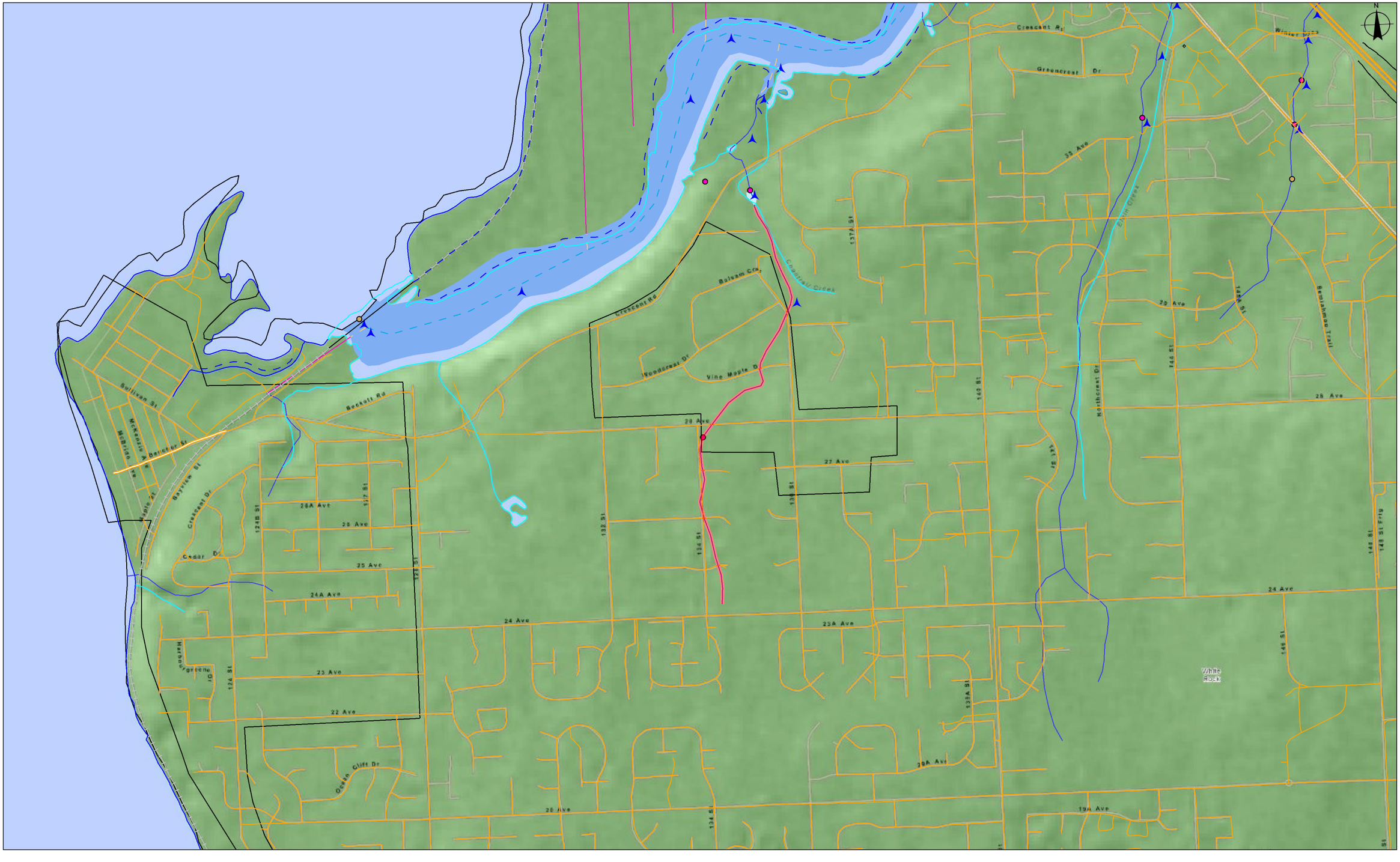
Ecosystem Corridors and Sites

Scale: 1: 25,000

Map created on: September-06-12

APPENDIX C

MINISTRY OF ENVIRONMENT'S (MOE) HABITAT WIZARD


N
Crescent Rd
Greencrest Dr
Winterburn
32 Ave
Dunsmuir Creek
Semiahmoo Trail
Balsam Cres
Crescent Creek
137A St
Crescent Rd
Woodcrest Dr
Vine Maple Dr
149 St
152 St
Northcrest Dr
28 Ave
27 Ave
Sullivan St
McKenzie Ave
McBride Ave
Beecher St
Beecher St
Bayview St
Crescent Dr
Maple Ln
Cedar Dr
28A Ave
28 Ave
25 Ave
24A Ave
24 Ave
23A Ave
23 Ave
22 Ave
Ocean Cliff Dr
Marine Dr
124 St
127 St
132 St
134 St
133A St
146 St
148 St
148 St Frtg
White Rock
20A Ave
19th Ave

Ministry of Environment

HABITAT WIZARD STREAMS REPORT

Sep. 6, 2012

WATERBODY INFORMATION	
Name:	CHANTRELL CREEK
Alias:	
Alias (2):	
UTM Co-ordinate (Stream Mouth):	UTM: 10 511284, 5434879
Primary Mapsheet:	092G02
Primary Region:	Lower Mainland
Watershed Code:	900-004300-06800
Waterbody Identifier:	00000LFRA
Stream Length:	2.38
Stream Order:	1
Stream Magnitude:	1

LIST OF ALL SURVEYS

SURVEY DATE	AGENCY	SOURCE

SPECIES PRESENT

FISH SPECIES	
Coho Salmon	Cutthroat Trout
Steelhead	

Note: The above list represents the species recorded in the Fisheries Data Warehouse and should NOT be considered a comprehensive list. The distributions should also be considered incomplete at this time.

STOCKING INFORMATION

DATE	SPECIES	RELEASED	STOCK	LIFE STAGE	HATCHERY

OBSTRUCTIONS

DESCRIPTION	HEIGHT	LENGTH	COMMENTS
Culvert	0	0	(SUBSTRATE BUILDUP HAS FORMED A CHECK DAM. REF# = HQ0150)

Culvert	0	0	(AT CRESCENT ROAD REF# = 29B-35) (CRESCENT ROAD CULVERT BLOCKS UPSTREAM MIGRATION. 0.3 KM FROM CONFLUENCE [ASSESSMENT MADE PRIOR TO ENHANCEMENT WORKS REF#=29B-38
Culvert	0	0	(AT CRESCENT ROAD REF# = 29B-35) (CRESCENT ROAD CULVERT BLOCKS UPSTREAM MIGRATION. 0.3 KM FROM CONFLUENCE [ASSESSMENT MADE PRIOR TO ENHANCEMENT WORKS REF#=29B-38
Culvert	0	0	CULVERT AT CONFLUENCE, MAY IMPEDE UPSTREAM MIGRATION; 70 METER LONG CONCRETE CULVERT HALFWAY BETWEEN THE MOUTH AND CRESCENT ROAD MAY DETER UPSTREAM MIGRATION OF ADULTS.
Culvert	0	0	CULVERT AT CONFLUENCE, MAY IMPEDE UPSTREAM MIGRATION; 70 METER LONG CONCRETE CULVERT HALFWAY BETWEEN THE MOUTH AND CRESCENT ROAD MAY DETER UPSTREAM MIGRATION OF ADULTS.

ONLINE WATER LEVELS

REFERENCE URL

This water body has online water level information available from Environment Canada and the Province of BC. Use the link(s) above to go directly to the station information on the BC River Levels website.

WATER QUANTITY INFORMATION

The most current water survey information is available from the following Water Survey of Canada websites:
http://scitech.pyr.ec.gc.ca/waterweb/selectProvince.asp provides access to real-time water station information.
http://www.wsc.ec.gc.ca/hydat/H2O/ provides access to archived water station information

REFERENCES

REFERENCE ID	REFERENCE TITLE
29B-34	Ministry of Environment, Habitat Protection Technician. 1:25,000 NTS Maps with personal observations.
29B-35	DFO, SEP, Community Advisor. Personal Communication 1986
29B-38	INVESTIGATIONS OF DOWNSTREAM MIGRATIONS, SUMMER RESIDENCY, ADULT SPAWNING AND STREAM HABITA
2FBSRY	FISHERIES BRANCH, SURREY: FISHERIES FILES: INVENTORY; ENHANCEMENT; BIOPHYSICAL DATA; & RECORDS
2PUB600	SURVEY OF FISH PRESENCE, FISH HABITAT AND POTENTIAL HABITAT ENHANCEMENT OPPORTUNITIES IN CHANT
2PUB600.1	CHANTRELL CREEK DRAINAGE STUDY-CITY OF SURREY
2PUB600.2	CHANTRELL CREEK BIOPHYSICAL SURVEY BETWEEN 20TH AND 24TH AVENUES, SURREY, BC
DFP001	Addition of zones & points re: FISS maps for fish distribution for G.I.S. display purposes
EW083	Untitled
EW105	Investigations of downstream migrations, summer residency, adult spawning and stream habitat for juvenile salmonids
HQ0150	ASSESSMENT OF RESTORATION ACTIVITIES AND SETBACK GUIDELINES
HQ0510	FISH AND WILDLIFE VALUES AND A DIFFERENT APPROACH TO WATERSHED MANAGEMENT IN THE SERPENTINE-

STREAM SURVEY DATA

ADDITIONAL INFORMATION

Please see the Fisheries Information Data Queries (FIDQ) for additional and more detailed queries of fish and fish habitat information: **http://www.env.gov.bc.ca/fish/fidq/index.html**

Please check the Ecological Reports Catalogue (EcoCat) for reference material and data that is available for online distribution: **http://www.env.gov.bc.ca/ecocat/**

APPENDIX D

FISHERIES INFORMATION SUMMARY SYSTEM FISS

Fisheries Inventory - FISS Fish Distributions Report

7 record(s) matched your query.
Report created on : Fri Nov 02 12:44:27 PDT 2012

Your report was based on the following criteria:

Gazetted Name/Alias : Chantrell Creek
Ordered By : Gazetted Name

Gazetted Name	Region Code	Species Name	Stock Type	Stock Char	Stock Name	Management Class	Activity	Map 1	Point 1	Type 1	Map 2	Point 2	Type 2	Refs And Dates	DFO District	DFO Sub-District	DFO Habitat	Watershed Code	Waterbody Identifier	Alias
CHANTRELL CREEK	2 CO	Coho Salmon	NOT SPECIF	Anadromous		Not Specified	OBL Fish observed at this point or zone	092G02	116	P				(29B-34, no date)				900-004300-06800	00000LFRA	
CHANTRELL CREEK	2 CO	Coho Salmon	NOT SPECIF	Anadromous		Not Specified	REA Rearing location	092G02	1227	P				(HQ0510, 01-JAN-1976)				900-004300-06800	00000LFRA	
CHANTRELL CREEK	2 CO	Coho Salmon	NOT SPECIF	Anadromous		Not Specified	SPM Major spawning location	092G02	1235	U	092G02	1229	D	(HQ0510, 01-JAN-1976)				900-004300-06800	00000LFRA	
CHANTRELL CREEK	2 CT	Cutthroat Trout	NOT SPECIF	Not Specif		Not Specified	OBL Fish observed at this point or zone	092G02	116	P				(29B-34, no date)				900-004300-06800	00000LFRA	
CHANTRELL CREEK	2 CT	Cutthroat Trout	NOT SPECIF	Not Specif		Not Specified	OBL Fish observed at this point or zone		263310	W				(2PUB600, 01-JAN-1993)				900-004300-06800	00000LFRA	
CHANTRELL CREEK	2 CT	Cutthroat Trout	NOT SPECIF	Not Specif		Not Specified	REA Rearing location	092G02	1228	P				(HQ0510, 01-JAN-1976)				900-004300-06800	00000LFRA	
CHANTRELL CREEK	2 ST	Steelhead	NOT SPECIF	Anadromous		Not Specified	OBL Fish observed at this point or zone	092G02	116	P				(29B-34, no date)				900-004300-06800	00000LFRA	

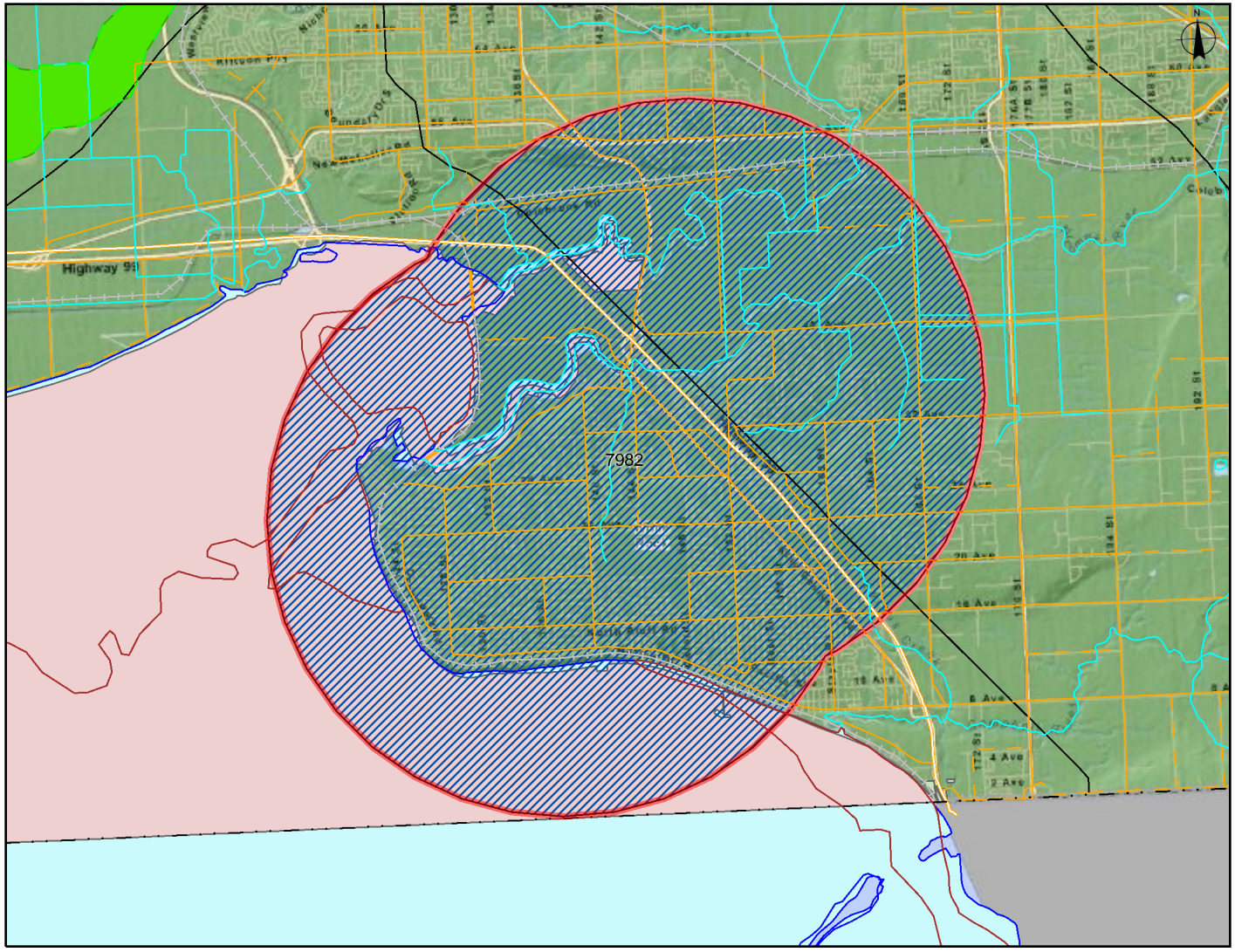
Download this information as a .csv file

Top of Page

APPENDIX E

CONSERVATION DATA CENTRE'S INTERNET MAPPING SERVICE IMAP

BC Conservation Data Centre - Occurrence Report
Masked occurrences



Map center: 49°3' N, 122°49' W

Legend

Non-sensitive Occurrences
- Animal - Vertebrate
- Animal - Invertebrate
- Plant - Vascular
- Plant - Non-vascular
- Ecological Community

Masked Sensitive Occurrences

Big Trees

Occurrence data is updated frequently. This map should be considered out of date 6 months after
September 7, 2012

For more information about the BC CDC visit: http://www.env.gov.bc.ca/cdc/

Index Map

MAP COMPILATION
Projection: Albers Equal Area Conic
Datum: NAD 83
Notes: Shape ID 7982

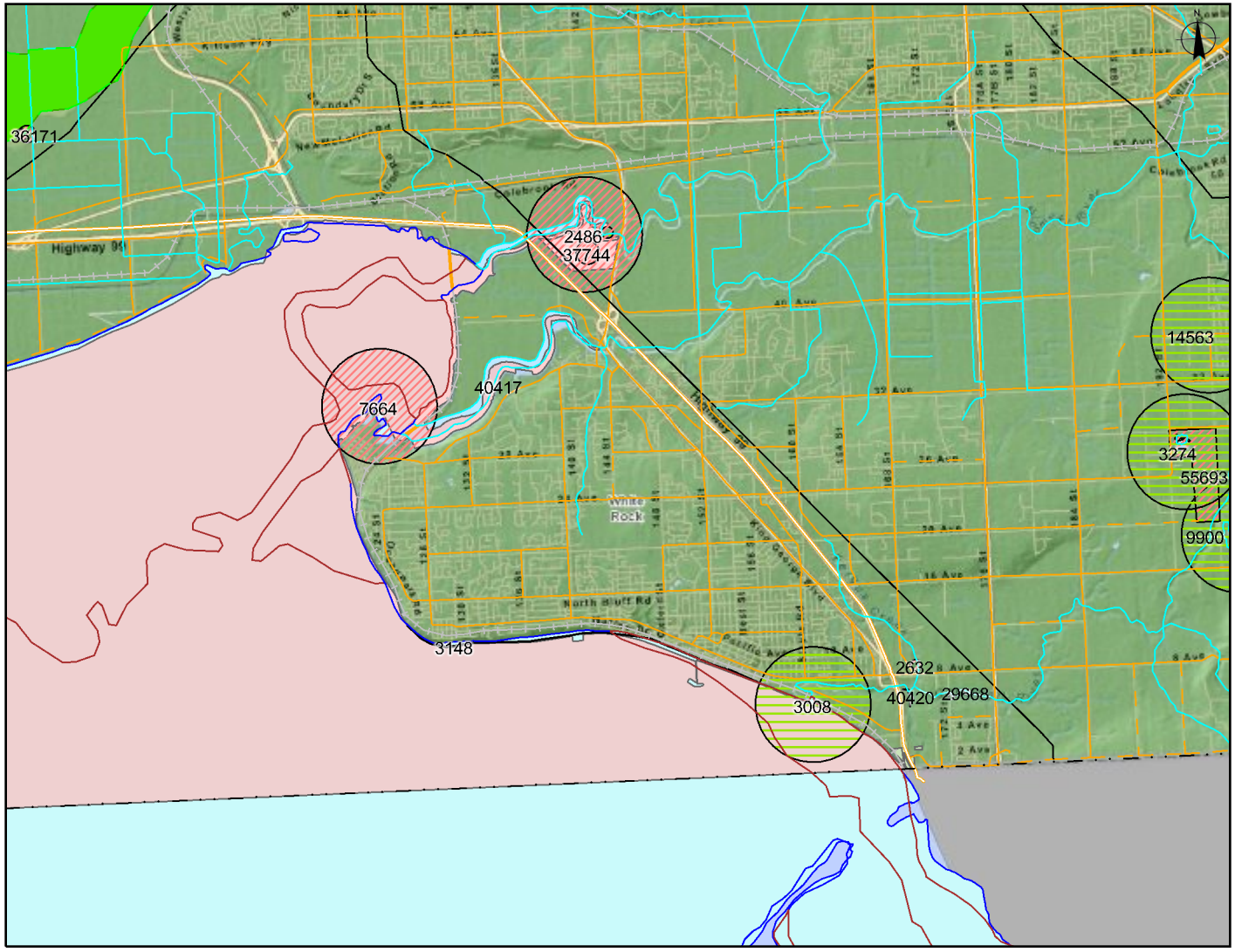
0 3.25 6.5 9.75 km.

Scale: 1:111,546

Province of British Columbia
Ministry of Environment

Map Created **September 7, 2012**

BC Conservation Data Centre - Occurrence Report
Non-sensitive occurrences



Map center: 49°2' N, 122°49' W

MAP COMPILATION
Projection: Albers Equal Area Conic
Datum: NAD 83

0 3.25 6.5 9.75 km.

Scale: 1:114,261

Legend

Non-sensitive Occurrences
- Animal - Vertebrate
- Animal - Invertebrate
- Plant - Vascular
- Plant - Non-vascular
- Ecological Community

Masked Sensitive Occurrences

Big Trees

Occurrence data is updated frequently. This map should be considered out of date 6 months after
September 7, 2012

For more information about the BC CDC visit: http://www.env.gov.bc.ca/cdc/

Index Map

Province of British Columbia
Ministry of Environment

Map Created **September 7, 2012**

BC Conservation Data Centre: Occurrence Report (2486)

September 7, 2012

Botaurus lentiginosus
American Bittern

Field definition document available at **http://www.env.gov.bc.ca/atrisk/ims.htm**

This is a summary report. For a complete record contact the CDC (cdcdata@gov.bc.ca).

Identifiers

Occurrence ID:	4257	**Status:**	
Shape ID:	2486	Global:	G4
Type:	Vertebrate Animal	Provinicial:	S3B
		COSEWIC:	
Taxonomic Class:	birds	BC List:	Blue
		SARA Schedule:	
Data Sensitive:	N		

Locators

Survey Site: ELGIN, NORTH OF, "SERPENTINE FEN"

Directions: Seen at "east marsh" and "long marsh" in Serpentine Fen.

Survey Information

First Obs. Date: 1985-04-07 **Last Obs. Date:** 1989-01-22

Occurrence Data: 1985 and 1986: 1-2 birds in April at east marsh. 1986: 2 flying in circles over east marsh in July. 1987: August and September. 1989: 1 in January. (B.C. Vertebrate Record File 1991)

Occurrence Rank and Occurrence Rank Factors

Rank: **Rank Date:**

Rank Comments:

Condition of Occurrence

Size of Occurrence:

Landscape Context:

Description

General Description:

Vegetation Zone:

Habitat: PALUSTRINE; BOG/FEN; HERBACEOUS WETLAND

Documentation

References:

British Columbia Vertebrate Record File. 2001. Royal B.C. Mus., Victoria, BC. V8V 1X4.

Version

Version Date: 22-NOV-93

Mapping Information

Estimated Representation Accuracy:
Confidence Extent:

BC Conservation Data Centre: Occurrence Report (37744)

September 7, 2012

Recurvirostra americana
American Avocet

Field definition document available at **http://www.env.gov.bc.ca/atrisk/ims.htm**

This is a summary report. For a complete record contact the CDC (cdcdata@gov.bc.ca).

Identifiers

Occurrence ID:	7467	**Status:**	
Shape ID:	37744	Global:	G5
Type:	Vertebrate Animal	Provinicial:	S2B
		COSEWIC:	
Taxonomic Class:	birds	BC List:	Red
		SARA Schedule:	
Data Sensitive:	N		

Locators

Survey Site: SERPENTINE FEN

Directions: Located in an area south of the Serpentine River and north of 44th Avenue between Highway 99 and 99A (D. Wilson pers. comm.).

Survey Information

First Obs. Date: 1987-05-12 **Last Obs. Date:** 1989-06-19

Occurrence Data: 1989: adult with 2 chicks observed (Wilson 1989); 1988: 2 nests containing 4 eggs each found, as many as 5 hatched but ultimately nesting was unsuccesful (Wilson 1989, D. Wilson pers. comm.); 1987: as many as 4 adults observed and some behaviours suggested a nesting attempt (Wilson 1989).

Occurrence Rank and Occurrence Rank Factors

Rank: E Verified extant (viability not assessed) **Rank Date:** 1989-06-19

Rank Comments:

Condition of Occurrence

Size of Occurrence:

Landscape Context:

Description

General Description:

Vegetation Zone:

Habitat:	LACUSTRINE: Shallow Water; PALUSTRINE: Pond, Herbaceous Wetland

Documentation

References:	Wilson, D. Personal communication. Wilson, D.J. 1989. Avocets on the B.C. coast: first breeding record. Discovery 18:95-97.

Version

Version Date:	12-OCT-07

Mapping Information

Estimated Representation Accuracy:	Medium
Confidence Extent:	?

September 7, 2012

BC Conservation Data Centre: Occurrence Report (7664)

September 7, 2012

Butorides virescens
Green Heron

Field definition document available at **http://www.env.gov.bc.ca/atrisk/ims.htm**

This is a summary report. For a complete record contact the CDC (cdcdata@gov.bc.ca).

Identifiers

Occurrence ID:	703	**Status:**	
Shape ID:	7664	Global:	G5
Type:	Vertebrate Animal	Provinicial:	S3S4B
		COSEWIC:	
Taxonomic Class:	birds	BC List:	Blue
		SARA Schedule:	
Data Sensitive:	N		

Locators

Survey Site: BLACKIE SPIT

Directions:

Survey Information

First Obs. Date: 1979-07-13 **Last Obs. Date:** 1987-08-02

Occurrence Data: 1979, 1983 and 1987: Adults with young seen in August. This may be a post breeding dispersal spot due to the time of year the groups seen.

Occurrence Rank and Occurrence Rank Factors

Rank: D Poor estimated viability **Rank Date:** 1987-08-02

Rank Comments: Brackish water and sightings later in summer (post breeding dispersal).

Condition of Occurrence

Size of Occurrence:

Landscape Context:

Description

General Description:

Vegetation Zone:

Habitat: TERRESTRIAL; ESTUARINE

Documentation

References:

British Columbia Vertebrate Record File. 2001. Royal B.C.

Mus., Victoria, BC. V8V 1X4.

Version

Version Date: 22-OCT-93

Mapping Information

Estimated Representation Accuracy:
Confidence Extent:
September 7, 2012

BC Conservation Data Centre: Occurrence Report (3008)

September 7, 2012

Cuscuta campestris
field dodder

Field definition document available at **http://www.env.gov.bc.ca/atrisk/ims.htm**

This is a summary report. For a complete record contact the CDC (cdcdata@gov.bc.ca).

Identifiers

Occurrence ID:	4470	**Status:**	
Shape ID:	3008	Global:	G5
Type:	Vascular Plant	Provinicial:	S2S3
		COSEWIC:	
Taxonomic Class:	dicots	BC List:	Blue
		SARA Schedule:	
Data Sensitive:	N		

Locators

Survey Site: LITTLE CAMPBELL RIVER, WHITE ROCK

Directions: At river mouth.

Survey Information

First Obs. Date: 1989-08-03 **Last Obs. Date:** 1989-08-03

Occurrence Data: Parasitic on *Aster subspicatus*, moist shore.

Occurrence Rank and Occurrence Rank Factors

Rank: E Verified extant (viability not assessed) **Rank Date:** 1989-08-03

Rank Comments: There is insufficient data to assign a viability rank.

Condition of Occurrence

Size of Occurrence:

Landscape Context:

Description

General Description:

Vegetation Zone: Lowland

Habitat: TERRESTRIAL

Documentation

References: University of British Columbia. Dep. Bot., Dep. Zool., Biol. Sci. Bldg., 6270 Univ. Blvd., Vancouver, BC.

Version

Version Date: 06-DEC-93

Mapping Information

Estimated Representation Accuracy:
Confidence Extent:
September 7, 2012

Version

Version Date: 22-NOV-93

Mapping Information

Estimated Representation Accuracy:
Confidence Extent:

BC Conservation Data Centre: Occurrence Report (3470)

September 7, 2012

Eleocharis parvula
small spike-rush

Field definition document available at **http://www.env.gov.bc.ca/atrisk/ims.htm**

This is a summary report. For a complete record contact the CDC (cdcdata@gov.bc.ca).

Identifiers

Occurrence ID:	428	**Status:**	
Shape ID:	3470	Global:	G5
Type:	Vascular Plant	Provinicial:	S2S3
		COSEWIC:	
Taxonomic Class:	monocots	BC List:	Blue
		SARA Schedule:	
Data Sensitive:	N		

Locators

Survey Site: SERPENTINE RIVER

Directions: Serpentine river, north bank, ca. 300 metres east of Highway 99A.

Survey Information

First Obs. Date: 1991-07-20 **Last Obs. Date:** 1991-07-20

Occurrence Data: 1991; Forming mats in saline mud, scattered patches.

Occurrence Rank and Occurrence Rank Factors

Rank: E Verified extant (viability not assessed) **Rank Date:** 1991-07-20

Rank Comments: There is insufficient data to assign a viability rank.

Condition of Occurrence

Size of Occurrence:

Landscape Context:

Description

General Description:	Thirty metre length along river, brackish tidal mud shore.
Vegetation Zone:	Lowland
Habitat:	ESTUARINE; TIDAL FLAT

Documentation

References:	University of British Columbia. Dep. Bot., Dep. Zool., Biol. Sci. Bldg., 6270 Univ. Blvd., Vancouver, BC.

Version

Version Date:	13-MAY-02

Mapping Information

Estimated Representation Accuracy:
Confidence Extent:
September 7, 2012

BC Conservation Data Centre: Occurrence Report (40417)

September 7, 2012

Bidens amplissima
Vancouver Island beggarticks

Field definition document available at http://www.env.gov.bc.ca/atrisk/ims.htm

This is a summary report. For a complete record contact the CDC (cdcdata@gov.bc.ca).

Identifiers

Occurrence ID:	7596	**Status:**	
Shape ID:	40417	Global:	G3
Type:	Vascular Plant	Provinicial:	S3
		COSEWIC:	SC (NOV 2001)
Taxonomic Class:	dicots	BC List:	Blue
		SARA Schedule:	1
Data Sensitive:	N		

Locators

Survey Site: NIKOMEKL RIVER, CHANTRELL CREEK

Directions: Adjacent to and below the Elgin Heritage Park boardwalk

Survey Information

First Obs. Date: 1915-08-15 **Last Obs. Date:** 2008-09-06

Occurrence Data: 2008-09-06: 2 mature plants, one in poor condition (Lee and Gebauer, 2009). 2000-06-20: 12 plants in cattails just off boardwalk (University of British Columbia herbarium).

Occurrence Rank and Occurrence Rank Factors

Rank: C Fair estimated viability **Rank Date:** 2008-09-06

Rank Comments: Known since 1915, this is a very small population with evidence of ongoing reproduction. Threatened by encroachement, trampling and collecting.

Condition of Occurrence 2000: Heavily eaten by insects, but managed to flower later in the season (Klinkenberg and Klinkenberg 2001b).

Size of Occurrence: 2000: 12 plants (Klinkenberg and Klinkenberg 2001b). 2008: 2 plants (Lee and Gebauer, 2009).

Landscape Context: Extensive stands of *Typha latifolia* and encroaching *Solanum dulcamara* dominated areas adjacent to *Bidens amplissima*. *Phalaris arundinacea* was prolific along the *Typha latifola* stand edges along with *Epilobium ciliatum.* Additional threats include trampling or plant collecting (Lee and Gebauer, 2009).

Description

General Description: Urban park with an undeveloped foreshore and wetlands.

Vegetation Zone: Lowland

Habitat:	RIVERINE: Floodplain
Documentation	
References:	Klinkenberg, B., and R. Klinkenberg. 2001b. COSEWIC Status Report on Vancouver Island Beggarticks (Bidens amplissima Greene) in Canada. Comm on the Status of Endangered Wildl in Can, Ottawa. Lee, C. and M. Gebauer. 2009. Vancouver Island Beggarticks (Bidens amplissima Greene) Priority Site Inventory - Region 2 (Lower Mainland). Prepared by Chris Lee and Martin Gebauer of Gebauer and Associates Ltd. for the B.C. Ministry of Environment. Surrey, BC. University of British Columbia. Dep. Bot., Dep. Zool., Biol. Sci. Bldg., 6270 Univ. Blvd., Vancouver, BC.
Version	
Version Date:	05-JUN-12
Mapping Information	
Estimated Representation Accuracy:	High
Confidence Extent:	?

September 7, 2012

BC Conservation Data Centre: Occurrence Report (3148)

November 4, 2012

Navarretia intertexta
needle-leaved navarretia

Field definition document available at **http://www.env.gov.bc.ca/atrisk/ims.htm**

This is a summary report. For a complete record contact the CDC (cdcdata@gov.bc.ca).

Identifiers

Occurrence ID:	82	**Status:**	
Shape ID:	3148	Global:	GNR
Type:	Vascular Plant	Provinicial:	S2
		COSEWIC:	
Taxonomic Class:	dicots	BC List:	Red
		SARA Schedule:	
Data Sensitive:	N		

Locators

Survey Site: WHITE ROCK, WEST OF

Directions: Along BNR tracks.

Survey Information

First Obs. Date: 1988-07-10 **Last Obs. Date:** 1988-07-10

Occurrence Data: Collected in railroad rock fill, along BNR tracks.

Occurrence Rank and Occurrence Rank Factors

Rank: NR Not ranked **Rank Date:**

Rank Comments:

Condition of Occurrence

Size of Occurrence:

Landscape Context:

Description

General Description:

Vegetation Zone: Lowland

Habitat: TERRESTRIAL; ROADSIDE

Documentation

References: University of British Columbia. Dep. Bot., Dep. Zool., Biol. Sci. Bldg., 6270 Univ. Blvd., Vancouver, BC.

Version

Version Date: 14-MAY-02

Mapping Information

Estimated Representation Accuracy:
Confidence Extent:
November 4, 2012

APPENDIX F
SPECIES AND ECOSYSTEMS EXPLORER DATABASE

BC Species and Ecosystems Explorer Search Results

		Status					
Scientific Name	**English Name**	**Provincial**	**BC List**	**COSEWIC**	**SARA**	**Global**	**CF Priority**
Isoetes nuttallii	Nuttall's quillwort	S3 (2001)	Blue			G4? (2011)	2
Anagallis minima	chaffweed	S3 (2008)	Blue			G5 (1984)	2
Bidens amplissima	Vancouver Island beggarticks	S3 (2008)	Blue	SC (2001)	1-SC (2003)	G3 (1988)	1
Callitriche heterophylla var. *heterophylla*	two-edged water-starwort	S2S3 (2000)	Blue			G5T5 (1998)	3
Caltha palustris var*. radicans*	yellow marsh-marigold	S2S3 (2012)	Blue			G5TNR (2009)	
Ceratophyllum echinatum	spring hornwort	S3 (2002)	Blue			G4? (1995)	4
Claytonia washingtoniana	Washington springbeauty	S2 (2000)	Red			G2G4 (2001)	3
Cuscuta campestris	field dodder	S2S3 (2000)	Blue			G5 (2007)	2
Elatine rubella	three-flowered waterwort	S2S3 (2000)	Blue			G5 (1988)	2
Eutrochium maculatum var. *bruneri*	Joe-pye weed	S1 (2008)	Red			G5T4T5Q (2000)	1
Helenium autumnale var. *grandiflorum*	mountain sneezeweed	S2S3 (2000)	Blue			G5T3T5 (2002)	2
Heterocodon rariflorum	heterocodon	S3 (2012)	Blue			G5 (1988)	2
Hydrophyllum tenuipes	Pacific waterleaf	S2 (2007)	Red			G4G5 (1988)	2
Idahoa scapigera	scalepod	S2 (2000)	Red			G5 (1987)	2
Lupinus rivularis	streambank lupine	S1 (2009)	Red	E (2002)	1-E (2005)	G2G4 (2009)	1
Megalodonta beckii	water marigold	S3 (2001)	Blue			G4G5 (1984)	4
Myriophyllum ussuriense	Ussurian water-milfoil	S3 (2002)	Blue			G3 (1998)	4
Navarretia intertexta	needle-leaved navarretia	S2 (2000)	Red			GNR	2

Rubus lasiococcus	dwarf bramble	S2S3 (2000)	Blue			G5 (1990)	2
Rubus nivalis	snow bramble	S3? (2008)	Blue			G4? (1990)	2
Rupertia physodes	California-tea	S3 (2001)	Blue			G4 (1985)	2
Sidalcea hendersonii	Henderson's checker-mallow	S3 (2001)	Blue			G3 (2004)	2
Toxicodendron diversilobum	poison oak	S2S3 (2000)	Blue			G5 (1999)	2
Alopecurus carolinianus	Carolina meadow-foxtail	S2 (2000)	Red			G5 (1986)	3
Carex interrupta	green-fruited sedge	S2 (2004)	Red			G4 (2006)	2
Carex scoparia	pointed broom sedge	S2S3 (2000)	Blue			G5 (1984)	2
Cephalanthera austiniae	phantom orchid	S2 (2000)	Red	T (2000)	1-T (2003)	G4 (1990)	2
Eleocharis parvula	small spike-rush	S2S3 (2000)	Blue			G5 (1984)	3
Eleocharis rostellata	beaked spike-rush	S2S3 (2000)	Blue			G5 (2000)	3
Glyceria leptostachya	slender-spiked mannagrass	S2S3 (2000)	Blue			G3 (1991)	2
Juncus oxymeris	pointed rush	S2S3 (2000)	Blue			G5 (1993)	3
Lilaea scilloides	flowering quillwort	S2S3 (2000)	Blue			G5? (1998)	3
Pleuropogon refractus	nodding semaphoregrass	S3 (2001)	Blue			G4 (1997)	2

Search Summary

Time Performed Sun Nov 04 14:28:42 PST 2012

Results 33 records.

Search Criteria Search Type: Plants & Animals
AND Species Groups: Vascular Plants OR Non-Vascular Plants OR Lichens
AND Forest Districts:Chilliwack Forest District (DCK) (Restricted to Red, Blue, and Legally designated species)

AND MOE Regions:2- Lower Mainland (Restricted to Red, Blue, and Legally designated species)
AND Habitat Types:Estuary,Forest,Ocean,Riparian,Stream/River,Urban,Wetland
AND BGC Zone:CDF
Sort Order:Phylogenetic Ascending

Notes

1. Citation: B.C. Conservation Data Centre. 2012. BC Species and Ecosystems Explorer. B.C. Minist. of Environ. Victoria, B.C. Available: http://a100.gov.bc.ca/pub/eswp/ (accessed Nov 4, 2012).

2. Forest District, MoE Region, Regional District and habitat lists are restricted to species that breed in the Forest District, MoE Region, Regional District or habitat (i.e., species will not be placed on lists where they occur only as migrants).

Modify Search | New Search | Results

BC Species and Ecosystems Explorer Search Results

Scientific Name	English Name	Biogeoclimatic Units	Status			Identified Wildlife	Land Use Objectives	CF Priority
			Provincial	BC List	Global			
Abies grandis / Mahonia nervosa	grand fir / dull Oregon-grape	CDFmm/04	S1 (2005)	Red	G1			1
Abies grandis / Tiarella trifoliata	grand fir / three-leaved foamflower	CDFmm/06	S1 (2004)	Red	G1			1
Alnus rubra / Carex obnupta [*Populus trichocarpa*]	red alder / slough sedge [black cottonwood]	CDFmm/14	S1 (2006)	Red	G1			1
Alnus rubra / Lysichiton americanus	red alder / skunk cabbage	CDFmm/Ws52	S2 (2010)	Red	GNR			1
Alnus rubra / Rubus spectabilis / Equisetum arvense	red alder / salmonberry / common horsetail	CDFmm/09 CDFmm/Fl51 CWHvh1/10 CWHvh1/Fl51 CWHvh2/10 CWHvh2/Fl51 CWHwh1/09 CWHwh1/Fl51	S3 (2004)	Blue	GNR		Haida Gwaii LUO	4
Carex lasiocarpa - Rhynchospora alba	slender sedge - white beak-rush	CDFmm/Wf53 CWHmm1/Wf53 CWHmm2/Wf53 CWHxm1/Wf53 CWHxm2/Wf53	S2 (2004)	Red	G2			1
Carex lyngbyei Herbaceous Vegetation	Lyngbye's sedge herbaceous vegetation	CDFmm/Em05 CWH/Em05	S3 (2004)	Blue	GNR		Haida Gwaii LUO	2
Deschampsia cespitosa ssp. *beringensis - Hordeum brachyantherum*	tufted hairgrass - meadow barley	CDFmm/Ed01 CWH/Ed01	S3 (2004)	Blue	G3		Haida Gwaii LUO	2
Deschampsia cespitosa ssp. beringensis - Symphyotrichum subspicatum	tufted hairgrass - Douglas' aster	CDFmm/Ed02 CWH/Ed02	S3 (2004)	Blue	G3		Haida Gwaii LUO	2
Distichlis spicata var. spicata Herbaceous Vegetation	seashore saltgrass Herbaceous Vegetation	CDFmm/Em03 CWHxm1/Em03	S2S3 (2008)	Red	GNR (2008)			2
Dulichium arundinaceum Herbaceous Vegetation	three-way sedge	CDFmm/Wm51 CWHmm1/Wm51 CWHxm2/Wm51 ICHwk1/Wm51	S2 (2004)	Red	GNR			2
Eleocharis palustris Herbaceous Vegetation	common spike-rush Herbaceous Vegetation	BGxw2/Wm04 CDFmm/Wm04 CWH/Wm04 ESSFdv d/Wm04 ESSFdv/Wm04 IDFxm/Wm04	S3 (2004)	Blue	GNR			3

		SBSdk/Wm04 SBSmk2/Wm04						
Juncus arcticus - Plantago macrocarpa	arctic rush - Alaska plantain	CDFmm/Ed03 CWH/Ed03	S1 (2007)	Red	GNR			1
Leymus mollis ssp. *mollis - Lathyrus japonicus*	dune wildrye - beach pea	CDFmm CWHdm CWHds1 CWHms2 CWHvh1 CWHvh2 CWHvm CWHvm1 CWHwh1 CWHwm CWHws1 CWHxm1 CWHxm2	S1S2 (2008)	Red	GNR			1
Menyanthes trifoliata - Carex lasiocarpa	buckbean - slender sedge	CDFmm/Wf06 CWHws1/Wf06 ICHwk1/Wf06 IDFdk2/Wf06 SBSdk/Wf06	S3 (2004)	Blue	G3			2
Myrica gale / Carex sitchensis	sweet gale / Sitka sedge	CDFmm/Wf52 CWHmm1/Wf52 CWHmm2/Wf52 CWHvh2/Wf52 CWHwm/Wf52 CWHxm1/Wf52 CWHxm2/Wf52	S2 (2004)	Red	G3		Haida Gwaii LUO	3
Pinus contorta / Sphagnum spp. CDFmm	lodgepole pine / peat-mosses CDFmm	CDFmm/10	S1 (2004)	Red	GNR			2
Pseudotsuga menziesii - Arbutus menziesii	Douglas-fir - arbutus	CDFmm/02	S2 (2004)	Red	GNR			1
Pseudotsuga menziesii / Mahonia nervosa	Douglas-fir / dull Oregon-grape	CDFmm/01 CWHxm1	S2 (2010)	Red	G2	Y		1
Rhododendron groenlandicum / Kalmia microphylla / Sphagnum spp.	Labrador tea / western bog-laurel / peat-mosses	CDFmm/Wb50 CWHdm/Wb50 CWHvm1/Wb50 CWHxm1/Wb50 CWHxm2/Wb50	S3 (2004)	Blue	G4			4
Ruppia maritima Herbaceous Vegetation	beaked ditch-grass Herbaceous Vegetation	CDFmm/Em01 CWH/Em01	S2 (2004)	Red	GNR		Haida Gwaii LUO	2
Salix sitchensis - Salix lasiandra var. *lasiandra / Lysichiton americanus*	Sitka willow - Pacific willow / skunk cabbage	CDFmm/Ws51 CWH/Ws51	S2 (2004)	Red	G2			1

		ICH/Ws51				
Sarcocornia pacifica - Glaux maritima	American glasswort - sea-milkwort	CDFmm/Em02 CWH/Em02	S2 (2004)	Red	G3G4	3
Schoenoplectus acutus Deep Marsh	hard-stemmed bulrush Deep Marsh	BGxh1/Wm06 BGxh2/Wm06 BGxw1/Wm06 BGxw2/Wm06 CDFmm/Wm06 CWHxm1/Wm06 ICHwk1/Wm06 IDFdk1/Wm06 IDFdk3/Wm06 IDFdk4/Wm06 IDFdk5/Wm06 IDFdm2/Wm06 IDFmw1/Wm06 IDFxh1/Wm06 IDFxh2/Wm06 IDFxk/Wm06 IDFxm/Wm06 MSdk/Wm06 MSdm2/Wm06 PPxh1/Wm06 PPxh3/Wm06 SBPSmk/Wm06 SBPSxc/Wm06 SBSmk2/Wm06	S3 (2004)	Blue	G5	4
Spiraea douglasii / Carex sitchensis	hardhack / Sitka sedge	CDFmm/Ws50 CWHxm1/Ws50 CWHxm2/Ws50 ICHmc1/Ws50 SBSmk1/Ws50 SBSwk1/Ws50	S4 (2004)	Yellow	G4	4
Thuja plicata / Achlys triphylla	western redcedar / vanilla-leaf	CDFmm/12	S1 (2004)	Red	G1	2
Thuja plicata / Oemleria cerasiformis	western redcedar / Indian-plum	CDFmm/13	S1 (2006)	Red	G1	2
Thuja plicata - Pseudotsuga menziesii / Eurhynchium oreganum	western redcedar - Douglas-fir / Oregon beaked-moss	CDFmm/05	S1 (2004)	Red	GNR	2
Thuja plicata / Symphoricarpos albus	western redcedar / common snowberry	CDFmm/07	S1 (2004)	Red	GNR	1
Typha latifolia Marsh	common cattail Marsh	BGxh1/Wm05 BGxh2/Wm05 BGxw1/Wm05 BWBSmw/Wm05	S3 (2004)	Blue	G5	1

CDFmm/Wm05
CWHdm/Wm05
CWHxm1/Wm05
CWHxm2/Wm05
IDFdk1/Wm05
IDFdk2/Wm05
IDFdk3/Wm05
IDFdk5/Wm05
IDFdm1/Wm05
IDFdm2/Wm05
IDFmw1/Wm05
IDFmw2/Wm05
IDFxh1/Wm05
IDFxh2/Wm05
IDFxk/Wm05
PPdh2/Wm05
PPxh1/Wm05
PPxh2/Wm05

Search Summary

Time Performed	Fri Sep 07 14:40:32 PDT 2012
Results	30 records.
Search Criteria	Search Type: Ecological Communities AND Forest Districts:Chilliwack Forest District (DCK) AND MOE Regions:2- Lower Mainland AND Municipalities: White Rock AND BGC Zone, Subzone, Variant, Phase:CDFmm Sort Order:Scientific Name Ascending
Notes	1. Citation: B.C. Conservation Data Centre. 2012. BC Species and Ecosystems Explorer. B.C. Minist. of Environ. Victoria, B.C. Available: http://a100.gov.bc.ca/pub/eswp/ (accessed Sep 7, 2012). 2. Biogeoclimatic Site Unit(s): This column indicates the BGC unit(s) on which each ecological community is known to occur (future inventories may indicate range extensions). The two digit number following the slash (01 and up) indicates that the ecological community occurs on a site series that is part of the B.C. Ministry of Forests (MOF) site series classification (see MOF Regional Field Guides to Site Identification and Interpretation for more information). A two digit number of '00' indicates that the ecological community occurs on a site unit that is not part of the MOF site series classification but is recognized from other vegetation and site classifications, and ecosystem mapping projects.

Modify Search | New Search | Results

BC Species and Ecosystems Explorer Search Results

		Status					
Scientific Name	**English Name**	**Provincial**	**BC List**	**COSEWIC**	**SARA**	**Global**	**CF Priority**
Acipenser medirostris	Green Sturgeon	S1N (2004)	Red	SC (1987)	1-SC (2006)	G3 (2004)	2
Acipenser transmontanus pop. 4	White Sturgeon (Lower Fraser River population)	S2 (2010)	Red	E (2003)		G4T2Q (2002)	1
Oncorhynchus clarkii clarkii	Cutthroat Trout, *clarkii* subspecies	S3S4 (2004)	Blue			G4T4 (1997)	2
Anaxyrus boreas	Western Toad	S3S4 (2010)	Blue	SC (2002)	1-SC (2005)	G4 (2008)	2
Rana aurora	Northern Red-legged Frog	S3S4 (2010)	Blue	SC (2004)	1-SC (2005)	G4 (2008)	1
Chrysemys picta pop. 1	Painted Turtle - Pacific Coast Population	S2 (2012)	Red	E (2006)	1-E (2007)	G5T2 (2007)	2
Lepus americanus washingtonii	Snowshoe Hare, *washingtonii* subspecies	S1 (2011)	Red			G5T3T5 (1996)	1
Sorex rohweri	Olympic Shrew	S1S2 (2010)	Red			G4G5 (2007)	1
Sorex trowbridgii	Trowbridge's Shrew	S3 (2010)	Blue			G5 (1996)	2
Corynorhinus townsendii	Townsend's Big-eared Bat	S3 (2006)	Blue			G4 (1996)	2
Myotis keenii	Keen's Myotis	S1S3 (2006)	Red	DD (2003)	3 (2005)	G2G3 (2006)	1
Sympetrum vicinum	Autumn Meadowhawk	S3S4 (2004)	Blue			G5 (1985)	4
Omus audouini	Audouin's Night-stalking Tiger Beetle	S1 (2008)	Red	C (2011)		G5 (2008)	1
Callophrys eryphon sheltonensis	Western Pine Elfin, *sheltonensis* subspecies	S3 (2006)	Blue			G5TNR	4
Danaus plexippus	Monarch	S3B (2006)	Blue	SC (2010)	1-SC	G5 (2011)	2

				(2003)		
Carychium occidentale	Western Thorn	S2S3 (2008)	Blue		G3G4 (2002)	2
Prophysaon vanattae	Scarletback Taildropper	S3S4 (2008)	Blue		G4 (2002)	4
Zonitoides nitidus	Black Gloss	S3S4 (2008)	Blue		G5 (2003)	2
Monadenia fidelis	Pacific Sideband	S3S4 (2008)	Blue		G4G5 (2002)	2

Search Summary

Time Performed Sun Nov 04 19:07:38 PST 2012

Results 19 records.

Search Criteria
Search Type: Animal
AND Forest Districts:Chilliwack Forest District (DCK) (Restricted to Red, Blue, and Legally designated species)
AND MOE Regions:2- Lower Mainland (Restricted to Red, Blue, and Legally designated species)
AND Municipalities: Surrey (Restricted to Red, Blue, and Legally designated species)
AND Habitat Types:Estuary,Forest,Riparian,Stream/River,Urban,Wetland
AND BGC Zone:CDF
Sort Order:Phylogenetic Ascending

Notes
1. Citation: B.C. Conservation Data Centre. 2012. BC Species and Ecosystems Explorer. B.C. Minist. of Environ. Victoria, B.C. Available: http://a100.gov.bc.ca/pub/eswp/ (accessed Nov 4, 2012).

2. Forest District, MoE Region, Regional District and habitat lists are restricted to species that breed in the Forest District, MoE Region, Regional District or habitat (i.e., species will not be placed on lists where they occur only as migrants).

Modify Search | New Search | Results

APPENDIX G
ANALYTICAL RESULTS

Table 1: Physical Properties & Inorganics

			Sample ID	CHANTRELL 1	CHANTRELL 2	DUNSMUIR	CHANTRELL 1	CHANTRELL 2	DUNSMUIR
			Date	9/27/2012	9/27/2012	9/27/2012	10/24/2012	10/24/2012	10/24/2012
			Lab ID	EP1082	EP1083	EP1084	EV4378	EV4379	EV4380
Chemical Group	**Analyte**	**Unit**	**BC WQG**						
Microbiology	Fecal Coliforms	CFU/mL	-	<1	19	1600	110	390	2600
Physical Properties	Alkalinity (total) as CaCO3	mg/L	-	93	60.4	202	58.7	59.8	153
	Bicarbonate	mg/L	-	113	73.7	247	71.7	72.9	187
	BOD	mg/L	-	<10	<10	<10	<10	<10	<10
	Carbonate	mg/L	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	Dissolved Hardness	mg/L	-	103	79.5	438	69.3	71.7	194
	Hydroxide	µg/L	-	<500	<500	<500	<500	<500	<500
	pH (Lab)	pH_Units	6.5 - 9.0	6.91	7.2	7.42	7.92	7.95	8.0
	phenolphthalein alkalinity	µg/L	-	<500	<500	<500	<500	<500	<500
	TDS	mg/L	-	134	118	1400	124	128	494
	Hardness as CaCO3	mg/L	-	90.6	66.3	367	66.5	70.9	165
	TSS	mg/L	-	17.5	<4	25	<4.0	<4.0	4.5
Inorganics	Ammonia	mg/L	-	0.12	0.023	0.17	0.0766	0.009	0.17
	Dissolved Chloride	mg/L	600	18	11	**610**	9.9	11	120
	Fluoride*	mg/L	1.17	0.043	0.036	0.29	0.035	0.035	0.26
	Nitrate (as NO3-)	mg/L	32.8	0.022	1.42	0.546	-	-	-
	Nitrite (as NO2-)	mg/L	0.06	<0.005	<0.005	0.0145	-	-	-
	Nitrogen (Total Oxidised)	mg/L	32.86	0.022	1.42	0.56	0.94	1.3	0.413

NOTES:

-	Not analyzed or no BC Water Quality Guideline
<	Concentration is less than the laboratory detection limit indicated.
BC WQG	BC Approved Water Quality Guideline for the protection of Freshwater Aquatic Life
CFU	Colony Forming Units
*	Guideline limit decreases with hardness. Lowest measured value of hardness used to obtain standard. Calculated by 0.01*(-51.73+95.27*log(hardness))
Bold	Bold and shaded indicates an exceedance of the BC Approved Water Quality Guidelines

Table 2: Hydrocarbons

			Sample ID	CHANTRELL 1	CHANTRELL 2	DUNSMUIR	CHANTRELL 1	CHANTRELL 2	DUNSMUIR
			Date	9/27/2012	9/27/2012	9/27/2012	10/24/2012	10/24/2012	10/24/2012
			Lab ID	EP1082	EP1083	EP1084	EV4378	EV4379	EV4380
Chemical Group	**Analyte**	**Unit**	**BC WQG**						
Oil and Grease	Oil and grease (total)	mg/L	-	<1	<1	<1	<1	<1	<1
PAH	2-methylnaphthalene	µg/L	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Acenaphthene	µg/L	6	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Acenaphthylene	µg/L	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Anthracene*	µg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Acridine*	µg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Benz(a)anthracene	µg/L	0.1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Benzo(a) pyrene	µg/L	0.01	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009
	benzo(b&j)fluoranthene	µg/L	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Benzo(g,h,i)perylene	µg/L	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Benzo(k)fluoranthene	µg/L	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Chrysene	µg/L	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Dibenz(a,h)anthracene	µg/L	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Fluoranthene*	µg/L	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
	Fluorene	µg/L	12	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Indeno(1,2,3-c,d)pyrene	µg/L	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Naphthalene	µg/L	1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	PAHs (Sum of total)	µg/L	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	HEAVY MOLECULAR WT. PAH SUM	µg/L	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Phenanthrene	µg/L	0.3	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	LIGHT MOLECULAR WT. PAH SUM	µg/L	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	Pyrene*	µg/L	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
	Quinoline	µg/L	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

NOTES:

-	Not analyzed or no BC Water Quality Guideline
<	Concentration is less than the laboratory detection limit indicated.
BC WQG	BC Approved Water Quality Guideline for the protection of Freshwater Aquatic Life
*	Standard for phototoxicity applied.
Bold	Bold and shaded indicates an exceedance of the BC Approved Water Quality Guidelines

Table 3: Dissolved Metals

			Sample ID	CHANTRELL 1	CHANTRELL 2	DUNSMUIR	CHANTRELL 1	CHANTRELL 2	DUNSMUIR
			Date	9/27/2012	9/27/2012	9/27/2012	10/24/2012	10/24/2012	10/24/2012
			Lab ID	EP1082	EP1083	EP1084	EV4378	EV4379	EV4380
Chemical Group	**Analyte**	**Unit**	**BC WQG**						
Metals (Dissolved)*****	Aluminium	µg/L	100	6.9	11.4	11.7	15.2	21.5	44.6
	Antimony	µg/L	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	Arsenic*	µg/L	5	4.61	0.78	2.44	**5.19**	3.84	3.24
	Barium	µg/L	-	23.3	15.9	13.6	18.0	14.9	10.8
	Beryllium	µg/L	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Bismuth	µg/L	-	<1	<1	<1	<1	<1	<1
	Boron*	µg/L	1200	<50	<50	365	<50	<50	202
	Cadmium	µg/L	-	0.018	<0.01	<0.01	<0.01	<0.01	0.046
	Calcium	mg/L	-	27.8	21.7	68.7	19.5	20	49.4
	Chromium (III+VI)	µg/L	-	3.8	<1	<1	3.2	2.3	2.5
	Cobalt*	µg/L	110	<0.5	<0.5	<0.5	<0.5	<0.5	0.55
	Copper*	µg/L	8.2	0.36	0.94	0.5	3.18	2.71	3.04
	Iron	µg/L	350	314	**364**	182	**365**	183	**929**
	Lead*	µg/L	48	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
	Lithium	µg/L	-	<5	<5	9.8	<5	<5	<5
	Magnesium	mg/L	-	8.11	6.15	64.6	5.01	5.28	17.2
	Manganese*	µg/L	800	8.2	115	87.3	76	19.7	81.4
	Mercury	µg/L	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Molybdenum*	µg/L	2000	<1	<1	2.9	<1	<1	3.2
	Nickel	µg/L	-	1.4	<1	2.3	<1	<1	2.9
	Potassium	mg/L	-	4.48	1.99	22.7	2.54	2.48	8.78
	Selenium	µg/L	2	<0.1	<0.1	0.45	<0.1	<0.1	0.17
	Silicon	µg/L	-	3310	9260	12,200	5030	5980	10300
	Silver*	µg/L	0.1	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
	Sodium	mg/L	-	15.4	11.3	468	8.7	9.24	97.1
	Strontium	µg/L	-	172	153	642	114	120	350
	Sulphur as S	mg/L	-	<3	4.48	44.8	4.7	4.9	19.1
	Thallium	µg/L	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Tin	µg/L	-	<5	<5	<5	<5	<5	<5
	Titanium	µg/L	-	<5	<5	<5	<5	<5	5.2
	Uranium	µg/L	-	<0.1	<0.1	0.74	<0.1	<0.1	0.76
	Vanadium	µg/L	-	<5	<5	<5	<5	<5	<5
	Zinc*	µg/L	33	**43.6**	<5	5.5	6.3	<5	11.6
	Zirconium	µg/L	-	<0.5	<0.5	<0.5	<0.5	<0.5	0.74

NOTES:

-	Not analyzed or no BC Water Quality Guideline
<	Concentration is less than the laboratory detection limit indicated.
BC WQG	BC Approved Water Quality Guideline for the protection of Freshwater Aquatic Life
*	BC Water Quality Guideline for total metal applied for screening purposes.
Bold	Bold and shaded indicates an exceedance of the BC Approved Water Quality Guidelines

Table 4: Total Metals

			Sample ID	CHANTRELL 1	CHANTRELL 2	DUNSMUIR	CHANTRELL 1	CHANTRELL 2	DUNSMUIR
			Date	9/27/2012	9/27/2012	9/27/2012	10/24/2012	10/24/2012	10/24/2012
			Lab ID	EP1082	EP1083	EP1084	EV4378	EV4379	EV4380
Chemical Group	**Analyte**	**Unit**	**BC WQG**						
Metals (Total)	Aluminium	µg/L	-	31.2	29.6	199	38.4	133	385
	Antimony	µg/L	-	<0.5	<0.5	<0.5	<0.50	<0.50	<0.50
	Arsenic	µg/L	5	**11.4**	0.99	4.44	**5.40**	4.28	**6.63**
	Barium	µg/L	-	43.5	14.3	16.1	17.7	16.3	14.7
	Beryllium	µg/L	-	<0.1	<0.1	<0.1	<0.10	<0.10	<0.10
	Bismuth	µg/L	-	<1	<1	<1	<1.0	<1.0	<1.0
	Boron	µg/L	1200	<50	<50	285	<50	<50	208
	Cadmium	µg/L	-	<0.01	<0.01	0.061	<0.010	<0.010	0.102
	Calcium	mg/L	-	24.1	18	56.8	18.3	19.5	42.1
	Chromium (III+VI)	µg/L	-	<1	<1	2.2	3.3	2.6	6.9
	Cobalt	µg/L	110	<0.5	<0.5	<0.5	<0.50	<0.50	0.96
	Copper*	µg/L	8.2	0.72	0.95	2.84	2.93	3.20	7.65
	Iron	µg/L	1000	**1570**	834	**2240**	518	519	**3400**
	Lead**	µg/L	48	<0.2	<0.2	1.14	<0.20	0.27	0.75
	Lithium	µg/L	-	<5	<5	8.7	<5.0	<5.0	<5.0
	Magnesium	mg/L	-	7.38	5.2	54.7	5.06	5.39	14.6
	Manganese***	µg/L	800	692	126	84.9	33.8	40.1	127
	Mercury	µg/L	-	<0.05	<0.05	<0.05	<0.050	<0.050	<0.050
	Molybdenum	µg/L	2000	<1	<1	2.8	<1.0	<1.0	3.1
	Nickel	µg/L	-	<1	1.1	1.7	1.3	2.3	6.0
	Potassium	mg/L	-	3.91	1.68	18.7	2.41	2.44	8.76
	Selenium	µg/L	2	<0.1	<0.1	0.39	<0.10	<0.10	0.21
	Silicon	µg/L	-	3040	8020	10,900	4630	5650	9110
	Silver***	µg/L	0.1	<0.02	<0.02	<0.02	<0.020	<0.020	0.021
	Sodium	mg/L	-	14	9.99	394	8.32	9.1	91.6
	Strontium	µg/L	-	154	131	562	114	121	289
	Sulphur as S	mg/L	-	<3	4.98	37.8	4.2	4.1	17.6
	Thallium	µg/L	-	<0.05	<0.05	<0.05	<0.050	<0.050	<0.050
	Tin	µg/L	-	<5	<5	<5	<5.0	<5.0	<5.0
	Titanium	µg/L	-	<5	<5	13.5	<5.0	6.7	17.4
	Uranium	µg/L	-	<0.1	<0.1	0.71	<0.10	<0.10	0.70
	Vanadium	µg/L	-	<5	<5	7.4	<5.0	<5.0	5.1
	Zinc***	µg/L	33	<5	<5	12.9	8.4	6.4	29.3
	Zirconium	µg/L	-	<0.5	<0.5	0.82	<0.50	<0.50	0.92

NOTES:

-	Not analyzed or no BC Water Quality Guideline
<	Concentration is less than the laboratory detection limit indicated.
BC WQG	BC Approved Water Quality Guideline for the protection of Freshwater Aquatic Life
*	Guideline limit decreases with hardness. Lowest measured value of hardness used to obtain standard. Calculated by 0.094*hardness + 2
**	Guideline limit decreases with hardness. Lowest measured value of hardness used to obtain standard. Calculated by exp(1.273*ln(hardness)-1.460)
***	Guideline is hardness dependent. Most stringent value used.
Bold	Bold and shaded indicates an exceedance of the BC Approved Water Quality Guidelines

APPENDIX H

COST ESTIMATE LOWER CHANTRELL CREEK RE-ALIGNMENT

APPENDIX 7: COST ESTIMATE FOR THE LOWER CHANTRELL CREEK REALIGNMENT

City of Surrey

TETRA TECH

Chantrell Creek Realignment

Item	Preliminary Estimate of Probable Costs Summary				Total
1.0	Preliminaries				$88,528
2.0	Earthworks & Bank Protection				$387,100
3.0	Miscellaneous				$652,000
				Sub-Total Construction Costs	**$1,127,628**
4.0	Project Contingencies			15.0%	$169,144
				Total Estimated Construction Cost	**$1,296,772**
5.0	Engineering Design / Construction Inspection / Record Drawings / Environmental Monitoring			10.0%	$129,677
				Total Estimated Project Cost - Excluding Taxes	**$1,426,400**

1.0	Preliminaries	Unit	Est Quantity	Est. Unit Price	Est. Total
1	Mob / Demob / Temporary Facilities - Security, Barricades, Survey, Quality Control, etc.	lump sum	1	$83,528.00	$83,528
2	Location of Existing Services	lump sum	1	$2,500.00	$2,500
3	Co-ordination with Service Authorities	lump sum	1	$2,500.00	$2,500
	Sub-total Item 1.0				**$88,528**

2.0	Earthworks & Bank Protection	Unit	Est Quantity	Est. Unit Price	Est. Total
1	Vegetation Removal and Stripping	sq.m.	80,000	$1.00	$80,000
2	Excavation and Onsite Disposal	cu.m.	20,000	$10.00	$200,000
3	Supply and Place Rip Rap, Boulders, Cobble and Spawning Gravel	Tonne	3,060	$35.00	$107,100
	Sub-total Item 2.0				**$387,100**

3.0	Miscellaneous	Unit	Est Quantity	Est. Unit Price	Est. Total
1	Sediments and Erosion Control	lump sum	1	$50,000.00	$50,000
2	Hydroseeding and revegetation of the riparian area	lump sum	1	$150,000.00	$150,000
3	Bridge 1 - Light Duty Timber Bridge	lump sum	1	$103,600.00	$103,600
4	Bridge 2 - Pedestrian and Heavy Machinery Bridge	lump sum	1	$154,800.00	$154,800
5	Bridge 3 - Pedestrian Boardwalk	lump sum	1	$83,600.00	$83,600
6	Damage Restoration	lump sum	1	$75,000.00	$75,000
7	Dewatering	lump sum	1	$35,000.00	$35,000
	Sub-total Item 3.0				**$652,000**

Notes:

1. Cost estimate is for planning & budgeting purposes only, and does not constitute a guarantee on the part of Tetra Tech.
   Actual costs will be determined by the tendering and construction processes.
2. Costs do not include GST.