City of Coquitlam

Partington Creek Integrated Watershed Management Plan

Final Report
July 2011

KERR WOOD LEIDAL associates limited CONSULTING ENGINEERS

RAINCOAST APPLIED ECOLOGY

HB LANARC

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July 4, 2011

Ms Melony Burton, A.Sc.T.
Infrastructure Management
City of Coquitlam
500 Mariner Way
Coquitlam, B.C.
V3K 7B6

Dear Ms Burton:

RE: PARTINGTON CREEK IWMP
July 2011 Final Report
Our File 456.038

Please find enclosed our Final Report for the Partington Creek Integrated Watershed Management Plan. This submission summarizes the complete study and development of the IWMP. This IWMP was developed in collaboration with City Staff, DFO, Advisory Committee members and members of the public. DFO's letter of support is appended.

It was our sincere pleasure to complete this interesting and challenging watershed plan on behalf of the City of Coquitlam. Please do not hesitate to contact the undersigned should you have questions or comments.

Yours truly,

KERR WOOD LEIDAL ASSOCIATES LTD.

Crystal Campbell, P.Eng.
Project Manager

CWC/sj
Encl.

cc. David Reid, HB Lanarc
Nick Page, Raincoast Applied Ecology

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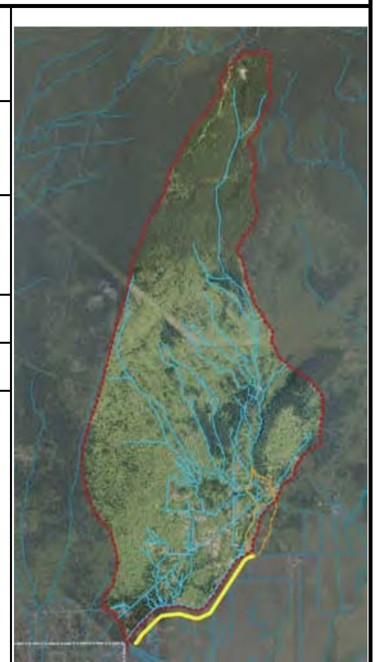
EXECUTIVE SUMMARY

Partington Creek is a near 'greenfield' watershed that is mainly covered by second growth forest with its headwaters protected in the Pinecone Burke Provincial Park. The watershed supports rich aquatic and wildlife ecosystems. There are key fish species present and the lower reaches are among the most productive coho spawning streams in the Lower Mainland. Key watershed characteristics are summarized as follows:

Description	Partington Creek Watershed	
Drainage Area	▪ 625 ha. ▪ Discharges to DeBoville Slough to Pitt River and then to the Fraser River.	
Stream Structure	▪ One main-stem with three main tributaries: Star Creek, Fox Creek, Dairy Creek and many minor tributaries.	
Topography	▪ Steep mountain creek with southern aspect. Elevation ranges from El. 960 m to El. 4 m. ▪ Flat channelized section at bottom of watershed.	
Erosion	▪ Minor erosion sites.	
Soils	▪ Mostly bedrock with shallow till.	
Land Use	▪ Existing land use is mostly undeveloped forested land with some residential acreages in lower watershed. ▪ Significant future development proposed in lower watershed; portion of *Partington Creek Neighbourhood Plan* including village core, high density, medium density, and low density residential. ▪ Total impervious area increases from 3% to 22%.	
Environmental Values	▪ Very healthy watershed B-IBI Score 31 – 4th highest in Lower Mainland. ▪ Diverse and abundant fish community – 14 species including chum/coho salmon/cutthroat trout. ▪ Excellent chum salmon spawning. ▪ Diverse wildlife. ▪ Species at risk including Pacific Water Shrew. ▪ Strong existing riparian corridor & integrity.	

Main issues addressed in this IWMP include:

- Mitigating impacts associated with significant future development
- Lower channel sedimentation and road/agricultural land flooding; and
- Sedimentation within Deboville Slough.

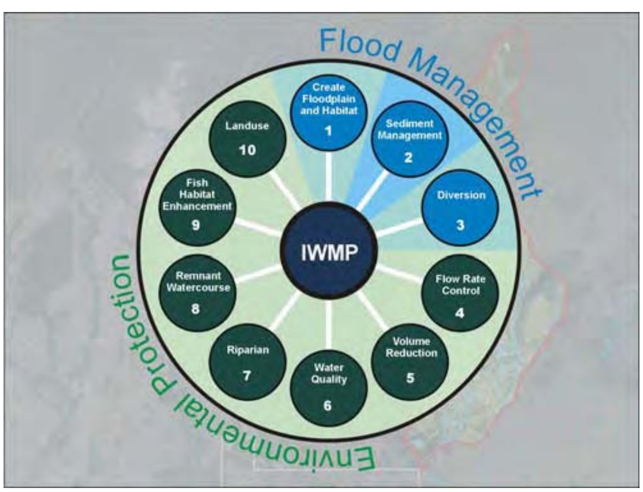
The City initiated both the Partington Creek Integrated Watershed Management Plan and the Partington Creek Neighbourhood Plan concurrently and successfully integrated the disciplines of land use planning, engineering and environment protection between these two studies.

Three main alternatives were developed and evaluated. Each alternative included components of stormwater engineering, land use planning and environmental protection. A multi-disciplinary consulting team of engineers, planners, and biologists, together with City Staff from multiple departments, DFO, and an Advisory Committee worked together to develop a plan that strived to meet the interests of many. The plan was developed and refined during an extensive consultation process. During the past year, City Staff from Engineering & Public Works, Planning and Development, Parks, Recreation & Culture Services and Land Management have worked in an intensive, integrated manner to address the environmental concerns without impairing the economic viability of development. The location of the planned village core was shifted and land use densities modified to retain and protect the Star Creek headwaters. This has produced improvements to environmental, social, and economic well being of this future area within Coquitlam.

RECOMMENDED IWMP

Table 1 summarizes the recommended IWMP components.

Components of Partington Creek IWMP

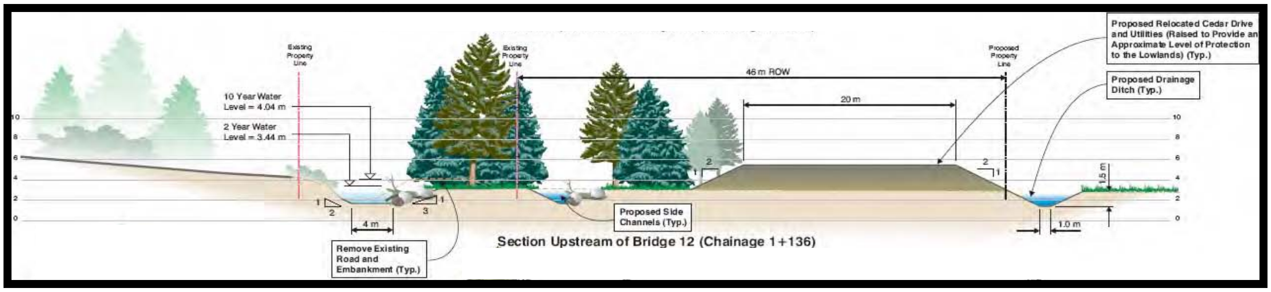


The recommended plan complements the City's OCP and overall development strategy for Northeast Coquitlam. DFO issued a letter (appended in Appendix O) stating that the Partington IWMP is a significant achievement and is expected to be instrumental in ensuring that future development activity is congruent with fish habitat values.

Table 1: Summary of Partington Creek Integrated Watershed Management Plan

Sediment and Flood Management		
1.	**WIDEN MAINSTEM CHANNEL AND RELOCATE/RAISE PORTION OF CEDAR DRIVE**	
	▪ Acquire land and relocate/raise portion of Cedar Drive	
	▪ Acquire land to widen/complex additional main-stem channel	
	▪ Relocate full length of Cedar Drive along mainstem channel in long-term plan	
2.	**SEDIMENT MANAGEMENT PLAN**	
	▪ Construct a sand trap	▪ Remove instream sediment at designated locations
	▪ Construct a sediment basin	▪ Monitoring
3.	**CONSTRUCT FLOW DIVERSIONS & UPGRADE UNDERSIZED CULVERTS AND BRIDGES**	
	▪ Divert large flows & mid-range flows for environmental protection away from creek directly to Deboville Slough, baseflows and pre-development flows maintained within creeks	
	▪ Upgrade 17 culverts and 1 bridge	
Environmental Protection Measures		
4.	**HYDROLOGIC RATE CONTROL**	
	▪ Utilize diversion with specialized flow splitters to convey mid-range excess flows away from creek	
	▪ Widen the Lower Partington main stem channel to convey future flows	
5.	**HYDROLOGIC VOLUME REDUCTION**	
	▪ Apply City's Rainwater Management Source Controls requirements	
	▪ Construct 1 underground baseflow release facilities (minimize erosion/destruction of fish habitat)	
	▪ Construct 5 underground baseflow augmentation facilities Star & Fox Creeks (sustain baseflows)	
6.	**STORMWATER QUALITY TREATMENT**	
	▪ Construct source controls for roads and parking lots	
	▪ Construct 8 regional water quality ponds/wetlands	
7.	**PROTECT RIPARIAN AREAS**	
	▪ Preserve excellent riparian areas within headwaters	
	▪ Apply RAR setbacks within developing areas	
	▪ Create enhanced 30 m riparian setbacks around Lower Partington main stem	
	▪ Reforest 4.8 ha of impacted riparian areas within RAR setbacks	
8.	**PROTECT EXISTING WATERCOURSES**	
	▪ Replace manmade ditches with source controls to sustain baseflows	
	▪ Preserve medium manmade ditches along Crouch & David Avenues that have natural headwater watercourses to support star creek with food and nutrients	
9.	**RESTORE INSTREAM COMPLEXING, FLOODPLAIN WETLANDS, OFF-CHANNEL HABITATS IN LOWER PARTINGTON MAIN STEM**	
	▪ Create and restore floodplain forest, marshes, side-channels, instream wood structures, boulder groups, boulder spurs, stable debris jams and gravel spawning platforms	
	▪ Create 40 instream structures: 5 on Fox Creek, 10 on Partington main stem between Victoria Drive and Cedar Drive, and 25 within lower restored Partington main stem	
	▪ Remove fish barriers and replace with fish passable structures: 1 bridge on Fox Creek, 5 culverts on Fox Creek, 2 culverts on Partington Creek/Partington Tribs, and 1 Culvert on Dairy Creek	
10.	**LAND-USE MEASURES**	
	▪ Land use areas were moved to preserve headwater watercourses (Item 8 above)	
	▪ Consider no isolated pockets of single family development in lower watershed or additional regional stormwater facilities will be required	
	Note: Refer to Figures 9-1 to 9-7.	

Proposed Creation of Floodplain, Riparian Setbacks and Instream Complexing with Immediate Partial Relocation and Raising Cedar Drive



FINANCIAL IMPLICATIONS

The IWMP works such as diversion pipe, baseflow augmentation facilities, water quality ponds, sediment traps, and relocation and enhancement of Cedar Drive has an estimated cost of about $31 million. The main components of the works will be constructed as City capital projects funded from DCCs. An allowance is already included in the existing DCC bylaw so the current drainage DCC rate is not expected to increase. Repair of existing deficiencies such as collapsed or undersized culverts will be funded from the Sewer and Drainage Utility. Future storm sewer system and site-level rainwater source controls will be the responsibility of the developer. Habitat enhancements may also be undertaken by developers as part of mitigation requirements. Some improvements may also qualify for funding from senior government or environmental grants, such as those provided by the Pacific Salmon Foundation. Streamkeepers may also assist with habitat enhancement works and education.

KEY PERFORMANCE INDICATOR MONITORING

On-going performance indicator monitoring is needed to assess the success of the IWMP implementation and allow for adaptive management to protect the watershed's environmental values. The monitoring program includes stream flow monitoring, benthic invertebrate surveys, fish counts and water quality testing to quantify the ecological health of the watershed. Tracking total and effective impervious area, riparian forest integrity and channel erosion over time would also be useful performance indicators.

CONCLUSIONS

The recommended IWMP is the culmination of extensive work by an integrated team including multi-departmental City Staff, multi-disciplinary consulting team, DFO and the project Advisory Committee. The plan strives to mitigate the impacts of proposed development and provide fish habitat improvements that will result in a "net-environmental benefit".

Section 1

Introduction

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1. INTRODUCTION

1.1 BACKGROUND

The City of Coquitlam (City) initiated the Integrated Watershed Management Plan (IWMP) for the Partington Creek watershed in 2005. The *Partington Creek Neighbourhood Plan (PCNP)* was also initiated in 2006 to establish the land use and form of the Partington Creek Village. The two studies interfaced and were working together to develop a Watershed Plan and a Neighbourhood Plan with common goals.

The first three phases of the IWMP study were completed during 2005 to 2007. The City then put both studies on hold while the City reviewed of its *Low Impact Development (LID) Policy and Procedures Manual, 2005* in light of recent development in the Hyde Creek watershed immediately west of the Partington Creek watershed. As a result of this review, the City has replaced the LID policy with the *Rainwater Management – Source Controls Design Requirements and Guidelines, 2009*. The IWMP study resumed during the spring of 2009.

PARTINGTON CREEK WATERSHED ENVIRONMENTAL GOALS

The watershed goals developed by the City and stakeholders are summarized as follows:

- Strive for a no-net-loss of ecological health for the watershed as a whole measured using the Watershed Health Tracking System.
- Provide a net environmental benefit for fish and fish habitat in the watershed.

Balancing Land Development and Environmental Values

The IWMP process preserves watershed health as a whole, while meeting community needs and allowing development and re-development to occur. It allows for tradeoffs so that environmental losses in one area within a watershed can be offset by gains in others, thereby meeting the guiding principle of no-net-loss.

PARTINGTON CREEK IWMP PURPOSE AND OBJECTIVES

The overall objectives of the Partington Creek IWMP are to safeguard human life and property, maintain or improve watershed health, and optimize the cost/benefit of the proposed drainage system. It should also accommodate population growth and increase demand for housing and services, while protecting and enhancing the environment. This would involve development of plans, projects, and procedures that will:

- establish specific objectives for the watershed;

- provide input into the *Partington Creek Neighbourhood Plan* to facilitate orderly land development within the Partington Creek watershed;
- protect or enhance environmental values (fish, wildlife, vegetation);
- protect private and public property from flood and erosion damage;
- maintain public safety through creek management and address flood overtopping Cedar Drive;
- develop a flood diversion plan for the Hyde Creek development reserve area;
- review the capacity of DeBoville Slough and potential erosion;
- strive to maintain ecological health of watershed; and
- develop cost effective solutions (capital, operation, and maintenance) complete with implementation and maintenance plans.

The plan is to be cost-effective, scientifically defendable, supported by the public, and endorsed by the environmental agencies.

1.2 SCOPE OF ASSIGNMENT

Table 1-1 summarizes the major tasks involved in undertaking this study.

Table 1-1: Engineering Work Program

<table>
<tr><th colspan="6">Major Tasks</th></tr>
<tr><td rowspan="6">Phase 1 - Reconnaissance</td><td>1.</td><td>Project Initiation</td><td rowspan="6">Phase 3 - Alternatives</td><td rowspan="3">11.</td><td rowspan="3">Develop and Evaluate Alternatives</td></tr>
<tr><td>2.</td><td>Drainage Inventory</td></tr>
<tr><td>3.</td><td>Environmental Inventory</td></tr>
<tr><td>4.</td><td>Hydrogeology Inventory</td><td rowspan="3">12.</td><td rowspan="3">Phase 3 Draft Report & Meetings</td></tr>
<tr><td>5.</td><td>Hydrologic and Hydraulic Modelling</td></tr>
<tr><td>6.</td><td>Phase 1 Draft Report & Meetings</td></tr>
<tr><td rowspan="4">Phase 2 - Assessment</td><td>7.</td><td>IWMP Framework</td><td rowspan="4">Phase 4 - IWMP</td><td>13.</td><td>IWMP</td></tr>
<tr><td>8.</td><td>Environmental Assessment</td><td>14.</td><td>Implementation and Maintenance Strategy</td></tr>
<tr><td>9.</td><td>Hydrotechnical Assessment</td><td>15.</td><td>Phase 4 Draft Report & Meetings</td></tr>
<tr><td>10.</td><td>Phase 2 Draft Report & Meetings</td><td>16.</td><td>Final Report & Meetings</td></tr>
</table>

1.3 STORMWATER AND DRAINAGE CRITERIA

The stormwater criteria required to meet the goals of the Partington Creek IWMP are set out in Table 1-2. These criteria are derived from:

- the City's:
  - *Rainwater Management – Source Controls Design Requirements and Guidelines, 2009,*
  - *Riparian Area Regulation Amendment, 2006, Bylaw No. 3746,*
  - *Stormwater Management Policy and Design Manual 2003,*
  - *Stream and Drainage System Protection Bylaw, 2001, Bylaw No. 3447;*
- Metro Vancouver's *Template for Integrated Stormwater Management Planning 2005*; and
- DFO's *Urban Stormwater Guidelines and BMPs for the Protection of Fish and Fish Habitat*, 2001.

Table 1-2: Summary of Stormwater Criteria

Application		Criteria/Methodology
Hydrotechnical Component (Flood and Erosion Protection)	Minor Drainage System	▪ 10-year return period design event.[1] ▪ 25-year return period design event in high-value commercial / industrial / downtown business areas[1]
	Major Drainage System	▪ 100-year return period design event[1] ▪ 200-year return period in floodplain HGL[1]
Environmental Component (Environmental Protection)	Volume Reduction Source Controls	▪ On-site rainfall capture (runoff volume reduction) for 6-month 24-hour storm (72% of the 2-year 24-hour storm) [2] ▪ Full source controls on multi-family, commercial, and institutional, industrial land uses and roads. 300 mm of absorbent topsoil on all pervious areas and grading hard surfaces to pervious areas on single family land uses. [3]
	Water Quality Treatment	▪ Collect and treat 90% of annual runoff from impervious areas with BMPs [2]
	Detention / Diversion Rate Control	▪ Control post-development flows in creeks to pre-development levels for 6-month, 2-year, and 5-year 24-hour event.[2] Event-based detention sizing should include a factor of safety (1.1 for post-development imperviousness of 20%, increasing linearly up to 1.5 for post-development imperviousness of 100%). [1]
	Riparian	▪ Establish riparian setbacks to comply with *Riparian Areas Regulation*.

[1] City of Coquitlam Stormwater Management Policy and Design Manual, July 2003.
[2] DFO Urban Stormwater Guidelines and BMPs for the Protection of Fish and Fish Habitat, 2001.
[3] City of Coquitlam Rainwater Management– Source Controls Design Requirements and Guidelines, 2009.

Fisheries and Oceans Canada (DFO) and Ministry of Environment (MOE) are keenly interested in Partington Creek for its strong environmental values. DFO's Stormwater Guidelines have detention requirements are to detain post-development flows to pre-development levels for the 6-month, 2-year, and 5-year events, while the City *Stormwater Management Policy and Design Manual 2003* prescribes that the 2-year, post-development flow be detained to 50% of the 2-year, pre-development flow. The DFO guidelines are recommended as the more up-to-date stormwater criteria and to obtain their acceptance of the IWMP and to streamline approvals for future works in the watershed. MOE is concerned about maintaining water quality, stream health, and wildlife habitat including suspected populations of Pacific water shrew, and endangered species.

1.4 STAKEHOLDER CONSULTATION PROGRAM

STEERING COMMITTEE

The Partington Creek IWMP Steering Committee provides direction and guidance to the IWMP process. It consists of City departments including:

- Melony Burton, Dana Soong, Engineering;
- Andrew Young, Pat Bell, Rob Innes, Planning;
- Dave Palidwor, Parks; and
- Margaret Birch, Hagen Hohndorf, Environmental Services.

ADVISORY COMMITTEE

The Partington Creek IWMP Advisory Committee provides background, input, and comments to the study. It includes the following members:

- Elaine Golds, Burke Mountain Naturalists;
- Ron Nordstrand, Janie Hiebert, Pitt River Boat Club;
- David Mounteney, Teri Madaisky, Friends of DeBoville Slough;
- Clara Brolese, North East Coquitlam Ratepayers Association;
- James McNeill, Partington Resident;
- Ted Wingrove, Darin McClain, Brian Wormald, Hyde Creek Watershed Society;
- Mike Bristol, Coquitlam Diking District (MOE);
- Heather Wornell, Ron Wood, Alison Evely, Regional Parks Central Area, Metro Vancouver;
- Perry Staniscia, City of Coquitlam;
- Steve Zuliani, Zuliani & Company Consultants Limited;
- Murray Manson, Corino Salomi, Brad Fanos, Mike Engelsjord, DFO;
- Ross Neuman, Scott Barrett, Ministry of Environment; and
- Allen Jensen, City of Port Coquitlam.

CONSULTATION PROCESS

The study team met with the Steering and Advisory Committee at each phase of the study as follows:

1. Initiation/Introductory.
2. Review of Phase 1 draft report.
3. Review of Phase 2 draft report.
4. Review of Phase 3 draft report.
5. Review of Phase 4 draft report.
6. Review of final draft report.

A Public Open House was conducted on March 14, 2007 to receive feedback on the first three phases of this study. A second Open House was held on June 21, 2011 to receive comments on the draft IWMP. One Council Committee presentation was conducted.

An initial draft plan was presented in March 2010 and review by the project Advisory Committee. While they were generally supportive, some Committee members expressed concern about the loss of some watercourses, diversion of flows, desire for greater riparian setbacks and need for better sediment management. DFO was particularly concerned about the loss of headwater streams in the Star Creek tributary. Rather than taking a 'positional' course of action, City Staff pursued an interest-based approach to the concerns expressed by DFO.

DFO SIGN-OFF

DFO provided a supportive letter for the IWMP commending the efforts of the City and study team; it is appended in Appendix O.

COORDINATION WITH PARTINGTON CREEK NEIGHBOURHOOD PLAN

The *Partington Creek Neighbourhood Plan* (PCNP) study was initiated in June 2006. The PCNP study team includes the some of the same members from the IWMP study team:

- HB Lanarc Consultants is leading the project;
- KWL responsible for engineering aspects; and
- Raincoast Applied Ecology responsible for aquatic environment aspects.

The two Partington Creek studies, the IWMP and the NP, interfaced and integrated throughout both study processes.

1.5 PROJECT TEAM

The project team consists of inter-disciplinary professionals, as outlined in Table 1-3.

Table 1-3: Project Team

Company	Team Members
Kerr Wood Leidal Associates Ltd.	Crystal Campbell, P.Eng., Project Manager David Zabil, P.Eng., Project Engineer Chris Johnston, P.Eng., Technical/Specialist Advisor Jennifer Young, P.Eng., Hydrotechnical Analysis David Lee, E.I.T., Drainage Inventory
Raincoast Applied Ecology	Nick Page, R.P.Bio., Biologist
HB Lanarc Consultants Ltd.	David Reid, Planner, Landscape Architect, Land Use Planning Don Crockett, Landscape Architect
Gartner Lee Limited	Rob Dickin, M.Sc., P.Geo., Hydrogeology

Special thanks are extended to the IWMP Steering and Advisory Committee members.

Section 2

Overview of Partington Creek Watershed

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2. OVERVIEW OF PARTINGTON CREEK WATERSHED

2.1 INTRODUCTION

This section describes the Partington Creek watershed, including:

- a description of the creek and drainage patterns;
- existing and future land uses;
- environmental values;
- soils and hydrogeology; and
- a summary of key watershed issues.

A summary of background information used for this study is summarized as follows.

Table 2-1: Summary of Background Material

Date	Title
2009	City of Coquitlam Rainwater Management – Source Control Design Requirements and Guidelines
April 2005	Guide to Best Site Development Practices (Formerly Hillside Development Standards & Guidelines)
Feb. 2005	DeBoville Slough Assessment, Associated Engineering (BC) Ltd.
Jan. 2005	Hyde Creek IWMP – Diversion Alignment Assessment, Associated Engineering (BC) Ltd.
Jan. 2005	Low Impact Development Policy and Procedures Manual, Dayton & Knight Ltd.
April 2004	Hyde Creek Integrated Watershed Management Plan, Associated Engineering (BC) Ltd.
2003	City of Coquitlam Stormwater Management Policy and Design Manual
2003	City of Coquitlam Subdivision and Development Servicing Bylaw No. 3558
March 2002	City of Coquitlam Northeast Area Plan, City of Coquitlam
2001	City of Coquitlam Citywide Official Community Plan
1998	City of Coquitlam Northeast Coquitlam Terrain and Watershed Study, Dayton & Knight Ltd.

2.2 PARTINGTON CREEK WATERSHED

The Partington Creek watershed is located in the northeast portion of the City of Coquitlam as shown in Figure2-1. It is approximately 625 ha in area, most of which is currently undeveloped. Partington Creek flows generally north to south and drains into the Pitt River via DeBoville Slough.

The following table summarizes watershed/creek characteristics. Figures 2-2 to 2-4 and Figures 3-1 to 3-6 graphically show these characteristics.

Table 2-2: Summary of Watershed Characteristics

Description	Partington Creek Watershed
Drainage Area	▪ 625 ha.
Stream Structure	▪ One 6.3 km main-stem (mainly open channel with a number of driveway bridges and one culvert at the outlet to DeBoville Slough). ▪ Thirteen small tributaries including Star Creek and Fox Creek (estimated total of 18 km of open creek channels).
Topography	▪ Topography ranges from El. 960 m at the headwaters to El. 4 m at the outlet to DeBoville Slough. ▪ The north area is mountainous with relatively steep slopes (33% average, over 200% maximum) in the Provincial Park area. ▪ The southern area is not as steep but slopes are still 10% to 20% on average.
Land Use	Existing (from land use code in GIS parcel layer): ▪ 76% undeveloped or vacant (including Burke Mountain Park), 14% acreage residential, 4% road ROWs, 2% parks, 2% single family residential, and 1% agricultural. Figure 2-2. Future (from OCP): ▪ 51% parks/recreation, 15% environmentally sensitive area, 10% medium density village, 7% low density village, 5% suburban residential, 4% large single family, 4% rural resource, 3% development reserve, 1% village core, and 1% high density village. Figure 2-3.
Drainage	▪ Partington Creek drains via the DeBoville Slough to the Pitt River and then to the Fraser River. The lower Partington Creek channel is influenced by backwater during high tidal conditions and by high Fraser River flows.
Channel Characteristics	▪ Mountain creek channels are generally well incised. ▪ Ditches generally can overflow onto adjacent roadways. ▪ Main-stem channel slopes range up to 82% in the mountainous areas, <1% to 2% below Victoria Drive. Refer to Figure 2-4 watercourse profile. ▪ Main-stem channel width ranges from 3 m to 9 m, and depth from 1.5 m to 9 m. Refer to Table A-1.
Hydraulic Structures	▪ 34 culverts, ranging in size from 450 mm to 2,500 mm. ▪ 22 bridges. Refer to Figure 3-1.
Erosion	▪ 9 minor erosion sites. See Figure 3-1.
Soils	▪ 92% granitic rock and 8% till. See Figures 3-5 and 3-6.

2.3 EXISTING AND PROPOSED FUTURE LAND USE

2003 LAND USE

The 2003 land use of the Partington watershed is shown on the air photo in Figure 2-2.

The majority of the watershed is in a second growth, forested, condition. In the upper portions of the watershed, this 'natural' condition is protected by Pinecone Burke Provincial Park. Hydro transmission corridor and related service roads/trails cross the Park.

The lower edge of the watershed is settled with acreage-scale housing, concentrated along Victoria and Cedar Roads and adjacent side streets. An undeveloped City Park (Fremont Park) is central to this semi-rural neighbourhood. NECAP shows Environmentally Sensitive Areas as protected along Partington Creek and known tributaries, including Star and Fox Creeks.

To the west of the watershed at its lowest corner, estate-size lots are developed to urban standards in the Baycrest Drive neighbourhood, including some relatively new large homes.

To the east of the watershed and the Partington Creek Main-stem lie active agricultural areas in the Agricultural Land Reserve (ALR). Blueberry crops are predominant.

Central areas of the Partington Creek watershed are largely in a natural wooded state, and are held in large part by a nearly equal proportion of private, City of Coquitlam and the Provincial Crown.

PROPOSED LAND USE

The Partington Creek watershed is within the development area identified in the *Northeast Coquitlam Area Plan* (NECAP), which calls for orderly development of a community of 7,500 dwelling units and 24,000 people over the next 20 years. The plan proposes a village centre located at the southwest edge of the Partington Creek watershed with residential areas of varying density occupying the southern half of the watershed. A majority of this growth will be Greenfield development. Figure 2-3 shows the NECAP Land Use Designations in relation to the Partington Creek watershed boundary.

Large portions of the Partington Creek upper watershed are designated Development Reserve, Environmentally Sensitive Area, Rural Resource and Parks and Recreation. All of these designations anticipate limited disturbance to these areas during the life of the plan, which should provide significant benefits in stormwater management.

Central to the Land Use Plan is the Village Core, which is considered the area of highest residential densities that supports a transit and walking lifestyle, provides the focal point for the area's employment, shopping, educational, recreational and social uses and for future direct transit service. Land use density decreases in a concentric manner as walking times from the village centre increases.

The parallel planning processes of the Integrated Watershed Management Plan and Neighbourhood Plan informed each other to obtain the optimal plan that integrates the environmental, social, and economic goals set out in the *Northeast Coquitlam Area Plan*. Refer to Section 7.3 Planning Alternatives for a discussion of the *Partington Creek Neighbourhood Plan* (PCNP) concepts under consideration.

2.4 EXISTING SEDIMENTATION AND FLOODING

The lower 1.5 km of Partington Creek is very flat (0.1% grade shown on Figure 2-4) and experiences considerable sediment deposition, decreasing the hydraulic capacity of creek channel adjacent to Cedar Drive.[1]

The lower reaches of Partington Creek are susceptible to flooding and Cedar Drive overtops on an annual basis. The lower reaches also experience backwater effects from DeBoville Slough. During a major flood event in Pitt River and DeBoville Slough, the banks of Partington Creek will overflow and flood the lowland agricultural fields to the east.[2]

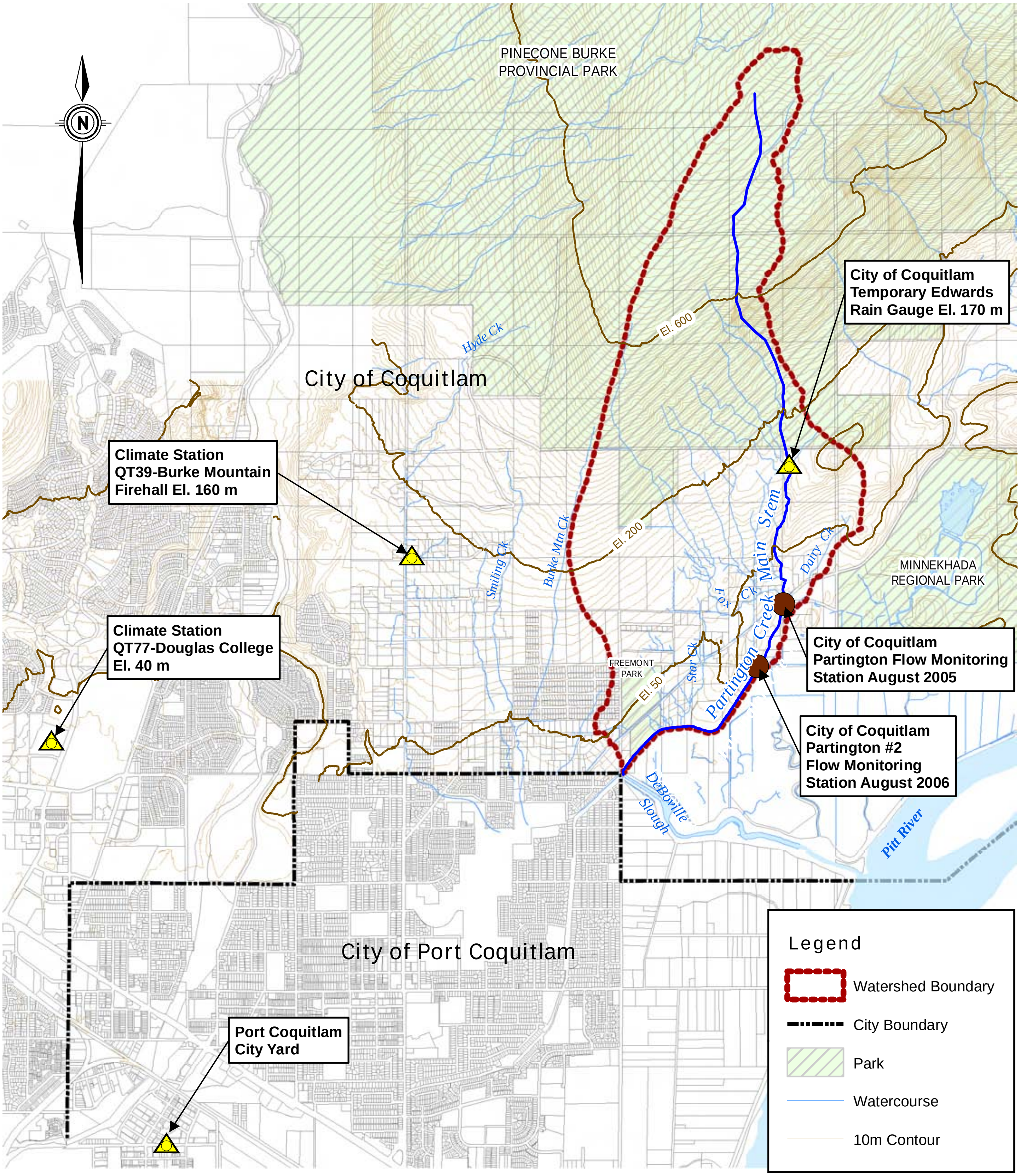
2.5 POTENTIAL FLOOD ROUTING FROM UPPER HYDE CREEK WATERSHED

The Hyde Creek watershed is situated to the west, adjacent to the Partington Creek watershed. The lower reaches of Hyde Creek drain through the City of Port Coquitlam and cause flooding. The proposed plan for the future development/redevelopment of the upper Hyde Creek watershed within the City of Coquitlam includes detention ponds and conveyance of large flows via diversion pipes directly into the DeBoville Slough. The two proposed diversions, as detailed in the *Hyde Creek IWMP – Diversion Alignment Assessment* report completed in January 2005, will service all development except for the Hyde Creek Development Reserve area shown on Figure 2-3.

One of the objectives of the Partington Creek IWMP is to investigate options for routing the large flows from the Hyde Creek Development Reserve area. The plan will examine the potential of diverting large flows from the Partington Creek development in a similar fashion, possibly using a common trunk to carry both diversion flows, Hyde and Partington, to the DeBoville Slough.

[1] Dayton & Knight Ltd. *Northeast Coquitlam Terrain and Watershed Study*, 1998

[2] City of Coquitlam. Request for Proposal for Consulting Services for Partington Creek IWMP, March 18, 2005



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City of Coquitlam
Partington Creek Integrated Watershed Management Plan

Project No.	Date
456-038	July 2011

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Scale in Metres

Location Map - Partington Creek and Climate Stations

Figure 2-1

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Author: JLau

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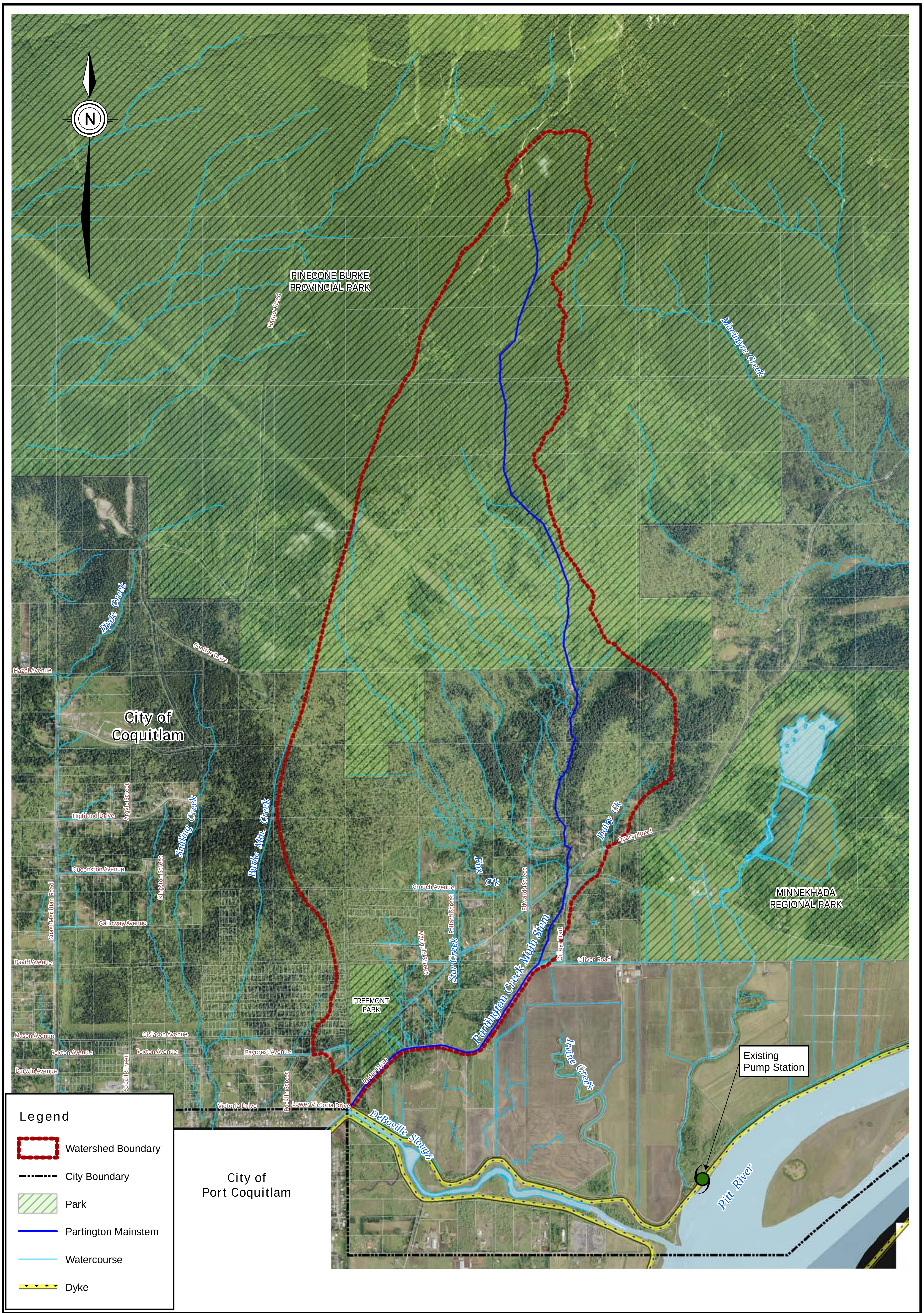
Author: JLau



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City of Coquitlam
Partington Creek Integrated Watershed Management Plan

Project No.	Date
456-038	July 2011

500 0 500

Scale in Metres 1:20,000

2003 Air Photo - Existing Land Use

Figure 2-2

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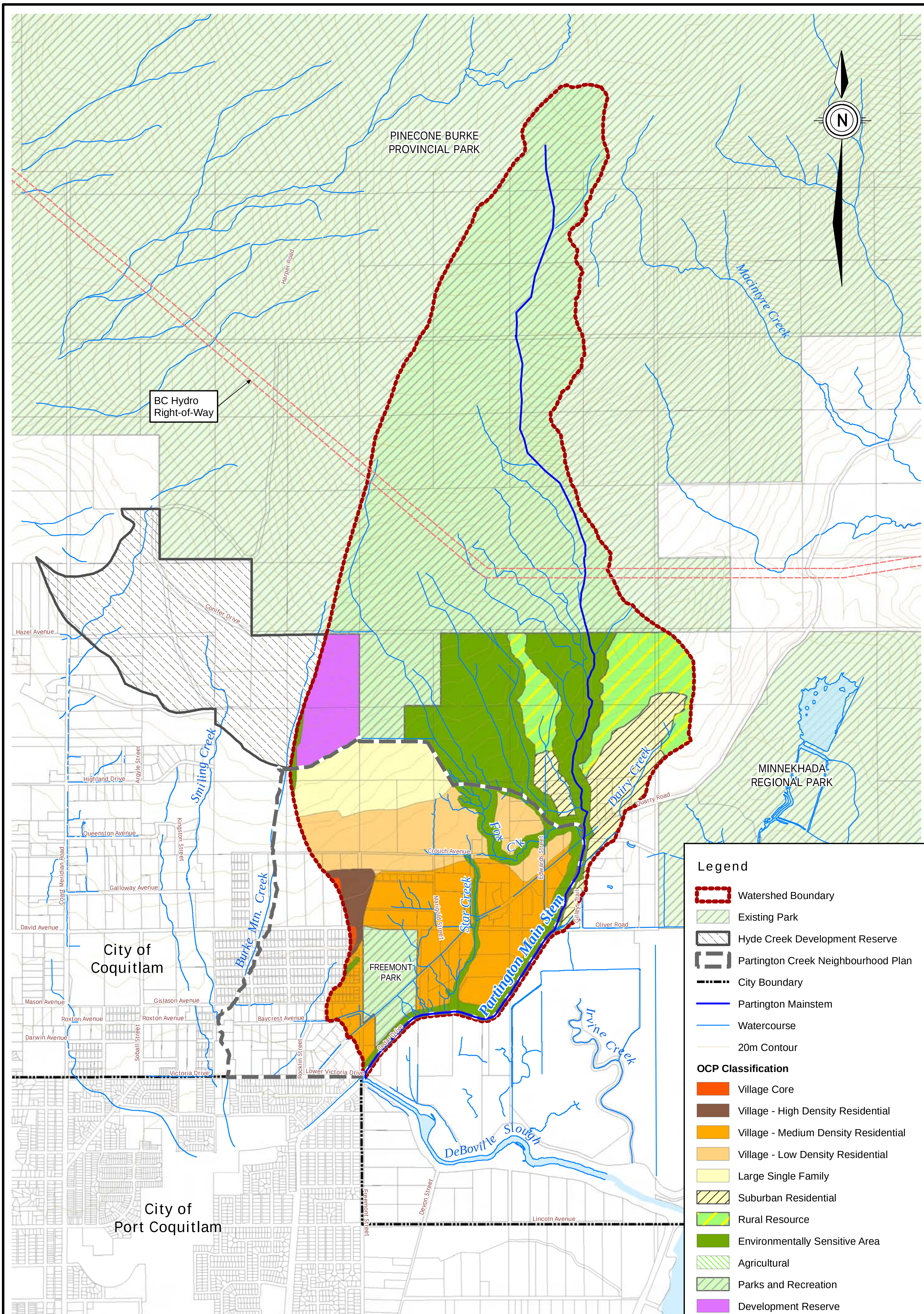
Author: JLau



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Partington Creek Integrated Watershed Management Plan

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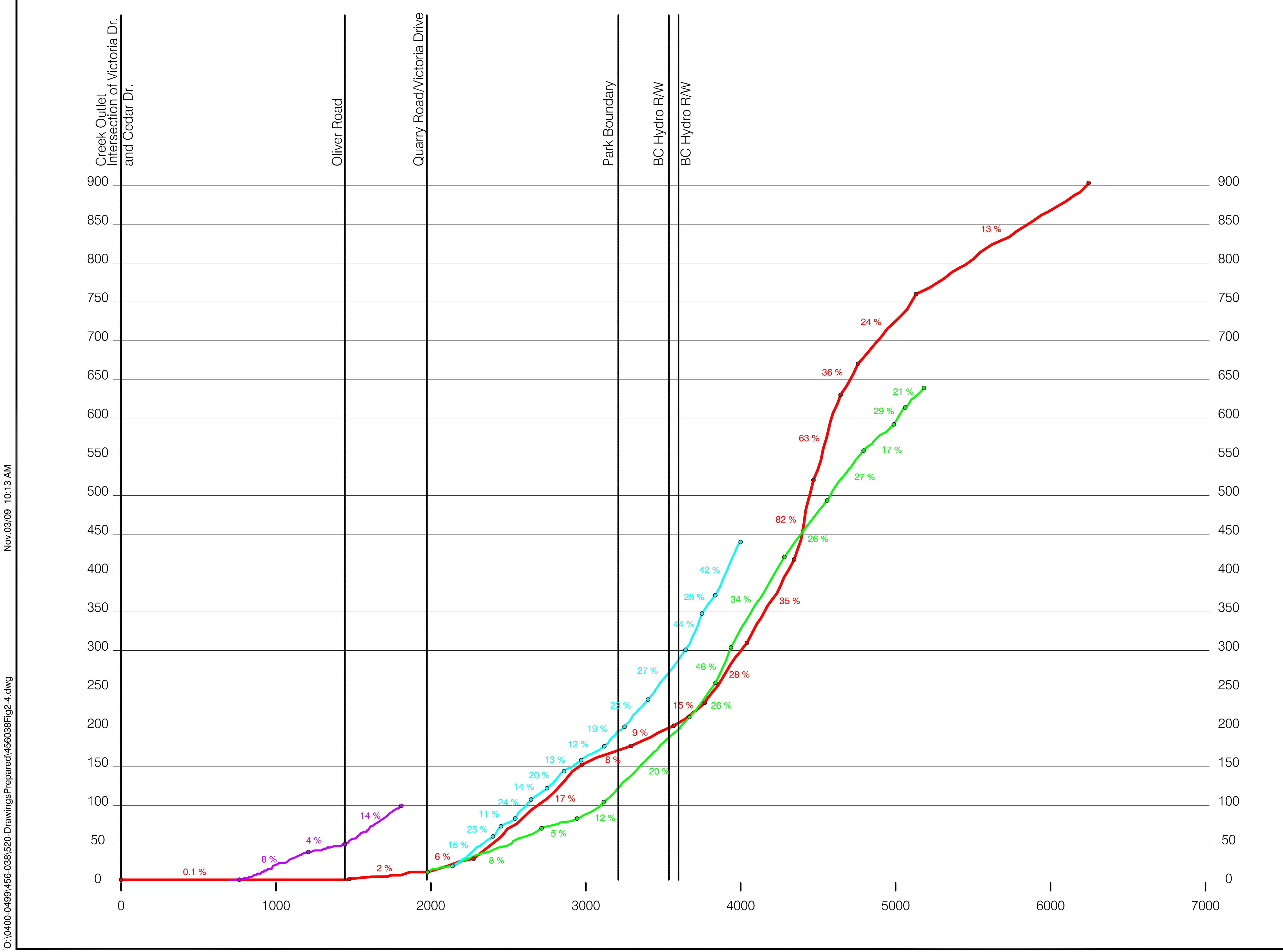
Proposed OCP Future Land Use and Hyde Creek Development Reserve

Figure 2-3



City of Coquitlam
Partington Creek
Integrated Watershed Management Plan

Legend

- Partington Creek Main Stem
- Fox Creek Tributary (T5C)
- Fox Creek
- Star Creek

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Scale: Horiz.1:25,000 : Vert. 1:5,000

Project No.	Date
456-038	November 2009

Creek and Tributaries Profiles

Figure 2-4

Section 3

Watershed Inventories

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3. WATERSHED INVENTORIES

3.1 DRAINAGE INVENTORY

Field visits were conducted in May to December 2005 to verify watershed and creek characteristics for a comprehensive inventory of the drainage system. The major drainage paths, mainly in the southern part of the watershed, were hiked with the following information noted:

- culvert sizes and bridge openings;
- typical channel cross sections, bank confinement/stability;
- erosion sites;
- detention facilities and any other hydraulic structures; and
- photographs of key watershed features.

Figure 3-1 depicts the drainage patterns, culverts and bridges.

Further field work was conducted by Raincoast Applied Ecology in January 2010 to verify all remnant watercourse locations in the Partington Creek Neighbourhood Plan area.

HYDRAULIC STRUCTURE INVENTORY

Hydraulic structures were investigated during the drainage inventory including culverts and bridges located on the main drainage paths. Most of the structures are found along Cedar Drive and Victoria Drive with a few on properties north of Victoria Drive and along trails in the northern part of the watershed. A large fish pond and diversion channel were found on the Edwards property that directs flow from Partington Main-stem along a series of ditches on Edwards Street. The information obtained including culvert and bridge size, type and condition is summarized in Tables A-1 and A-2 in Appendix A.

CHANNEL SECTIONS

Creek channel sections were estimated during the field visits. Typical channel cross section dimensions, approximate side slopes, and bank confinement were recorded as field notes at intervals coinciding with the GPS location measurements. Cross sections of lower Partington Creek along Cedar Drive were surveyed by the City.

EROSION SITES

Erosion sites noted in Partington Creek were minor in nature and none of the sites were near buildings or other structures of value. These are shown on Figure 3-1 and are listed in Table A-3 in Appendix A. Erosion is a natural process and can result from both frequently occurring events and extreme events. It is exacerbated by increased peak flows and frequency of flows from unmitigated development and channelization.

REMNANT WATERCOURSES

The portion of the watershed identified for development in the PCNP was inventoried in greater detail in January 2010 in order to locate all watercourses that would potentially be affected by the development. The locations and channel characteristics were recorded for all watercourses including ephemeral and remnant watercourses. Please note that only figures in Section 9 have been updated to include these extra watercourses.

3.2 ENVIRONMENTAL INVENTORY

INTRODUCTION

An overview environmental assessment of Partington Creek was undertaken to summarize information on fish populations, fish habitat, water quality, wildlife and wildlife habitat, and vegetation and land cover patterns. This information sets the context in which the IWMP is developed by establishing the current biological condition of the stream, identifying sensitive habitat areas or features, and describing critical environmental concerns that need to be addressed in IWMP activities. The environmental inventory details are found in Appendix B.

A separate objective of the fish and fish habitat assessment was to review, confirm, and update the City of Coquitlam's watercourse classification mapping for the Partington Creek watershed. GPS-based mapping, additional information on flow regime, and observations of fish populations provided new information with which to identify watercourse sensitivity based on their fish habitat value.

FISH POPULATIONS

Partington Creek supports a diverse fish community because of its low gradient lower reaches and connection to the Pitt River. Based on sampling records from fish salvages and other observations, at least 14 fish species occur in the Partington Creek or its tributaries.

Fish populations were primarily assessed using existing information on fish presence and no new sampling (e.g., electrofishing or minnow trapping) was undertaken except to review flow levels in seasonally flowing streams during the August–September 2005, and to make visual observations of fish presence during field surveys. In addition, a detailed survey of chum salmon spawning density was undertaken in the lower reaches of Partington, Star, and Fox creeks in November 2005.

Some watercourses in the southwest portion of the watershed (e.g., near David Avenue and Crouch Avenue) were previously unclassified because of insufficient information.

These sites were reviewed in September 2005 and most were found to lack surface flow. It is important to note that watercourse classification mapping should be considered preliminary as the upper extent of some resident fish populations need to be confirmed through additional sampling.

Partington Creek, as shown on Figure 3-2 can be divided into three units that reflect differences in the fish community:

1. **Floodplain Stream Channel** which is low gradient and supports a diverse fish community because of its connection to the Pitt River. Some floodplain fish use is seasonal as fish move in during periods of flooding or in relation to the tide;

2. **Anadromous Fish Use** which encompasses the lower reaches and reaches accessible to chum salmon, coho salmon, and resident sea-run coastal cutthroat trout. Anadromous fish are species that spend a portion of their lifecycle in the ocean and return to freshwater habitats to spawn; and

3. **Resident Fish Use** which encompasses headwater stream reaches with resident cutthroat trout. Resident fish spend their entire life in freshwater, often within a short section of stream or river.

Figure 3-3 shows the preliminary classification of watercourses based on existing information of fish distribution and flow regime in the watershed.

A total of 2,933 adult chum were counted in the lower reaches of Partington, Star, and Fox creeks; 98.1% were found on the main-stem. Chum Salmon spawning was distributed from DeBoville Slough at the mouth of Partington Creek to the gradient transition that occurs approximately 75 m upstream of Victoria Drive. The highest spawning density occurs in 600 m section of stream below the corner of Cedar Drive and Oliver Road. Refer to Figure 3-4.

Species at Risk

Three fish species that are considered species at risk occur, or may occur, in Partington Creek:

- white sturgeon (Lower Fraser River population) (S2, Endangered);
- Dolly Varden (S3S4, blue); and
- coastal cutthroat trout (S3S4, blue).

Protection of fish species at risk will be addressed through the management of aquatic ecosystems and fish habitat at a watershed-scale.

FISH HABITAT

The description of fish habitat in the Partington Creek watershed focused on physical characteristics, patterns, and processes that are directly affected by urban development. Partington Creek and its tributaries were divided into reaches based on broad differences in channel form, gradient, riparian conditions, or fish use. The field assessment focused on identifying and mapping stream channel location and describing physical habitat characteristics. Most sections of the Partington Creek Main-stem and tributary streams below the BC Hydro transmission corridor were walked and habitat characteristics were measured at intervals of between 100 and 200 m. Habitat characteristics were summarized by reach in Table 2 in Appendix B.

Fish Passage

A number of barriers to fish passage were identified during the field survey. Anadromous fish access on the Partington Creek Main-stem is limited by high channel gradient (small cascades, falls, plunge pools, etc. approximately 240 m upstream of Victoria Drive. Anadromous fish are not able to use much of Fox Creek because of an old concrete dam 60 m upstream from the confluence with Partington Creek, as well as culvert barriers on Edwards St and Crouch Ave. Other barriers, either natural or manmade, restrict fish movement in other tributaries but are generally outside the area proposed for development as part of the Partington Village.

WATER QUALITY

Comprehensive water quality measurements were not undertaken as part of the initial phase of the IWMP. Based on land cover and preliminary observations, the water quality characteristics of Partington Creek are similar to undeveloped watersheds in coastal BC.

Water quality changes predictably in response to urban development. Water quality sampling programs rarely identify specific contaminants of concern in urbanizing streams in the Metro Vancouver, particularly those with primarily residential development. For this reason, a comprehensive water quality monitoring program, including the use of continuous monitoring stations, has not been recommended as part of the Partington Creek IWMP.

A preliminary water quality sampling program is recommended to focus on baseflow sampling for metals, nutrients, fecal coliforms, and other parameters prior to the start of development. Other parameters or monitoring techniques may also be included after discussions with the IWMP Steering Committee.

BENTHIC INVERTEBRATE COMMUNITY

Benthic invertebrate sampling was used to assess the biological condition or health of Partington Creek using the benthic index of biotic integrity (B-IBI) protocol developed by the Metro Vancouver for urban streams. Benthic invertebrates are useful indicators of the biological condition of the stream or watershed and can be monitored over time to track changes in stream or watershed health. The objectives of the sampling were to: (1) assess the current biological condition of Partington Creek; and, (2) define a baseline condition that can be used to monitor the effectiveness of stormwater management in maintaining the biological condition of Partington Creek over time.

Benthic invertebrates were collected from four riffles in a 500 m long sampling reach which extended from the corner of Cedar Drive to the Victoria Avenue bridge. Sampling was completed on September 8, 2006 during low flow conditions.

Forty-four invertebrate taxa were identified in the four composite samples from Partington Creek. Mean taxa richness (per composite sample) was 28.5 (SD 2.2). This is third highest taxa richness value we have recorded in 34 streams in the Metro Vancouver in last five years. B-IBI values ranged from 28 to 32 with an overall mean of 30.5 (standard deviation 1.9. This is the fourth highest mean B-IBI value we have measured in 34 streams in the Metro Vancouver.

LAND COVER AND VEGETATION

Land cover sets the context for assessing a range of watershed-scale patterns including watershed health associated with imperviousness and riparian forest conditions, hydrologic changes from vegetation change, and wildlife habitat connectivity. It is also useful in assessing the effects of future development patterns. Second-growth forests are the dominant land cover type in the Partington Creek watershed and reflect the region's recent history of logging and rural development. Over 90% of the watershed is presently forested. Other prominent vegetation patterns are the large BC Hydro transmission corridor which bisects the watershed near its midpoint, and the assemblage of shrub patches, landscaped areas, roads, and buildings in the south and southeast portion of the watershed.

Land cover types in the Partington Creek watershed were mapped in Arcview 3.2 using 2005 orthophotos supplemented with limited field review. Not all polygons were visited in the field. Land cover polygons were delineated based on broad vegetation or urban development patterns (e.g., physiognomy or dominant plant species; buildings, roads, etc.) that could be assessed using orthophotos.

Eleven land cover types were identified in Partington Creek watershed ranging from buildings, roads, and landscaped areas, to three types of forest vegetation. Forests cover 91.1% of the watershed water, and impervious surfaces (roads and buildings) cover only 1.3% of the total areas. Developed areas (roads, buildings, grass, and landscaped areas) account for 5.8% of the watershed which is concentrated in the southeast. There are three dominant forest types in the Partington Creek watershed (in order of total area occupied):

1. deciduous forest dominated by red alder (32.2%);

2. mixed forest composed of red alder, big-leaf maple, Douglas-fir, western red cedar, and western hemlock (31.2%; and

3. coniferous forest with Douglas-fir, western red cedar, western hemlock or western hemlock and amabilis fir (26.2%).

Rock bluffs are considered a rare vegetation type in the Partington Creek watershed. They may require specific management activities to protect their sensitive plant communities, soils, and drainage patterns, however, most will not be affected by proposed development. The large bluff that overlooks the Pitt Lowlands (west of Edwards Ave) should be protected during development by preventing blasting and regrading during development, restricting recreational access, and removing invasive plants such as Scotch broom and non-native grasses.

No plant species at risk or ecological communities ranked by the BC Conservation Data Centre have been recorded within the Partington Creek watershed. This reflects both the lack of inventory and the low habitat diversity; wetlands and other nonforested plant communities are more likely to have rare plants than second-growth forest. The BC Conservation Data Centre (BCCDC) has several records of rare plants in the vicinity of the Partington Creek watershed: western mannagrass has been recorded in wetlands in the Minnekhada / Addington Point area; rice cutgrass in Pitt River marshes; water-pepper in the Coquitlam watershed; and streambank lupine along the Coquitlam River; and blue vervain, three-flowered waterwort, small spike-rush, Nuttall's waterweed, soft-leaved willow, and false-pimpernel on the Pitt River south of the study area. No ecological communities were identified during the preliminary survey that are currently ranked by the BC Conservation Data Centre as rare, threatened or endangered. Rock bluffs in the watershed have similarities to a rare ecological community (Douglas-fir - lodgepole pine / grey rock-moss; S2, red) but are often disturbed by invasive plants, recreation, or development. Most forest communities in the watershed are too young to support structural features (e.g., snags and downed logs) and plant community composition characteristic of regionally rare "old growth" ecological communities.

Invasive Plants

Invasive plants are often associated with disturbed plant communities and they were more common in the lower Partington Creek watershed. Nowhere were they prevalent. Commonly observed invasive plants included Japanese knotweed, reed canary grass, Himalayan blackberry, and policeman's helmet. Japanese knotweed, Himalayan blackberry, and policeman's helmet are scattered but often locally abundant in riparian areas along lower Partington Creek. Japanese knotweed was observed in riparian areas of the Edward's homestead and may have dispersed downstream.

WETLANDS AND ROCK BLUFFS

Wetlands are rare in the Partington Creek watershed because of the steeply sloped topography and historic stream channel relocation in the lower watershed. Wetland development typically requires impeded drainage which does not occur on steeply sloped hillsides. Three rock bluffs were identified in the study area. They are rare and account for <1% of the land cover in the watershed. All have similar plant communities dominated by bryophytes and grasses surrounded by Douglas-fir forest and occur on shallow (<10 cm) organic soils on sloping rock. Intense drought during the summer limits the development of trees and shrubs and maintains the open conditions.

WILDLIFE

A reconnaissance level wildlife inventory was undertaken as part of the neighbourhood planning process for the portion of the Partington Creek watershed (Summers, 2006). Wildlife surveys were conducted on seven days between April 17 and August 29, 2006 and focused on owls, amphibians, creek characteristics for Pacific water shrew, and general reconnaissance of the uplands.

Additional information includes:

1. recent Christmas Bird Count (CBC) data for the Cedar Drive–Victoria Drive area;
2. incidental sightings during stream and vegetation surveys;
3. anecdotal observations of wildlife from Elaine Golds and Niall Williams;
4. species at risk information from the BC Conservation Data Centre; and
5. ecological information on wildlife use in forested landscapes of the Lower Fraser Valley.

Wildlife use in the Partington Creek watershed reflects its location in the transition between the developed Pitt River lowlands and the lower slopes of the Coast Mountains, as well as its predominantly forested character. Wildlife use appears to be diverse but there are also few features such as large wetland complexes that make rare or other species of conservation significance common. The Partington Creek watershed, in this respect, is typical of a small forested watershed that was logged approximately 100 years ago.

Wildlife species of conservation significance in the Partington Creek watershed may include (with subnational (provincial) ranks[3], red and blue list designation, and COSEWIC status (if available)):

[3] Subnational (provincial) ranks are defined as:

S1 (Critically Imperiled) - Critically imperiled in the nation or state/province because of extreme rarity (often 5 or fewer occurrences) or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the state/province.

S2 (Imperiled) - Imperiled in the nation or state/province because of rarity due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation from the nation or state/province.

S3 (Vulnerable) - Vulnerable in the nation or state/province due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation.

S4 (Apparently Secure) - Uncommon but not rare; some cause for long-term concern due to declines or other factors.

- Pacific water shrew (S1S2; red, Endangered);
- Trowbridge's shrew (S3S4: blue list);
- snowshoe hare, *washingtonii* subspecies (S1; red);
- coastal tailed frog (S3S4: blue, Special Concern);
- rubber boa (S4, Special Concern);
- western toad (S4, Special Concern);
- band-tailed pigeon (S3S4B: blue, Special Concern);
- great blue heron *(*S2S3B; S4N, Special Concern);
- green heron (S3S4B);
- barn swallow (S3S4B);
- western screech-Owl, *kennicottii* subspecies (S3, blue, Special Concern);
- red-legged Frog (S3S4: blue, Special Concern); and
- Townsend's Big-eared Bat (S3; blue).

PACIFIC WATER SHREW

Pacific Water Shrew is likely the only species at risk that could have implications for development planning in the Partington watershed. It is currently designated as Endangered in Canada (COSEWIC, 2006); the status report summarized that: "the habitat of this rare species, confined to the lower Fraser valley region of British Columbia, continues to decline and fragment as a result of development. There is little chance of rescue. It is extremely rare throughout its range". The best quality habitat for Pacific water shrew is described as: "a riparian area around and including a permanent stream or creek (<10 m wide [channel]) or any size wetland (including swamps, marshes, lakes, ocean beaches, etc.) with a mature coniferous forest of western red cedar and/or western hemlock or a mature deciduous or mixed forest". Summers (2006) identified most of the lower reaches of Star Creek (downstream Victoria Drive) and Fox Creek (downstream of confluence of Tributary T5) as being high suitability for Pacific water shrew.

One Pacific water shrew was recently captured (March 2009) in MacIntyre Creek in Coquitlam approximately 5 km northeast of lower Partington Creek. Habitat at the capture site is similar to Partington Creek and indicates that Pacific water shrew likely occurs in the Partington study area. Riparian setbacks to protect Pacific water shrew populations are generally much wider than current RAR standard. For example, recent critical habitat mapping by the Pacific Water Shrew Recovery Team (2009) used a buffer 100 m wide on each side of small streams to protect known occurrences of Pacific water shrew. They noted: "The 100 m area of critical habitat on each side of the watercourse is likely sufficient to buffer the riparian microclimate from edge effects in the long term, as well as from potential damage from run-off from adjacent developments, roads or agricultural fields."

Based on existing land cover patterns, connectivity between different areas of the watershed and between the watershed and adjacent habitat is generally unimpeded. Planning for wildlife habitat and connectivity, including Pacific water shrew protection, acknowledged and considered in the IWMP, but is specifically addressed in the PCNP where land use decisions are investigated.

3.3 HYDROGEOLOGY INVENTORY

The main findings of the hydrogeology inventory are summarized in this subsection. The full report and details are found in Appendix C. Figures 3-5 and 3-6 show the surficial geology plan view and cross-section through the watershed.

- Ground surface within the Partington Creek watershed is steeply sloping and soil cover is generally shallow. The underlying silt, glacial till and bedrock units have a low permeability (hydraulic conductivity) and severely limit groundwater infiltration. Groundwater flow is a relatively small component of the hydrologic cycle within the Partington Creek watershed under natural conditions.

- Surficial weathered soils and channel fill deposits will provide some short-term, temporary storage of water during precipitation events. This storage mechanism will quickly be exhausted during periods of intense or prolonged rainfall and surface runoff will increase rapidly.

- Most of the Partington Creek watershed functions as a recharge area. Groundwater will flow within both a shallow perched aquifer (within the weathered surficial soils) as well as a deeper groundwater flow system that includes the confined sand and gravel sediments and upper region of bedrock.

- Development within the watershed should be conducted so that the native soils are disturbed as little as possible and creeks are not further channelized. This will retain the limited natural capacity to store precipitation and provide recharge into the deep aquifer system.

- Native vegetation should be left intact where possible, or restored to preserve and enhance evapotranspiration.

The following are suggested principles and measures that could be implemented during the future development of the Partington Creek watershed:

- Minimize the removal of vegetation and/or disturbance of native soils. Avoid stripping native soils from the land prior to development where possible.

- Natural creek ravines and areas overlain by coarse textured materials should be conserved to maintain infiltration potential.

- Further channelizing streams within the watershed should be avoided and the channel fill deposits should be left intact to assist in reducing the magnitude of peak flow events.

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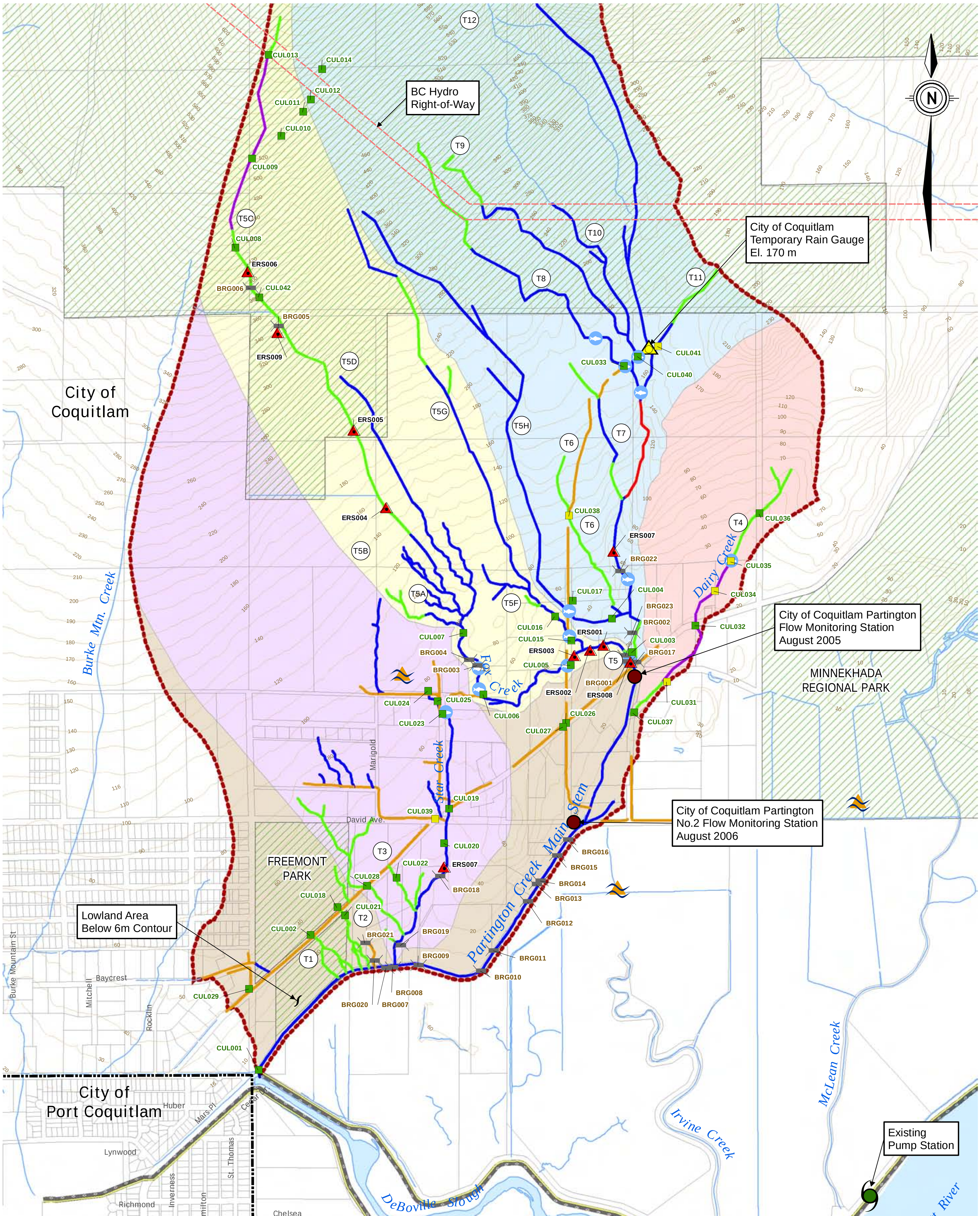

Legend

- Watershed Boundary
- Park
- City Boundary
- Watercourse
- Dyke
- Existing Flood
- Bridge (Bridge ID)
- Erosion (Erosion ID)
- Culvert (Cuvlert ID)
- Culvert (Unknown Size)
- Fish Passage/Barrier
- Tributary ID (T3)

Study Team Creek Reconnaisance

- Existing Channel
- New Channel Found
- New Channel Outside Original Watershed Boundary
- Poor GPS Coverage
- Ditch

Subwatershed

- Partington Main Stem
- Partington Upstream of Victoria Drive
- Dairy Creek
- Fox Creek
- Star Creek

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Partington Creek Integrated Watershed Management Plan

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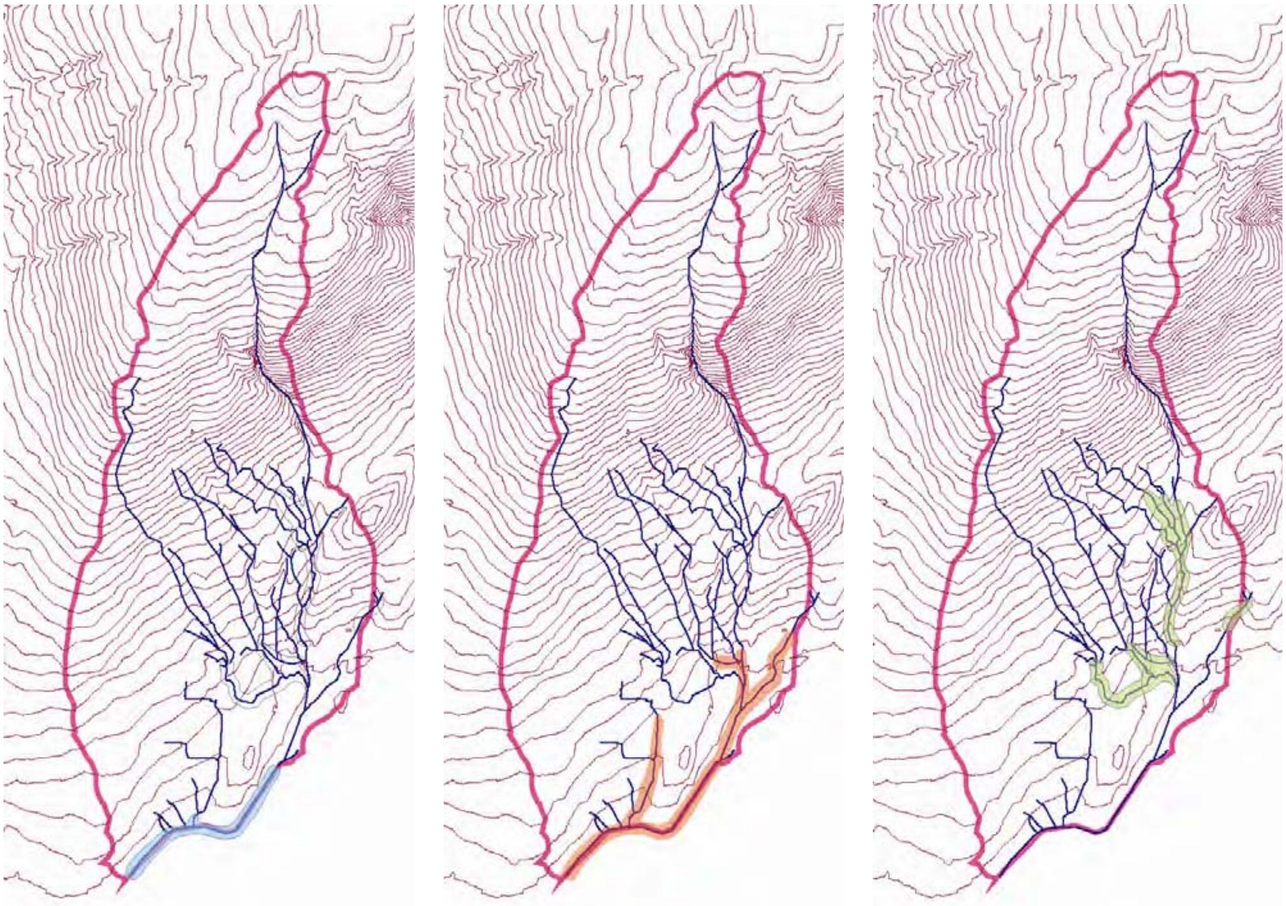
250 125 0 250
Scale in Metres

Drainage Inventory

Figure 3-1



Unit 1: Floodplain Fish Community

Unit 2: Anadromous Fish Community

Unit 3: Resident Fish Community

Figure 3-2: Fish Community Characteristics of Partington Creek.

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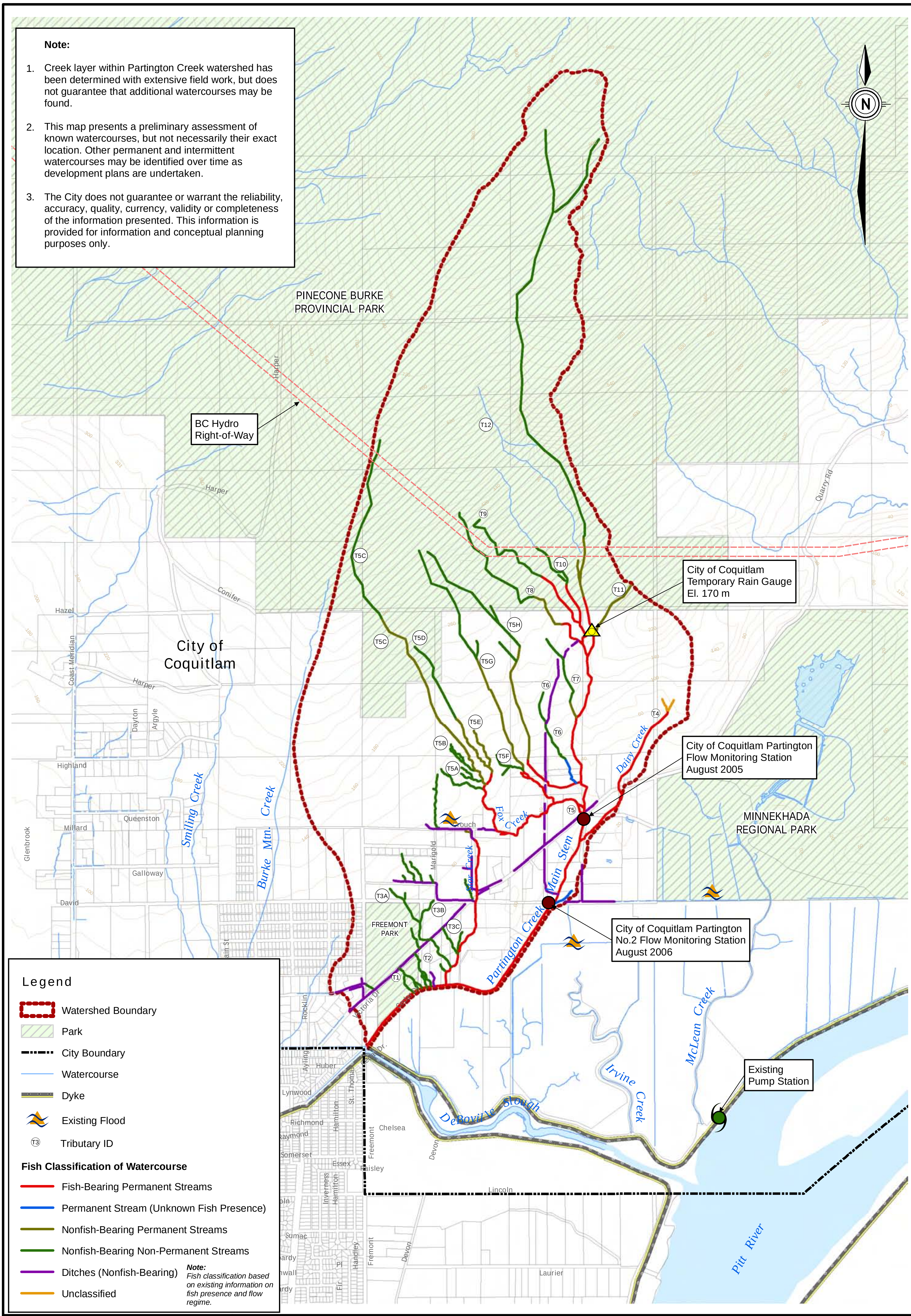
Author: JLau



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Partington Creek Integrated Watershed Management Plan

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500 250 0 500
Scale in Metres

Watercourse Classification

Figure 3-3

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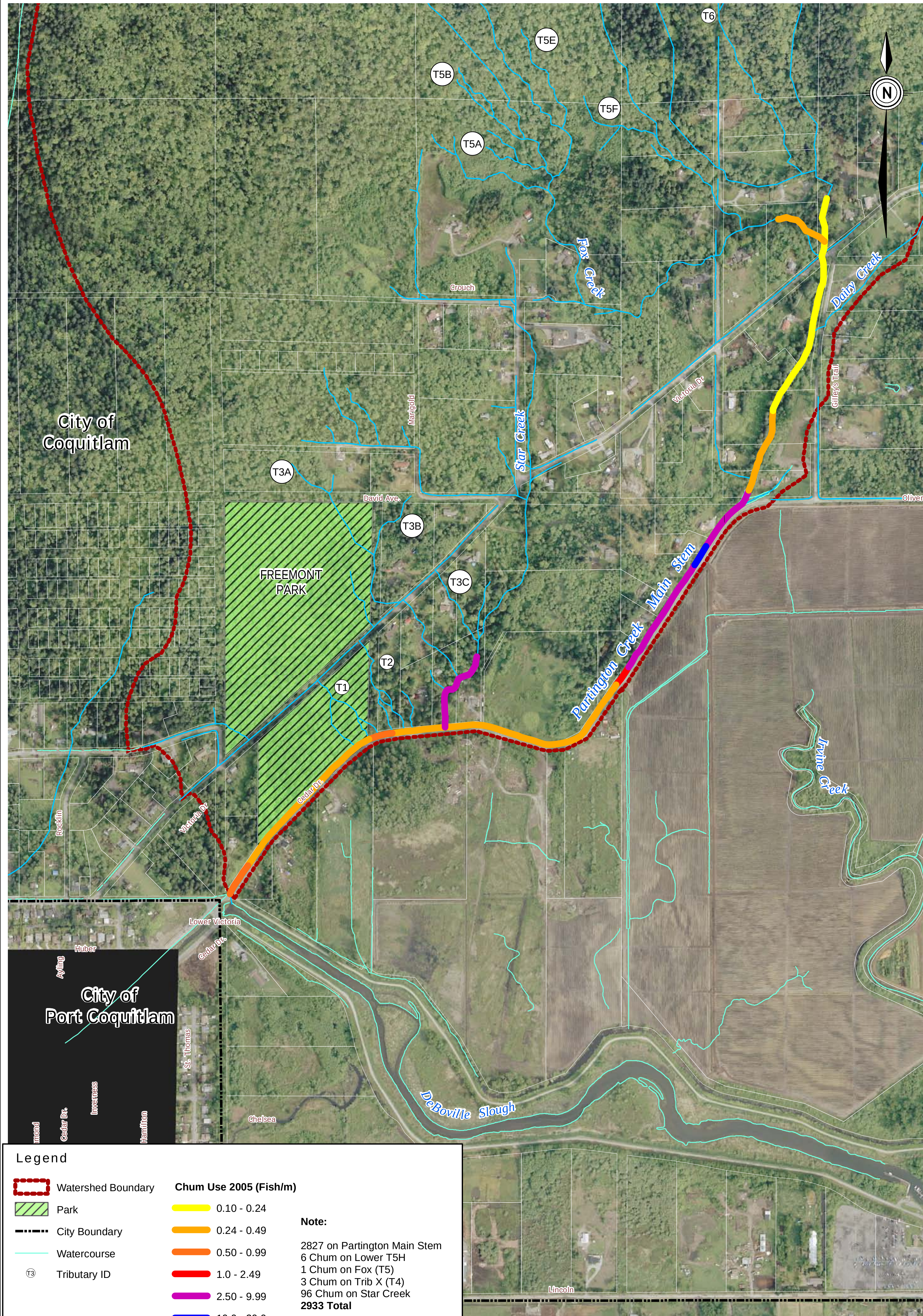

Legend

Watershed Boundary	
Park	
City Boundary	
Watercourse	
Tributary ID	

Chum Use 2005 (Fish/m)

- 0.10 - 0.24
- 0.24 - 0.49
- 0.50 - 0.99
- 1.0 - 2.49
- 2.50 - 9.99
- 10.0 - 20.0

Note:

2827 on Partington Main Stem
6 Chum on Lower T5H
1 Chum on Fox (T5)
3 Chum on Trib X (T4)
96 Chum on Star Creek
2933 Total

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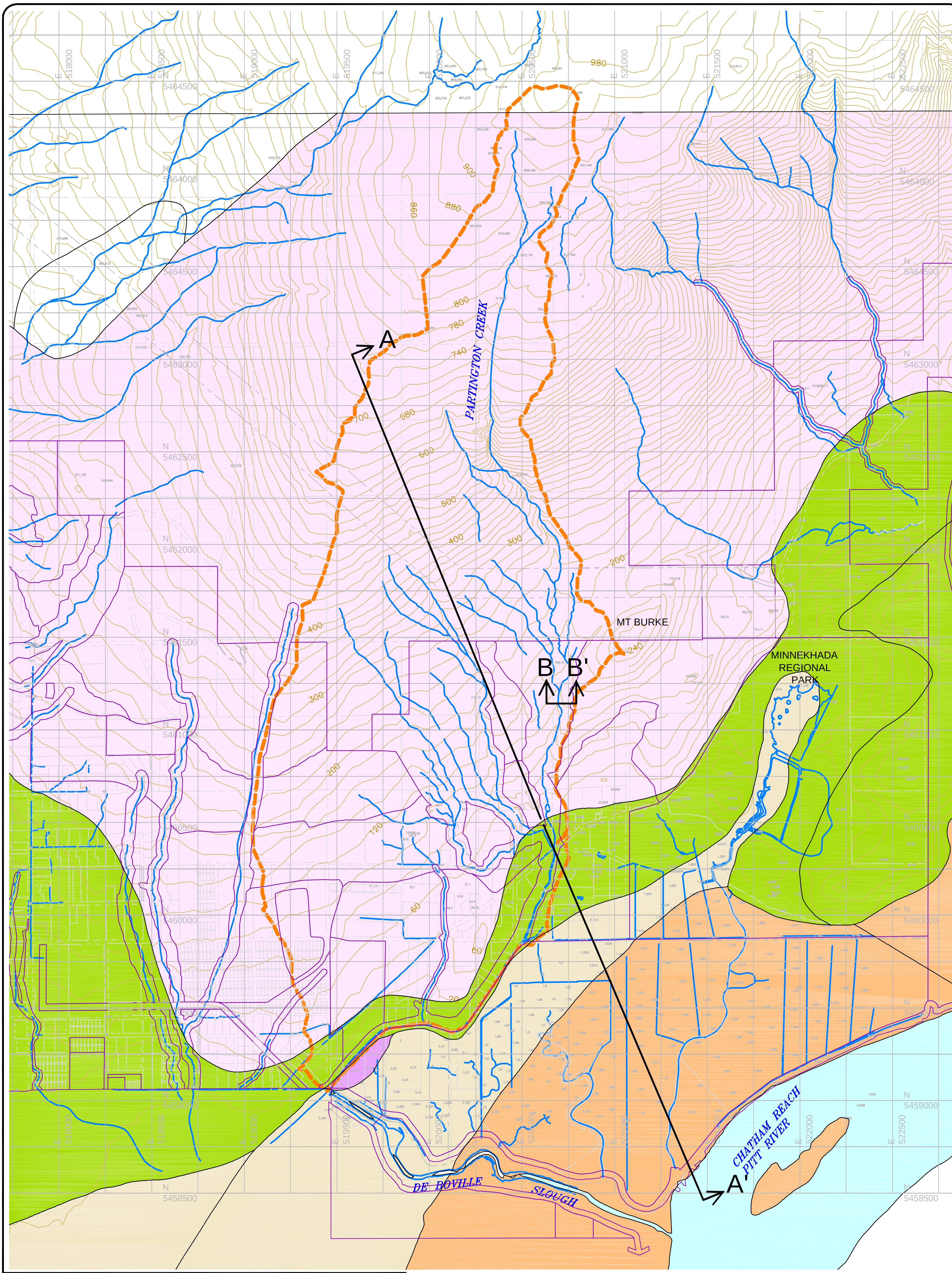
City of Coquitlam
Partington Creek Integrated Watershed Management Plan

Project No.	Date
456-038	July 2011

150 75 0 150
Scale in Metres

Chum Salmon Spawning Density: 2005

Figure 3-4



LEGEND:

- SURFACE DRAINAGE
- GROUND CONTOUR (20m)
- RIGHT OF WAY
- LAND USE BOUNDARY
- PARCELS
- PARTINGTON CREEK WATERSHED
- GRANITIC/ METAMORPHIC ROCK
- VASHON TILL
- CAPILANO SEDIMENTS (SAND AND GRAVEL)
- FRASER RIVER SEDIMENTS (SILT AND CLAY)
- SURFACE WATER BODY
- ORGANIC (PEAT)

0 100 200 400 600 800 1000 Metres

SCALE 1:20,000

N

DATA SOURCES:

WATER WELL LOCATIONS OBTAINED FROM MINISTRY OF SUSTAINABLE RESOURCES WEBSITE – WATER WELL DATABASE

BASE MAP DATA SUPPLIED BY KERR WOOD LEIDAL

SURFICIAL GEOLOGY FROM MAP 1484A: SURFICIAL GEOLOGY NEW WESTMINSTER (1:50,000)

PROJECTION: NAD 27 ZONE 10
CONTOUR INTERVAL: 20 m (ASL)

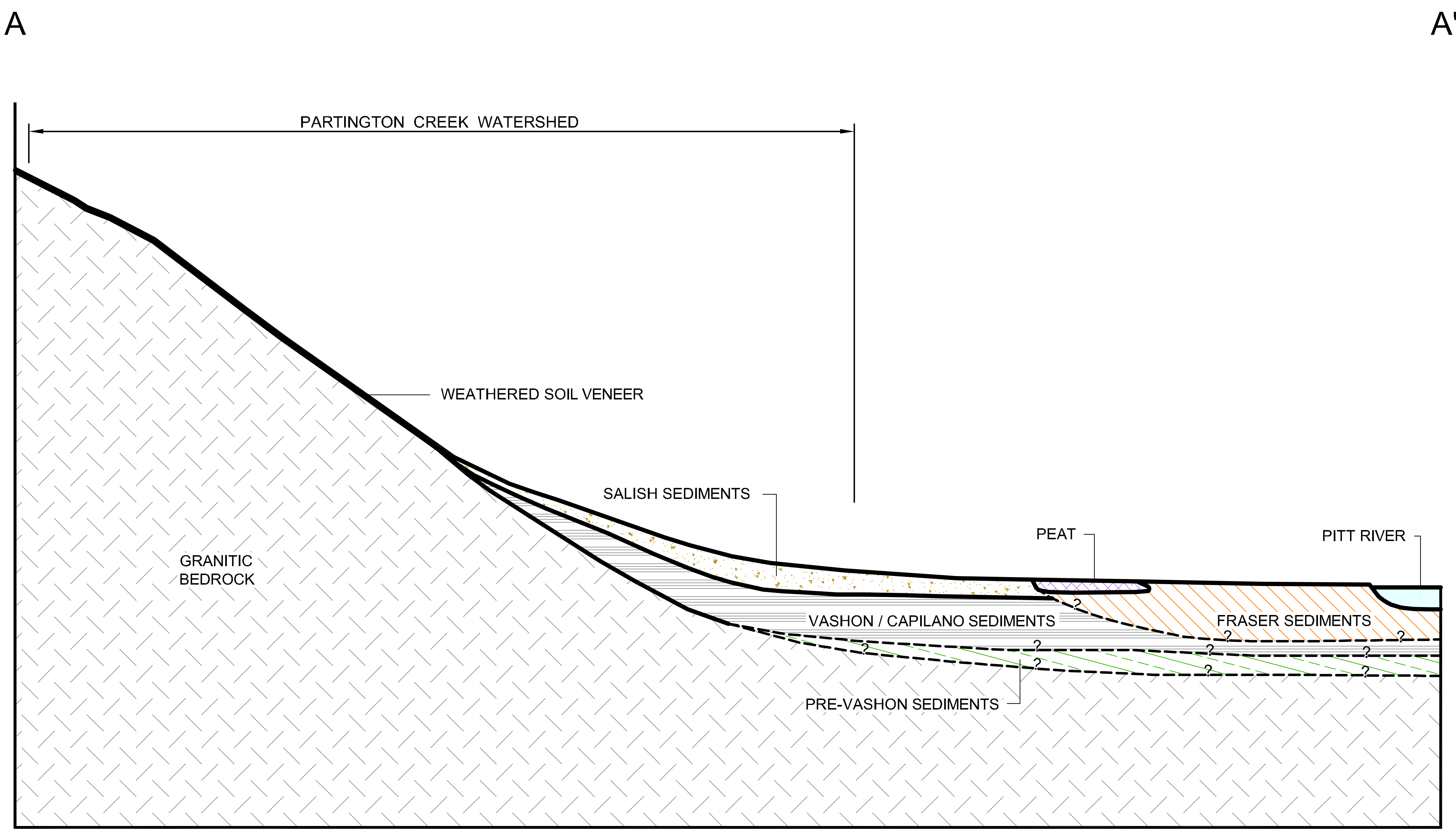
REVIEWED BY: RM
PREPARED BY: PW
DATE ISSUED: SEPTEMBER, 2005
PROJECT NUMBER: 50-547
FILE NAME: 50547-1D-02.dwg
REVISION: 0

Project: Partington Creek ISWMP
Location: Coquitlam, BC
Client: Kerr Wood Leidal

SITE PLAN AND SURFICIAL GEOLOGY

Gartner Lee

Figure 3-5



Legend

Legend		
Granitic/Metamorphic Bedrock	Fraser Sediments	Weathered Soil veneer
Pre-Vashon Sediments	Salish Sediments	Organic (Peat)
Vashon/Capilano Sediments	Surface Water	

SCALE: NTS

File Name: 50547-1D-03R1-Section.dwg
Reviewed by: RD Prepared by: PW/GB/NT
Date Issued: January, 2007 Project Number: 50-547

Kerr Wood Leidal

Project: Partington Creek ISWMP
Location: Coquitlam, BC

CONCEPTUAL CROSS-SECTION A-A'

Gartner Lee

Figure 03
Revision 1

Date Plotted: January 12, 2007 File Location: S:\AutoCad\acad-Prj\2005\50-547 Partington Ck - No Image\1D-draft-June05\50547-1D-03R1-Section.dwg

Section 4

Hydrologic and Hydraulic Modelling

KERR WOOD LEIDAL
associates limited
CONSULTING ENGINEERS

4. HYDROLOGIC AND HYDRAULIC MODELLING

4.1 INTRODUCTION

This section outlines the hydrologic and hydraulic modelling analysis. The purpose of the analysis was to:

- calibrate and verify the hydrologic model to ensure accurate predictions of watershed rainfall-runoff response;
- determine effective impervious area of the watershed; and
- determine peak design flows at strategic locations under existing and future conditions.

Calibration of the hydrologic model is particularly important for Partington Creek for two reasons. First, the tributary area can be difficult to accurately determine from contour drawings in undeveloped areas. Second, the large elevation range of the watershed (El. 4 m to El. 960 m) makes it possible for snow to accumulate in the higher elevations during precipitation events and also the quantity of precipitation can increase with elevation.

4.2 FLOW MONITORING DATA COLLECTED BY CITY

The City installed a flow monitoring station on Partington Creek at the Victoria Drive bridge (see Figures 2-1 and 3-1 for the gauge location). Data collection commenced on August 25, 2005. At the time of model calibration/validation the City had supplied data up to January 25, 2006. There are several gaps in the data namely from November 26 to December 20, 2005, December 20 to December 29, 2005, and January 3 to January 6, 2005. On December 20, 2005 there are approximately 8 hours of data.

Water level data was collected, adjusted, and quality controlled by the City. The rating curve to convert water levels to flows was also developed by the City. The rating curve could be improved with more intermediate and high flow points. With project time constraints, the current flow data was used for calibration and validation.

The City also installed a rain gauge in the Partington Creek watershed near the Edwards' property which operated from November 2006 to March 2007. Rainfall at this location was compared to the GVRD Burke Mountain Firehall (QT39) gauge rainfall. It was found that on average, there was approximately 5% more rainfall at the Edwards' gauge than at QT39. Given such little difference in rainfall, the QT39 rainfall was accepted as representative for the similar elevation band (160m Geodetic) in the Partington watershed.

HISTORICAL RAINFALL DATA

Rainfall data spanning the period of record of the flow data was obtained from Metro Vancouver for the period of August 2005 to March 2006. Two gauges of different elevation were utilized in the model, Burke Mountain Firehall (QT39) at elevation 177 m and Douglas College (QT77) at approximately El. 40 m. Refer to Figure 2-1. The 5-minute data sets for both stations were complete during this period.

4.3 XP-STORM MODELLING

The STORM model (RUNOFF and HYDRAULICS blocks) was selected for hydrologic and hydraulic analysis. The details of the model development, assumptions and details are provided in Appendix D.

MODEL CALIBRATION AND VALIDATION

The model was developed for existing conditions, and calibrated and validated with the following events.

Table 4-1: Calibration Storm Events

Application	Date	Rainfall Depth[1]	Duration of Rainfall
Calibration Events	October 30-31, 2005	51 mm	17 hours
	October 16-17, 2005	72 mm	34 hours
Validation Events	January 8-9, 2006	62 mm	45 hours
	January 12-13, 2006	59 mm	28 hours

1. QT39 – Burke Mountain Firehall.
All events were proceeded by wet saturated conditions.

The calibrated model results matched the recorded peak flows and the recession limb well, but slightly underestimated the hydrograph volumes in large events, and slightly overestimated the volume for small events.

4.4 BURKE MOUNTAIN FIREHALL AND PORT COQUITLAM CITY YARD DESIGN STORMS

The design storms were developed using the IDF curves and rainfall distributions found in the City's *Stormwater Management Policy and Design Manual, July 2003*. Design storms were created for the two stations (that had IDF curves) closest in proximity to Partington Creek.

Design storms for the *Port Coquitlam City Yard* station were used for the lower subcatchments ranging from El. 0 m to El. 50 m Geodetic. Design storms for *Burke Mountain Firehall* (Metro Vancouver Station QT39) were used for the midrange subcatchments ranging from approximately El. 50 m to El. 200 m Geodetic. The *Burke Mountain Firehall* design storms were factored up 125% and 160% for subcatchments ranging in elevation from approximately El. 200 m to El. 600 m and El. 600 m to El. 1,000 m, respectively to account for orographic effects. Refer to Figure 2-1.

Table 4-2 shows precipitation totals for all events for the two stations.

Table 4-2: Total Precipitation Amounts for Climate Stations

Duration	Total Rainfall (mm)				
	2-year	5-year	10-year	25-year	100-year
QT39 Burke Mountain Firehall					
1-hour	13.7	16.5	17.7	20.4	22.1
2-hour	21.2	25.0	27.2	30.5	34.6
4-hour	36.3	40.9	45.9	52.4	59.9
6-hour	45.2	51.5	56.1	65.7	75.6
12-hour	66.1	77.9	85.5	96.1	110.6
24-hour	86.8	106.6	117.6	135.4	159.4
Port Coquitlam City Yard					
1-hour	12.0	17.2	20.5	24.5	30.9
2-hour	16.85	21.4	24.1	27.9	33.7
4-hour	28.6	34.3	39.0	44.8	53.0
6-hour	35.2	41.0	44.9	50.9	58.1
12-hour	54.3	64.2	70.8	79.2	91.7
24-hour	77.1	91.8	103.4	115.6	134.8
Design storms were developed for the 2-year, 5-year, 10-year, 25-year, and 100-year return periods. The City's short rainfall distribution was used for the 1, 2, and 4-hour storms and the long rainfall distribution was used for the 6, 12, and 24-hour storms.					

4.5 SNOWMELT AND BASEFLOW ASSUMPTIONS

SNOWMELT ASSUMPTIONS

Existing and future models were also created to examine the worst-case rain-on-snow conditions. A snowmelt assumption of 300 mm snowpack (30 mm water equivalent) in areas above El. 400 m, melting over 24 hours on the day of the 100-year rain storm.

The 100-year rain-on-snow event peak flows are approximately 3-5% higher than those without snowmelt. The rain-on-snow peak flows were used in the culvert and bridge assessment.

BASEFLOW ESTIMATES

A unit baseflow of 0.2 L/s/ha was also added to the Partington models. This resulted in an additional 0.13 m^3/s of flow from the entire 625 ha catchment. This flow was added to the model at the upstream end of the flat lower Partington Main-stem (at Oliver Drive) as it is believed that in the steeper portions of the catchment, baseflows largely remain subsurface or move through the cobble creek bed. At Oliver Drive the Main-stem gradient flattens forcing the baseflows to surface.

The 0.2 L/s/ha unit baseflow was also used in the Hyde Creek IWMP model and compares well with the initial flow monitoring data on Partington Creek. In the summer, the flow monitoring data at Victoria Drive showed baseflow smaller than 0.2 L/s/ha. This is likely due to flow through the cobbles in the creek bed that do not appear in the measured flows.

4.6 PEAK FLOW ESTIMATES

To estimate the existing and future peak flows, the calibrated model was run using saturated soil conditions typical of winter conditions. The peak flow estimates at strategic locations are summarized in the following table for existing land use conditions.

Table 4-3: Peak Flow Estimates for Existing Land Use

Location	Area (ha)	Peak Flow Estimate (m^3/s)						
		2-year	5-year	10-year	25-year	100-year	100-year with snowmelt	200-year[1]
Main-stem at Park Boundary	143	4.04	5.11	6.20	7.58	9.08	9.56	10.44
Fox Creek at Outlet	170	2.17	2.97	3.46	4.35	5.50	5.66	6.33
Main-stem at Victoria Drive	430	7.30	9.44	10.73	14.48	18.25	18.96	20.99
Main-stem at Outlet to DeBoville Slough[2]	636	9.13	11.88	13.52	15.93	19.99	20.83	22.99
Hyde Creek Development Reserve	100	1.76	2.26	2.67	3.46	4.37	N/A	5.03

[1] 200-year estimate calculated by factoring up the 100-year peak flow by 1.15 - North Shore Hydrology Report, 1992.
[2] Peak flows are attenuated in the large, flat channel in lower Partington Creek.

Table 4-4: Peak Flow Estimates for Unmitigated Future Development

Location	Area (ha)	Peak Flow Estimate (m^3/s)						
		2-year	5-year	10-year	25-year	100-year	100-year with snowmelt	200-year[1]
Main-stem at Park Boundary	143	4.04	5.11	6.20	7.58	9.08	9.57	10.44
Fox Creek at Outlet	170	2.41	3.18	3.63	4.92	6.28	6.36	7.22
Main-stem at Victoria Drive	430	7.74	9.82	12.11	15.82	19.56	20.27	22.49
Main-stem at Outlet to DeBoville Slough[2]	636	10.38	13.70	16.10	19.34	22.76	23.55	26.17
Hyde Creek Development Reserve	100	5.94	7.30	8.10	9.66	10.56	N/A	12.14

[1] 200-year estimate calculated by factoring up the 100-year peak flow by 1.15 - North Shore Hydrology Report, 1992.
[2] Peak flows are attenuated in the large, flat channel in lower Partington Creek.

COMPARISON OF ESTIMATED 100-YEAR PEAK FLOWS

Although the model is calibrated, the predicted design peak flows were also verified and confirmed to ensure full confidence in the modelling results. Table 4-5 shows a comparison of other 100-year peak flow estimates in the region. *MacKay Creek at Montroyal* in North Vancouver has a lengthy flow monitoring record from 1971 to present. For comparison purposes, more confidence is placed on the recorded, rather than modelled, flows. MacKay Creek is similar to Partington Creek in that it is a steep mountain creek with a southern aspect at similar elevations (up to as high as El. 1,100 m compared with Partington's El. 960 m). A statistical analysis of the MacKay Creek flow shows a 100-year peak instantaneous flow of 51 L/s/ha. This watershed is partially developed and compares very well with Partington's predicted future flows at Victoria Drive of 45 L/s/ha.

The unit flows at Victoria Drive (43 – 45 L/s/ha) are higher than at the outlet for Partington Creek (31 – 36 L/s/ha) because as the flows are routed through the large, flat channel in lower Partington Main-stem significant flow attenuation occurs. The unit flows for the Hyde Development Reserve at significantly higher, 44 – 106 L/s/ha, because it is located in the mid watershed at a higher elevation and the flows reported at not routed through creek channel sections.

The *DeBoville Slough Assessment* study reported Partington Creek flows as high as 47 and 61 m^3/s (73 – 95 L/s/ha) for existing and future conditions, but the Associated model showed 29 m^3/s (45 L/s/ha) for existing conditions. This is more inline with the results of this study. Differences in modelling results between the two studies can be attributed to the DeBoville Slough Partington model was a preliminary uncalibrated lumped catchment model without routing; as can be seen in the IWMP results flow routing through the channel sections, especially the large, flat lower section, can reduce the peak flows. As the DeBoville Slough Partington model used a 'Chicago' style rainfall distribution, where more intense, shorter duration rainfall events are embedded within the less intense, longer duration events. The IWMP used the Atmospheric Environmental Services 'AES' style storms recommended in the City of Coquitlam's *Stormwater Management Policy and Design Manual, 2003*. The AES storms are separate events ranging from intense, short duration events to less intense, long duration events. The manual was not released at the time of the *DeBoville Slough Assessment* modelling.

IMPACTS OF DEVELOPMENT

The future land use condition yields increases in flows at all locations except in the Partington Creek Main-stem at the Pinecone Burke Provincial Park boundary where there were no predicted changes to land use.

The increase in peak flows is most evident in the Hyde Creek Development Reserve catchment that is assumed to change from forested to 50% impervious residential development. As a result, the future flows are two to three times higher than existing. Increases in peak flows due to development are less pronounced in Partington Creek and Fox Creek. This is because the peak flows from the developed portion of the watershed do not occur with the same timing as the peak flows from the undeveloped portion of the watershed. The developed catchments produce their highest flows during the short duration events (1 hour) while the forested catchments peak during slightly longer events (4 to 12 hour). Therefore, the overall increase in the combined peak flow is not as prominent as expected for developing land.

Based on this analysis and comparison, we have confidence in the predicted IWMP design peak flows. As a result of the predicted development, the 100-year unmitigated flows at the mouth of Partington Creek increase by 2.8 m^3/s or 14%. The peak flows in Tables 4-3 and 4-4 represent a worst-case condition that does not include any detention. The IWMP will investigate mitigative measures to address the impacts of development.

Table 4-5: Regional Comparison of 100-Year Peak Flows

Watershed	Catchment Properties			100-Year Pre-Development			100-Year Post-Development		
	Area (ha)	Slope	Elev.	% Imp	Flow (m^3/s)	Unit Flow (L/s/ha)	% Imp	Flow (m^3/s)	Unit Flow (L/s/ha)
MacKay Cr. @ Montroyal Statistical Analysis of Flow Monitoring Data 1971 - 2005 (KWL)	301	Steep	180 m to 1,100 m	-	-	-	17%	18.5	51
Hyde Cr. @ Mouth (Associated)	1,157	Half steep, half flat	0 m to 750 m	20%	44.0	38	40%	60.0	52
McDonald Cr. @ 1,200' - Calibrated (KWL)	153	Steep	360 m to 960 m	5%	10.6	69	-	-	-
McDonald Cr. @ Burrard - Calibrated (KWL)	374	Steep	0 m to 960 m	-	-	-	17%	23.6	63
Hyde Development Reserve (IWMP)	100	Steep	240 m to 380 m	0%	4.4	44	50%	10.6	106
Partington Cr. @ Victoria Drive - Calibrated (IWMP)	430	Steep	20 m to 960 m	2%	18.3	43	8%	19.6	45
Partington Cr. @ Mouth (IWMP)	636	Steep	0 m to 960 m	3%	20.0	31	21%	22.8	36

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Section 5

Drainage System Assessment

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5. DRAINAGE SYSTEM ASSESSMENT

5.1 INTRODUCTION

The drainage system assessment includes:

- an overview of mountain creek hazards;
- identification of conveyance system deficiencies;
- identification of the impacts of future development increased flows and velocities to the DeBoville Slough;
- assessment of backwater effects in the lower Partington Creek Main Stem due to high Pitt River/Fraser River freshet; and
- the need for an emergency response plan.

5.2 CREEK HAZARD OVERVIEW

An overview assessment of the watershed was conducted as part of the IWMP and a number of observations were made:

- upper reaches (tributary channels) of Partington Creek may be subject to debris flow activity; however, debris flows deposition would likely occur in the upper watershed (upstream or at the margin of present development);

- existing dam and pond structures were encountered and may worsen flood events in the event of failure;

- a creek fan (depositional) feature was identified upstream and downstream of Quarry Road, and is an intrinsically hazardous landform; and

- lower Partington Creek (downstream of Oliver Road) has been relocated to the present alignment, and natural processes (floods and sedimentation) will continually act to re-establish former creek planform.

A detailed discussion is presented in Appendix F and a summary below.

Partington Creek is a steep mountain creek with creek gradients of over 80% in places and, as such, may be subject to various hazardous geomorphic processes. It flows from about 900 m elevation down to the floodplain of the Pitt River, and drains predominantly south-facing slopes. The watershed area is approximately 6.4 km^2 and the main channel length is about 6.2 km. Historical air photographs suggest that the Partington Creek main channel may have been active in the past, although signs of slope disturbances are limited.

Observations from a site visit document evidence of active sediment transport such as the development of sediment berms (see Figure 5-1) through much of the upper channel above and immediately below the BC Hydro ROW, as well as fresh gravel deposits in the channel in the lower reaches near Cedar Drive. Overbank pure water flooding is a documented hazard on the creek and has occurred repeatedly in the past in the lower reaches of the creek. Given the availability of in-channel sediment and debris as well as the possibility of extreme precipitation events, there is a moderate risk posed by debris floods. Debris floods may pose a hazard to development in the lower reaches of the creek where the channel is not well confined. The risk of debris flows is low. It is recommended that the risk due to debris flood be quantified and that a risk map be developed for the lower unconfined reaches of the Partington Creek Main-stem prior to development.

The Partington Creek corridor can be roughly segmented into different hazard areas.

UPPER REACH

The upper reaches can be generally typified as steep terrain with potential debris flow and geotechnical hazards. An incised ravine is present above the BC Hydro ROW. Active sediment movement and channel erosion may occur in this area; however, poor access prevented field inspection. Proposed development should be well set back from slope areas, where preliminary guidelines for ravine setbacks are recommended in the Riparian Areas Regulation guidelines and detailed geotechnical guidance may be required.

MIDDLE REACH

The middle reach of Partington Creek is the creek fan reach, and extends from the fan apex to the lowland areas upstream of Cedar Road as shown on Figure 5-1. Creek fans are depositional features, where creek channels lose confinement, and overtopping of banks and channel avulsion (rapid channel shifting) can occur. There are a number of structures on the Partington Creek fan which are currently at risk to flood and channel avulsion. Future development or redevelopment of any properties on the creek fan should be in conformance with the Flood Hazard Area Land Use Management Guidelines (Ministry of water, Land and Air Protection, May 2004), in addition to the other environmental regulations. A detailed hazard assessment of the fan area could be required prior to redevelopment.

LOWER REACH

The lowest hazard reach of Partington Creek is the Partington Main Stem, that is along Cedar Drive. This low gradient reach, if left to natural processes, would likely try to relocate to a more efficient alignment across the agricultural area. Ongoing maintenance and engineering structures will be required to keep Partington Creek trained along Cedar Drive. Should land-use change and development be considered in the agricultural areas below Partington Creek, appropriate floodplain management planning and flood protection works would be required for this area.

5.3 INADEQUATE CHANNEL CONVEYANCE CAPACITY DUE TO SEDIMENT ACCUMULATION

There is evidence of coarse sediment transport down Partington Creek with substantial, relatively recent accumulation of gravel in the lower channel adjacent to Cedar Drive. Stakeholders identified sediment deposition as a key issue in lower Partington Creek and DeBoville Slough. It was reported that historically the Partington Creek channel was deep enough to ride horses through the channel and pass underneath the numerous bridges in the lower reach along Cedar Drive. Today, there is generally less than 2 m of clearance under the bridge decks.

Most of the sediment deposition occurs near the junction of Cedar Drive and Oliver Road. Gravel, sand, and cobble accumulate in the transition between the moderate gradient stream segment upstream to Victoria Drive and the low gradient portion of the channel along Cedar Drive. Further downstream, most of the sediment is sand and fine gravel. The main sediment deposition site was excavated in 1996 to address flood risk. More recent sediment removal proposals by the City of Coquitlam have not been approved by DFO because of concerns about impacts to spawning habitat for chum salmon.

Sediment deposition in the lower channel is causing flooding, overtopping Cedar Drive and subsequent flooding in the lowlands, during larger events. Figure 5-1 shows the approximate extent of road overtopping in plan view and Figures 5-2 and 5-3 show the flood profiles along Cedar Drive for the 10-year, 25-year, and 100-year return period storms. It appears that Cedar Drive overtops during events smaller than the 10-year return period. The model results are corroborated by the January 16 - 18, 2005 rainfall event that caused overtopping of Cedar Drive. When compared against the Burke Mountain Firehall IDF curve, the January 2005 storm falls between a 10-year and 25-year, 24-hour return period event. The January 2005 event was simulated using the calibrated XP-SWMM model. The peak water level profile exceeds the Cedar Drive road elevation as shown on Figure 5-2.

Flooding at the intersection of Cedar Drive and Oliver Road has also been reported and is related to the overtopping of Cedar Drive downstream. This intersection is located at Chainage 1+400 and as shown on Figure 5-2, flooding of the road occurs during events smaller than 10-year return. Flooding of the properties just north of this intersection likely occurs during storms smaller yet as the land is generally lower than the road and the peak water level profiles continue to rise with distance to the north.

Transport and settlement is a natural process – mountains breakdown, steep creeks transport bedload, cobbles and gravels settle out in flatter creek gradients, and sediments settle out in tranquil zones such as Slough which are subjected to standing or slow moving waters. A long term Sediment Management Plan is required and will be investigated in Section 7.

5.4 CULVERT ASSESSMENT

There are numerous culverts within the Partington Creek watershed as shown on Figure 3-1. Using the model results and field inventory, culverts under roadways were assessed for their ability to pass the 100-year peak instantaneous flow without surcharge. This minimizes the possibility of debris blockage and is particularly important on mountain creeks. Culvert blockages on mountain creeks can wash out roads and/or divert flows that cause flooding. Culverts under driveways were assessed as adequate if the 100-year flow was conveyed without the upstream depth exceeding the culvert obvert by more than 50% of the culvert height (less stringent criterion).

The results of the existing and future land use scenario models are presented in Table 5-1 for modelled culverts on the creek channels only. Culverts under paved municipal roadways are shown in bold; the other culverts are under driveways. Eight of the modelled culverts were flagged as under capacity for existing land use conditions, and twelve culverts for future conditions. The undersized culverts are shown on Figure 5-1.

Table 5-1: Culvert Assessment for Existing and Future Land Use

Culvert ID	Existing Diameter (mm)	Culvert Length (m)	Existing		Unmitigated Future	
			100-Year Peak Flow (m^3/s)	Meets Criteria (Y/N)	100-Year Peak Flow (m^3/s)	Meets Criteria (Y/N)
CUL001	**4270 x 2950 Arch**	**15.4**	**20.83**	**Y**	**23.55**	**Y**
CUL002	**525 CSP**	**Unknown**	**0.19**	**Y**	**0.76**	**N**
CUL003	600 CSP	Unknown	Not Modelled			
CUL004	600 CSP	Unknown	1.31	N	1.32	N
CUL005	**1200 CSP**	**12.5**	**2.59**	**Y**	**3.26**	**N**
CUL006	900 WS	4.8	2.38	N	3.09	N
CUL007	1050 CONC	Unknown	2.38	Y	3.02	N
CUL008	450 CSP	3.6	0.05	Y	0.05	Y
CUL009	600 CONC	6.7	0.06	Y	0.05	Y
CUL010	450 CSP	Unknown	Not Modelled			
CUL011	450 CSP	Unknown	Not Modelled			
CUL012	600 CSP	Unknown	Not Modelled			
CUL013	600 CSP	6.5	0.05	Y	0.06	Y
CUL014	450 CSP	Unknown	Not Modelled			
CUL015	**900 CONC**	**Unknown**	**1.59**	**N**	**1.65**	**N**
CUL016	900 CSP	Unknown	1.75	N	1.79	N
CUL017	**525 CONC + 1350 CSP**	**9.9**	**1.17**	**Y**	**1.17**	**Y**

Culvert ID	Existing Diameter (mm)	Culvert Length (m)	Existing		Unmitigated Future	
			100-Year Peak Flow (m^3/s)	Meets Criteria (Y/N)	100-Year Peak Flow (m^3/s)	Meets Criteria (Y/N)
CUL018	**600 CONC**	**Unknown**	**0.53**	**Y**	**0.84**	**N**
CUL019	**1350 CSP**	**Unknown**	**1.27**	**Y**	**2.12**	**Y**
CUL020	1200 CSP	10	1.60	Y	3.89	N
CUL021	600 CONC	12	0.55	Y	0.86	N
CUL022	750 CSP	6	0.06	Y	0.34	Y
CUL023	**900 WS**	**Unknown**	**1.28**	**N**	**2.14**	**N**
CUL024	**600 CONC**	**Unknown**	**0.92**	**N**	**1.52**	**N**
CUL025	1050 CSP	Unknown	1.28	Y	2.13	Y
CUL026	**450 CONC**	**Unknown**	**Not Modelled**			
CUL027	**375 CONC**	**Unknown**	**Not Modelled**			
CUL028	**450 CONC**	**Unknown**	**0.44***	**N**	**1.06***	**N**
CUL029	**375 CONC**	**Unknown**	**Not Modelled**			
CUL031	Unknown	Unknown	0.95	N/A	2.42	N/A
CUL032	**900 PVC + 1050 CSP**	**Unknown**	**0.95**	**Y**	**2.42**	**Y**
CUL033	1200 CSP Deformed	Unknown	0.54	Y	0.54	Y
CUL034	450 CSP	8	0.63	N	1.67	N
CUL035	450 CSP	11	0.63	N	1.67	N
CUL036	**300 CONC**	**Unknown**	**0.63**	**N**	**1.67**	**N**
CUL037	**2 x 600 CONC**	**Unknown**	**1.11**	**Y**	**2.82**	**N**
CUL038	Unknown	Unknown	0.35	N/A	0.38	N/A
CUL039	**750 CSP**	**16**	**1.76***	**N**	**4.24***	**N**
CUL040	1050 CSP	10	1.85	N	2.15	N
CUL041	Unknown	Unknown	0.14	N/A	0.14	N/A
CUL042	500 CSP	Unknown	0.05	Y	0.05	Y

Shading indicates culverts undersized to safely convey the 100-year event.
Bolding indicates culverts under paved municipal roadways.
* Estimated using catchment area and unit flow values in Table 4-5 (Hyde Development Reserve).

Flooding was reported near the intersection of Pollard Street and Crouch Avenue. Undersized culverts are believed to be the cause. Culverts CUL023 and CUL024 were identified as undersized for the existing 100-year flows.

Culverts that constrict and accelerate flow should be equipped with energy dissipators at the downstream end as per the City's design criteria to minimize downstream erosion. Furthermore, debris racks to trap material and prevent blockages of culverts should be installed at the upstream end of mountain creek culverts where channel material accumulates and then can be transported.

5.5 BRIDGE ASSESSMENT

There are numerous bridges within the Partington Creek watershed, most of them on the Partington Creek main-stem as shown on Figure 3-1. Using the model results and field inventory, most of the bridges were assessed for their ability to pass the 100-year peak flow. Freeboard on bridges should be 1.0 m to 1.5 m to allow for floating debris on rivers and at least 0.6 m on creeks. The City may wish to go to 1.0 to 1.5 m on lower Partington to allow for sediment accumulation that is occurring to extend maintenance periods. This will be further explored in the development of a Sediment Management Plan in subsequent sections.

The results of the existing and future land use scenario models are presented in the Table 5-2 and on Figure 5-1. Only three bridges had over 0.6 m freeboard. The bridges with light shading had less than 0.3 m, the dark shading indicates that bridges were overtopped, and the bolding indicates collapsed bridges.

Table 5-2: Bridge Assessment for Existing and Future Land Use

	Bridge ID	Bridge Height (m)	Existing		Unmitigated Future	
			100-Year Peak Flow (m^3/s)	Freeboard (m)	100-Year Peak Flow (m^3/s)	Freeboard (m)
	BRG001	1.55	5.66	0.58	6.37	0.53
	BRG002	**Collapsed**	**5.66**	**-1.22**	**6.37**	**-1.27**
	BRG003	0.80	2.38	0.23	3.02	0.18
	BRG004	1.30	2.38	0.74	3.02	0.71
	BRG005	0.20	0.05	0.12	0.05	0.12
	BRG006	0.18	0.05	0.05	0.05	0.05
Lower Partington Channel with Sedimentation	BRG007	2.16	20.09	0.07	22.28	-0.17
	BRG008	2.13	20.09	-0.20	22.29	-0.49
	BRG009	2.80	18.43	-0.23	19.82	-0.55
	BRG010	2.70	18.51	-0.92	19.91	-1.40
	BRG011	2.60	18.51	-1.37	19.91	-1.85
	BRG012	2.57	18.44	-1.20	19.96	-1.75
	BRG013	2.13	18.50	-1.99	20.10	-2.57
	BRG014	2.16	18.53	-1.85	20.16	-2.45
	BRG015	2.31	21.91	-1.45	20.81	-2.08
	BRG016	3.00	19.13	-0.93	21.23	-1.58
	BRG017	3.30	18.96	1.66	20.27	1.63

Bridge ID	Bridge Height (m)	Existing		Unmitigated Future	
		100-Year Peak Flow (m^3/s)	Freeboard (m)	100-Year Peak Flow (m^3/s)	Freeboard (m)
BRG018	0.90	1.60	0.21	3.89	0.00
BRG019	1.00	1.79	0.28	4.80	-0.04
BRG020	0.90	0.59	0.50	1.03	0.44
BRG021	2.00	0.55	1.06	0.86	1.02
BRG022	**Collapsed**	**13.16**	**-0.51**	**13.51**	**-0.52**
BRG023	1.76	13.62	0.52	14.10	0.53

Insufficient freeboard highlighted in light grey.
No freeboard or road overtopping highlighted in dark grey.
Bolding indicates collapsed bridges (to be removed immediately).

Adequate freeboard is not achieved for most of the bridges in the Partington Creek system. Zero freeboard or overtopping is noted for 11 bridges under existing land use flows and for 14 bridges under future land use flows.

The bridges in the flat lower section of Partington Creek (bridges BRG007 to BRG016) are surcharged or have inadequate freeboard due to sedimentation and backwater effects from insufficient channel capacities downstream. Figures 5-2 and 5-3 show water level profiles for lower Partington Creek for existing and unmitigated future conditions respectively. There is little head loss at each bridge and therefore the inadequate channel capacity leads to overtopping of the bridges and or Cedar Drive. Lack of channel capacity, opposed to deficient bridges, appears to be the problem. The need for increased channel capacity and the removal of sediment is a key issue in lower Partington Creek.

Bridges BRG002 and BRG022 are collapsed and should be removed immediately. These two bridges are a hazard and may trap debris that could result in a channel blockage during flood events.

The bridges without adequate freeboard will be furthered assessed under the development of a Sediment Management Plan. They should be monitored for sediment and debris build-up annually.

5.6 MINIMAL EROSION

Several small erosion sites were identified during the field reconnaissance within the Partington Creek watershed as shown on Figure 3-1. All of these erosion sites would be considered minor and no works are proposed to address them at this time. However, it is recommended that they be monitored as the watershed develops and rehabilitated if the erosion worsens and starts to pose a risk to adjacent properties.

5.7 DeBoville Slough

Partington Creek discharges through DeBoville Slough to the Pitt River. Hyde and Cedar Creeks also drain to the Slough. The *DeBoville Slough Assessment Report* (Associated Engineering Ltd., February 2005) concluded that future development in Hyde and Partington Creek watersheds would have minimal impact on the Slough.

Summary of 2005 DeBoville Slough Assessment Report

The *DeBoville Slough Assessment Report* summarized the following findings:

- Slough exhibits both daily tidal cycles and freshet influences on water levels. Water levels fluctuate considerably on a seasonal and daily basis. Slough water levels are heavily influenced by Pitt River water levels. During the Fraser River freshet, water levels in both the Pitt River and DeBoville Slough are governed by regional rather than local drainage.

- Slough is a settling zone for fine sediments from three creeks (Partington, Cedar, and Hyde creeks).

- 200-year flood construction level and dyke crest for Pitt River at DeBoville Slough is El. 5.2 m (includes 0.6 m freeboard).

The *Hyde Creek IWMP* reported 100-year peak flows of 44 m^3/s for pre-development conditions and 55 m^3/s for post-development conditions with diversion (a 20% increase). The *DeBoville Slough Assessment* reported that the impact of development and the proposed diversion on worse-case low water boundary conditions (low waters levels in the Slough and Pitt River) would:

- increase Slough water levels by 0.15 m under the 100-year event; and
- increase 100-year flow velocities from 1.38 m/s to 1.45 m/s (5% increase) at the upstream end of the Slough and 1.55 m/s to 1.7 m/s (10% increase) at the downstream end.

Under high water boundary conditions, such as 200-year freshet flood event, the impact of Hyde Creek development and diversion would raise the water level by less than 2 cm, and notable velocities changes were not evident. The report concluded that increases in water level and flow velocities would be small, particularly for frequently occurring events. Envirowest concluded that these flow regime changes would not significantly impact the habitat and species in DeBoville Slough.

Flows and impacts for the proposed development within the Partington Creek watershed were also assessed in the *DeBoville Slough Assessment.* Peak flows were predicted as 47 m^3/s for existing conditions and 61 m^3/s for post-development conditions (a 30% increase) for the 100-year event. The assessment concluded that Slough water levels would increase 2 cm under the high water boundary condition, for a total of 4 cm for both Hyde and Partington Creek development. Increases to flow velocities and water levels under the low water boundary condition as a result of Partington development would be similar to those identified for the Hyde development.

UPDATED PARTINGTON CREEK ASSESSMENT

Under the IWMP, the Partington Creek hydrologic modelling for existing and future conditions predicted lower peak flows than those determined in the *DeBoville Slough Assessment* as discussed in Section 4 and summarized below.

Table 5-3: Predicted 100-Year Peak Flows at DeBoville Slough

Consultant	Partington Creek 100-year Peak Flows	
	Existing Land Use	Future Land Use
Associated[1]	47 m^3/s	61 m^3/s 30% increase
KWL	20.8 m^3/s*	23.6 m^3/s* 13% increase
Hyde Development Reserve100-year Peak Flows		
KWL	4.4 m^3/s	10.6 m^3/s

1 Taken from DeBoville Slough Assessment Report, Feb. 2005.
* peak flow estimates include snow melt and baseflow allowance.

The IWMP model has been calibrated with flow monitoring results in Partington Creek, design flows have been compared with regional information, and model results coincide with observed flooding such as Cedar Drive overtopping. We have confidence in the IWMP predicted design flows. These updated flows were used to assess impacts to the Slough by prorating them with findings from the Hyde Creek development impacts.

Given that, the development of Partington Creek alone is predicted to have the following impacts (impacts associated with the development of the 100 ha Hyde Development Reserve alone are also noted in brackets):

- increase 100-year Slough water levels by 0.04 m (Hyde Development Reserve 0.08 m) during low water boundary conditions;

- increase 100-year velocities by 0.2 m/s (Hyde Development Reserve 0.04 m/s) at the upstream end of the Slough and 0.04 m/s (Hyde Development Reserve 0.02 m/s) at the Slough outlet during low water boundary conditions; and

- increase Slough water level by 0.5 cm (Hyde Development Reserve 1.1 cm), with no notable velocities change under the high water boundary conditions, such as 200-year freshet flood event.

The combined impacts of development within both Hyde and Partington Creeks, including the development of both Hyde and Partington Development Reserves (see Figure 2-3), would be:

- increase 100-year Slough water levels by 0.27 m during low water boundary conditions;

- increase 100-year velocities by 0.13 m/s (increase 8%) at the upstream end of the Slough and 0.27 m/s (increase 15%) at the Slough outlet during low water boundary conditions; and

- increase Slough water level by 3.6 cm, with no notable velocities change under the high water boundary conditions, such as 200-year freshet flood event.

Similar to the *DeBoville Slough Assessment* conclusions, the incremental increases in peak water levels and velocities are of relatively small magnitude. Further, the analysis considered large, infrequent events. During frequently occurring, average, storm and boundary water level conditions, the incremental changes would be less evident.

ENVIRONMENTAL EFFECTS

The effects of increased urban stormwater drainage on fish habitat and other environmental values in DeBoville Slough are predicted to be minor. A range of potential effects were evaluated including:

1. changes to wetland vegetation from changes to flood frequency, duration, and magnitude;
2. changes to fish habitat from increased flow velocity during floods;
3. reduction in fish habitat quality from reduced summer water levels; and
4. increased concentrations of urbanization-related contaminants in water and sediment.

Changes to Wetland Vegetation

Wetland vegetation communities in DeBoville Slough are primarily marsh or wet meadow areas dominated by reed canary grass marsh or shrub thickets with hardhack and reed canary grass (see photo below). Both plant communities are characteristic of disturbed wetlands and are tolerant of fluctuating water levels. The predicted changes to flood elevation (increase of 0.04 –0.27 m under different development scenarios during large floods) will not cause any vegetation changes.

Extensive Reed Canary Grass Marsh and Hardhack Shrub Thicket Communities in DeBoville Slough

Changes to Fish Habitat from Increased Water Velocity

Predicted increases in water velocity during infrequent (>100-year event) flood events range from 0.2–0.3 m/s under different development scenarios. Because of the rarity of large floods, combined with the low gradient of the Slough and the ability of fish to find low-velocity refuge areas such as side-channels and channel margins during flood events, effects to fish populations are predicted to be minor.

Reduction in Summer Fish Habitat Quality

Fish habitat in DeBoville Slough is affected by poor shading, shallow water depth, and eutrophication (elevated nutrients from surface run-off). Reduced summer flow from Partington and Hyde creeks from reduced infiltration of precipitation during the spring may worsen fish habitat conditions in DeBoville Slough. However, summer discharge is predicted to remain stable during development of the Hyde and Partington watersheds with implementation of source controls and potential changes to summer fish habitat are also minor.

Increased Discharge of Contaminants from Urban Areas

Data on existing water and sediment quality is not available for DeBoville Slough, however, observations indicate it is moderately degraded by existing urban, rural, and agricultural land uses in the Hyde and Partington watersheds. Further development has the potential to further degrade water and sediment quality including elevated metals, hydrocarbons, nutrients, organic compounds, and sediment. Source controls on new development will effectively mitigate many sources of contaminants, however, loading (mass/year) of contaminants associated with urbanization are expected to increase.

PARTINGTON CREEK OBJECTIVE FOR DEBOVILLE SLOUGH

The IWMP will focus on mitigating the impacts of future development from exacerbating the sedimentation problem within the DeBoville Slough. Further study is needed to determine the sources of sediment contributing to aggradation at the Pitt River Boat Club marina.

5.8 POTENTIAL SOLUTIONS TO HYDROTECHNICAL ISSUES

A list of potential solutions is summarized here. Flood management alternatives, together with environmental/groundwater protection alternatives, will be discussed in Section 7.

To address flood protection and sedimentation issues, the following measures will be considered and developed into alternatives if appropriate.

- conveyance improvements, such as culvert and bridge upgrades, channel deepening/widening and/or berming;
- long term sediment management plan, including online sedimentation pond(s) (sediment traps), periodic dredging, or creation of a larger floodplain area to allow for increased deposition;
- raising Cedar Drive to be a dyke;
- allowing for more creek movement, a designated floodplain zone and riparian setbacks by moving Cedar Drive 30 m south and raising to be dyke;
- restoration of floodplain areas along lower Partington Creek;
- high flow diversion(s), for example, to DeBoville Slough and/or Irvine Creek; and
- bank stabilization (bioengineering, riprap).

These measures will be considered during development of alternatives.

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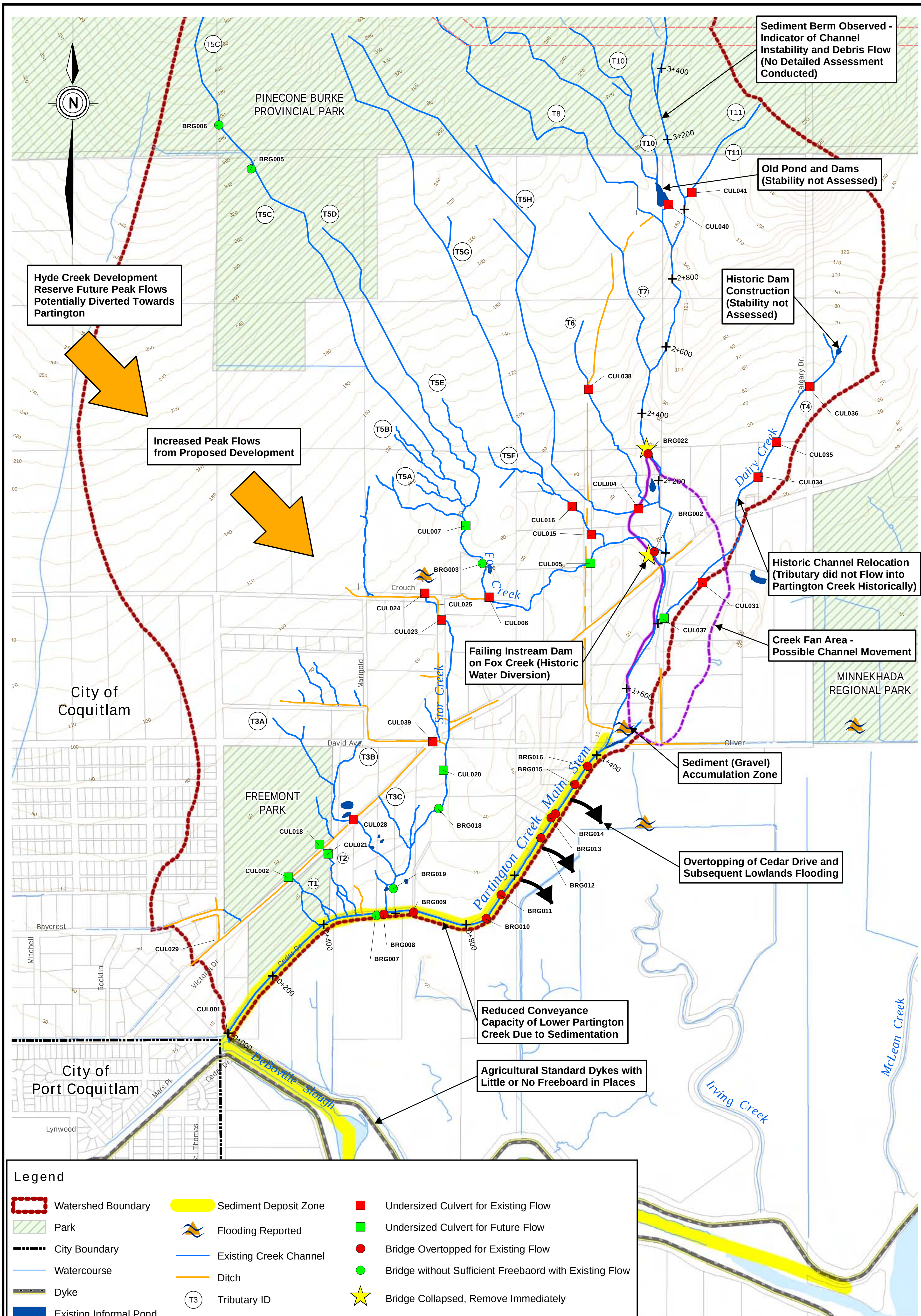

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City of Coquitlam
Partington Creek Integrated Watershed Management Plan

Project No.	Date
456-038	July 2011

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Scale in Metres

Hydrotechnical Issues

Figure 5-1

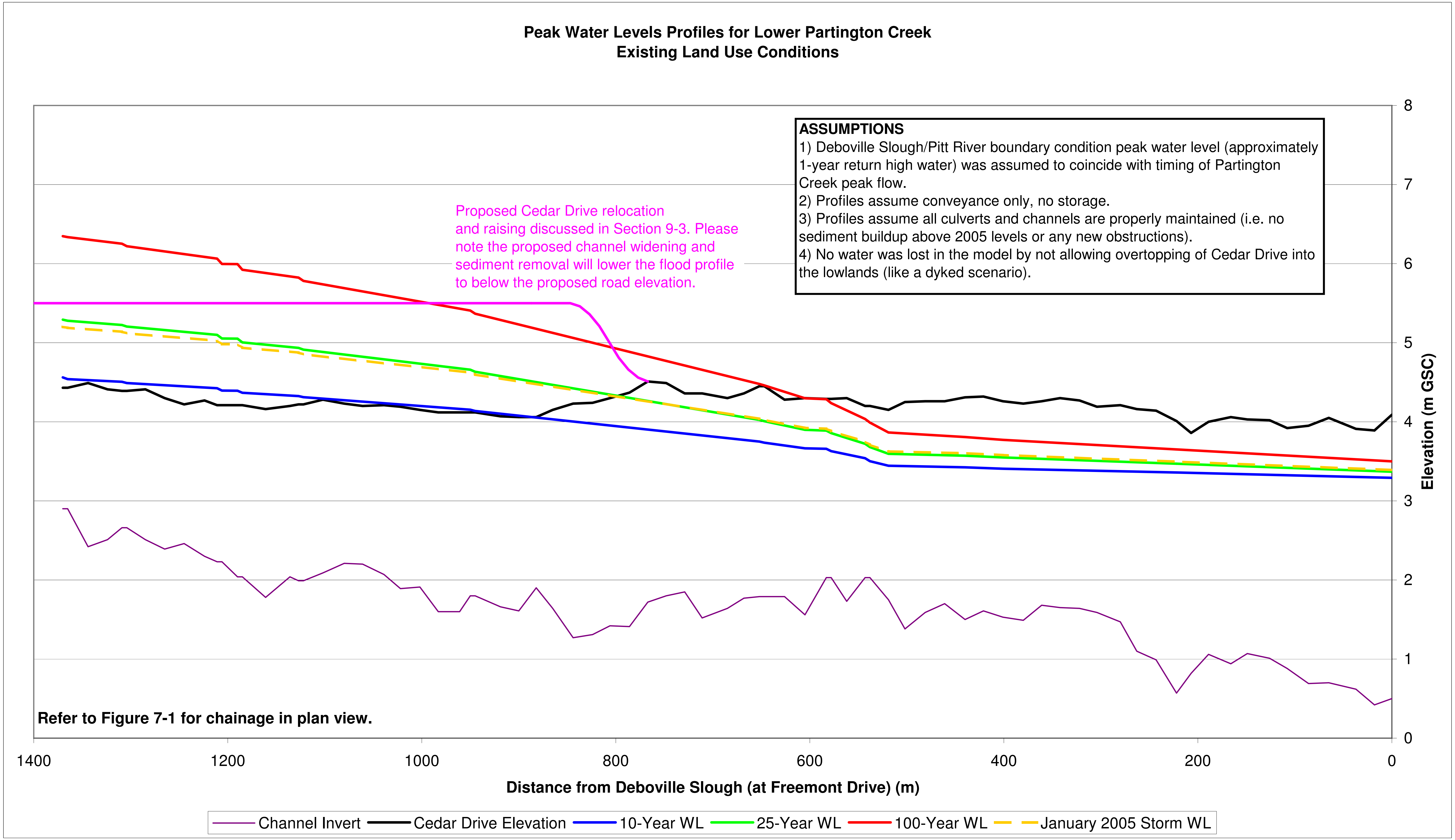

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Figure 5-2

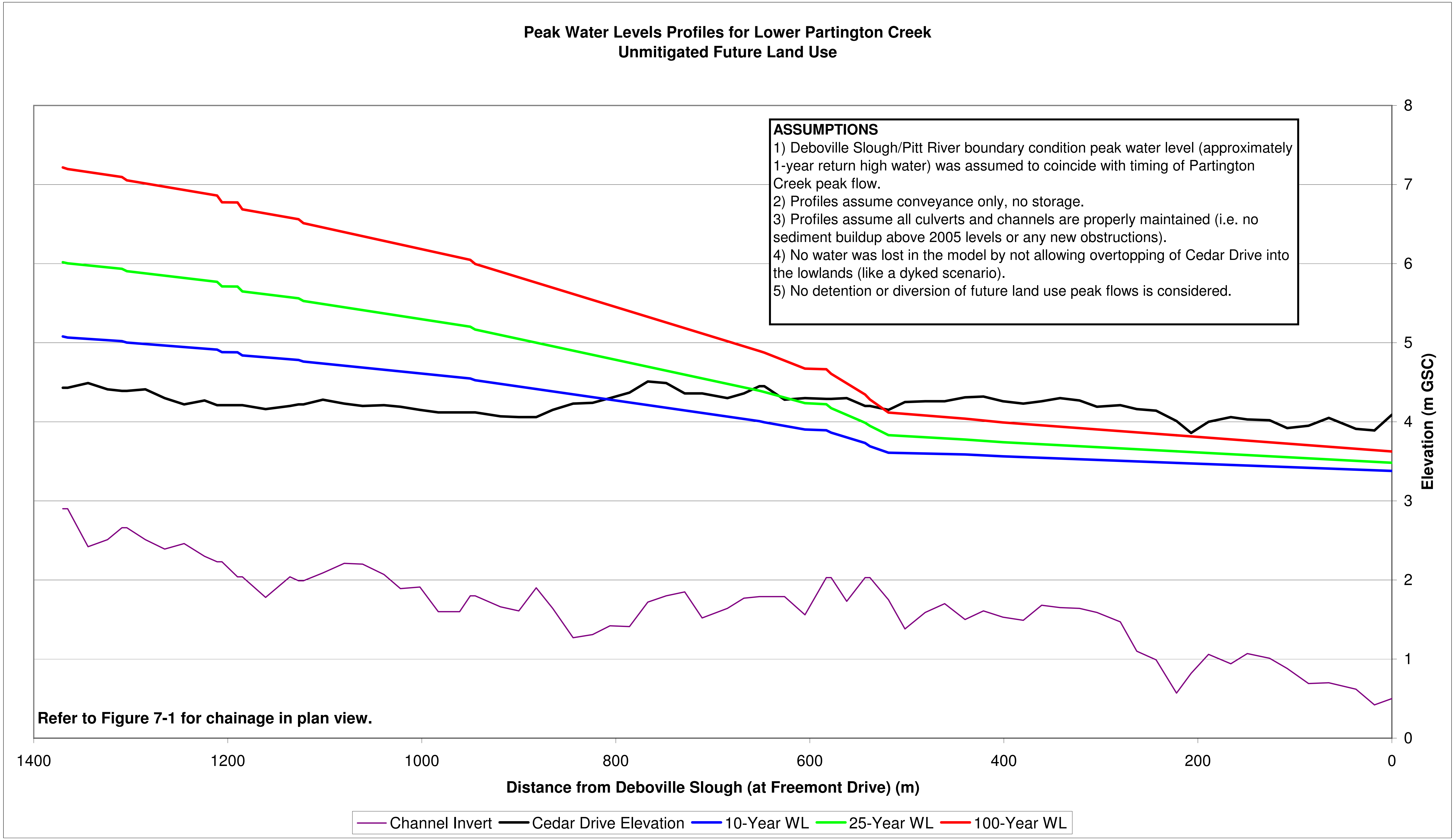

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Figure 5-3

Section 6

Environmental Assessment

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associates limited
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6. ENVIRONMENTAL ASSESSMENT

6.1 INTRODUCTION

Watershed health is a broad measure of the degree to which watershed-scale ecological processes such as hydrology are functioning. Changes to watershed health may be measured using indicators such as land use, forest cover, riparian forest cover, or road density. It can also be measured with biological or chemical indicators like the streambed (benthic) insect community, fish populations, water temperature, conductance or other chemical parameters. The streambed insect community is particularly useful because it integrates a range of stressors (hydrologic, habitat, chemical, and physical) that influence the stream ecosystem.

The concept of watershed health is also a useful tool during the IWMP process because it allows for predictions of how changing land use and stormwater management activities may affect Partington Creek. It can also be used for monitoring future change and providing data on the success of the stormwater management.

6.2 WATERSHED HEALTH TRACKING SYSTEM

The watershed health tracking system used for the Partington IWMP uses two indicators: (1) riparian forest; and (2) watershed imperviousness. Maintaining riparian forest and minimizing imperviousness are the two most effective methods of preserving watershed health.

IMPORTANCE OF IMPERVIOUSNESS (INDICATOR #1)

Research shows a strong relationship between the impervious area in the watershed and a stream's health (based on its fish and benthic insect community) as outlined in the following table:

Table 6-1: Stream Health Relative to Impervious Area

Health	Total Impervious Area (%TIA)
Stressed (minor changes to watershed health)	1 - 10 %
Impacted (moderate changes to watershed health)	11 - 25 %
Degraded (severe changes to watershed health)	26 - 100%
The Importance of Imperviousness, 1994, by T.R. Schueler.	

IMPORTANCE OF RIPARIAN FOREST INTEGRITY (INDICATOR #2)

Riparian areas are those adjacent to watercourses that may be subject to temporary, frequent, or seasonal inundation, and which support plant life typical of the wetter soil conditions. These riparian areas provide natural features, functions and conditions that support a productive fish community, such as:

- multi-canopied forest and ground cover that:
  - moderates water temperature,
  - provides a source of food, nutrients, and organic matter,
  - stabilizes the soil with root systems, thereby minimizing erosion,
  - filters sedimentation and pollution;
- sources of large woody debris;
- active floodplain areas;
- side channels, intermittent streams; and
- infiltration that can aid in sustaining baseflows.[4]

Figure 6-1 shows the Riparian Forest Integrity (RFI) assessment areas on the permanent watercourses.

PARTINGTON CREEK EXISTING AND FUTURE WATERSHED HEALTH INDICATORS

Watershed health indicators were used to quantify predicted changes between existing and future conditions and to define targets to be achieved; they are:

- B-IBI (benthic index of biological integrity);
- effective impervious area – meet the DFO Stormwater Guidelines to mitigate the hydrologic impacts of development;
- riparian forest integrity;
- watershed forest cover; and
- baseflow.

The pre- and post-development values associated with the indicators are summarized in Table 6-2. Figure 6-2 shows the Watershed Health Tracking System with predicted B-IBI scores based on impervious area and riparian forest integrity for two locations, Partington Creek at the mouth and at Victoria Drive. Both existing and future scores are predicted. The future predicted B-IBI scores assume the impacts of the proposed development without mitigation measures to reduce effective impervious area and degradation of riparian forest integrity based the *Riparian Areas Regulation* (RAR) setbacks as delineated according to the Detailed Assessment methodology (from a conceptual watershed planning perspective) on the permanent streams. Riparian setbacks for Partington Main-stem were estimated to be 24 m (instead of 30 m RFI) and for Star and Fox Creeks were estimated to vary between 10 and 15 m depending on channel width (instead of 30 m RFI).

[4] Jan 2001, Streamside Protection Regulation

Table 6-2: Watershed Health Indicators at Partington Creek Outlet

Land Use	B-IBI Score	EIA[1] (%)	To Mitigate Hydrologic Impacts Using DFO Urban Stormwater Guidelines: Volume Reduction* – Capture Capacity	Water Quality Treatment* – 6-mnth, 24-hr[2] wet event Vol.	Water Quality Treatment* – 6-mnth, 24-hr[2] wet event Peak	Peak Design Flows*[1] – 6-mnth, 24-hr[2]	Peak Design Flows*[1] – 2-year, 24-hr	Peak Design Flows*[1] – 5-year, 24-hr	RFI (%)[1]	Forest Cover	Summer Baseflow
Existing Conditions	36	3	680 m^3/ha	N/A	5.23 m^3/s 0.039 m^3/s/ha imp	5.2 m^3/s	9.1 m^3/s	11.9 m^3/s	79.5%	93.4%	0.05 m^3/ha
Post-dev Unmitigated Conditions	19 est.	22	470 m^3/ha	428,000 m^3 3200 m^3/ha imp	5.38 m^3/s 0.040 m^3/s/ha imp	5.4 m^3/s	10.4 m^3/s	13.7 m^3/s	67.8%[3]	72.3%	N/A

* To Meet DFO Urban Stormwater Guidelines
[1] Indicators measured at Partington Creek Outlet.
[2] 6-month return period values are derived by taking 72% of the 2-year rainfall.
[3] Based on preliminary estimate of riparian forest change in developed areas.

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The goal of the IWMP is to achieve a no-net-loss of watershed health for the watershed as a whole and strive to maintain the indicators at 2005 levels. One way to define no-net-loss of ecological health is within the context of the Watershed Health Tracking System – mitigating the hydrologic impacts of development using the DFO Stormwater Guidelines and protecting riparian areas.

B-IBI is widely used for monitoring the biological condition of small streams because it shows a consistent relationship with independent measures of watershed-level change. B-IBI has been found to be strongly correlated with watershed imperviousness and riparian forest cover in streams in the Metro Vancouver and elsewhere in the Pacific Northwest. These watershed land cover variables encompass a broad range of hydrologic, chemical, and physical stressors that affect small streams generally and the benthic invertebrate community specifically even if the causal mechanisms of their effects are unclear. Further discussion on B-IBI is summarized in Section 3-2.

To meet the IWMP goal of no-net-loss of ecological health, maximum areas of riparian corridors are to be protected and proposed mitigative measures will be sized to achieve the DFO Stormwater Guidelines – infiltrate/capture and provide water quality treatment for the 6-month event, and detain the 6-month, 2-year, and 5-year events to pre-development levels.

6.3 POTENTIAL STORMWATER MITIGATIVE SOURCE CONTROLS AND BMPS

To mitigate the environmentally-based hydrologic impacts associated with development, the following measures will be considered.

Table 6-3: Stormwater Best Management Practices for Environmental Protection

Best Management Practices
Planning Measures
▪ Protection of interception/evapotranspiration/infiltration processes in forests and forest soils
▪ Reduction in road density and road width
▪ Protection of soil structure during development
▪ Increased building density to allow for enhanced riparian forest or terrestrial forest protection
Source Controls
▪ Rain gardens, vegetated swales, pervious pavers, infiltration facilities, absorbent landscapes, green roofs, baseflow release facilities
▪ Oil/Grit Separators for high-risk sites (surface parking areas, commercial sites, etc.)
Best Management Practices (BMPs)
▪ Water quality sedimentation ponds, sediment removal traps
▪ Detention Ponds
▪ Diversions, baseflow augmentation facilities

SOURCE CONTROLS

Source controls reduce runoff volumes (and localized erosion) and provide water treatment. In addition, source controls have the benefit of providing groundwater recharge and maintaining baseflow in the creek.

Selection of appropriate source controls for a particular site is dependent on the proposed land use, surficial soil type, and ground slope. The impacts of these parameters are as follows:

- Proposed Land Use: The proposed land use determines the impervious percentage of the lot, the types of pollutants that can be expected in the runoff, and the physical space constraints. Proposed land use is shown on Figure 2-3.
- Surficial Soil Type: The surficial soil type is used to calculate the infiltration rate and therefore the size of infiltration source controls. Surficial geology is shown on Figure 3-5. Most of the watershed is rock, with a one kilometre band of till at the southern end.
- Land Slope: Land slope determines the feasibility of constructing source controls and whether infiltration into lawn/garden areas will be effective. Figure 6-3 shows the land slopes within the developing area.

Source controls are easily implemented on land slopes of 10% or less. Unfortunately this represents a small area within Partington Creek, therefore mitigative measures that can be applied to steeper areas will be explored in Section 7.

6.4 HABITAT RESTORATION AND ENHANCEMENT

Opportunities for aquatic, riparian, and terrestrial habitat enhancement are limited by the undeveloped, primarily forested character of the Partington watershed. Approximately 91% of the watershed remains forested and 86% of the riparian corridor is treed. All of the potential restoration and enhancement opportunities are found in the lower watershed where roads, rural and agricultural development have affected environmental values. Potential opportunities are summarized by ecosystem type in the following sections: (1) aquatic; (2) riparian; and (3) terrestrial. They are also shown in Figures 6-4 and 6-5. Appendix G provides photos of many of the sites.

AQUATIC HABITAT RESTORATION AND ENHANCEMENT

The long-term goal of aquatic habitat restoration and enhancement is to increase fish populations through the development of new habitat, providing access to historic habitat, or improvements to existing habitat. Five in-stream or floodplain activities were identified: (1) removal of fish passage barriers; (2) off-channel pond creation; (3) in-stream habitat complexing; (4) restoration of floodplains with complex channels and ponds; and (5) reconnection of Partington and Irvine Creeks. Sites are summarized in Table 6-4 and Figure 6-4.

Table 6-4: Aquatic Habitat Restoration and Enhancement Opportunities

Site	Description
Removal of Fish Passage Barriers	
Site 1: Lower Fox Ck.	Removal of 2.1 m high and 0.5 m high dams to allow fish passage
Site 2: Fox Ck. at Edwards Rd.	Replacement or retrofitting of culvert (0.9 m outlet drop) to allow fish passage
Site 3: Fox Ck. at Crouch Ave. ROW	Replacement or retrofitting of wood culvert (1.0 m outlet drop) to allow fish passage
Site 4: Fox Ck. upstream of Crouch Ave. ROW	Replacement or retrofitting of wood dam (1.2 m outlet drop) to allow fish passage
Site 5: Trib T5H at Edwards Rd.	Replace or retrofit steel culvert to allow fish passage (0.5 m outlet drop; no pool)
Off-channel Pond Creation	
Site 6: Dairy Creek downstream of Quarry Rd.	Off-channel pond site downstream of Quarry Rd (private property) including downstream fish passage improvements
Site 7: Dairy Creek downstream of Quarry Rd.	Off-channel pond site on or near Victoria Drive ROW (public and private property)
Site 8: Partington Ck., west of Gilleys Trail	Off-channel pond site in cleared site (private property)
Site 9: Partington Ck., west of Gilleys Trail	Off-channel pond site; expand existing wetland (private property)
Restoration of Floodplains with Complexing	
Site 10: Partington Ck., Cedar Dr. and Oliver Rd.	Potential large floodplain restoration site with meandering channel, ponds, and sediment trap (private and public land)
Site 11: Partington Ck., outside of large meander on Cedar Dr.	Potential large floodplain restoration site with meandering channel, ponds, and sediment trap (private and public land)
In-stream Habitat Complexing	
Site 12: Lower Fox Ck. (Edwards Rd area)	In-stream habitat complexing; high priority below Edwards Rd.
Site 13: Partington Ck.; below Victoria Bridge	In-stream habitat complexing; priority site between Victoria Dr. Bridge and Oliver Rd.
Site 14: Partington Ck.; downstream of Oliver Rd.	In-stream habitat complexing; channelized portion of lower Main-stem.
Reconnection of Partington and Irving Creeks	
Site 15: Site Partington Ck. + Irvine Ck.; Cedar Dr. area	Reinstate flow to Irvine Ck through agricultural land through low/high flow pipe or meandering open channel.
Refer to Figure 6-4.	

The highest priority activity is to remove fish passage barriers (dams and culverts) on Fox Creek and its major tributaries. Removal of the barriers would provide coho salmon up to 500 m of new habitat and would also provide new spawning habitat in the lower reaches of Fox Creek. The only fish passage barrier on Partington Creek is a natural falls / canyon, that cannot (and should not) be modified to improve fish passage.

The creation of floodplain habitats and off-channel ponds that provide high quality over-wintering habitat for juvenile salmon, particularly coho, is also a high priority activity. These floodplain habitat features were likely much more common historically on lower Partington Creek. Six potential sites for small-scale off-channel pond development were identified. As well, two larger areas where the dyke and road could be relocated to restore floodplain habitat were identified. These large floodplain sites would allow for the development of a meandering channel and ponds. The site at Cedar Drive and Oliver Road would also provide an opportunity for sediment management and flood storage.

In-stream habitat enhancement through the addition of large logs and boulders is also appropriate on lower Fox Creek and lower Partington Creek where channel gradient is less than 2%. In-stream logs and boulders create a hydraulic complex channel with deep pools, undercut banks, and other channel features that support juvenile salmon and trout. The increased flood risk in lower Partington Creek may preclude in-stream complexing, however, some hydraulic complexity may reduce sediment deposition.

The final aquatic habitat restoration activity is to restore the connection from Partington Creek to Irvine Creek through the agricultural area. This was the historic alignment of Partington Creek. This would be a complex project and more evaluation of the advantages, disadvantages, and costs from both a hydrologic and fish habitat perspective is required. It could range from a simple diversion pipe that provides flow to Irvine Creek during high and low flows, to a meandering, open channel with direct fish habitat value. A full diversion of Partington Creek to its former channel is likely impractical because of the requirement for new dykes and other flood infrastructure, as well as the loss of fish habitat in the existing Partington Creek channel.

RIPARIAN HABITAT RESTORATION AND ENHANCEMENT

The long-term goal of riparian habitat restoration is to increase native tree and shrubs along Partington Creek to support diverse fish, wildlife, and plant communities. Riparian areas are considered inappropriate for landscaping, lawns, or agricultural uses. Sites are summarized in Table 6-5 and Figure 6-5.

Because of the limited rural and urban development and the high amount of riparian forest cover, opportunities for riparian habitat restoration are limited. All are confined to the lower watershed. All focus on reforesting riparian areas that are currently landscaped, cleared, or support dense patches of Himalayan blackberry and Japanese knotweed. Both knotweed and blackberry are invasive plants that form dense stands in riparian areas and exclude or prevent the establishment of native trees and shrubs.

Table 6-5: Riparian Habitat Restoration and Enhancement Opportunities

Site	Description
Site 1: Partington Ck. Main-stem upstream of Victoria (on east bank)	Rural residential area cleared of understorey vegetation to top of bank; maple canopy remains; encourage owners to plant conifers and shrubs
Site 2: Dairy Creek downstream of Quarry Rd.	Rural residential lots with grass or landscaping to channel margin; replant native trees and shrubs
Site 3: Dairy Creek downstream of Victoria	Hobby farm with extensive clearing to top of bank; replant native trees and shrubs
Site 4: Partington Ck. Main-stem, north of Oliver Rd. on east bank	Cleared area with narrow forested riparian zone remaining; opportunity to reforest
Site 5: Partington Ck. Main-stem, Cedar Dr.	Residential properties with landscaped areas within riparian zone or blackberry and knotweed; reforest or plant native shrub communities
Site 6: Partington Ck. Main-stem, Cedar Dr.	Rural property with extensive Himalayan blackberry and knotweed in riparian zone; few trees; reforest or plant native shrubs
Site 7: Partington Ck. Main-stem, Cedar Dr.	Rural property with extensive Himalayan blackberry in riparian zone; few trees; reforest or plant native shrubs
Site 8: Star Cr. east of Pollard Rd.	Extensive landscaped stream ravine with grass; replace native trees and shrubs
Site 9: Fox Ck. upstream of Crouch ROW	Rural residential property with landscaping around stream; replace with native trees and shrubs

Because of the limited rural and urban development and the high amount of riparian forest cover, opportunities for riparian habitat restoration are limited. All are confined to the lower watershed. All focus on reforesting riparian areas that are currently landscaped, cleared, or support dense patches of Himalayan blackberry and Japanese knotweed. Both knotweed and blackberry are invasive plants that form dense stands in riparian areas and exclude or prevent the establishment of native trees and shrubs.

Reforestation with native and shrubs is the recommended approach for all riparian sites identified. This should focus on native conifers (western red cedar, Douglas-fir, western hemlock) with smaller amounts of native deciduous trees (red alder, big-leaf maple, black cottonwood). Appropriate native shrubs include willows (multiple species), red-osier dogwood, Indian-plum, snowberry, and salmonberry. More diverse plantings, including non-native species, are appropriate in residential areas.

Invasive plants occur primarily along lower Partington Creek, where Himalayan blackberry and Japanese knotweed have become abundant. English ivy is prevalent near the confluence of Fox and Partington creeks. Invasive plant management should be addressed during riparian enhancement projects. As well, other construction activities conducted as part of the IWMP such as flood works, dyke upgrades, in-stream habitat enhancement, and culvert upgrades should address invasive plant management. This includes reducing the spread of existing infestations through construction phase BMPs and, where possible, removing existing patches.

TERRESTRIAL HABITAT RESTORATION AND ENHANCEMENT

Terrestrial habitat restoration and enhancement activities are directed at wildlife, or more generally, at restoring native plant and wildlife communities outside of riparian and aquatic areas. The low amount of development of the Partington watershed limits opportunities for terrestrial habitat restoration.

The primary opportunity is to begin to reduce the amount of red alder forest in the mid-portion of the Partington watershed. While red alder forest is rich in some species, its habitat value is generally lower than mixed or coniferous forest. Red alder prevalence can also affect hydrologic processes because they transpire primarily during the summer and do not intercept rainfall in their canopy during the winter when they lack leaves. Underplanting of shade-tolerant conifers or patch cutting and more conventional reforestation methods using native conifers are possible habitat restoration options.

Habitat restoration or enhancement activities focusing on specific species such as Pacific Water Shrew or raptors may also be appropriate. These activities focus on creating physical habitat conditions including snag, downed logs, or nest sites that are appropriate for each species. It may also include the creation of isolated wetlands for amphibians such as western toad, or the planting of plant communities that are used by songbirds, invertebrates, or other species groups.

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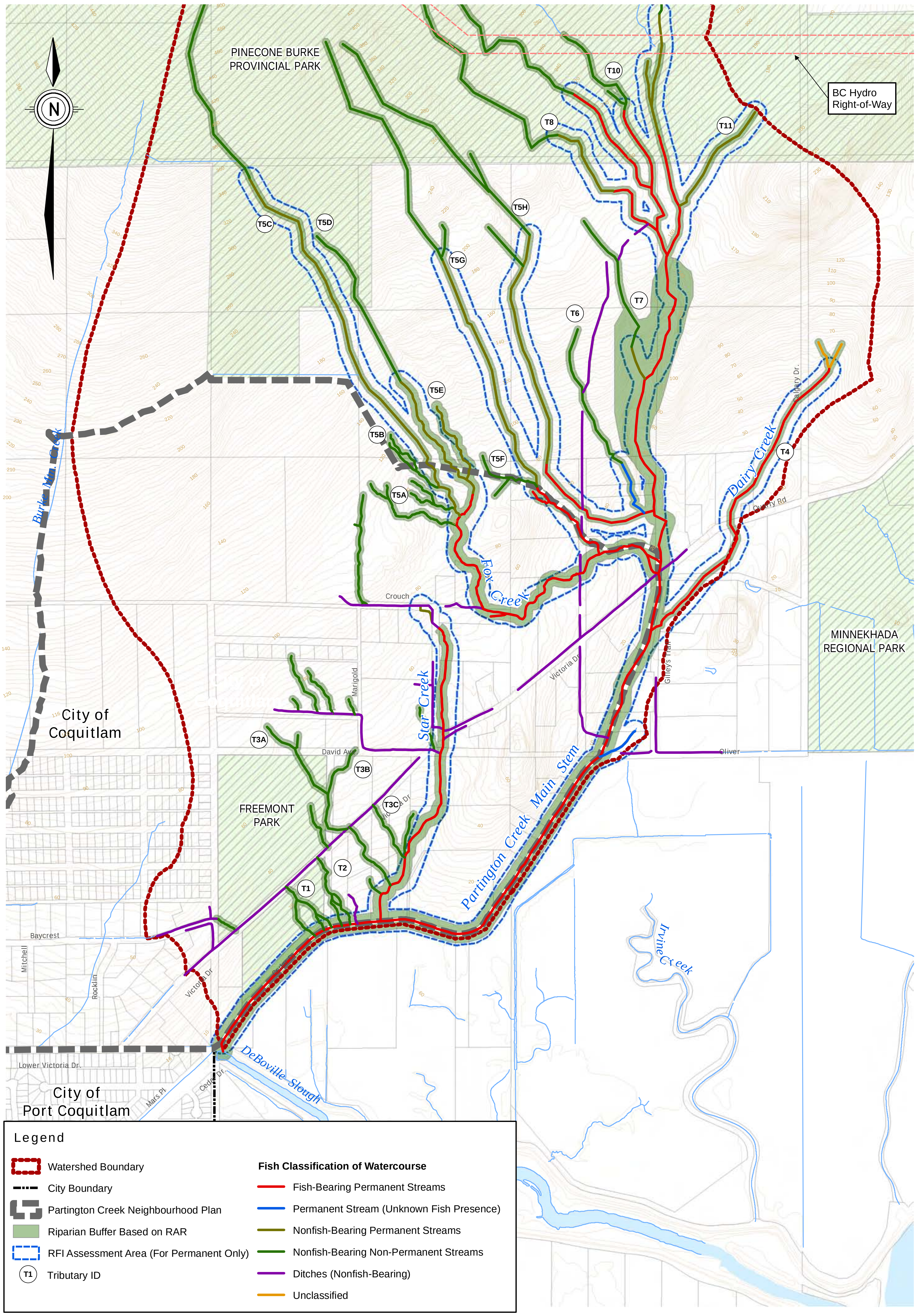

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250 125 0 250
Scale in Metres

Riparian RFI Assessment Areas and RAR Setbacks

Figure 6-1

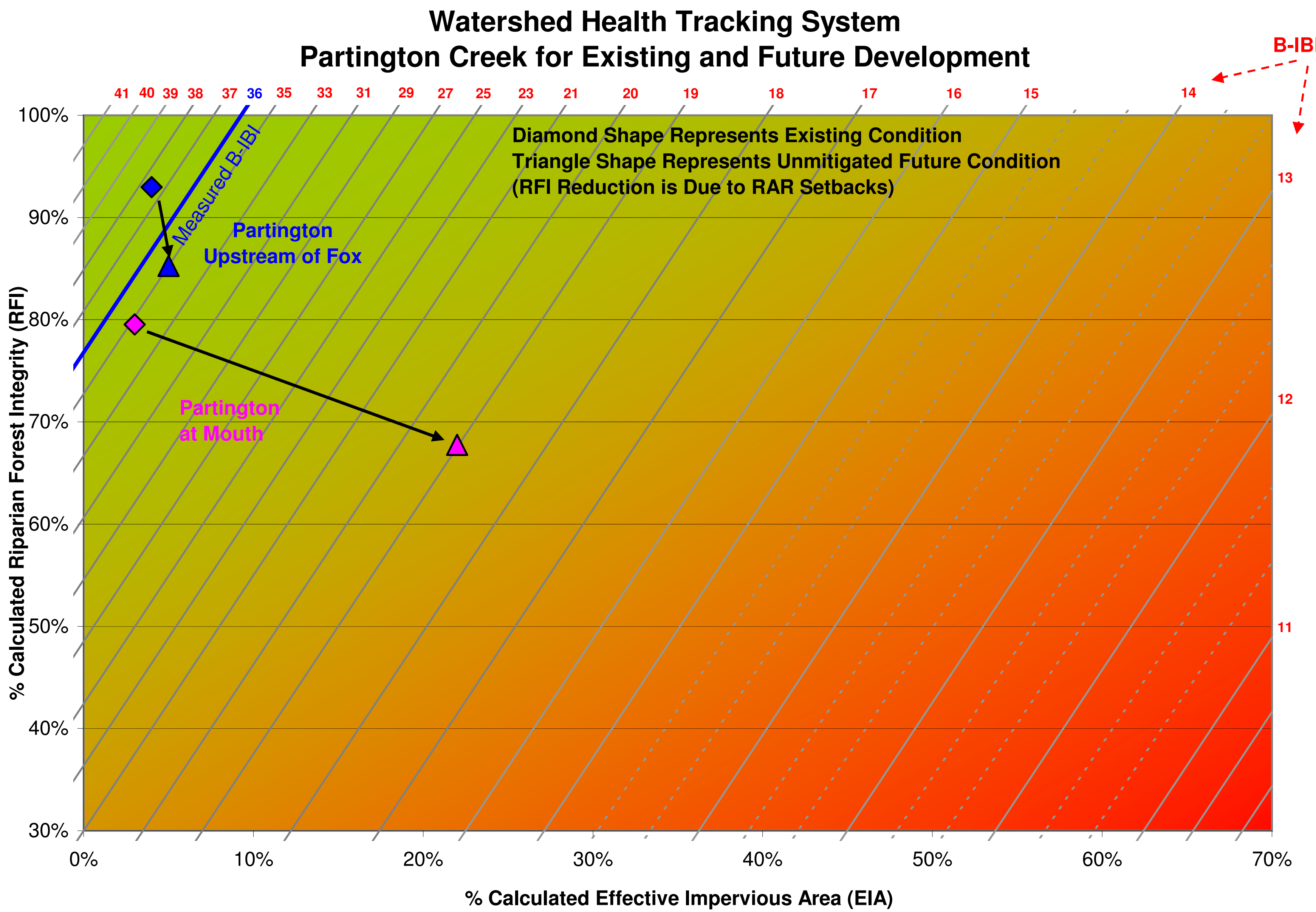

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Figure 6-2

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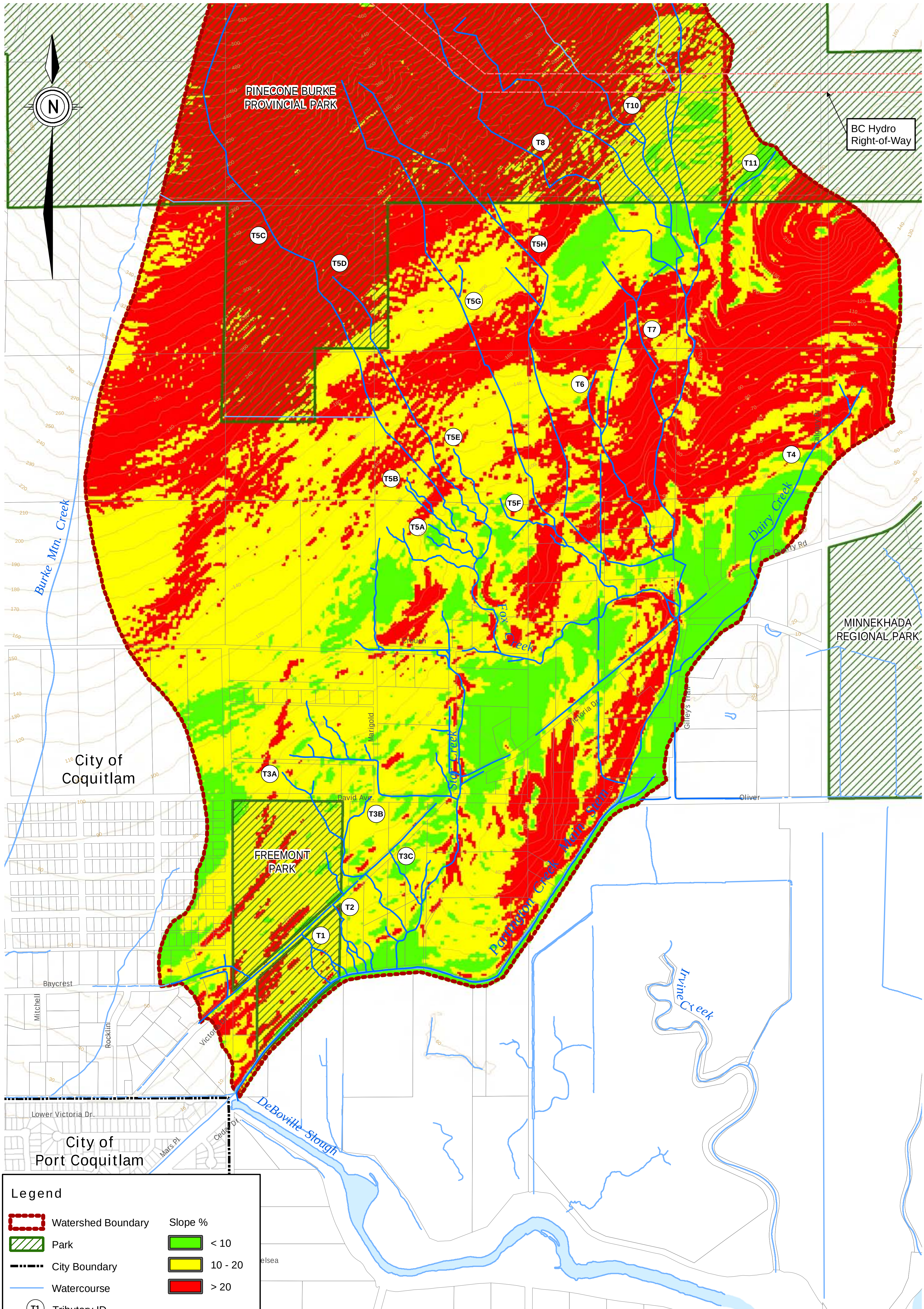

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Scale in Metres

Ground Slope Analysis

Figure 6-3

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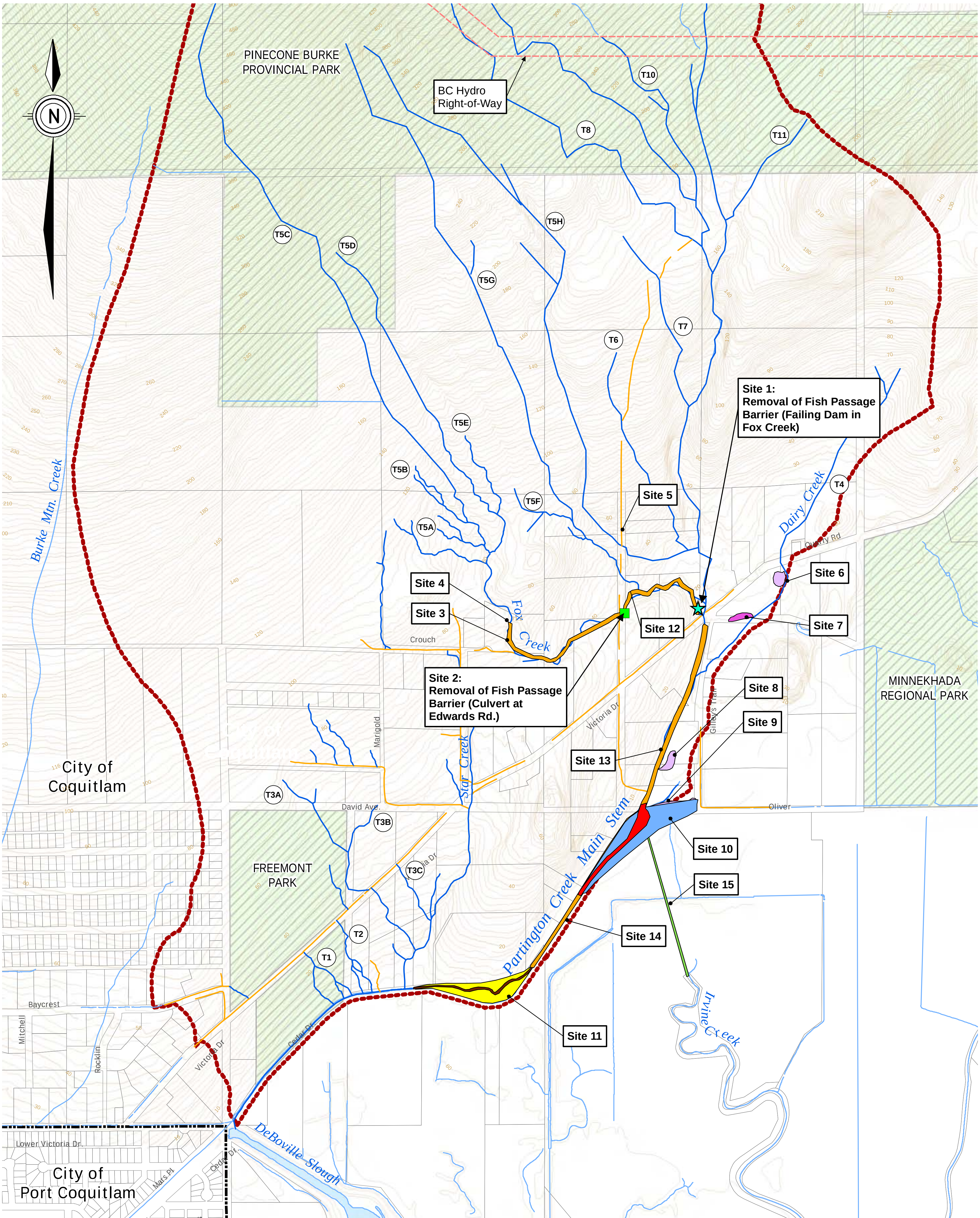

Legend

- Watershed Boundary
- Park
- Watercourses Mapped by City, but not Confirmed by Study Team
- 20m Contour
- Existing Creek Channel
- Ditch
- T1 Tributary ID
- Floodplain Creation Site (Private Land)
- Floodplain Creation Site; Relocation of Road and Dyke; Creation of Sediment Trap
- Low and High Flow Diversion (Pipe or Open Channel) to restor Flows to Old Partington Creek Channel
- Potential Low-Gradient Instream Enhancement Reach (Log and Boulder Placements)
- Potential Off-Channel Pond (Private Land)
- Potential Off-Channel Pond (Public and Private Land)
- Relocated Channel with Complex Instream Habitat
- Relocated Channel with Sediment Trap

* Refer to Table 8-6

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Aquatic Habitat Enhancement and Restoration Opportunities

Figure 6-4

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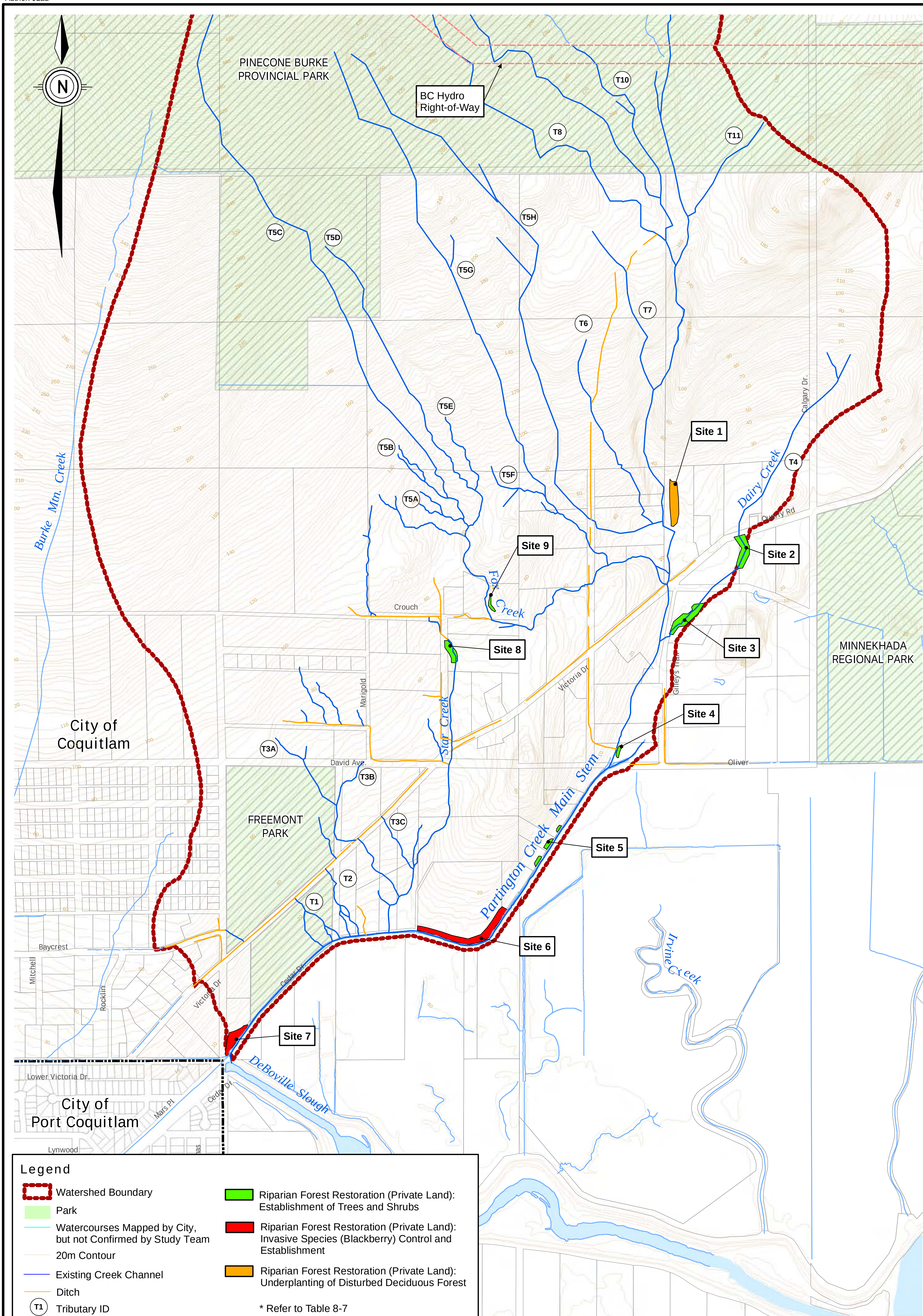

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Scale in Metres

Riparian Habitat Restoration and Enhancement Opportunities

Figure 6-5

Section 7

Develop and Evaluate Concept Alternatives

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7. DEVELOP AND EVALUATE CONCEPT ALTERNATIVES

7.1 KEY WATERSHED ISSUES

The following table summarizes the key watershed issues.

Table 7-1: Summary of Watershed Key Issues

Engineering	**Sedimentation and Flooding** ▪ Considerable sedimentation and reduce conveyance capacity in lower reach of Partington Creek. Creek flood flows overtop Cedar Drive, spilling into ALR. ▪ Existing lowland (farmland and Metro Vancouver Park) flooding. Substandard DeBoville Slough and Pitt River dykes (crest lower than 200-year water levels), pump station and floodgates to protect agricultural areas. (Outside of the Partington watershed boundary and the scope of this study) ▪ Balance maintenance activities and aquatic values. DFO has concerns about sediment removal and impacts to fish and their habitat. ▪ Existing sedimentation in DeBoville Slough. ▪ Existing flooding at Oliver Road/Cedar Drive and Crouch Ave/Pollard St. **Creek Hazards** ▪ Creek fan (possible channel movement) upstream and downstream of Quarry Road. ▪ Moderate risk for debris floods. **Development** ▪ Mitigate hydrologic impacts of development (increased flows and frequency of flows) – exacerbating flooding, impacts to DeBoville Slough water levels/sedimentation and impacts to dykes. ▪ Investigate major event post-development flood routing for future development including upland Hyde Creek Development Reserve area. **Hydrogeology** ▪ Limited infiltration/storage potential given shallow glacial till soil cover over bedrock and steep slopes.
Land Use	▪ NECAP future residential and commercial development. ▪ Increase watershed impervious area from 3% to 22%. ▪ Space limitations for source controls in high density low rise land uses. ▪ Balance human needs with environmental and engineering needs. ▪ Coordinate with Partington Creek Neighbourhood Plan.
Environmental	▪ Very healthy watershed, B-IBI score 31 is the 4^{th} highest in 34 Metro Vancouver streams. ▪ Rich fish community (14+ species including 3 species at risk). Protect fish populations including the large chum salmon population. ▪ Maintain summer baseflows. ▪ Maintain forest cover for hydrology and biodiversity values. ▪ Strong riparian corridor and integrity. Establish sufficient riparian setbacks for aquatic habitat protection and wildlife habitat including Pacific Water Shrew. ▪ Maintain stream channel morphology; mitigate changes to hydrology due to development. Prevent excessive flushing of stream from increased post-development flows. ▪ Maintain wildlife corridors and connections to large protected areas. ▪ Protect red and blue listed fish, wildlife, and plant species. Manage invasive plants. ▪ Maintain water and sediment quality and habitat in Partington Creek and DeBoville Slough.

7.2 INTEGRATED WATERSHED MANAGEMENT ALTERNATIVES

Three conceptual alternatives were developed for the IWMP. These concepts integrate directly with the *Partington Creek Neighbourhood Plan* (PCNP) draft land use plan. They are identified as Alternative A, B, and C. There is no favoured alternative at this point – all three are equally under consideration.

The purpose of the alternatives is to identify the 'book-ends' of potential solutions for both the IWMP and PCNP. By reviewing alternatives, the consulting team, staff and public gain a better understanding of the implications of various approaches. New ideas come out of the process, and established ideas are refined. In the end, the review of alternatives allows a more informed choice of the best features of each alternative for the final recommended plan. The point of the study is to find which features or combinations of features provide the 'optimum' result. It is unlikely that the final recommendations will be for one of the alternative plans. It is more likely that a blending of the plans will be the best solution.

Table 7-2 in Appendix L provides a detailed comparison of the key differences among the alternatives. The comparison is organized under Environmental, Land Use, and Stormwater Alternative Concepts.

Each alternative is highly schematic. However, the alternatives are sufficiently developed to allow for comparison. The preferred and best aspects of the alternatives will be brought forward with refinements during the development of the recommended plan.

The land use planning, engineering and environmental details of each of the three alternatives are presented in Sections 7.3 to 7.7.

7.3 LAND USE PLAN (DRAFT)

The figure in Appendix H provides a graphic illustration of the draft land use plan for the area. Note that road alignments, land use distribution and parcel pattern are schematic, and are not intended to represent final recommendations. Key objectives for the draft land use plan:

- Strive to meet the objectives of NECAP.
- Show the general neighbourhood designations (B, I, J, K, L, and Village Core) in NECAP (boundaries vary).
- Meet the conceptual housing mix targets of NECAP.
- Generally envision the residential housing forms and densities anticipated by NECAP.

- Provide park sites in quantities anticipated in NECAP (locations vary).
- Provide a Neighbourhood Centre that meets the objectives of NECAP and the City's development goals.
- Provide Neighbourhood Commercial as anticipated by NECAP.
- Protect existing watercourses (some local exceptions considered at non-permanent, non-fish bearing streams).
- Protect watercourse riparian areas in accordance with the Riparian Area Regulation at a minimum (some alternatives consider wider riparian areas which would involve park dedication or land purchase).
- Protect selected forest areas in areas that are constrained to development due to steep slopes or lack of access.
- Attempt to recognize existing parcel boundaries and the constraints of phased development.

The planning alternatives are being developed in the concurrent *Partington Creek Neighbourhood Plan.*

IMPERVIOUS AREA OF NEIGHBOURHOOD PLAN ALTERNATIVES

In considering stormwater impacts, the effect of urban development on the small drainage basins is important, as the new impervious area may take up a large percentage of the drainage basin, leading to large changes in flow regime in the small creeks. In the Partington Creek watershed, sub-basins like those of Star Creek or other smaller tributaries of Partington Creek deserve closer analysis.

Figures 7-1 to 7-3 in Appendix L show the Partington Creek watershed roughly divided into smaller drainage basins and indicate how these basins outfall into the various tributaries. Note that the exact boundaries between these drainage basins may change slightly once the road pattern is finalized and storm pipes are arranged.

7.4 ENGINEERING ALTERNATIVES

The engineering alternatives focus on:

1. Mitigating the impacts of development by providing:
    - Post-development volume reduction using on-site source controls or baseflow augmentation facilities (released at infiltration rates) to mimic pre-development

conditions and minimize watercourse degradation from everyday rainfall events and sustain baseflows.

- Post-development detention to pre-development levels for the 6-month, 2-year, 5-year using surface or underground facilities (ponds or tanks/trenches) or diversions to minimize watercourse degradation from mid-sized storm events.

- Water quality treatment of 90% of annual runoff from impervious areas using ponds, wetlands, or source controls. The 90% target is selected as an economically feasible amount where the runoff from small rainfall events is treated while larger events overflow or bypass the treatment process. Enlarging the treatment facilities to treat more than 90% of annual runoff has diminishing returns and would be prohibitively expensive.

- Safe flood conveyance and protection for 100-year event.

2. Addressing lower channel sediment management.

3. Mitigate impacts to DeBoville Slough.

4. Addressing existing flooding problems.

The engineering aspects of the three alternatives are described below.

ENGINEERING ALTERNATIVE A

Alternative A recognizes the constraints on-site source controls given the steep nature of the developing area and proposes minimal source controls for pervious areas only (replacing disturbed soil areas with adequate absorbent soil layer and vegetation) and regional facilities for water quality (WQ), volumetric reduction, and detention as well as a diversion into the DeBoville Slough for post development flows for the western and mid parts of the development and the Hyde Creek development reserve area. The engineering components of Alternative A are shown on Figure 7-1 in Appendix L and include the following:

- 400 mm of absorbent soil on all pervious surfaces disturbed by development;

- regional WQ treatment / baseflow augmentation facilities for the western and mid portions of the development area, together with a high flow diversions into the DeBoville Slough for flows in excess of the 5-year pre-development flows;

- diversion of all flows greater than 5-year pre-development to DeBoville Slough for the western and mid portions of the development area (includes a siphon on Victoria Drive);

- disconnected roof leaders in the rural area;

- regional WQ treatment / baseflow augmentation / detention up to 5-year event ponds for the roads in the rural area;
- minimal culvert and bridge upgrades due to reduced flows resulting from diversions; and
- large scale sediment removal in 2011 followed by annual sediment removal from strategic creek sections.

ENGINEERING ALTERNATIVE B

Alternative B recognizes that the development of the Partington Creek watershed will occur over the next three to twenty years and that there will be ongoing technological advancements in the future. Some of today's more advanced, innovative technologies will be further developed and more efficient and affordable during the development of Partington and new technologies will emerge. Examples of these upcoming advancements may include dual plumbing and water reuse, permeable pavements, and green roofs. The engineering components of Alternative B are shown on Figure 7-2 in Appendix L and include the following:

- 400 mm of absorbent soil on all pervious surfaces disturbed by development;
- provide 300 mm thick green roofs, roof runoff reuse for irrigation and/or toilets, regional WQ treatment ponds/wetlands, and baseflow augmentation facilities for roads and lots in the Village core;
- construct rain gardens for both roofs and paved areas where slope is <20%, except in Village Core;
- construct a post-development flow diversion into the DeBoville Slough for flows in excess of the pre-development flows for the western portion of the urban area (no siphon required with the alignment shown through Freemont Park);
- construct infiltrating tree wells for roads in single family areas;
- construct regional detention up to 5-year event ponds for the eastern and mid development areas not serviced by the diversion;
- disconnected roof leaders, roadside rain gardens and detention up to 5-year event ponds for the roads in the rural area;
- upgrade culverts and bridges identified in the Section 5;
- raise Cedar Drive to act as a dyke to prevent flood overtopping during events up to 200-year return;

- partial sediment removal from identified creek sections in 2007 followed by annual sediment removal from strategic creek locations until desired creek bed invert is achieved; and

- construct a gravel sediment trap at Oliver/Cedar intersection and a sand sediment trap at mouth of Partington Creek (removals as required every 3-4 years).

Because the ground slope and development density dictate the achievable extent of on-site source controls, there is some variability in how and where the above features can be applied. Table 7-3 in Appendix L shows how they could be applied to each land use type/density and ground slope.

ENGINEERING ALTERNATIVE C

Alternative C is much the same as Alternative B except that it strives to achieve the full water quality, volumetric reduction, and detention for storms up to 5-year return period on-site without diversions using source controls and on-site underground detention. This alternative also strives to reduce building footprints and impervious areas and therefore the source controls/detention facilities would be slightly smaller than in Alternative B. The engineering components of Alternative C are shown on Figure 7-3 in Appendix L and include the following:

- 400 mm of absorbent soil on all pervious surfaces disturbed by development;

- provide 300 mm thick green roofs, roof runoff reuse for irrigation and/or toilets in Village core;

- construct rain gardens for both roofs and paved areas where slope is <20%, except in Village Core;

- construct infiltrating tree wells for roads and lanes, roof runoff reuse for irrigation and/or toilets in single family areas;

- roof runoff storage and reuse in Village Core;

- construct roadside rain gardens in rural areas;

- construct underground on-site detention up to 5-year event throughout;

- upgrade the culverts identified as undersized in Section 5;

- remove the bridges along Cedar Drive and provide access to properties from Victoria Drive above;

- offset and raise Cedar Drive to widen the floodplain and prevent road overtopping during event up to 200-year return;

- construct gravel sediment trap at Oliver/Cedar intersection (removals as required every 3-4 years); and

- widen floodplain pockets along Lower Partington Creek to settle out sands (removals as required every 3-4 years).

Stormwater Injection into Underlying Aquifer Not Considered Viable

Stormwater injection into the underlying aquifer was considered as an innovative stormwater solution. The concept involves collecting stormwater, providing adequate pre-treatment, and discharging it to well shafts at strategic locations to the underlying aquifer. Groundwater recharge and baseflow protection are considered a high priority in this watershed. This concept was explored as follows.

1. Reported well yields within the Partington Creek watershed are generally less than 10 US gallons per minute. This indicates that any aquifers located within the Partington Creek watershed generally exhibit low permeability and, based on available well logs, do not conduct significant quantities of water to supply wells. Injection wells are generally less efficient than groundwater supply wells and would require a significant number of wells to be capable of injecting the necessary quantities of stormwater over a short period of time.

2. The aquifers within the watershed exhibiting the highest permeability are located at low elevations and near the Fraser River floodplain. Because the water table is close to surface adjacent to the floodplain, there is little additional storage available within these aquifers.

3. Because the groundwater resource is currently used to supply domestic potable water within the watershed, protection of its drinking water quality is paramount. Stormwater pre-treatment, and surface water and groundwater monitoring to verify water quality would be expensive.

4. Groundwater injection wells require frequent maintenance in order to function optimally. This maintenance is often costly, especially given that numerous wells would be required to recharge large storm flows to the groundwater system within this watershed.

Given the low permeability of underlying aquifers and the expense to protect groundwater quality, recharge of stormwater to underlying aquifers using groundwater injection wells was ruled out as a viable option at this location.

Groundwater recharge and baseflow protection will be addressed through infiltrating source controls.

7.5 LOWER PARTINGTON SEDIMENT MANAGEMENT ALTERNATIVES

BACKGROUND

In 1998, accumulated sediment was removed from a long section of stream channel to address flood risk. Approximately 800 tandem dump truck loads of material were removed resulting in a lowering of the channel bottom up to 1.5 m. Since that time, deposition has gradually raised the channel bed to current levels. As a response to the flooding and damage caused by the January 2005 rainfall event, the City sought to complete another round of sediment removal. Recommendations for mitigating the impacts of gravel removal on fish habitat were presented in a letter by Raincoast Applied Ecology to the City dated July 12, 2005. Following discussions with DFO, the City decided to wait until this IWMP was completed before conducting any sediment removals.

TYPICAL STEPS IN DEVELOPING SEDIMENT MANAGEMENT STRATEGIES

Erosion, gravel bedload transportation, and deposition are natural processes that occur episodically in all creeks; however, in urban streams these processes become hazards due to the problematic conflict between infrastructure and development and the watercourse. Erosion and gravel bedload transport generally only occur in higher average flows, typically once or twice a year in natural creeks, but more often in urban creeks due to the quick response of the urban watershed and more frequent peak flows.

Sediment deposition typically occurs broader sections of creek channel, and in lower gradient areas. In the upper steep areas of most creeks, the larger sized cobble and boulder material typically form bed structures such as steps, rapids, and pools, where the creek channel is usually narrow and well confined. At transition areas between steep slope areas and lower gradient sections, depositional areas known as alluvial or creek fans are formed. Fans will often form at the intersection of slopes and the floodplain (i.e. Fraser River floodplain) or the ocean and can also occur on the mountainside. Flooding, and lateral erosion is often common on fans as gravel and cobble is deposited. Fans lower in a creek system may also represent the limit of gravel transport. In these type of features, there is not sufficient energy (grade) in the creek to transport gravel any further, and therefore no erosion of gravel bedload is possible, and deposition will continue to occur indefinitely. If the creek has been constrained, and there is insufficient capacity to store bedload, flooding becomes a very common problem.

These types of urban creek systems need long-term management strategies to address the gravel bedload in accumulations in a systematic manner that considers the rate of accumulation, the required capacity for flood conveyance, and the in-stream aquatic habitat, as these areas are often spawning areas for salmon. To begin to address the problem, usually the following steps are taken:

- collect all data regarding former creek channel surveys, mapping, and former gravel removals;
- conduct a current topographic survey and develop a sediment budget, if possible;
- relate to local hydrometric records if available;
- assess local aquatic habitat use;
- determine desired levels of gravel removal based on a flood analysis; and
- develop a sediment management plan based on consideration of the above, and subject to discussions with the environmental agencies.

The above level of detail is beyond the scope of the current IWMP study.

SEDIMENT MANAGEMENT OPTIONS FOR PARTINGTON CREEK

For the purposes of this report, various alternatives were conceptually considered. The sediment in Lower Partington Creek is composed of gravels which tend to deposit near the intersection of Oliver Road and Cedar Drive and sands which tend to deposit in the last kilometre of the creek and in the DeBoville Slough.

The sediment can be managed by periodic removals from the creek bed in strategic locations, or by constructing sediment traps, or through a combination of the two. Removals of gravel from the creek bed tend to disturb the aquatic habitat and DFO approvals are necessary before commencing such works. Potential impacts to fish and fish habitat from conventional gravel removals are discussed in Section 7.7. The impacts can be reduced if only the tops of gravel bars are removed during low water.

Furthermore, the frequency of removals can be reduced by increasing the width of the creek floodplain and increasing the depositional area. This could be done by cutting into the slope on the north bank in several places thereby creating wider sections that would promote deposition. It could also be accomplished to a greater degree if the entire (or significant) length of Cedar Drive was offset to the south into the agricultural area. Both of these methods would give the creek more area and volume for deposition; sediment removal frequency would be reduced. This would also have the added benefit of allowing the creek channel natural movement within a wider floodplain and would increase and enhance riparian areas and therefore watershed ecological health. Issues such as cost and negotiations with the Agricultural Land Commission (ALC) are disadvantages.

For the sediment trap option, a very rough and preliminary estimate of size was determined. For the purposes of this report a typical sediment yield range was roughly estimated using regional analyses (Church et al., 1999[5]). The upper envelope for sediment yield for a 6.5 km^2 watershed is approximately 500 kg/km^2/day which equates to approximately 540 m^3 per year for Partington Creek. Examination of the British Columbia watersheds, including Pemberton Creek, Lynn Creek, and Miller Creek,

[5] Church et al., 1999. Fluvial clastic sediment yield in Canada: scaled analysis. Canadian Journal of Earth Sciences, 36: 1267-1280.

suggests a maximum sediment yield of approximately 100 kg/km^2/day which equates to approximately 108 m^3 per year. Using the upper limit of this range it can be estimated that a 2,500 m^3 sediment trap (50 m x 50 m x 1 m deep) at the intersection of Oliver Road and Cedar Drive, as shown on Figure 7-2 in Appendix L, would take 4 years or more to fill up. A sediment budget study is needed to refine the sediment volumes and sediment trap sizes.

Appendix I includes a letter report entitled *Fish Habitat Assessment of Proposed Gravel Removal Site on Partington Creek* by Raincoast Applied Ecology dated July 2005. It summarized the potential impacts and mitigation measures for gravel removals in Lower Partington Creek.

7.6 FLOOD MANAGEMENT ALTERNATIVES

The type of works required to manage flooding and erosion depend on the selected measures to mitigate the hydrologic impacts of development and sediment management. However, each alternative includes some culvert and bridge upgrades. Furthermore, to prevent the overtopping and subsequent erosion of Cedar Drive and flooding of lowlands, a combination of sediment removal and/or Cedar Drive rising is included in each alternative.

7.7 ENVIRONMENTAL ALTERNATIVES

The comparison of the environmental implications of the three alternatives was divided into four components:

1. riparian forest;
2. upland habitat;
3. wildlife habitat; and
4. fish habitat.

ENVIRONMENTAL ALTERNATIVE A

Alternative A maintains core environmental values, including fish and wildlife habitat, through the implementation of the provincial riparian areas regulation along all streams and upslope forest protection in limited park areas.

For most streams in the Partington watershed, riparian buffers are estimated to be between 10 and 15 m from the high water mark (e.g., 3 times channel width). Larger buffers will be required along the Partington Creek Main-stem and in stream segments within ravines. Some riparian reforestation could occur in areas currently cleared or landscaped. Riparian buffers adjacent or within parks may be larger.

Upland habitat will focus on protecting forests in areas of steep slopes as well as in park areas including Freemont Park. Additional rock bluffs and patches of upslope coniferous forest such as Douglas-fir forest associated with dry rocky areas will not protected. Minor tree protection in school sites and smaller municipal parks will be accomplished where possible however, this is expected to be minimal because of the difficulty in ensuring wind firmness in small forest patches.

Wildlife habitat protection will focus on habitat in riparian areas and forested parks, and by maintaining habitat connections to undeveloped areas to the north. Many wildlife species will decline because of the reduced amount of forest. For example, populations of Douglas' squirrel, brown creeper, and owl species are expected to decline in the lower watershed. Habitat for wildlife associated with riparian areas will also be reduced, particularly for species that require interior forest conditions. Conflicts between wildlife and humans may increase as the amount of habitat is reduced and historic habitat connections are severed. Wildlife habitat enhancement such as the creation of snags or the addition of downed logs could be incorporated into retained forest areas.

Fish habitat protection will focus on minimizing changes to summer base flow and storm flows (see Section 7.4), minimizing stream crossings (one new crossing of Fox Creek is planned) or other direct modifications to stream channels, and riparian protection. Fish habitat enhancement is included as a separate activity described later in this section.

ENVIRONMENTAL ALTERNATIVE B

Alternative B includes more habitat protection compared to Alternative A including riparian buffers along important stream areas that are wider than provincial standards and more upslope habitat protection.

Riparian protection will use a mixed approach including: (1) wider riparian buffers (20–30 m) on larger streams; and (2) more narrow (10–15 m; same as Alternative A) buffers on a small number of streams that have been previously disturbed. Riparian habitat restoration may occur along the lower Partington Main-stem if floodplain restoration is undertaken. Riparian restoration could also occur in previously disturbed areas to increase riparian forest.

Upland habitat protection would be similar to Alternative A (Freemont Park, smaller municipal parks, steep slopes) with the inclusion of the large rock bluff area (rock knob) overlooking the Pitt River lowlands. Rock bluffs are a rare habitat in the Coquitlam area and some may be considered a threatened habitat by the BC Conservation Data Centre.

Wildlife habitat protection is similar to Alternative A in that it focuses on riparian forest protection and some upslope habitat areas in parks, however, riparian corridors would be wider. Riparian-dependent wildlife will benefit from wider riparian corridors with more interior forest. Larger riparian buffers may also reduce human-wildlife conflicts by providing adequate travel corridors for bears and coyotes. Populations of focal wildlife such as Douglas' squirrel and brown creeper that depend on larger patches of conifer forest will decline. Wildlife habitat enhancement such as the creation of snags or the addition of downed logs could be incorporated into retained forest areas.

Fish habitat protection includes riparian buffers that are generally wider than those required under provincial standards. Wider riparian areas encompass more floodplain areas as well as areas for future fish habitat restoration (e.g., off-channel ponds). One new stream crossings is proposed; this is the same as Alternative A. Stormwater management issues are addressed in Section 7.4.

ENVIRONMENTAL ALTERNATIVE C

Alternative C includes wider riparian buffers compared to the provincial riparian areas regulation and increased protection of upslope habitats to maintain wildlife populations.

Riparian protection uses 30 m buffers on all streams except for roadside ditches. Riparian habitat restoration may occur along the lower Partington Main-stem if floodplain restoration is undertaken. Riparian restoration could include reforestation in existing cleared or landscaped areas.

More upland forest and other habitats are protected because increased development density allows for more protection of parks and natural areas. Freemont Park remains the largest upslope forest area but other parks encompass rock bluffs, patches of coniferous forest, and steep slopes. Where possible, forested parks and other upslope habitats are linked using riparian corridors and greenways to improve habitat connectivity.

Wildlife habitat protection and connectivity is increased over Alternatives A and B. Larger riparian buffers and more upslope forest increase the amount of habitat for some focal wildlife such as Douglas' squirrel. Connections between parks and riparian areas also promote wildlife use and may reduce human-wildlife conflicts by maintaining sufficient habitat outside of urban areas. Wider riparian areas along lower Partington Creek may also maintain seasonal wildlife use associated with chum salmon spawning.

Like Alternative B, riparian buffers are generally wider than those required under provincial standards. Wider riparian areas encompass more floodplain areas as well as areas for future fish habitat restoration (e.g., off-channel ponds). One new stream crossings is proposed; this is the same as Alternative A. Stormwater management issues are addressed in Section 7.4.

FISH HABITAT ENHANCEMENT

There are three general strategies for fish habitat enhancement in the Partington Creek watershed. They are considered separate from the land use and stormwater management alternatives described in the previous sections. The benefits of these strategies should be incorporated into the overall assessment of the environmental implications of the alternatives.

1. Remove fish passage barriers on lower Fox Creek (old dam: BRG001+BRG002), culvert barrier at Edwards Road on Fox Creek (CUL005), and culvert barriers on T5H tributary (CUL004 and CUL017 at Edwards Road). This will provide access to new habitat for coho and chum salmon.

2. Increase habitat complexity in the reach of Partington Creek between the Oliver/Cedar corner and the Victoria Drive bridge. This should include the installation of boulder clusters, rootwads, and large anchored logs. The lack of in-stream complexity reduces the fish habitat value of this reach.

3. Restore floodplain habitat along lower Partington Creek and incorporate off-channel habitats (ponds, wetlands, etc) and complex stream channel features (meanders and in-stream logs). Existing channel morphology in the lower channel limits opportunities for fish habitat enhancement because of flood risks. However, restoration of floodplain areas will allow for more diverse fish habitat to be created in combination with activities to reduce flooding and address sediment management. Riparian habitat restoration should be undertaken as part of floodplain restoration.

7.8 EVALUATE ALTERNATIVES

The alternatives contain many stormwater, environmental protection and land use planning solutions. It is not the intent that one of the three alternatives will be selected as a whole, but rather that components from each alternative be assessed and evaluated. The recommendations for the watershed management plan are likely to be a blend of components from the three alternatives, rather than a choice of one alternative.

A multi-account system was set-up for the technical evaluation as shown in Table 7-4 in Appendix L. There is a separate evaluation for five key stormwater and ecological components, as follows:

1. mitigate hydrologic impacts of development – volume reduction/water quality treatment;
2. mitigate hydrologic impacts of development – detaining post-development flow to pre-development levels;
3. provide adequate flood conveyance;
4. riparian protection for fish and wildlife; and
5. upslope habitat for wildlife and greenspace.

The land use alternatives will be evaluated under the Partington Creek Neighbourhood Plan and therefore do not appear in the table.

For each component, an evaluation criteria and brief descriptions are outlined. Members of the Steering and Advisory Committees were asked to select their preferences from each component. For example, the first table seeks input for selecting a preference to address volume reduction and water quality treatment. The choices are:

a. water quality/baseflow augmentation ponds,
b. infiltration source controls, and
c. innovative source controls including stormwater reuse.

For the public open house process, a ‘summary’ evaluation was used, combined with a detailed public open house response form that focuses on the issues.

The stakeholder and public input to the alternative components is summarized in the next section and were used to assess the alternatives and determine preferred mitigation measures to proposed in the watershed management plan.

Section 8

Direction for IWMP Strategy

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8. DIRECTION FOR IWMP STRATEGY

8.1 INTRODUCTION

CITY'S RAINWATER MANAGEMENT REQUIREMENTS/GUIDELINES

Since the Phase 3 Alternatives Draft Report was submitted in February 2007, the City put the Partington Creek IWMP study on hold while they reviewed of their low impact development (LID) policies in light of recent development in the Hyde Creek watershed immediately west of the Partington Creek watershed. As a result of this review, the City replaced the *Low Impact Development Policy and Procedures Manual 2005* with the *Rainwater Management – Source Controls Design Requirements and Guidelines 2009* included in Appendix J.

PARTINGTON CREEK LAND USE ASSUMPTIONS

The proposed land uses assumed within the development of the IWMP are based on the PCNP Conceptual Land Use Plan dated May 2007. For areas outside the PCNP, the Northeast Coquitlam Area Plan (NECAP) land use designations were used.

RECAP WATERSHED GOALS AND CRITERIA

In 2009 the watershed goals and criteria were revisited and added to as follows:

- Strive for a no-net-loss of ecological health for Partington Creek watershed as a whole.

- Provide a Net Environmental Benefit for fish and fish habitat in the watershed.

- Apply DFO's *Urban Stormwater Guidelines for the Protection of Fish and Fish Habitat* – 6-month volume reduction, 6-month, 2-year, 5-year rate control, and water quality treatment for 90% of annual runoff. The 6-month 24-hour volume reduction target of 63 mm was found to be appropriate for this watershed by examining the recorded stream flows following a 110 mm dry initial condition rainfall event (September 28-29, 2005) which resulted in a flow volume of 40 mm over the watershed area. Therefore the watershed captured 70mm of rain in this event.

- Apply the *Riparian Area Regulation* (RAR) requirements to aquatically significant watercourses.

- Apply the City's Rainwater Management Guidelines to mimic the natural hydrology of the watershed and compensate for the loss of constructed ditches that have minimal aquatic habitat value.

- Apply the City's flood conveyance criteria of 100-year major drainage system and appropriate flood protection within the floodplain.

These goals and criteria, together with stakeholder input from Phases 1 to 3, were applied in the development of the IWMP Strategy.

Figure 8-1 shows the importance of stormwater impacts of increasing urbanization (decreasing riparian and increasing impervious area) on fish.

8.2 STAKEHOLDER INPUT AND GUIDANCE

The meeting records for the Advisory Committee meetings and a summary of input from the Advisory Committee and the public regarding the IWMP alternatives are included in Appendix E. The items that were strongly preferred by the Advisory Committee, City Council, and Staff are summarized as follows:

- environmental protection was widely valued;
- increased riparian setbacks for all streams;
- maximized forest cover;
- widened corridors for wildlife migration to prevent conflicts with humans and improved wind firmness & community amenity;
- maximize green space and conservation areas;
- full hydrologic mitigation through source controls, diversion, and ponds;
- widening Partington Main-stem;
- regular sediment removal;
- re-instating flows to Irvine Creek;
- maximize use of diversions instead of detention ponds;
- apply the *Rainwater Management Source Control Requirements and Guidelines;*
- apply the *Riparian Area Regulation*; and
- relocate and raise Cedar Drive as a dyke to protect farmland to an appropriate level of protection as a long term strategy.

GUIDANCE INTO DEVELOPMENT OF IWMP STRATEGY

The stakeholder preferences and input provided guidance into the development of the IWMP Strategy.

8.3 PRESERVATION OF RIPARIAN AREAS IN ACCORDANCE WITH RAR

The *Riparian Areas Regulation* (RAR) was enacted under Section 12 of the *Fish Protection Act* in July 2004. These setbacks will be preserved and enhanced with restoration works.

Partington Creek has strong riparian forest integrity because the forested headwaters and tributaries protected in the Pinecone Burke Provincial Park and proposed conservation areas north of Fox Creek. The proposed setbacks in accordance with RAR will be approximately 24 m on Partington Main-stem and 10 m on Star, Fox and Dairy Creeks.

The RFI related to ecological health is based on 30 m setbacks each side of the creek. The RAR setbacks in the urbanizing areas calculated as a 10% loss in RFI in Partington Creek and therefore as a loss in ecological health as shown on Figure 6-2.

Recent critical habitat mapping by the Pacific Water Shrew Recovery Team (2009) used a buffer 100 m wide on each side of small streams to protect known occurrences of Pacific water shrew. They noted: "The 100 m area of critical habitat on each side of the watercourse is likely sufficient to buffer the riparian microclimate from edge effects in the long term, as well as from potential damage from run-off from adjacent developments, roads or agricultural fields."

Based on existing land cover patterns, connectivity between different areas of the watershed and between the watershed and adjacent habitat is generally unimpeded. Planning for wildlife habitat and connectivity, including Pacific water shrew protection, is acknowledged and considered in the IWMP, but is specifically addressed in the PCNP where land use decisions are investigated.

8.4 NEW RAINWATER MANAGEMENT - SOURCE CONTROL GUIDELINES

The allowable measures within the *Rainwater Management – Source Controls Design Requirements and Guidelines 2009* are summarized as follows:

Table 8-1: Rainwater Management –Source Control Guidelines, March 2009

- Minimum 300 mm absorbent topsoil for all grassed and vegetated areas;
- Single-family Residential Lots:
  - Grade hard surfaces (sidewalks, driveways, parking pads, patios) toward lawn/planted areas;
  - Encourage connection of roof downspouts to rain barrels with soaker hoses;
  - Encourage permeable pavers;
- Multi-family Residential, Commercial, Institutional, Industrial Lots:
  - Design, certify and inspect volume reduction, water quality treatment and on-site retention systems;
- Roadways in Urban Residential Areas:
  - Require surface swales and bio-filtration facilities where allowed or utilize boulevard retention trenches.

The most significant change resulting from the new policy is that single family residential lots would not be required to fully mitigate their effective impervious area (EIA) increase on site. Also, the roadway standard would not fully mitigate EIA at the source. In light of this new policy, the alternatives for Partington Creek were revisited and regional facilities were considered downstream of single family areas where needed. Refer to Figure 8-2 IWMP Alternative - Maximize Diversions and Figure 8-3 IWMP Alternative - Diversion and Ponds in Appendix L.

8.5 MINIMIZING EFFECTIVE IMPERVIOUS AREA

Minimizing the effective impervious area (EIA) has a predominant effect on ecological health as shown in Figure 8-1. EIA can be minimized by meeting the stormwater volume reduction target (63 mm) in disturbed developing areas. Volume reduction is typically achieved through stormwater source controls.

It is assumed that with the City's *Rainwater Management – Source Controls Design Requirements and Guidelines* that volume reduction would be entirely achieved on the multi-family residential, commercial, institutional, and industrial lots with full source controls and partially achieved on the single-family residential lots and roadways.

The PCNP land use planning study will consider taller buildings with smaller footprints resulting in 10-12 storey buildings for multi-family in the Village Core. This will help to ensure that full stormwater volume reduction can be achieved on-site for multi-family land uses in that it will allow space to incorporate ground-level source controls.

Through the City's required source controls, EIA can be reduced to 12% watershed wide. This is a substantial reduction in the TIA which is estimated to be as high as 22% if no source controls were implemented. This assumes that the full stormwater target of 63 mm will be captured in the source controls (including road source controls). An EIA of 12% is greater than the current EIA of 3% and therefore will negatively impact watershed health. Additional measures would help to preserve watershed health.

OPTIONS TO SUPPLEMENT CITY SOURCE CONTROLS

To maintain existing ecological health, the following options were considered and further developed or ruled out:

Table 8-2: Options to Achieve Additional 6-month Volume Reduction

Option to Capture 6-month Flow		Viability
1.	Regional underground baseflow release facilities	Prefer underground facilities to keep water cool as it will be stored for extended times.
2.	Stormwater injection into underlying aquifer	Technically not viable with low permeability underlying aquifer in lower watershed area.
3.	Divert frequently occurring flows to proposed diversion and supplement baseflow with pumped groundwater	Technically not viable with low permeability, low yield underlying aquifer in lower watershed area. Not sustainable with low groundwater recharge in developed areas.
4.	Convert all single family land uses to multi-family so full source controls could be applied	It is doubtful that all SF could be converted to MF due to market forces. One of the PCNP principles is to provide a variety of housing types that will serve a broad socio-economic population. There will be demand for SF housing – but the proportion of SF to total unit type could be challenged.
5.	Allow for wider road right-of-ways to provide source controls (sized for lots and roads) on public property for single family areas	Use treewells and/or larger swales / rain garden retention areas.
6.	Single family stormwater reuse	SFR toilets would not use enough stormwater in winter months to adequately reduce the EIA. This option would not help sustain baseflow in creeks.
7.	Pipe single family stormwater runoff to storage facility for reuse in higher density area(s)	Underground storage facilities at schools and public buildings.
8.	Offset EIA losses with gains in riparian enhancement	Riparian restoration within the RAR setbacks of all existing development encroachment results in 7% increase in RFI.
Smaller building footprints and impervious areas will allow for source controls on-site for land uses other than single family and in all land uses will require less down-slope mitigation.		

Options 1 and 8 were considered in the development of the IWMP.

8.6 INTRODUCTION OF BASEFLOW AUGMENTATION/RELEASE FACILITIES

Because single family areas will have limited source controls, there are two issues:

1. no volume reduction to meet DFO's *Stormwater Guidelines* that cause wearing away of creek banks and channels and habitat; and

2. lack of baseflow to the creeks.

Sustaining Baseflows - Baseflow Augmentation Facility

In areas serviced by diversions, volume reduction can be achieved by directing low flows as well as high flows to the diversion, however creek baseflows still need to be mitigated. On the Partington Main-stem with upper headwaters in the undeveloped forested park areas, it is assumed that adequate baseflows are sustained from headwaters. However on smaller tributaries, such as Star, Fox and Dairy Creeks, that have little or no undeveloped headwaters but are still valuable fish-bearing permanent watercourses, baseflow augmentation measures are needed.

Baseflow augmentation facilities (assumed to be rock trenches for costing, located underground to keep water temperatures low) were sized to sustain minimal baseflow (0.05 L/s/ha) to creeks during summer months (volume = 300 m^3/ha of contributing single family area catchment). This sizing was performed using a water balance spreadsheet which kept track of rainfall, runoff, storage, and outflow over a typical year of rain.

Mitigating Erosive Flows and Volumes – Baseflow Release Facility

In areas without the benefit of diversions where volumetric reduction needs to focus on capturing frequently-occurring flows to minimize creek erosion and destruction to fish habitat, baseflow release facilities (assumed to be rock trenches for costing, located underground to keep water temperatures low) were sized to meet 10% EIA by storing 90% of annual flows and releasing them at baseflow rates (0.5 L/s/ha maximum) and sustaining baseflows (0.05 L/s/ha minimum) during summer months. These Baseflow Release facilities are substantially bigger than the Baseflow Augmentation facilities with a unit volume of 1,000 m^3/ha of contributing single family area catchment.

8.7 ENVIRONMENTAL ENHANCEMENTS TO OFFSET LOSSES

The IWMP process strives to preserve watershed health as a whole, while meeting community needs to allow development to occur. It allows for tradeoffs so the environmental losses in one area within a watershed can be offset by gains in others, thereby meeting the watershed goals of preventing loss of stream health. Formal habitat compensation to meet DFO’s no-net-loss policy for productive fish habitat may also be required. Various environmental enhancements such as riparian restoration, in-stream complexing, and removal of fish passage barriers will be maximized.

INCREASED RIPARIAN SETBACKS AND IN-STREAM COMPLEXING ON MAIN-STEM

Fish and wildlife values are strongly valued in the watershed. The City proposed increased riparian setbacks and in-stream complexing along the Main-stem where there is high quality spawning habitat to provide a Net Environmental Benefit of Fish Habitat.

8.8 WATER QUALITY TREATMENT

Water quality source controls or regional treatment facilities are required for impervious areas exposed to vehicle traffic (roads, driveways, parking lots, etc), prior to discharge to creek.

Source controls, which also provide water quality treatment, were assumed for all land uses. However, the single family residential and potentially the Village Core source controls are likely inadequate to meet the watershed water quality treatment criteria. The roadways were assumed to have adequate source controls and water quality treatment to meet both requirements; however this may not be achieved on roads with steeper slopes. For the single family residential (approximately 77 ha within the PCNP area) and Village Core (approximately 10 ha) areas, regional water quality ponds/wetlands are proposed to address treatment not met by the site level rainwater source controls.

The regional water quality treatment facilities were sized based on holding the 6-month 24-hour event flows for a minimum of 24 hours for settling time. This resulted in a pond/wetland size of 325 m^3 per hectare of tributary impervious area which equates to approximately 230 m^2 of land required per hectare of single family residential development or 420 m^2 per hectare of Village Core.

Water quality treatment is not only required for the benefit of Partington Creek and its tributaries, but also to minimize water quality and sediment impacts to DeBoville Slough.

8.9 DETENTION STRATEGY

Feedback from the City and stakeholders indicated that there was preference for diversion pipes rather than detention ponds for rate control. Figure 8-2 in Appendix L shows an alternative with the diversion strategy maximized and Figure 8-3 in Appendix L shows the diversion and pond alternative. These figures also show proposed water quality ponds, baseflow augmentation and release facilities and RAR riparian setbacks and Net Environmental Benefit for Fish Habitat areas.

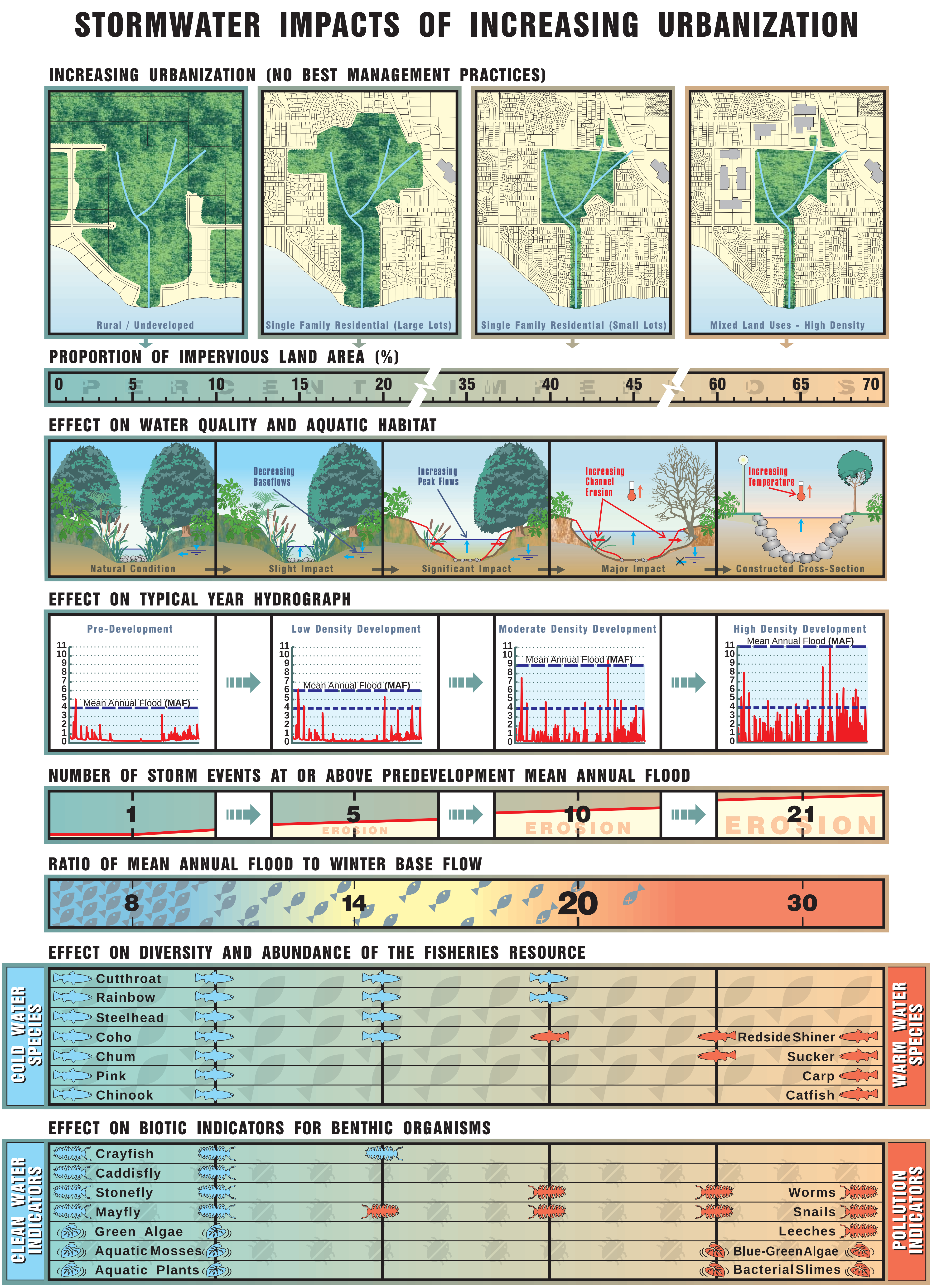

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Figure 8-1

Section 9

Proposed Partington Creek IWMP

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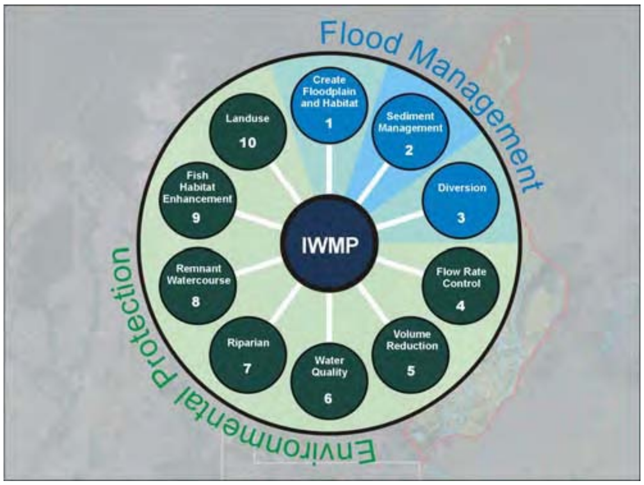
9. PROPOSED PARTINGTON CREEK IWMP

9.1 INTRODUCTION

The overall strategy for Partington Creek consists of many components for flood management and environmental protection as summarized in the following graph and in Table 9-1.

Recommended Components of IWMP



The Strategy was developed by incorporating preferred elements of the alternatives, taking into account the new Rainwater Management Source Controls policy, and including the updates and revisions to draft reports.

The IWMP Strategy is depicted in plan view on three figures and described in this section:

- **Figure 9-1: Hydrotechnical Upgrade Plan** that addresses safe flood conveyance for both existing and future conditions.

- **Figure 9-5: Hydrological Environmental Protection Plan** that addresses stormwater land development impacts for frequently occurring events.

- **Figure 9-7: Ecological Protection Plan** that addresses riparian preservation/ restoration and in-stream enhancements.

The conceptual land use layer (included in Appendix H) shown on the figures was developed in the PCNP and was presented at the June 21, 2011 public open house; proposed land use may change. The sizing of facilities in the IWMP is conceptual in nature and should be thoroughly assessed during pre-design. Cost estimates were separated into three categories: drainage maintenance items, Development Cost Charges (DCC) items, and 'By Developer/Owner' items (see Table 9-7).

Table 9-1: Summary of Partington Creek Integrated Watershed Management Plan

Sediment and Flood Management		
1.	**WIDEN MAINSTEM CHANNEL AND RELOCATE/RAISE PORTION OF CEDAR DRIVE**	
	▪ Acquire land and relocate/raise portion of Cedar Drive	
	▪ Acquire land to widen/complex additional main-stem channel	
	▪ Relocate full length of Cedar Drive along mainstem channel in long-term plan	
2.	**SEDIMENT MANAGEMENT PLAN**	
	▪ Construct a sand trap	▪ Remove instream sediment at designated locations
	▪ Construct a sediment basin	▪ Monitoring
3.	**CONSTRUCT FLOW DIVERSIONS & UPGRADE UNDERSIZED CULVERTS AND BRIDGES**	
	▪ Divert large flows & mid-range flows for environmental protection away from creek directly to Deboville Slough, baseflows and pre-development flows maintained within creeks	
	▪ Upgrade 17 culverts and 1 bridge	
Environmental Protection Measures		
4.	**HYDROLOGIC RATE CONTROL**	
	▪ Utilize diversion with specialized flow splitters to convey mid-range excess flows away from creek	
	▪ Widen the Lower Partington main stem channel to convey future flows	
5.	**HYDROLOGIC VOLUME REDUCTION**	
	▪ Apply City's Rainwater Management Source Controls requirements	
	▪ Construct 1 underground baseflow release facilities (minimize erosion/destruction of fish habitat)	
	▪ Construct 5 underground baseflow augmentation facilities on Star & Fox Creeks (sustain baseflows)	
6.	**STORMWATER QUALITY TREATMENT**	
	▪ Construct source controls for roads and parking lots	
	▪ Construct 8 regional water quality ponds/wetlands	
7.	**PROTECT RIPARIAN AREAS**	
	▪ Preserve excellent riparian areas within headwaters	
	▪ Apply RAR setbacks within developing areas	
	▪ Create enhanced 30 m riparian setbacks around Lower Partington main stem	
	▪ Reforest 4.8 ha of impacted riparian areas within RAR setbacks	
8.	**PROTECT EXISTING WATERCOURSES**	
	▪ Replace manmade ditches with source controls to sustain baseflows	
	▪ Preserve medium manmade ditches along Crouch & David Avenues that have natural headwater watercourses to support star creek with food and nutrients	
9.	**RESTORE INSTREAM COMPLEXING, FLOODPLAIN WETLANDS, OFF-CHANNEL HABITATS IN LOWER PARTINGTON MAIN STEM**	
	▪ Create and restore floodplain forest, marshes, side-channels, instream wood structures, boulder groups, boulder spurs, stable debris jams and gravel spawning platforms	
	▪ Create 40 instream structures: 5 on Fox Creek, 10 on Partington main stem between Victoria Drive and Cedar Drive, and 25 within lower restored Partington main stem	
	▪ Remove fish barriers and replace with fish passable structures: 1 bridge on Fox Creek, 5 culverts on Fox Creek, 2 culverts on Partington Creek/Partington Tribs, and 1 Culvert on Dairy Creek	
10.	**LAND-USE MEASURES**	
	▪ Land use areas were moved to preserve headwater watercourses (Item 8 above)	
	▪ Consider no isolated pockets of single family development in lower watershed or additional regional stormwater facilities will be required	
	Note: Refer to Figures 9-1 to 9-7.	

FOCUS ON PCNP DEVELOPMENT AREA AND NOT DAIRY CREEK

The IWMP Strategy is focussed on the Partington Creek Neighbourhood Plan (PCNP) development area. The OCP indicates that the area outside the PCNP area is zoned to be Rural Resource and Suburban Residential development. Refer to Figure 2-3. The time frame for development of this area, which includes the Dairy Creek catchment, may occur after the urban area is built-out. The zoning and stormwater criteria and technologies will change over time. Thus the City advised that the IWMP Strategy not be developed for areas outside the PCNP.

The servicing for the Dairy Creek catchment should be reviewed in detail in the future when development is more imminent. If development should take place in the meantime, the stormwater criteria outlined in this IWMP would still apply. Given the low density of this type of development, disconnected roof leaders and grading paved areas to pervious areas should be sufficient to meet the volumetric reduction and water quality targets. Detention for the 5-year and smaller storms may be required depending on the efficiency of the conveyance system. If ditches are used to service the area, detention may be achieved through ditch design.

9.2 INCREASE FLOOD CONVEYANCE FOR PARTINGTON MAIN-STEM

Currently lower Partington Creek overflows its banks and overtops Cedar Drive flooding the agricultural fields during the 2-year event. This is due to the creek being pinned between the existing low-lying roadway to the southeast and steepening ground to the northwest, and the channel aggrading with sediment. DFO hasn't allowed in-stream gravel removals in the past few years until this study is completed.

To address the existing flooding issues, multiple measures are required:

- sediment management;
- relocate and raise portion of Cedar Drive (remove existing private bridges in long-term); and
- widen section of Partington Main-stem.

These measures are also needed to provide safe flood conveyance for future development conditions together with additional measures.

SEDIMENT MANAGEMENT PLAN

Sediment continues to accumulate in the lower portion of Partington Creek constricting the hydraulic conveyance capabilities of the channel. Sediment is supplied naturally by the steep and unstable upper reaches of Partington Creek and accumulates in the low-gradient lower reaches. Channel confinement and sediment build-up reduces hydraulic conveyance capacity. Sediment management is proposed by:

1. identifying and designating sediment removal sites where impacts can be better managed; and

2. removing accumulated sand and gravel to re-establish the historic channel invert elevations.

A sediment budget should be estimated for Partington Creek by resurveying the lower channel and comparing the elevations to the 2006 survey, taking into account removal volumes. The gradation of the sediment should also be determined by taking samples at a number of locations. This approach allows individual constituents of the deposited sediments to be quantified and sediment traps and removals to be optimized.

In the interim until a sediment budget is determined, removal of approximately 500 m^3 (based on upper limit of the regional sediment analysis presented in Section 7.5) of sediment per year for the first five years is proposed to remove the accumulated sediment. Beyond the first five years, approximately 100 m^3 (to be confirmed by the sediment budget study) would be removed annually from sediment traps and targeted in-stream deposition sections to balance the sediment influx. Monitoring of aggradation every 10 years is proposed to refine the sediment budget for Partington Creek and adjust the frequency and volumes of sediment removals accordingly to balance the inputs and outputs into the lower reach.

Construct Sand Trap

In order to control the sand accumulation in the Partington Creek lower reach (along Cedar Drive), a sand trap is proposed at the downstream end of the high chum use area at Chainage 0+900. Refer to Figure 9-1. This sand trap would capture a majority of the sands and would require maintenance every few years during the fisheries window. This removal volume would be part of the short-term 500 m^3 per year and long-term 100 m^3 per year sediment removals.

Construct Sediment Basin

Cobbles, gravel, and sand are accumulating in Partington Creek adjacent to the intersection of Oliver Road and Cedar Drive. To prevent an increase in water levels due to accumulations of sediment at this location from flooding the roadway and adjacent private property, this area is proposed as a designated sediment removal site.

This area would be fitted with a permanent diversion pipe to bypass stream flow during maintenance periods in the fisheries window, and an access road and access ramp to minimize ongoing disturbance. A large off channel trap was considered however it would be difficult to prevent the main creek from shifting to flow through this trap resulting in almost all sediment being caught including the spawning gravels which are needed downstream. This removal volume would be part of the short-term 500 m^3 per year and long-term 100 m^3 per year sediment removals.

Remove Designated In-stream Sediment Areas

In order to improve the flood conveyance capacity in lower Partington Creek, in-stream sediment removals are required to lower the channel invert in the short term especially in the vicinity of Star Creek. Refer to Figure 9-1. There is a large accumulation of sediment at this location that is significantly reducing the channel capacity.

It is desired to have some sediment movement along lower Partington Creek to continue to provide for good fish habitat and spawning gravels. Over time, sands and gravels would continue to accumulate in the lower portion of Partington Creek, however at a reduced rate due to the sand trap and gravel/cobble sediment basin. Infrequent targeted in-stream sand/gravel removals performed during the fisheries window in the main channel or in the side channels would be required to maintain the channel invert elevation. This removal volume would also be part of the short-term 500 m^3 per year and long-term 100 m^3 per year sediment removals. It is proposed that sediment be removed in 100 m long sections all the way to the desired invert to avoid disturbing the same section multiple times. Furthermore, the instream removals should be performed at the same time as the Cedar Drive relocation and Partington Creek Main Stem widening and complexing to limit the duration of disturbance. Dewatering of the channel prior to excavation would be required. If required, localized placement of gravel and cobble could be made using material excavated from the sediment removal site. Excavated gravels could also be used in Hyde Creek where spawning gravels are needed.

ACQUIRE LAND AND RELOCATE/RAISE PORTION OF CEDAR DRIVE

To provide adequate flood conveyance, floodplain, sediment management and environmental enhancements, it is proposed to relocate 600 m of the lowest elevation portion of Cedar Drive and raise the road grade to provide an appropriate level of flood protection to the lowlands. Figure 9-2 shows three typical cross sections with the relocated and raised Cedar Drive embankment. The riparian area along the south side of Partington Creek will be re-established to 30 m width.

There are seven existing bridges over Partington Creek along the stretch of Cedar Drive to be relocated. In order to maintain access in the interim until those lots are redeveloped and serviced from the north, temporary access is needed. It is proposed that the existing bridges be retained and access extended to the relocated Cedar Drive. Figure 9-3 shows three typical cross sections at the bridges for the interim scenario. Once the lots develop and are serviced from the north, the bridges and access road fill will be removed.

Raising this portion of Cedar Drive will decrease the frequency of road overtopping to approximately a 25-year return period at the next lowest elevation in the road at chainage 0+700 (see Figure 5-2). Sediment removal will also increase the conveyance capability of the lower Partington Mainstem.

Relocating the road away from Partington Creek will provide many benefits – increased flood conveyance, much needed floodplain area so the creek is not pinned between the road and steep slope, opportunities in-stream complexing and an enhanced riparian setback. This is discussed in more detail in the environmental restoration and enhancement section.

Initial discussions with the Agricultural Land Commission about the relocation of Cedar Drive onto farm land have yielded no concerns at this time. A formal application under the ALC will be required.

ACQUIRE LAND TO WIDEN/COMPLEX CHANNEL ADDITIONAL MAIN-STEM CHANNEL

Some fish habitat compensation will be required to offset the impacts from ongoing sediment removal activities and channel maintenance. Widening the channel between Chainage 0+400 and 0+900 to a 6 m bottom width (see Figure 9-4) together with fish habitat enhancements is proposed to provide a bench for additional flood conveyance, habitat creation and complexing while maintaining the conveyance capacity given the additional roughness. The channel widening was based on providing capacity to convey the 2-year post-development peak flow within the main channel. The capacity of the cross sections was also checked to confirm that the existing bridges would not be overtopped in a post-development 10-year peak flow.

A 6 m width of riparian setback in addition to the Riparian Areas Regulation (RAR) minimum is needed to ensure a 30 m setback along the north side of the main stem in this area (see Riparian sub-section).

9.3 CREEK FAN HAZARDS

An overview assessment of the watershed was conducted as part of the IWMP and a number of observations and recommendations were made.

- Debris floods may pose a moderate risk to development in the reaches of the creek where the channel is not well confined. It is recommended that the risk due to debris flood be quantified and that a risk map be developed for the lower unconfined reaches of the Partington Creek Main-stem prior to development.

- Proposed development should be well set back from creek slopes and ravine areas, where preliminary guidelines for ravine setbacks are recommended in the RAR guidelines and detailed geotechnical guidance may be required.

- There are a number of structures on the Partington Creek fan (roughly delineated on Figure 9-1) which are currently at risk to flood and channel avulsion. Future development or redevelopment of any properties on the creek fan should be in conformance with the *Flood Hazard Area Land Use Management Guidelines* (Ministry of water, Land and Air Protection, May 2004), in addition to the other environmental regulations. The proposed future park east of Gilley's Trail is a land use that is in conformance with these guidelines. A detailed hazard assessment of the fan area could be required prior to redevelopment.

- Ongoing maintenance and engineering structures will be required to keep Partington Creek trained along Cedar Drive. Should land-use change and development be considered in the agricultural areas below Partington Creek, appropriate floodplain management planning and flood protection works would be required for this area.

9.4 FLOOD CONVEYANCE THROUGH DEVELOPING AREAS

The City's drainage criteria will be applied for sizing storm pipes for the 10-year return period and the major overland flow paths for the 100-year return period.

UPGRADE HYDRAULIC STRUCTURES

Fourteen culverts and fourteen bridges were identified as undersized to convey the 100-year flow without surcharge in the hydrotechnical assessment. A number of culverts were undersized for the future flows. However, these culverts are either in the areas to be serviced by the diversion pipe that will limit flows to these culverts, or the culverts will be removed during the development.

Hydraulic structure deficiencies are recommended to be addressed in a phased approach based on priority:

- immediate works that should be addressed to reduce blockage and flooding;
- short term works that should be upgraded within the 5-year capital plan where culverts are undersized for existing land use flows; and
- during development where culverts have capacity for existing flows but are undersized for future land use flows.

Refer to Tables 9-2 to 9-4.

Bridges BRG002 and BRG022 are collapsed and should be removed immediately. These two bridges are a hazard and may trap debris that could result in a channel blockage during flood events. Furthermore if any of these bridges contain creosote or other preservative material, removing them will be of further environmental benefit.


Photos: Bridge BRG002

Table 9-2: Remove Damaged/Collapsed Bridges Obstructing Creek Channel

Watercourse Location	ID #	200-year Design Flow[1] (m^3/s)	Proposed Size (mm)	Priority
Remove Damaged/Collapsed Bridges Obstructing Creek Channel				
Fox Creek near Victoria Dr.	BRG002	7.3	Remove	Immediate
Partington Main-stem Above Victoria Dr.	BRG022	15.5	Remove	
1. Existing Conditions				

Bridges BRG018 and BRG019 on Star Creek and culverts CUL005 and CUL007 on Fox Creek were shown as under capacity for the future land use flow. However, with the proposed diversion in place, these existing bridges and culverts will be adequate to convey the design flow. BRG018 may still require replacement at time of development for other reasons such as traffic capacity or lane width.

Bridges BRG005 and BRG006 on Fox Creek T5C were shown to have inadequate freeboard. However, these bridges are located in Pinecone Burke Provincial Park and do not have a large tributary area upstream. The condition of these bridges should be monitored and if they show signs of deterioration should be replaced with 450 mm CSP culverts.

The culverts and one bridge that are proposed to be upgraded are given a priority in Table 9-3. In general, culverts under municipal roadways or those within the proposed development area undersized for existing flows are a high priority upgrade. All other culverts are low priority including those of unknown size are considered low priority.

Three culverts had unknown sizes and were not checked in the hydrotechnical analysis. The City should investigate these culverts (CUL031, CUL038, and CUL041 are shown on Figure 3-1) and assess their adequacy if flooding complaints are received at these locations or during upstream redevelopment applications.

Table 9-3: Proposed Hydraulic Structures Upgrades

Watercourse Location	ID #	Design Flow (m^3/s)	Proposed Size (mm)	Priority
Upgrade Structure and Improve Fish Passage[1]				
Fox Creek	CUL006	2.7[5]	1500 CSP	High
Fox Tributary T5G	**CUL015**	**1.7[4]**	**1200 CSP**	**High**
Fox Creek	BRG003	2.7[5]	1500 CSP	Low
Fox Tributary T5H	CUL004	1.3[4]	1200 CSP	Low
Dairy Creek	CUL035	1.7[4]	1200 CSP	Low
	CUL037	**2.8[4]**	**1500 CSP**	**Low**
Tributary T10	CUL040	2.2[4]	1350 CSP	Low
Upgrade Structure				
Star Creek	**CUL023**	**1.3[3]**	**1200 CSP**	**High**
	CUL024	**0.9[3]**	**1050 CSP**	**High**
Tributary T3A	**CUL028**	**0.4[3]**	**600 CSP**	**High**
David Ave Ditch	**CUL039**	**1.8[3]**	**1200 CSP**	**High**
Fox Creek T5G	CUL016	1.8[4]	1200 CSP	Low
Dairy Creek	CUL031[2]	2.4[4]	1350 CSP	Low
	CUL034	1.7[4]	1200 CSP	Low
	CUL036	**1.7[4]**	**1200 CSP**	**Low**
Tributary T6	CUL038[2]	0.4[4]	675 CSP	Low
Tributary T11	CUL041[2]	0.1[4]	525 CSP	Low

BRG = Bridge, CUL = Culvert
Bolding indicates culverts under paved municipal roadways to be upgraded by the City. Culverts not bolded are on private property and should be upgraded by the owner.
1 Partially bury culvert invert by 0.1m to provide a natural bottom.
2 Culvert size is unknown. Existing size should be checked prior to scheduling upgrade.
3 100-Year Existing Land Use flow.
4 100-Year Future Land Use flow.
5 200-Year Existing Land Use flow.

Table 9-4 lists the bridges and culverts that will become obsolete once the area develops and new roads and storm sewers are constructed as per the PCNP latest land use plan. The development area on the north side of the Partington Creek Main Stem will be accessed from the north with the exception of the land opposite bridges BRG012-BRG014. That area is expected to be turned into a park/conservation area.

Table 9-4: Remove & Abandon Hydraulic Structure During Future Development

Watercourse Location	ID #		Comment
Remove & Abandon Structure During Future Development			
Lower Partington Main-stem Cedar Road to be Relocated and Floodplain Created	BRG007	BRG012	To be removed during future development after Cedar Road relocation
	BRG008	BRG013	
	BRG009	BRG014	
	BRG010	BRG015	
	BRG011	BRG016	
Star Creek	CUL020		To be removed during future development
Tributary T2	CUL021		
Victoria Dr Ditch	CUL026		
	CUL027		
	CUL029		
BRG = Bridge, CUL = Culvert			

CONSTRUCT DIVERSION PIPE

A diversion pipe is proposed to drain the major flows and minor flows in excess of pre-development flows from a majority of the PCNP development area and from the Hyde Creek Development Reserve area into the DeBoville Slough. Estimated pipe sizes are summarized on Figure 9-1.

Baseflows and pre-development flows would continue to the creek system, while high flows would be diverted and conveyed directly to DeBoville Slough.

CONSTRUCT UPSLOPE CUT-OFF DITCHES

Cut-off ditches are proposed to intercept the shallow interflow and any surface runoff from the undeveloped areas upslope of the proposed development. These ditches will divert the pre-development natural surface flows and interflow away from the development and into the existing streams. This will prevent water quality contamination, flooding of homes, and reduce the burden on foundation drains while feeding natural flows back into the creeks albeit somewhat farther upstream than they would have entered naturally. The slightly higher peak flows and baseflows in the portion of creeks immediately downstream of where the cut-off ditch enters the creek may result in slight channel changes to adjust to the slightly higher flows. However, it is anticipated that most of the intercepted flow will be slow shallow groundwater interflow and will not contribute to peak flows and erosion in the creeks.

9.5 ENVIRONMENTAL PROTECTION VOLUMETRIC REDUCTION

The purpose of volumetric reduction is to hydrologically simulate the natural forested condition (hold onto frequently occurring rainfall volumes on-site in the vegetation canopy and soil layer). This serves two ecological protection functions:

1. eliminates surface runoff from typical summer storms therefore mitigates peak flows that cause erosive wear on creeks; and

2. recharges groundwater that sustains baseflows in creeks.

Rainwater source controls in the Partington Creek watershed should be designed to capture the first 63 mm of rain in a 24-hour period.

The 6-month 24-hour volume reduction target of 63mm was found to be appropriate for this watershed by examining the recorded stream flows following a 110mm dry initial condition rainfall event (September 28-29, 2005) which resulted in a flow volume of 40mm over the watershed area. Therefore the watershed captured 70mm of rain in this event. The target should be met on-site to the greatest extent possible as site conditions permit and any shortfall made up in downstream regional facilities.

IMPLEMENT CITY'S RAINWATER MANAGEMENT SOURCE CONTROLS

All surfaces (impervious and pervious) will be required to incorporate on-site source controls as per the City's *Rainwater Management – Source Controls – Design Requirements and Guidelines* (March 2009). On-site source controls include:

- **All single family lots:** 300 mm of absorbent topsoil for all pervious areas so that they are self mitigating; impervious areas graded onto the pervious areas; and encourage use of permeable paving and rain barrels;

- **Multi family, commercial, institutional, industrial:** all of the above plus on-site infiltration/retention trenches or alternative measures (rain gardens, swales, re-use strategies) designed to maximize stormwater volume reduction targets; and

- **City roadways in urban residential areas:** 300 mm of absorbent topsoil for all pervious areas within ROWs (boulevards); roadside surface swales in unobstructed boulevards (adjacent to parks and open spaces) or below grade retention trenches in all other locations.

Full source controls to meet the Partington stormwater target of 63 mm will be implemented on all land uses except for single family residential as per the City's policy. Partial source controls (listed above) will be applied to single family land uses, together with regional facilities described below.

CONSTRUCT UNDERGROUND BASEFLOW RELEASE FACILITY

In the area east of Star Creek not serviced by the proposed diversion, volumetric reduction needs to focus on capturing frequently-occurring flows to minimize creek erosion & destruction to fish habitat. Refer to Figure 9-5. A Baseflow Release facility (assumed to be and underground rock trench for costing) is proposed to make up for the shortfall in meeting the 63 mm volumetric reduction target on-site in single family areas. A 2,913 m^3 2 m deep rock trench is proposed near the mouth of Star Creek (Facility 4 on Figure 9-5) to store 90% of annual flows and release them at baseflow rates (0.5 L/s/ha maximum in the winter and 0.05 L/s/ha minimum in the summer). It is recommended that baseflow flow measurements be made prior to development at strategic locations so that the baseflow release facility outlets can be sized properly.

Table 9-5: Proposed Base Flow Release Facility

Pond ID	Location	Tributary Area (ha) & Type	6-Month 24-Hour Flow Volume (m^3)	Pond Volume (m^3)
4	At Fox Creek mouth	2.9 (SFR)	914	2,913

CONSTRUCT UNDERGROUND BASEFLOW AUGMENTATION FACILITIES FOR STAR & FOX CREEKS

In the area serviced by the diversion, Baseflow Augmentation facilities are proposed to make up for the shortfall in meeting the 63 mm volumetric reduction target on-site in single family areas. Wholesale diversion of all flows from these areas without sufficient source controls was examined but this would adversely reduce baseflows in creeks that rely on groundwater recharge.

It was assumed that baseflow augmentation would not be required for the Partington main stem with large headwater areas in Pinecone Burke Provincial Park sustaining baseflow. However, to maintain baseflows in the creeks with headwaters that will largely be developed, namely Star Creek and to some extent Fox Creek, baseflow augmentation will be required.

Baseflow augmentation facilities could consist of underground 2 m deep rock trenches to store sufficient quantities of water to sustain 0.05 L/s/ha minimum baseflows throughout dry periods in a typical year of rain. These facilities are proposed to be located underground to keep the water cool and to maximize surface land use. It is recommended that baseflow flow measurements be made prior to development at strategic locations so that the baseflow augmentation facility outlets can be adjusted to match existing conditions.

In order to achieve the desired flow splits between creeks and diversion pipes a series of control structures will be required. This is further discussed in sub-Section 9.8 and Figure 9-6.

Table 9-6: Proposed Base Flow Augmentation Facilities

Pond ID	Location	Tributary Area (ha) & Type	6-Month 24-Hour Flow Volume (m^3)	Pond Volume (m^3)
1	Near Star Creek Tribs	25.8 (SFR)	8,127	7,737
3	Top of Trib T5A Fox Cr	3.4 (SFR)	1,071	1,031
2	Top of Star Creek	25.9 SFR)	8,159	7,782
12	Star Creek Mainstem on Pollard	4.5 (SFR)	1,418	1,356
13	Star Creek Mainstem East	7.9 (SFR)	2,489	7,902
Refer to Figure 9-5.				

9.6 WATER QUALITY TREATMENT

IMPLEMENT SOURCE CONTROLS FOR ROADS, PARKING LOTS

The purpose of water quality treatment is to clean a majority of stormwater flows (90% of typical year flows) to an acceptable level for fish prior to discharge into receiving waters. In order to meet the water quality treatment criterion, runoff from roadways, lanes, driveways, sidewalks, and parking areas should be treated using onsite source controls as per the City's *Rainwater Management – Source Controls – Design Requirements and Guidelines* (March 2009) and regional water quality ponds to make up for any on-site shortfalls. On-site source controls include grading sidewalks to adjacent grassed areas, draining roadways and parking areas to vegetated swales and rain gardens. In the case of below grade retention trenches, water quality treatment of road runoff prior to entering the trenches will be required to minimize clogging and ensure long term operation of infiltration.

CONSTRUCT WATER QUALITY POND/WETLANDS

Where the City's source controls may not fully meet the water quality treatment targets for single family residential areas and some roads (due to steepness or overland flow routes), regional water quality treatment pond/wetlands are proposed. Figure 9-5 shows the locations of the proposed water quality ponds. The sizes are summarized as follows.

Table 9-7: Proposed Water Quality Ponds

Pond ID	Location	Tributary Area (ha) & Type	6-Month 24-Hour Flow Volume (m^3)	Pond Area (m^2)
5	Top of Trib T5A Fox Cr	3.4 (SFR)	1,071	791
6	Top of Star Creek	25.9 SFR)	8,159	5,966
7	Near Partington mouth	6.2 (SFR)	1,953	1,426
8	At Fox Creek mouth	2.9 (SFR)	914	670
9	Near Star Creek Tribs	25.8 (SFR)	8,127	5,932
10	Top of Freemont Park	9.7 (Village Core)	5,500	4,074
11	Star Creek Mainstem on Pollard	4.5 (SFR)	1,418	1,040
14	Star Creek Mainstem East	7.9 (SFR)	2,489	1,817
Refer to Figure 9-5.				

9.7 ENVIRONMENTAL PROTECTION FLOW RATE CONTROL

UTILIZE PROPOSED DIVERSION – CONSTRUCT SPECIALIZED FLOW SPLITTERS

The purpose of flow rate control of runoff up to the 5-year event is to minimize the rates of erosion and sedimentation in creeks and maintain them at existing or natural values. In order to meet the environmental protection rate control criteria, the proposed diversion pipe can be used for a majority of the development area. The diversion pipe can be utilized to reduce the post-development 6-month, 2-year, and 5-year peak flows and volumes for all storm durations and antecedent moisture conditions to pre-development levels into the Partington Creek tributaries.

Specialized flow control structures will be required to split a range of flows between the diversion and the creeks. This is complicated by the need to provide water quality treatment for up to the 6-month flows and in certain locations baseflow augmentation/release prior to discharge to creeks. The flow control structures should be adjustable so that fine tuning is possible if monitoring results show impacts to creeks. Figure 9-6 shows the flow control concept. The proposed diversion can be used for multiple purposes: high flow conveyance and mitigating frequently occurring peak flows and volumes for environmental protection. This will aid in protecting Fox Creek and its tributaries, Star Creek, and the tributaries in Freemont Park. Baseflows and pre-development peak flows will continue to the natural watercourses.

SIZE AND WIDEN PORTION OF MAIN STEM

For the area south of Victoria Drive below the 100-year diversion pipe, no hydrologic rate control is proposed. A more extensive hydrologic analysis is required to:

1. determine the erosion susceptibility of Star Creek and the main stem given the proposed flow regime and

2. properly size channel modifications and the proposed diversion structures such that the stability and environmental values of Star Creek and the main stem are protected.

A flow exceedance duration analysis using long term rainfall data (30 years) is needed determine the proper channel size together with environmental enhancements. Drainage from the urban area south of Victoria Drive is to be conveyed and discharged downstream of the prime chum spawning area. Star Creek flows could be adjusted at the 100-year diversion to compensate for any increases from this undetained area south of Victoria Drive (see Figure 9-5).

The creek receiving environment is one of few high fish use left in the Lower Mainland and is highly sensitive; the proper sizing and design of these elements are critical to protecting existing values. It is recommended that a specialist consultant be retained to ensure proper analysis and design for the following:

- lower Partington channel sizing to mitigate erosion especially for the unmitigated development area not serviced by the proposed diversion;

- specialized flow control structures to make certain intended flow interactions between the water quality ponds, baseflow augmentation/release facilities, diversion and creeks are met; and

- design event and continuous simulation modelling to validate intended operation of flow control structures and Partington Creek Main Stem channel widening to ensure both flood and environmental protection.

9.8 WATERCOURSE PRESERVATION

DFO values headwater streams and requested that they be preserved. The Partington Creek Neighbourhood Plan land use was reworked to preserve these watercourses. A number of existing ditches are proposed to be removed at the time of development. The plan as shown on Figure 9-7 strives to minimize the loss of natural watercourses. The figures in Appendix M document the characteristics of the watercourses within the proposed development area. Appendix N summarizes the watercourse loss and compensation assessment that was undertaken. It documents the philosophy and evolution of determining and negotiating which watercourses would be retained and which eliminated as shown in Figure 9-7.

Table 9-8: Percentages of Creeks and Ditches Preserved

Total Linear Channel Preserved	Within Partington Watershed	Within PCNP Area (Within Partington Creek Watershed Only)
Natural watercourses	100%	100%
Ditch	50%	32%

Figure 9-7 shows the creek layer within the Partington watershed. This layer was developed through extensive ground-truthing in the field during the wet season (2010), however it does not guarantee that additional watercourses may be present and found in the future.

ESTIMATED WETTED AREA AND RIPARIAN LOSSES

Wetted Area Loss is based on the measured channel lengths and estimated wetted channel widths of seasonally flowing watercourses that will be removed or modified (culverted, buried, or diverted). This encompasses 2,906 m of watercourse most of which are roadside ditches. Potential new road crossing and widened existing crossings account for a further loss. The total potential wetted area loss in the overall Partington Creek watershed is 1,423 m^2.

Riparian Area Loss is based on predicted RAR setbacks (10 m surrounding natural and channelized streams less than <3 m in bankfull width; 2 m surrounding non-fish bearing ditches). Potential new road crossings, widened existing crossings, and new outfalls account for a further loss. The total potential riparian area loss in the overall Partington Creek watershed is 19,982 m^2.

PROPOSED MITIGATION AND COMPENSATION

The IWMP provides direction on the use of stormwater source controls and riparian protection measures to mitigate the effects of urban development on stream condition (see previous sections). The mitigation and compensation for the channel and riparian area losses associated with ditch replacement and potential road crossings are summarized in Sections 9.10 and 9.11 and include:

- Relocating the upstream section of Cedar Drive away from Partington Creek in the short term to create floodplain, sidechannels, and riparian area along the south side of the creek (1,800 m^2 of wetted area and 12,000 m^2 of riparian area);
- Removing bridges from Cedar Drive across Partington Creek once the land is serviced from the north (200 m^2 of wetted area and 1,200 m^2 of riparian area);
- Relocating the downstream section of Cedar Drive away from Partington Creek in the long term to create floodplain, sidechannels, and riparian area along the south side of the creek (2,700 m^2 of wetted area and 18,000 m^2 of riparian area);

- Reforestation in the short term within Star Creek RAR setbacks (3,000 m^2 of riparian area);
- Reforestation in the short term within Partington Creek RAR setbacks (20,000 m^2 of riparian area); and
- Reforestation in the long term within Dairy Creek RAR setbacks (20,000 m^2 of riparian area).

In the short term, the proposed mitigation/compensation works achieve a greater than 1:1 compensation ratio. Over the long term, a compensation ratio of over 3:1 and a net environmental benefit is expected in the overall watershed.

ENVIRONMENTAL APPROVALS AND NOTIFICATIONS

Removal of small watercourses and ditches require approval under the Fisheries Act and would require mitigation to avoid causing any harmful alternation, disruption or destruction (HADD) of fish habitat (or areas that contribute food and nutrients to fish-bearing waters). Ministry of Environment approvals under the *Water Act* may also be required. The City may submit a "batch" application for *Water Act* approval in which a watershed-wide agreement may be negotiated for the removal of ditches within the watershed.

If additional watercourses are to be filled in or removed during development, additional applications would have to be made to MOE and DFO HADD.

9.9 PROTECT RIPARIAN SETBACKS

EXCELLENT RIPARIAN FOREST INTEGRITY PRESERVED IN HEADWATERS

All of the developing lands in the Partington watershed are in the lower third of the watershed; the upper two thirds will remain undeveloped forest. Most of the headwaters are in Pinecone-Burke Mountain Provincial Park and others include private or Crown land that are outside the current boundaries of NECAP. Freemont Park (municipal) and several smaller municipal parks are located in the lower watershed. These park areas, particularly in the headwaters, ensure that substantial riparian areas are protected from urban development. They help sustain ecological health in the lower watershed by filtering sediment and other components of water quality, maintaining cool water temperature through shading, and providing litter and leaf materials to small headwater stream channels.

IMPLEMENT RAR SETBACKS WITHIN DEVELOPING AREAS

The purpose of riparian setbacks is to provide shade, food and litter, and large wood debris to stream channels, primarily to sustain healthy streams and fish habitat. A secondary emphasis is to maintain wildlife populations including landscape-level connectivity. To meet regulatory requirements, the City follows the Riparian Areas Regulation (RAR)[6] – a provincial standard for riparian protection in urban areas that has been endorsed by DFO. RAR setbacks (based on the detailed assessment method) will be applied to all streams within the developing area of the Partington Creek watershed.

Detailed RAR methods typically result in riparian setbacks that are 3 x channel width (minimum 10 m; maximum 30 m) measured from the high water mark and extend on both sides of the stream channel. Ravine areas require additional protection. As examples, riparian setbacks for lower Partington Creek are estimated to be 24 m wide (estimated channel width: 8 m), 15 m on Fox Creek (estimated channel width: 5 m), and 15 m to 20 m on Star Creek (estimated channel width: 5 m to 7 m). The riparian setbacks shown on Figure 9-7 are approximate shown for conceptual purposes only. They were based on the location of the stream centreline as either inventoried during this study or from the City's GIS information. They do not account for ravine areas. Detailed survey of the high water marks and top of ravine banks will be required to accurately define the riparian setbacks at the time of development.

Use of minimum RAR setbacks on most streams will result in some degradation of watershed health and wildlife habitat because of the incremental and cumulative impacts to riparian ecosystems and ecosystem processes at a watershed-scale. While substantial headwater areas will remain undeveloped, relatively narrow riparian setbacks along Fox and Star creeks will likely contribute to a decline in ecological health. It is also important to note that minimum riparian setbacks under RAR are not adequate to protect some riparian-dependent wildlife species such as Pacific water shrew. As noted in Section 3.2, critical habitat designation for Pacific water shrews has used 100 m setbacks to maintain suitable habitat (Pacific Water Shrew Recovery Team, 2009).

The IWMP and PCNP strive to maximize the riparian setbacks. Within the development boundary, there are specific areas where the setbacks may be enhanced beyond RAR widths to protect wildlife habitat, maintain wildlife corridors, provide opportunities greenways with trails, or to create windfirm park boundaries. More detailed assessment work will also be required to identify the boundary of stream channels and to locate the top of bank in ravine areas. The PCNP will explore opportunities to provide additional setbacks.

ENHANCED 30 M RIPARIAN SETBACKS AROUND PARTINGTON MAIN-STEM

Relocation of Cedar Drive and its associated dyke approximately 30 m east will provide an opportunity to reforest degraded riparian areas along lower Partington Creek. This section was channelized and dyked historically which limits tree growth in many areas.

[6] "The Riparian Areas Regulation (RAR), enacted under Section 12 of the Fish Protection Act in July 2004, calls on local governments to protect riparian areas during residential, commercial, and industrial development by ensuring that proposed activities are subject to a science based assessment conducted by a Qualified Environmental Professional (QEP). The purpose of the Regulation is to protect the features, functions and conditions that are vital in the natural maintenance of stream health and productivity." From: http://env.gov.bc.ca/habitat/fish_protection_act/riparian/riparian_areas.html

Within the restored channel and floodplain area there will likely be a combination of floodplain forest, sedge swamps, willow thickets, and more terrestrial areas with mixed forest. Further design work will refine the range and configuration of riparian habitat within the restored area.

Additional riparian area will also be provided between Chainage 0+400 and 1+000 on the north side of the creek in the widened channel area. In addition to the 24 m RAR setback here, an additional 6 m setback will be purchased to provide a full 30 m riparian setback in the area of the prime fish use habitat.

This 30 m riparian setback area along the high value fish area of Partington Creek strives to provide a Net Environmental Benefit for Fish Habitat. Floodplain restoration along Cedar Drive is associated with Chum Salmon spawning areas which provide new habitat in proximity to an important seasonal food source for many species (e.g., gulls ducks, River Otter, Mink, Black Bear, etc). Riparian reforestation is expected to increase habitat connectivity, as well as provide an increase in habitat area for riparian dependent species.

ENHANCED RIPARIAN SETBACKS ON STAR AND FOX CREEKS

Additional riparian setbacks above and beyond the RAR setbacks would provide better protection of watershed health for Star and Fox tributaries, but also for Partington Creek overall. It is recommended that the PCNP study explore land use planning tools to gain additional riparian setbacks for these watercourses for environmental benefits.

9.10 RESTORATION AND ENHANCEMENT STRATEGIES FOR FISH HABITAT

Four strategies are proposed to restore and enhance fish habitat in Partington Creek and its tributaries. They focus on improving in-stream and riparian habitat for fish populations, particularly in lower Partington Creek, providing a Net Environmental Benefit to Fish Habitat. Together with riparian setbacks, stormwater source controls, and park protection, they contribute to the mitigation of the direct and indirect effects of urbanization in the watershed.

RESTORE IN-STREAM COMPLEXITY, FLOODPLAIN WETLANDS, AND RIPARIAN FOREST

Lower Partington Creek was channelized and dyked historically resulting in loss of complex in-stream habitats, floodplain wetlands, and riparian forest. Channelization has also contributed to sediment accumulation in the lower channel which requires periodic channel maintenance. At the same time, lower Partington Creek is critical for chum salmon spawning (approx. 2,000 fish annually), as well as rearing for juvenile coho salmon, cutthroat trout, and other fish species.

Currently, approximately 1,450 m of lower Partington Creek is channelized and dyked. The IWMP proposes to undertake a comprehensive restoration project to improve fish and wildlife habitat in this reach, and mitigate some of the effects of urban development on stream health. As well, channel modifications will be used to reduce flooding and sediment management by increasing channel dimensions and creating a permanent sediment removal area.

The proposed restoration program will be phased. Approximately 600 m (2.8 ha) of channel downstream of the corner of Cedar Drive and Oliver Road will be restored prior to development, the inner toe of the Cedar Drive dyke will be relocated 30 m to the southeast into the lowlands. In the long term, the remaining downstream 800 m of Cedar Drive will be relocated away from the stream.

The Partington Creek channel will be reconstructed and will incorporate floodplain forest, marshes, side-channels, in-stream wood and boulder structures, and gravel spawning platforms. Riparian shrub and forest communities will be established on both sides of the channel. The relocated road “dyke” height will be raised to convey flood flows during infrequent large storms, and prevent flooding of the adjacent lowlands. A fine sediment (sand) trap immediately downstream of the restored channel and coarse sediment (gravel and cobble) removal site upstream are proposed.

These proposed works will benefit all the aquatic species, including the species at risk that occur, or may occur, in Partington Creek such as white sturgeon, Dolly Varden and coastal cutthroat trout. The increase in spawning habitat will have the greatest benefit to chum salmon (25% increase expected over the long term) which use low gradient gravel-rich streams and rivers. Unlike juvenile coho which overwinter in the stream for one year, chum fry rapidly move into marine areas following emergence from the gravel. At the same time, part of the purpose of restoring the lower reach of Partington is to provide productive floodplain habitat for juvenile coho, cutthroat trout, and other species that do rear in the lower reaches. The size of their populations will depend on a range of factors including spawning habitat, freshwater rearing habitat, and marine habitat conditions.

REMOVE FISH PASSAGE BARRIERS

Anadromous fish access into Fox Creek is limited by an abandoned dam (BRG002) approximately 60 m upstream of its confluence with Partington Creek at Victoria Drive. The hanging culvert at Edwards St. on the Fox Creek main-stem (CUL005), the culvert on the northern tributary to Fox Creek (Tributary T5F) at Edwards St. (CUL015), and the culvert at the east end of Crouch Ave. are also barriers to fish (CUL006). All four barriers will be removed resulting in approximately 250 m of new chum spawning habitat, and 350 to 750 m of spawning and rearing habitat for coho salmon (based on areas used by resident cutthroat trout at present). Other minor fish passage barriers will be removed during improvements to road and stormwater infrastructure.

The following table lists the fish barriers that are proposed to be removed.

Table 9-9: Proposed Fish Barrier Removals

	Culvert / Bridge ID	Design Flow (m^3/s)	Proposed Size (mm)	Priority
Remove Damaged/Collapsed Bridges				
Fox Creek near Victoria Dr	BRG002	7.3[3]	Remove	To be removed immediately
Partington Cr Above Victoria Dr	BRG022	15.5[3]	Remove	
Upgrade Fish Passage along with Proposed Capacity Upgrade[1]				
Fox Creek	CUL006	2.7[3]	1500 CSP	High
Fox Creek Trib T5F	**CUL015**	**1.7[2]**	**1200 CSP**	**High**
Fox Creek	BRG003	2.7[3]	1500 CSP	Low
Partington Cr Above Victoria Dr	CUL004	1.3[2]	1200 CSP	Low
Dairy Creek	CUL035	1.7[2]	1200 CSP	Low
	CUL037	**2.8[2]**	**1500 CSP**	**Low**
Partington Creek Tributary T10	CUL040	2.2[2]	1200 CSP	Low
Upgrade for Fish Passage Only[1]				
Fox Creek	**CUL005**	**3.0[3]**	**1500 CSP**	**High**
Fox Creek	CUL007	2.8[3]	1500 CSP	Low
Fox Tributary T5H	**CUL017**	**1.2[2]**	**1350 CSP**	**Low**

BRG = Bridge, CUL = Culvert
1 Partially bury culvert invert by 0.1m to provide a natural bottom.
2 100-Year Future Land Use flow.
3 200-Year Existing Land Use flow.
Bolding indicates culverts under paved municipal roadways to be upgraded by the City. Culverts not bolded are on private property and should be upgraded by the owner.

REPLANT RIPARIAN FOREST

Rural development in the Partington Creek area has resulted in loss of some riparian forest. Most sites are on private land, but the restoration of lower Partington Creek will also provide a substantial opportunity for riparian reforestation. Underplanting of shade tolerant conifers will be undertaken in treeless riparian areas (4.8 ha identified within RAR setbacks of Star Creek, Dairy Creek, and the Partington main stem below Victoria Drive) and those dominated by red alder. Riparian reforestation efforts will be coordinated and facilitated by the City of Coquitlam by identifying priority sites, providing plant materials, and other assistance to private landowners.

RESTORE IN-STREAM COMPLEXING ON PARTINGTON AND FOX CREEKS

The addition of large wood structures, boulder groups, boulder spurs, stable debris jams, and other structural in-stream features will be used to increase in-stream complexity on lower Partington and Fox Creeks. Forty structures will be created by 2020 (4 per year); 5 on lower Fox Creek, 10 between Victoria Drive and Cedar Drive on Partington Creek; and 25 on the restored section of lower Partington Creek.

9.11 QUANTIFY IWMP THROUGH WATERSHED HEALTH TRACKING SYSTEM

The IWMP strives for No-net-loss of watershed health. One way to estimate watershed health is by using the Metro Vancouver Watershed Health Tracking System (WHTS) which uses riparian forest integrity (RFI) along permanent watercourses and Effective Impervious Area (EIA) as inputs to determine a B-IBI score. The goal is to maintain the pre-development watershed health at a B-IBI score (36 measured or 35 predicted).

The watershed health indicators for existing conditions and proposed future land use conditions are summarized in Table 9-10. In order to simply quantify the ecological gains and losses in the watershed as a result of the proposed development and mitigative IWMP Strategy, the WHTS was used. Figure 9-8 shows the pre-development and unmitigated post-development watershed health, and the effects of the mitigation measures for Partington watershed as a whole. As proposed mitigation measures were developed, an attempt to theoretically quantify the impact to watershed health was made. Figure 9-9 shows the WHTS for the two major tributaries: Star Creek and Fox Creek.

Table 9-10: Partington Watershed Health Tracking System Indicators

	Existing Conditions	Unmitigated Future Development Conditions	Mitigated Future Development Conditions
B-IBI	Measured 31 (Predicted 35)	Predicted 19	Predicted 35
EIA	3%	22%[1]	5%[3]
RFI	80%	68%[2]	84%[4]

RFI calculated for permanent watercourses only
1 Based on Partington Creek Neighbourhood Plan development & Northeast Coquitlam Area Plan development
2 Based on RAR setbacks
3 With City source controls, diversions, and baseflow facilities
4 With Cedar Drive relocation, extra riparian on north side of Main-stem, and reforestation within RAR setbacks

As a nearly pristine watershed, a true no impact development is unlikely. It is difficult to find enough improvements that could be made to offset the impacts of developing a large portion of the watershed.

The 625 ha Partington Creek watershed encompasses Partington, Fox, Dairy, and Star Creeks. Each stream will be affected differently by the proposed development of the Partington Town Centre and adjacent residential areas based on the location and type of urban land use. The smaller tributaries will be more impacted than Partington as a whole.

UPPER PARTINGTON CREEK

The 300 ha upper Partington Creek subwatershed encompasses the forested headwaters of Partington Creek. It terminates at Victoria Drive (Fox Creek confluence) and does not include the lowland reach of Partington Creek or any of the Partington Creek Neighbourhood Plan proposed development. Most of the subwatershed is protected as park or is not proposed for development. The predicted change in TIA is from 4% to 5% and RFI would be reduced by 8% with RAR setbacks. Most of this will be single family residential and rural residential land use on the eastern margin of the subwatershed. Stream health is not expected to change in this portion of Partington Creek.

FOX CREEK MINIMAL IMPACTS

Most of the 130 ha Fox Creek subwatershed will remain forested and undeveloped, however, the western flank will be developed for single family residential use. The predicted change in TIA is from 1% to 11% and RFI would be reduced by 13% with RAR setbacks. Summer base flow is an important issue in Fox Creek and rainwater source controls and regional facilities focusing on infiltration and base flow augmentation will be used in the developed areas on the western margin of the subwatershed. The WHTS shows that the source controls and regional facilities may be able to reduce the future TIA of 11% to an EIA of 3% resulting in a decline of roughly 4 B-IBI points.

STAR CREEK MOST IMPACTED

Of the subwatersheds, Star Creek will experience the most substantial land use change because of its proximity to the town centre and its small area (80 ha); the predicted change in TIA is from 5% to 65%. RFI would also be significantly reduced from 72% to 37% with the RAR setbacks. A number of ditches will be removed and replaced by source controls.

This substantial increase in urban land use will result in a decline in overall health. Even with the proposed rainwater source controls, water quality ponds, baseflow augmentation, diversion and riparian buffers, reduced summer baseflows, increased concentrations of urban contaminants in water and sediment, and changes to channel structure due to hydrologic changes are expected to occur in Star Creek. It is not known how chum salmon spawning in lower Star Creek will be affected by increased urban development. Maintenance of baseflow is a priority on Star Creek as it does not have forested headwaters. The WHTS shows that the source controls and regional facilities may be able to reduce the future TIA of 65% to an EIA of 11% resulting in a decline of roughly 11 B-IBI points.

OVERALL PARTINGTON CREEK WATERSHED – STRIVING FOR NO-NET-LOSS OF ECOLOGICAL HEALTH

The predicted change in TIA of the overall Partington Creek watershed is from 3% to 22% with a decline in RFI of 12% corresponding to unmitigated future development and RAR setbacks. Water quality may be affected but rainwater source controls and water quality ponds and wetlands will be used to mitigate impacts. The source controls and regional baseflow augmentation/release facilities are expected to mitigate the predicted EIA to approximately 5%. RFI loss can be partially mitigated with restoration areas along relocated Cedar Drive and reforestation of bare patches within the RAR setbacks. With the long term Cedar Drive relocation, the predicted ecological health is expected to remain at its current estimated B-IBI score of 35 points.

Additional measures can be investigated to improve the B-IBI score, such as:

- explore additional enhanced riparian setbacks beyond RAR widths on Star and Fox Creeks in the PCNP to protect wildlife habitat, maintain wildlife corridors, provide opportunities greenways with trails, and to create windfirm park boundaries and setbacks. Additional riparian areas as shown on the May 2007 Land Use Concept would yield additional 2% RFI; and

- bigger volume reduction measures (to capture more than the 63 mm and further reduce the EIA).

NET ENVIRONMENTAL BENEFIT FOR FISH HABITAT

The City is striving for a Net Environmental Benefit for Fish Habitat in Partington Creek overall. This is expected as comprehensive stream and riparian restoration projects, including floodplain restoration, are implemented.

Fish habitat improvements as shown on Figure 9-7 are intended to mitigate some of the direct and indirect effects of urbanization on fish habitat in Partington Creek and its tributaries. Habitat restoration may also be used for fish habitat compensation if required by DFO.

Proposed restoration actions include moving Cedar Drive and its associated dyke 30 m east (from the existing inner toe of the dyke) and restoring a more complex channel and floodplain with floodplain marshes, flood benches, riparian forest, and a meandering stream channel with in-stream logs and other structural features. Approximately 600 m of stream channel will be restored in the short term and a further 900 m in the long term. Existing chum salmon spawning will be maintained or improved through the installation of coarse gravel substrates. Wildlife habitat value will also be enhanced in the restored reach. Complexing and removal of fish passage barriers along the lower Partington Main Stem and lower Fox Creek will also contribute to the Net Environmental Benefit for Fish Habitat.

9.12 CAPITAL COST ESTIMATES AND FUNDING

CAPITAL COST ESTIMATE

The sizing of facilities in the IWMP is conceptual in nature and should be thoroughly assessed during pre-design. The cost estimates of the overall proposed works in the IWMP are summarized in Table 9-11. The detailed cost estimates are included in Appendix K.

CLASS 'D' COST ESTIMATE AND ASSUMPTIONS

The cost estimates provided in this study are of Class 'D' accuracy. This means that the general requirements for upgrading including size and approximate depth of excavation, as well as some general site conditions are known. The projects identified have not considered the following factors affecting construction:

- relocation of adjacent services (gas, hydro, telephone, etc.);
- special permitting requirements (fisheries windows, contaminated site, etc.);
- geotechnical issues requiring special construction such as pile-supported piping, buoyancy problems or rock blasting; and
- critical market shortages of materials.

As the above factors have not been allowed for in estimating construction unit rates or project design, the following factors are applied to all projects:

- Contractor Markup/Overhead – 6% (included in unit price);
- PST at 7% (included in unit price);
- Mobilization/Demobilization – 6%;
- Bonding/Insurance – 2%;
- Engineering – 10%; and
- Contingency – 40%.

GST has not been included in the estimated project costs. The unit prices reflect KWL's recent experience with similar work, and therefore represent the best prediction of actual (2009) costs as of the date prepared. Actual tendered costs would depend on such things as market conditions generally, remoteness factor the time of year, contractors' work loads, any perceived risk exposure associated with the work, and unknown conditions.

The following unit prices were used:

- $25 per square meter for riparian planting;
- $50 per square meter for floodplain creation/complexing;
- $2000 per lineal meter for Cedar Drive relocation;
- $40 per cubic meter of excavation;

- $40 per cubic meter of drain rock; and
- $2 per square meter of hydroseeding.

Property costs are assumed as:

- $2.47 million per ha of proposed urban land (City estimate $1 M/acre); and
- $250,000 per ha of agricultural land (from City of Coquitlam Properties department).

FUNDING STRATEGIES

The cost estimates in Table 9-11 are divided up into three categories, 1) DCC Items, 2) Maintenance Items, and 3) 'By Developer/Owner' Items.

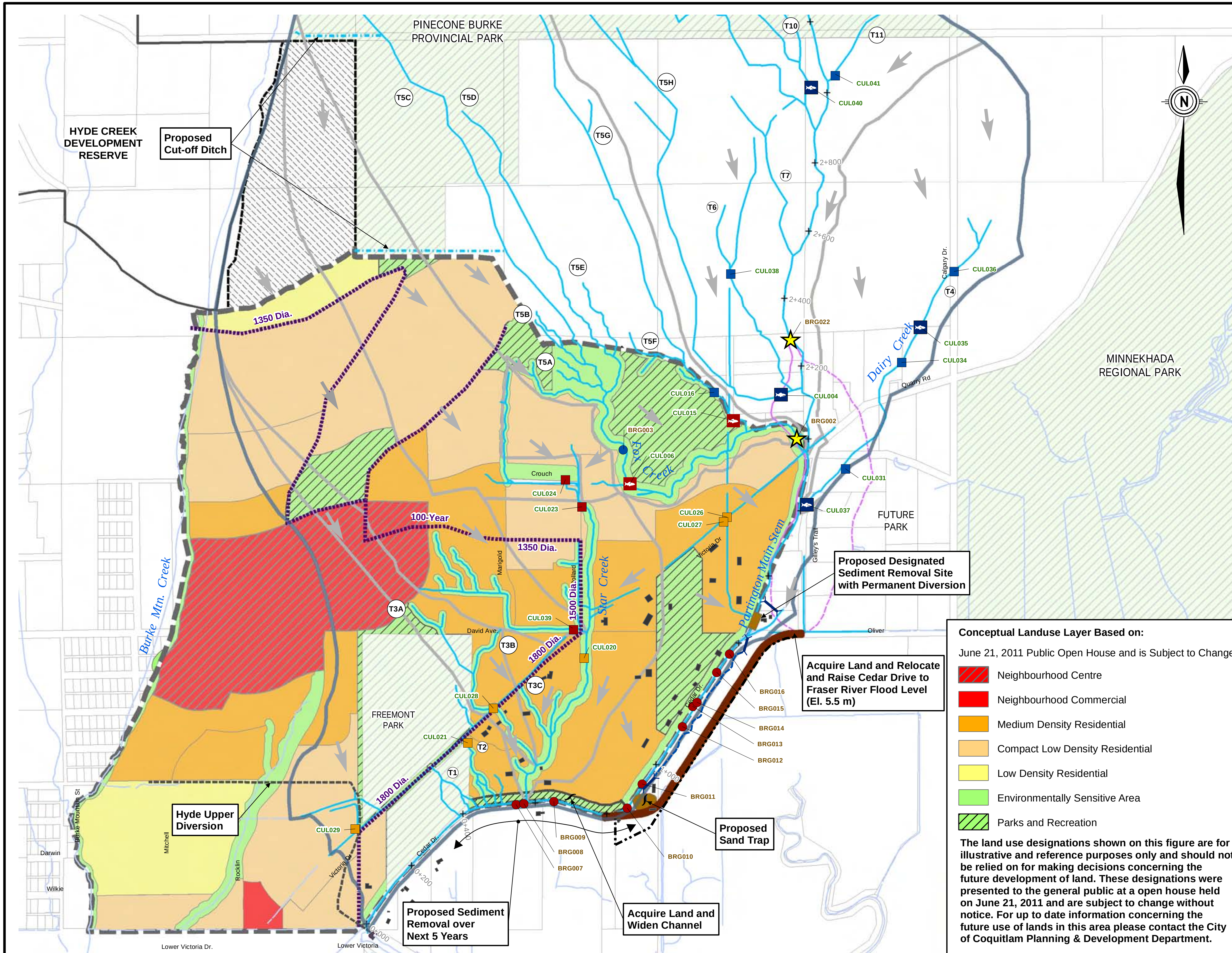
Funding opportunities from senior governments should be pursued for some of the items for example:

- Cedar Drive relocation - cost sharing with the provincial government as it will form a portion of the dyking system;
- Fish barrier removals and complexing – Wildlife Habitat Canada Conservation Grant;
- Riparian enhancement and conservation areas – Environment Canada Habitat Stewardship Program; and
- Conveyance upgrades – Infrastructure grant programs.

Table 9-11: IWMP Class D Cost Estimate

IWMP Component	Result	Class D Cost Estimates	
Sediment Management			
Construct 2,500 m^3 sediment trap at Cedar/Oliver intersection.	Will trap a majority of gravels and larger sediment.	$316,000	
Remove accumulated sediment in main stem (100 m per year 0.3 m deep). In first 5 years focus removals in 500 m area around Star Creek mouth. Do not disturb prime Chum spawning area southwest of Oliver.	Will lower HGL; 10-year peak flow will be conveyed without overtopping Cedar Drive.	$143,000	
Provide 100-year Flood Conveyance			
Remove two collapsed bridges immediately (BRG002, BRG022).	Will provide safe conveyance of 100-year flow and reduce likelihood of debris mobilization upon sudden failure.	$10,000	
Upgrade five high priority culverts under municipal roadways within next five years (CUL015 including fish passage upgrade, CUL023, CUL024, CUL028, CUL039).	Will provide safe conveyance of 100-year flow past roads and driveways.	$316,000	
Upgrade one high priority private culvert crossing and improve fish passage within next five years (CUL006).	Will provide safe conveyance of 100-year flow on provate property.		
Continue sediment removals from Sediment Traps and specified areas to provide adequate 100-year flood conveyance along Partington Main Stem.			**Existing Flood Conveyance $785,000**
Upgrade two low priority culverts under municipal roadways at time of development or as opportunities arise (CUL036, CUL037 including fish passage upgrade).	Will provide safe conveyance of 100-year flow past roads and driveways.		
Upgrade eight low priority private culverts and one bridge at time of development or as opportunities arise (BRG003, CUL004, CUL016, CUL031, CUL034, CUL035, CUL038, CUL040, CUL041).	Will provide safe conveyance of 100-year flow on provate property.		
Remove ten bridges along Cedar Drive (BRG007-BRG016) and five culverts (CUL020, CUL021, CUL026, CUL027, CUL029) at time of development.	Will improve conveyance by removing unnecessary crossings.		
Construct Diversion pipe from upper Hyde Development Reserve area to existing Hyde Creek Diversion near mouth of Partington Creek. Diversion sized for 100-year post-dev minus 5-year pre-dev flow. 5-year pre-dev flow to creeks. Diversion will alleviate flood flows to Star and Fox Creeks.	Will provide safe 100-year conveyance for Star Creek and other Partington Tributaries to prevent flooding of adjacent properties.	$11,758,000	**Future Flood Conveyance**
Relocate 600m of Cedar Drive adjacent to prime Chum spawning area and restore 30 m setback on south side of Partington Main Stem. Rebuild road up to 5.5 m Geodetic elevation to match the Fraser River Freshet design flood level + freeboard and contain the Partington Creek 100-year event flow.		$5,016,000	**$16,774,000**
DFO 6-month, 2-year, 5-year Peak Flow Reduction			
Utilize Flood Conveyance Diversion to mitigate post development flows to pre-development levels for Star and Fox Creeks. Excess flows to diversion, pre-development flows to creeks up to 5-year event.	Will meet DFO detention criteria to protect Star Creek and other Partington tributaries.		
For area west of Star Creek, south of Victoria Drive, designate a land use that will have full source controls for volume reduction and construct diversion pipe to route post development peak flows away from Star Creek and into the Partington Main Stem.	Erosion analysis for Partington Main Stem required to determine if it can take the undetained post development flows.		
Construct specialized diversion inlets to mitigate hydrologic impacts of development. Allow undetained peak flows into Partington Creek Main-stem east of Star Creek and south of Victoria Drive. Align 10-year storm sewer to discharge next to mouth of Star Creek. Offset this peak flow increase by reducing the peak flows in Star Creek by a similar amount. Higher flows to continue undetained via major flow routes to Partington Main Stem.			
Volumetric Reduction to Mitigate Frequently Occurring Flows and Sustain Baseflows			
Implement onsite volume reduction source controls for all roads and land uses except for SF residential areas.	Will meet the DFO volumetric reduction criterion.		
Construct Diversion Inlet to divert low flows to diversion for Volume Reduction for SF areas West of Star Creek, but provide Baseflow Augmentation Tanks (underground to keep temperature low, sized to maintain minimal baseflows during summer) at top ends of Star Creek tributaries **(ID# 1 and ID# 2),** Fox Creek Tributary T5A **(ID# 3) and midway along Star Creek (ID# 12)** to maintain baseflows and make up for lack of source control in single family areas (300 m^3/ha). Located on school lands and park land therefore land allowance not included in the cost estimate.	Will meet the DFO volumetric reduction criterion & provide baseflow to Star Creek.	$4,020,000	
Construct underground Baseflow Release Facility Volume Reduction EIA to 10% = 1000 m3/ha) **(ID# 4 and ID# 13)** for SF area east of Star Creek & west of Partington Main-stem.	Will meet the DFO volumetric reduction criterion.	$2,978,000	
Construct Water Quality Facilities			
Implement onsite water quality source controls for all roads and land uses except for SF residential areas.	Will meet the DFO WQ criterion.		
Construct water quality ponds downstream of SF areas: at top end of Fox Creek Tributary T5A **(ID# 5)**, at top end of Star Creek **(ID# 6), midway Star Creek (ID# 11 and ID# 14)**, near Deboville Slough **(ID# 7)**, near the mouth of Fox Creek **(ID# 8)**, and near the top of the Star Creek tributaries **(ID #9)**.	Will meet the DFO WQ criterion.	$5,147,000	
Construct one Water Quality pond at top end of Tributary T3A **(ID# 10)** for the Village Core (assume 10 ha of pavement area directed to pond).	Will meet the DFO WQ criterion.	$163,000	**Hydrologic Environmental Protection $12,308,000**
Compensate for Development Impacts & Create Net Environmental Benefit of Fish Habitat Around Critical Habitat Areas			
Protect RAR Setbacks for all creeks.			
Purchase additional 6m setback along north side of Partington Creek and Construct complexing to provide 30m riparian setback and instream environmental enhancement.		$1,057,000	
Remove two fish passage barriers on Fox Creek (CUL005, CUL017).		$195,000	
Remove one fish passage barrier on Fox Creek (CUL007).			
Construct instream complexing (large woody debris, boulders, spurs, etc) to Fox Creek and Partington Creek. Assume 40 structures total.		$200,000	**Environmental Compensation $1,452,000**
	TOTAL (Excluding GST)	**$31,319,000**	**$31,319,000**
	Total Cost Estimate for DCC Items	**$30,798,000**	
	Total Cost Estimate for Drainage Maintenance Items	**$521,000**	
	Total Cost Estimate for 'By Developer/Owner' Items	**not estimated**	

Refer to Figures 9-1 to 9-7



City of Coquitlam
Partington Creek
Integrated Watershed Management Plan

Legend

- Subcatchment Boundary
- Existing Park
- Development Reserve
- Partington Creek Neighbourhood Plan
- Flow Direction Arrow
- Watercourse
- Proposed Diversion Pipe
- Creek Fan Area - Possible Channel Movement

Proposed Upgrades

Bridge

- Collapsed Bridges to be Removed Immediately
- Remove Bridge Permanently During Future Development and not to be Replaced
- Low Priority - Upgrade Bridge at Time of Development

Culvert

- High Priority - Upgrade Culvert to Address Existing Flooding
- Remove Culvert Permanently During Future Development and not to be Replaced
- Low Priority - Upgrade Culvert at Time of Development
- High Priority - Upgrade Culvert and Improve Fish Passage
- Low Priority - Upgrade Culvert and Improve Fish Passage

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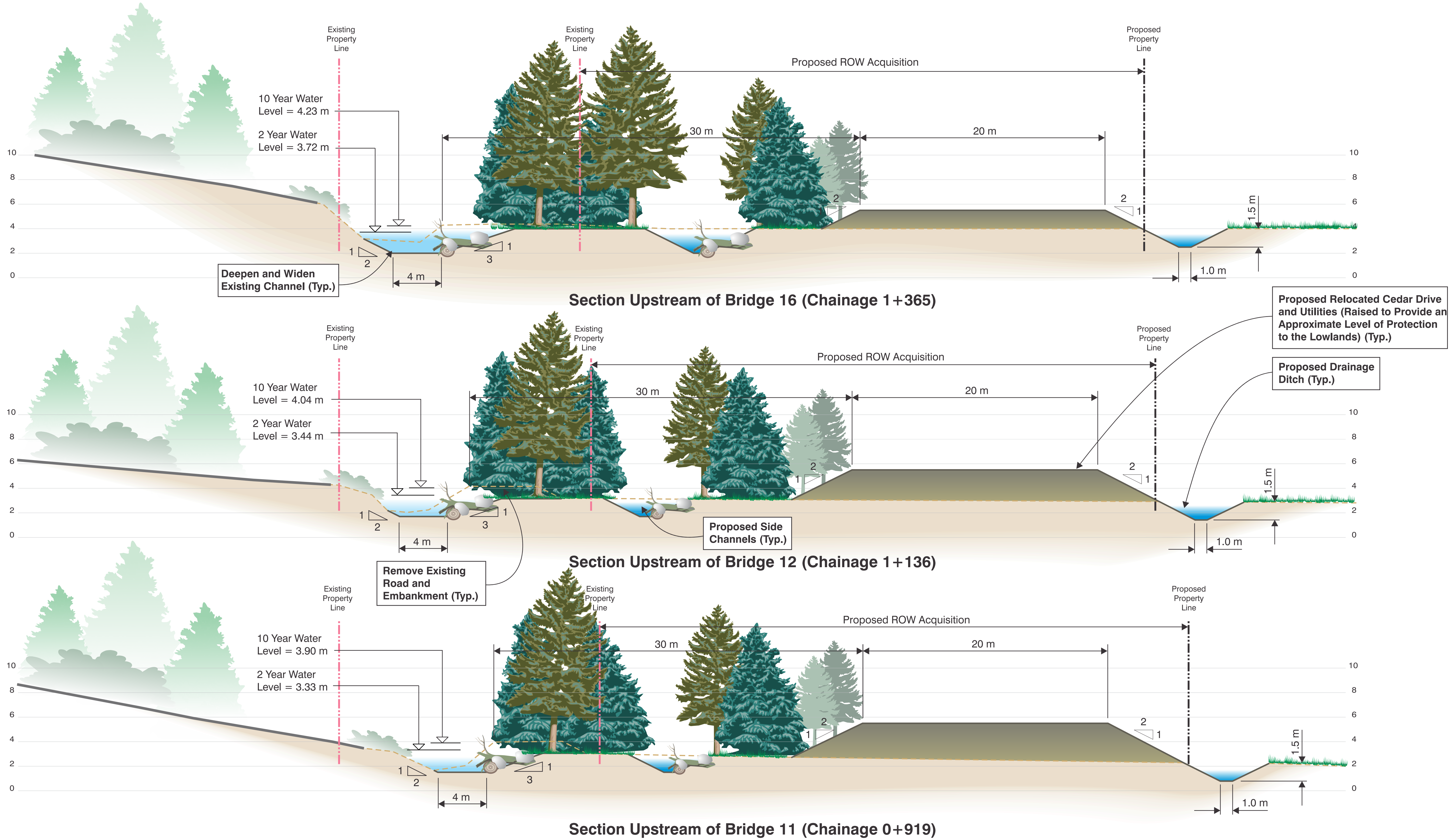
Scale in Metres 1:10,000

Project No.	Date
456-038	July 2011

Hydrotechnical Upgrade Plan

Figure 9-1



Scale 1:300 (Approximate)

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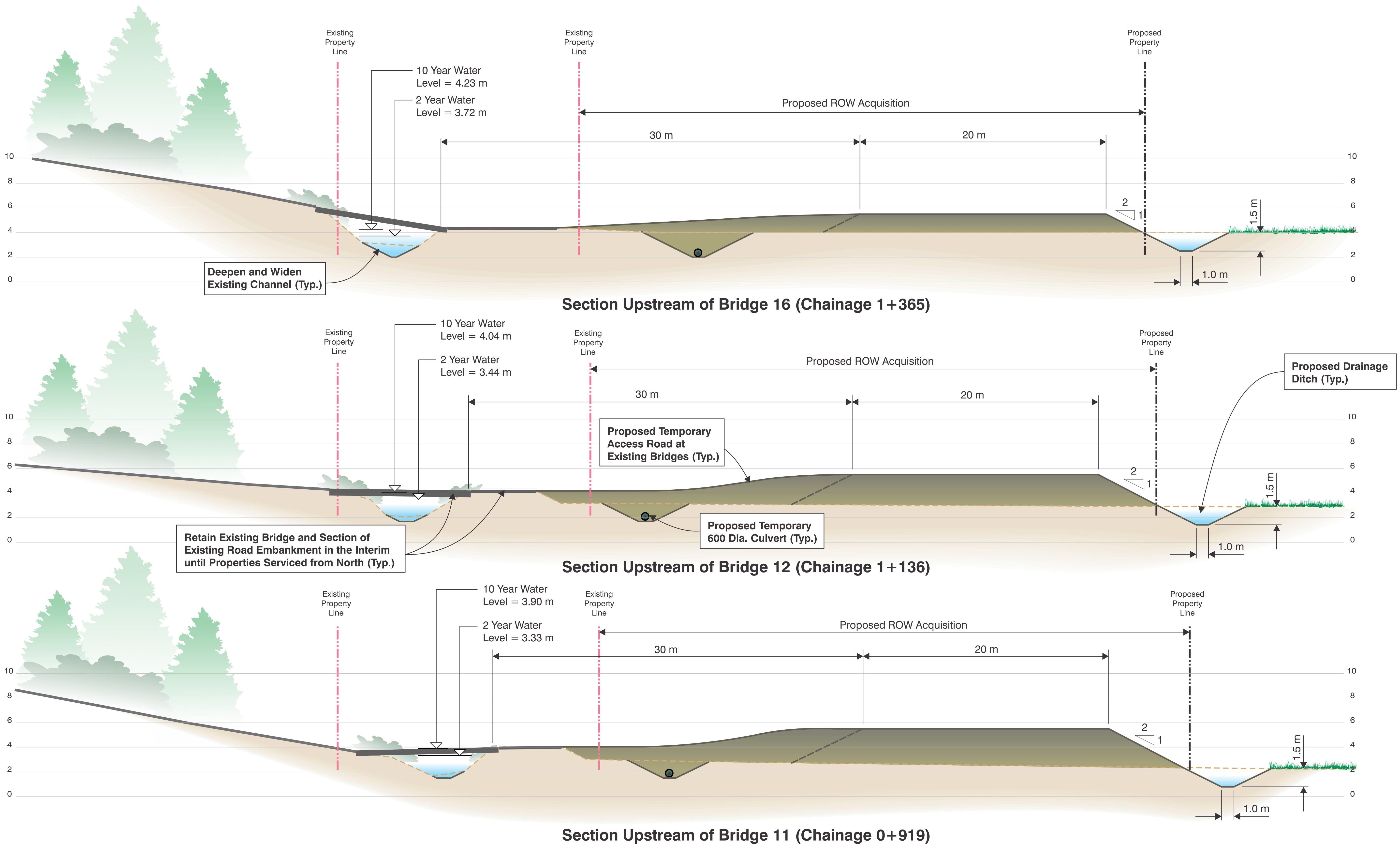
Typical Sections - Relocated Cedar Drive

(Looking Upstream)

Figure 9-2



Typical Sections at Bridges - Interim Scenario

(Looking Upstream)

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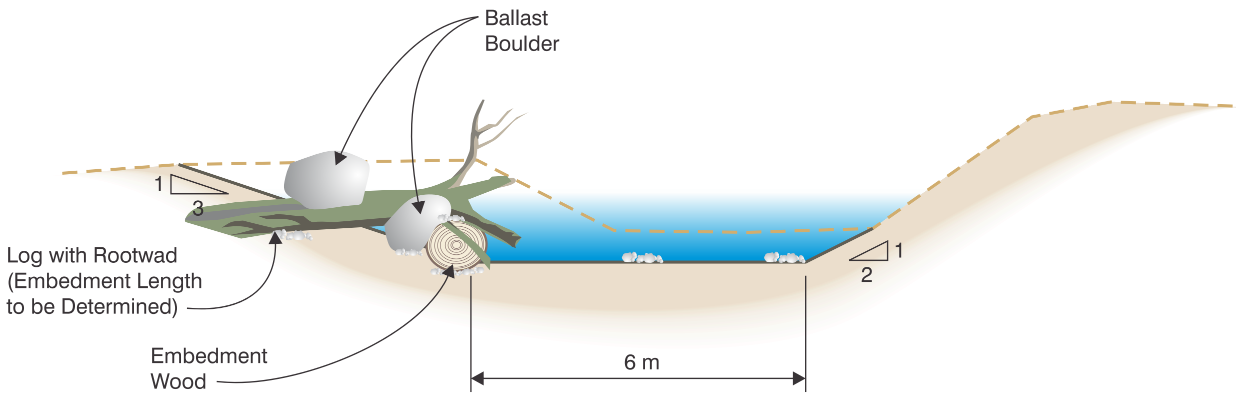
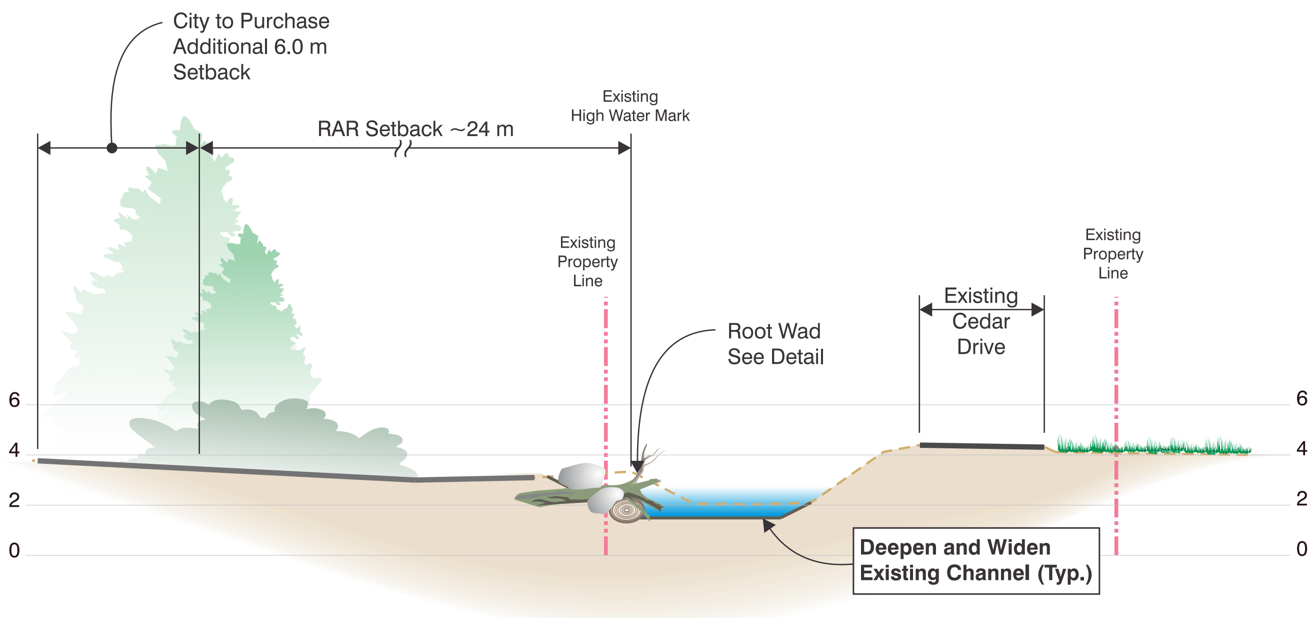
Figure 9-3



Root Wad Detail



Section Upstream of Bridge 4 (Chainage 0+538)
(Looking Upstream)

Scale 1:300 (Approximate)

Typical Section Downstream of Upper Cedar Drive Relocation

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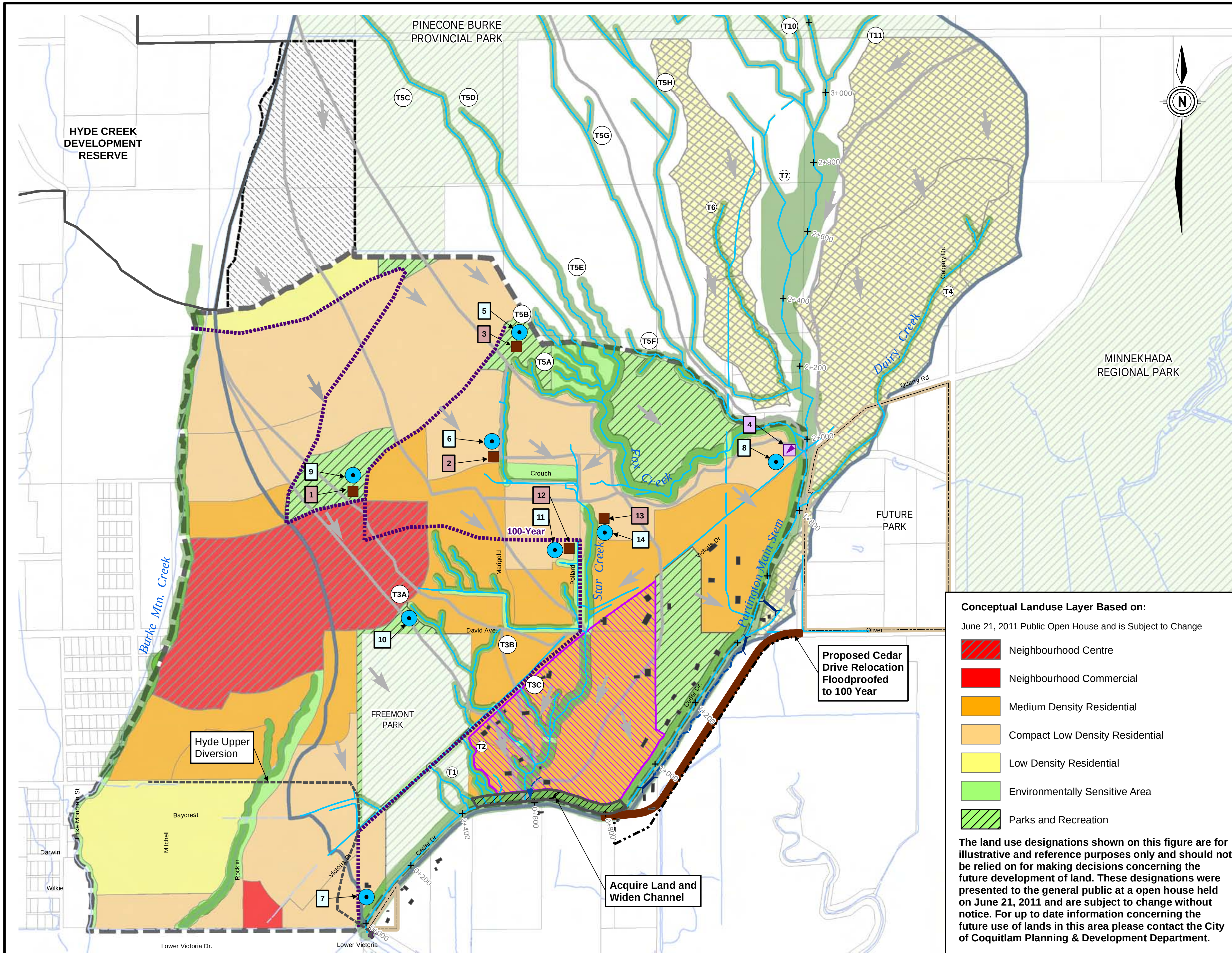
Figure 9-4



City of Coquitlam
Partington Creek
Integrated Watershed Management Plan

Legend

- Subcatchment Boundary
- Existing Park
- Lands to be Acquired by City
- Partington Creek Neighbourhood Plan
- Development Reserve
- Flow Direction Arrow
- Watercourse
- Proposed Diversion Pipe
- Proposed Water Quality Pond
- Proposed Baseflow Augmentation Facility (Sustain Baseflow)
- Proposed Baseflow Release Facility (Mitigate Peaks/Volumes)
- No Outfalls into Star Creek or any Star Creek Tributaries from this Area
- Suburban Residential and/or Rural Resource
- Existing Riparian Forested Setback Areas Based on RAR

Implement City's Rainwater Management Source Controls on all Proposed Land Uses and Roads. Supplement with Regional Facilities to meet Volume Reduction Target of 63mm and Water Quality Treatment Objectives.

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Scale in Metres 1:10,000

Project No.	Date
456-038	July 2011

Hydrologic Environmental Protection Plan

Figure 9-5

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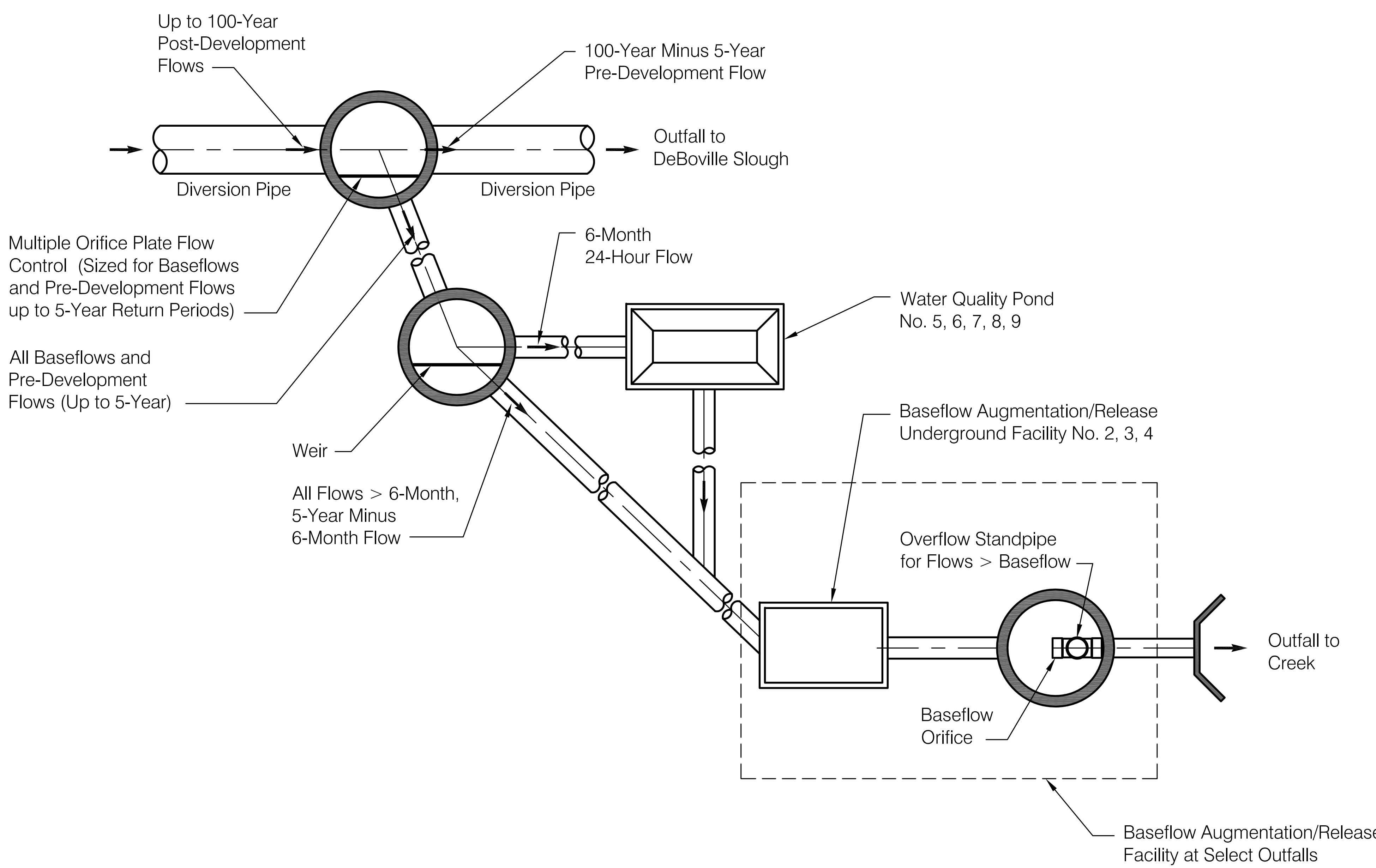
Author: JLau



Regional Facility - Flow Control Concept

City of Coquitlam
Partington Creek
Integrated Watershed Management Plan

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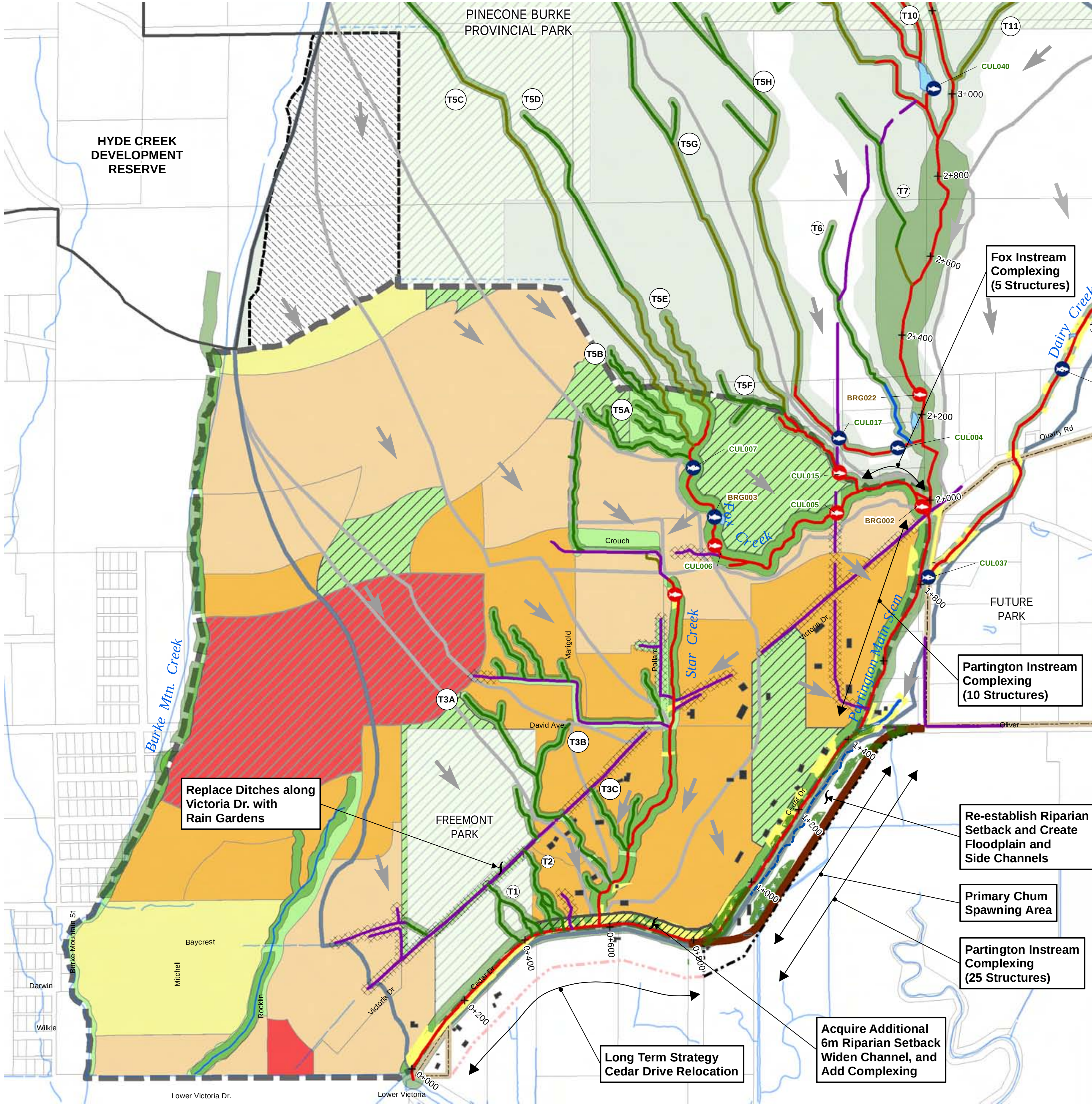
Not to Scale

Project No.	Date
456-038	March 2010

Flow Control Concept

Figure 9-6



Partington Creek Neighbourhood Plan

Conceptual Landuse Layer Based on:

June 21, 2011 Public Open House and is Subject to Change

- Neighbourhood Centre
- Neighbourhood Commercial
- Medium Density Residential
- Compact Low Density Residential
- Low Density Residential
- Environmentally Sensitive Area
- Parks and Recreation

The land use designations shown on this figure are for illustrative and reference purposes only and should not be relied on for making decisions concerning the future development of land. These designations were presented to the general public at a open house held on June 21, 2011 and are subject to change without notice. For up to date information concerning the future use of lands in this area please contact the City of Coquitlam Planning & Development Department.

Notes:

1. This map presents a preliminary assessment of known watercourses, but not necessarily their exact location. Other permanent and intermittent watercourses may be identified over time as development plans are undertaken.
2. The City does not guarantee or warrant the reliability, accuracy, quality, currency, validity or completeness of the information presented. This information is provided for information and conceptual planning purposes only.
3. This map show a preliminary assessment of riparian areas, measured from approximate stream centreline. The locations of high water mark and top of ravine bank, where applicable, will need to be determined during future detailed riparian areas assessments. Therefore the riparian extents may change.

City of Coquitlam
Partington Creek
Integrated Watershed Management Plan

Legend

- Subcatchment Boundary
- Lands to be Acquired by City
- Development Reserve
- Flow Direction Arrow
- Watercourse to be Incorporated into Stormwater Source Controls. Wetted Area Loss to be Compensated for by Partington Creek Main Stem Side Channels. Riparian Loss to be Compensated for by Riparian Restoration/Reforestation Elsewhere.
- Remove Fish Passage Barriers (High Priority)
- Remove Fish Passage Barriers (Low Priority)
- Proposed Riparian Restoration/ Reforestation within RAR Setbacks
- Existing Riparian Forested Setback Areas Based on RAR

Enhanced Riparian Area

- Areas to Remain Forested
- Existing Park

Fish Classification of Watercourse

- Fish-Bearing Permanent Streams
- Permanent Stream (Unknown Fish Presence)
- Nonfish-Bearing Permanent Streams
- Nonfish-Bearing Non-Permanent Streams
- Ditches (Nonfish-Bearing)
- Unclassified

(Fish classification based on existing information on fish presence and flow regime)

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Scale in Metres 1:10,000

Project No.	Date
456-038	July 2011

Ecological Protection Plan

Figure 9-7

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Author: JLau

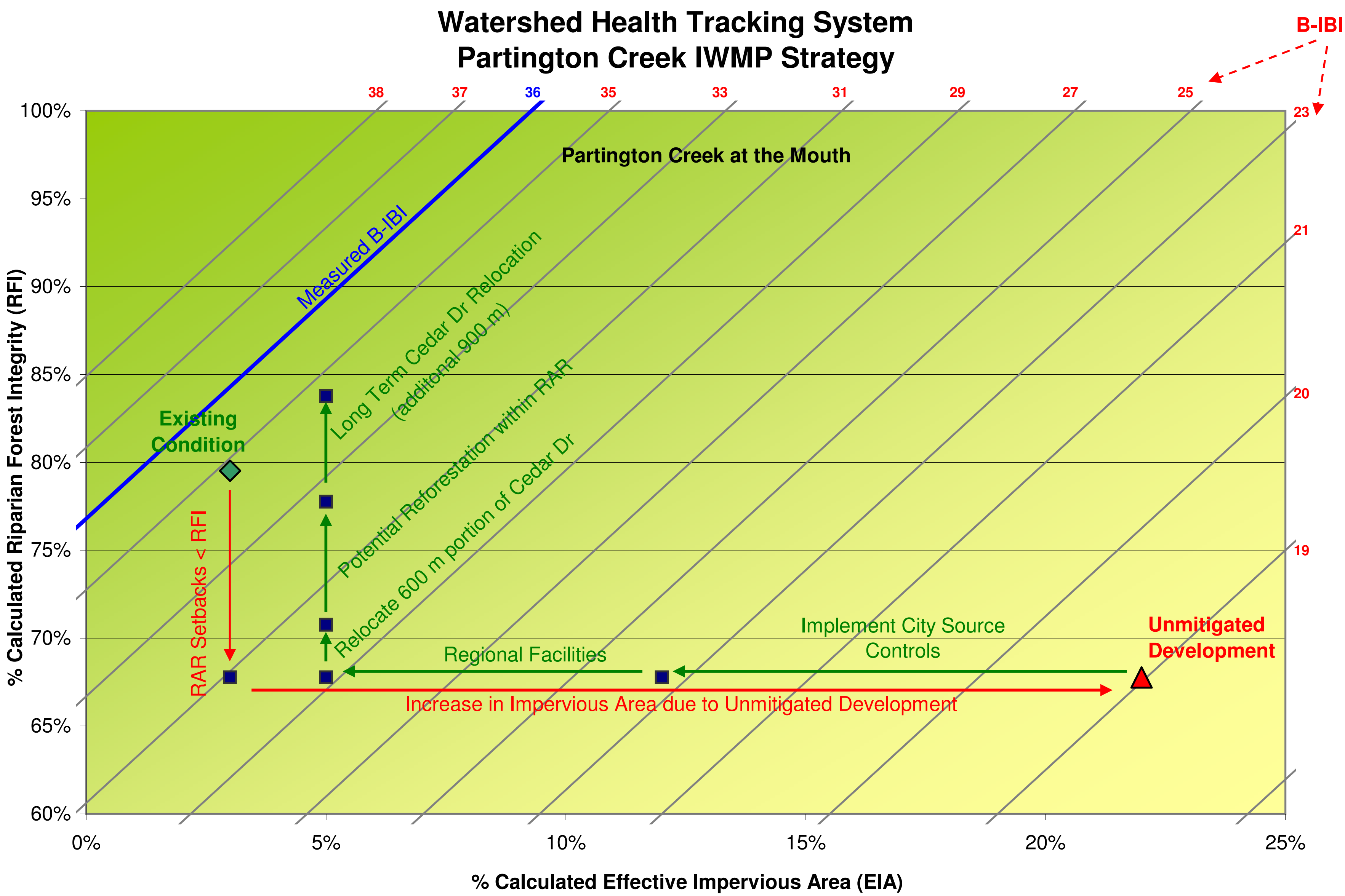

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Figure 9-8

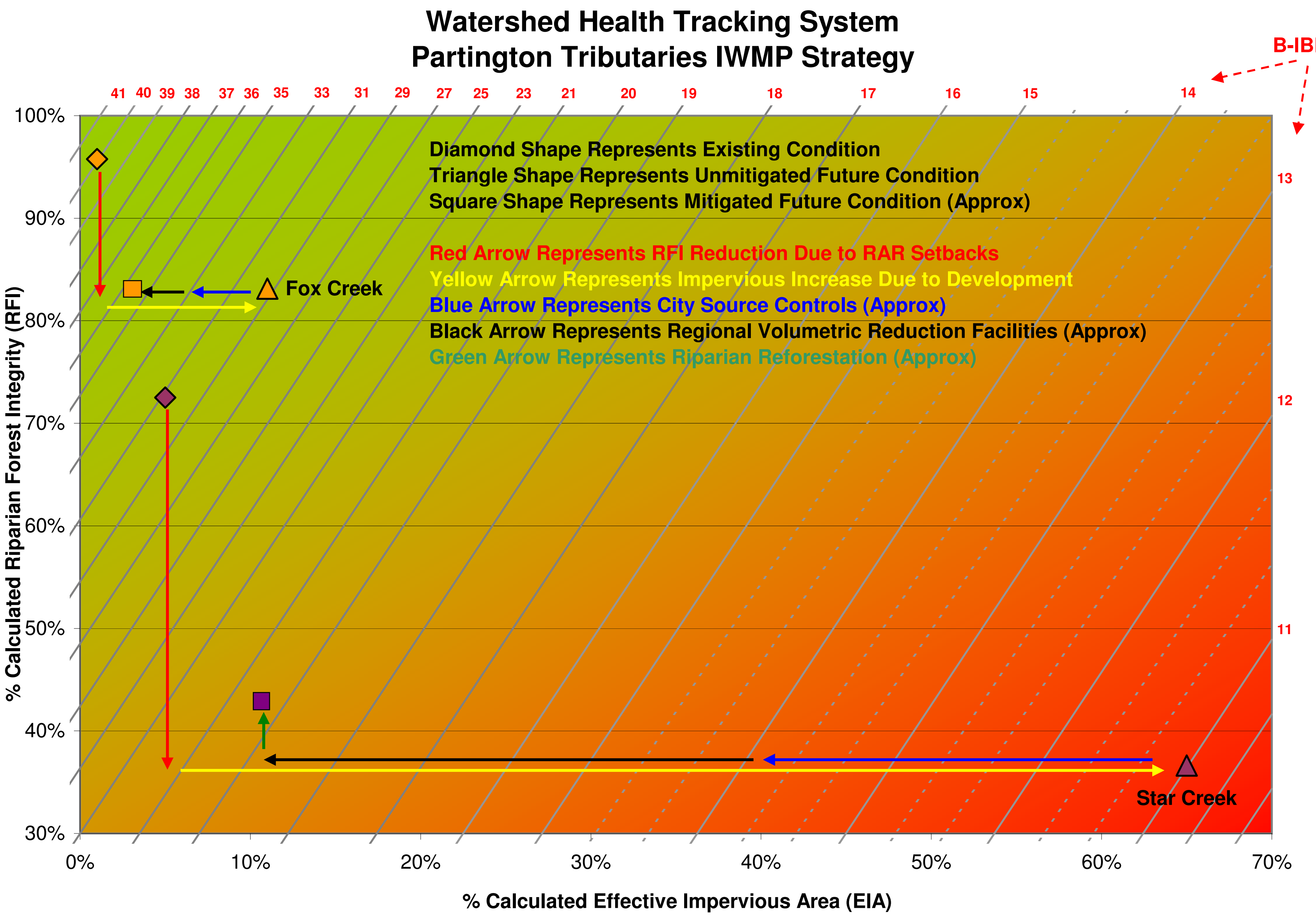
Watershed Health Tracking System
Partington Tributaries IWMP Strategy
B-IBI
41 40 39 38 37 36 35 33 31 29 27 25 23 21 20 19 18 17 16 15 14
13
12
11
Diamond Shape Represents Existing Condition
Triangle Shape Represents Unmitigated Future Condition
Square Shape Represents Mitigated Future Condition (Approx)
Red Arrow Represents RFI Reduction Due to RAR Setbacks
Yellow Arrow Represents Impervious Increase Due to Development
Blue Arrow Represents City Source Controls (Approx)
Black Arrow Represents Regional Volumetric Reduction Facilities (Approx)
Green Arrow Represents Riparian Reforestation (Approx)
Fox Creek
Star Creek
100%
90%
80%
70%
60%
50%
40%
30%
% Calculated Riparian Forest Integrity (RFI)
0%
10%
20%
30%
40%
50%
60%
70%
% Calculated Effective Impervious Area (EIA)

Figure 9-9

Section 10

IWMP Implementation Strategy

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10. IWMP IMPLEMENTATION STRATEGY

10.1 MONITORING AND ADAPTIVE MANAGEMENT

To measure the success of stormwater management and other mitigation measures, the following adaptive management plan is proposed. The implementation plan and schedule will be monitored continuously and reviewed annually to assess:

1. How education/permitting/enforcement by the City is progressing once the IWMP is adopted. Are all developers being told to incorporate proposed mitigation measures?

2. How development is incorporating the proposed mitigation measures. Are developers incorporating the measures properly?

The monitoring strategy will include the following performance indicators and the duration and frequency associated with each.

1. Continuous flow monitoring of Partington, Fox, and Star Creeks beginning in 2011 and ending a minimum of 10 years following completion of Partington Creek Neighbourhood Plan construction.

2. Benthic invertebrate monitoring on Partington, Fox, and Star creeks every second year beginning in 2011 and ending a minimum of 10 years following completion of Partington Creek Neighbourhood Plan construction.

3. Calculation of total and effective impervious area, and riparian forest integrity every second year and comparison with 2005 baseline values.

Table 10-1: Partington Watershed Health Tracking System Indicators

	Existing Conditions	Unmitigated Future Development Conditions	Mitigated Future Development Conditions
B-IBI	Measured 31 (Predicted 35)	Predicted 19	Predicted 35
EIA	3%	22%[1]	5%[3]
RFI	80%	68%[2]	84%[4]
RFI calculated for permanent watercourses only 5 Based on Partington Creek Neighbourhood Plan development & Northeast Coquitlam Area Plan development 6 Based on RAR setbacks 7 With City source controls, diversions, and baseflow facilities 8 With Cedar Drive relocation, extra riparian on north side of Main-stem, and reforestation within RAR setbacks			

4. Monitor key channels for erosion every few years.

5. Annual assessment of chum salmon spawning (November–December visual surveys) and juvenile coho salmon use (summer baseflow trapping) in all streams.

6. Assessment of vegetation and channel conditions in the restored section of lower Partington creek.

The continuous monitoring should be set up such that baseflows can be monitored. The existing flow monitoring station at Victoria Drive is not ideal for low flow and baseflow measurements given the wide channel width, the large cobbles/boulders in the creek bed, the likely amount of flow through the bed sediments, and the potential groundwater that may be bypassing this location and emerging in the lower channel. A monitoring station should be established closer to the mouth of Partington Creek to properly quantify low flows and baseflows. Monitoring prior to development will establish baseflow targets to be met once development commences.

In addition to monitoring the implementation plan it is also necessary to have a method for correcting any shortcomings. The results of the monitoring program will be reviewed annually and modifications to City policies, the rainwater source controls, and other mitigation strategies will be made and implemented in the remaining development in the watershed.

Monitoring of sediment aggradation every 10 years is proposed to refine the sediment budget for Partington Creek and adjust the frequency and volumes of in-stream sediment removals accordingly to balance the inputs and outputs into the lower reach.

10.2 LONG TERM FLOODPLAIN AND ENVIRONMENTAL ENHANCEMENT STRATEGY

The City's long term strategy is to relocate and raise Cedar Drive to act as a dyke to protect the agricultural areas from the Pitt River 200-year water level. As ownership of the agricultural lots changes hands or development applications are received, the City will endeavour to acquire a right-of-way from these properties to relocate the road southward. The goal will be to move and raise Cedar Drive as a dyke and add in-stream complexing, floodplain areas and wetlands, and riparian forest similar to that proposed in the 600 m long section upstream.

The ultimate plan is to remove the driveway bridges across Partington Creek in this reach once the area to the north is developed and access is provided from Victoria Drive. Access will be maintained from Cedar Drive to any properties who do not wish to redevelop in a similar manner as shown on Figure 9-3.

10.3 DEBOVILLE SLOUGH SEDIMENT MANAGEMENT

Sediment accumulation in DeBoville Slough was identified as one of the key issues during the stakeholder process. The Pitt River Boat Club, which has a marina near the mouth of the slough, has dredged the downstream portion of the slough to maintain boat access to the marina.

Sediment aggradation in DeBoville Slough is a natural process as a result of a low-lying slow moving water body. Very fine silts aggrade it this area due to the long settling times afforded by this waterbody. Silt/sediment sources to DeBoville Slough include Hyde Creek as well as Partington Creek.

URBAN AREA WATER QUALITY TREATMENT, SAND AND SEDIMENT BASINS

The Partington IWMP proposes numerous sediment reduction measures such as: source controls measures, water quality treatment ponds to settle out typical stormwater sediments from urbanized areas, and on-line sediment and sand traps (or removal basins/areas) on lower Partington Creek channel. Sand influx into DeBoville Slough from Partington Creek should not increase with development with these measures. Furthermore, a large portion of the development’s 100-year peak flows would be diverted away from the creek channels thereby reducing the flows and therefore the sediment transport that is occurring naturally in Partington Creek and its tributaries.

With the proposed diversion discharging into the upstream end of the DeBoville Slough, there is a possibility that a certain portion of the accumulated sediments in the slough will be resuspended and transported down the slough. Analysis shows post-development velocities in the top end of the slough will be up to 0.2 m/s higher than pre-development. To avoid impacting the marina, the sediment could be removed at the wide part of the slough approximately 400 m downstream of Cedar Drive.

MONITOR AGGRADATION AT MARINA TO QUANTIFY ANY INCREASES

Sediment aggradation monitoring and removal should continue as needed at the marina to determine if the accumulations are increasing and if so, by how much. Sources and causes of sediment aggradation should be further investigated.

10.4 SEDIMENT AND EROSION CONTROL DURING CONSTRUCTION

Potential sediment loadings are highest during the construction phase where earth works are being performed. It is critical that proper sediment and erosion control measures are implemented during construction. The *Land Development Guidelines* (DFO 1992 and soon to release an update) provide a list of Best Management Practices for sediment and erosion control during construction such as silt fencing, covering exposed soil areas and stockpiles, wheel wash stations, settling ponds, etc. It is important that the City's Sediment Control Bylaw No. 2929 – 1995 is strictly enforced and is a requirement of development.

10.5 SPILL CONTROL AND EMERGENCY RESPONSE PLANS

In conjunction with the development of an IWMP, it is recommended that an Emergency Response Plan be implemented. There are two main areas of interest:

- a Spill Control Plan to deal with contaminated spills, and
- an Emergency Flood Response Plan to deal with blocked channels, culverts, and bridges during flood events.

SPILL CONTROL PLAN

The City currently has a spill control plan in their *Drainage Policy & Procedures Manual* dated April 2008. This plan should be followed to protect the watercourses, aquatic habitat and species, and groundwater.

EMERGENCY FLOOD RESPONSE PLAN

The City currently has a flood response plan in their *Drainage Policy & Procedures Manual* dated April 2008. This plan should be followed to respond to emergency conditions. For gravel removal activities, the provisions of Section 5.3 shall apply.

10.6 RECOMMENDATIONS FOR PCNP

A number of issues have been identified in the IWMP that will impact the PCNP planning process. The following issues should be considered in the planning process.

1. Opportunities for enhanced riparian protection should be investigated. This may include expanded setbacks for wildlife habitat, wildlife corridors, greenways and trails, and parks. Additional riparian areas along Star and Fox Creeks would benefit the watershed health. Assess the need for additional riparian setbacks above RAR along the south side of Fox Creek and Star Creek for Pacific water shrew. More detailed assessment of Pacific water shrew habitat suitability may be required.

2. Assess a wildlife corridor linking the area north of Fox Creek with the lowlands. This may be accomplished by connecting the Fox Island (forested area surrounded by the Fox Creek main-stem and Fox Tributary T5F to the Star Creek riparian area with a forested park at the north end of Pollard Street.

3. Opportunities for protecting Fox Island should be investigated to mitigate changes to ecological health through increased riparian protection, as well as protect wildlife habitat.

4. Consider no single family development in the area bounded by Freemont Park, Star Creek, Victoria Drive, and Partington Creek. Single family residential land use would require regional water quality treatment and volumetric reduction baseflow release facilities. All the other land uses address these two issues onsite thereby eliminating such regional facilities in this small area.

5. Future development or redevelopment of any properties on the Partington Creek fan area shown on Figure 9-1 should be in conformance with the *Flood Hazard Area Land Use Management Guidelines* (Ministry of water, Land and Air Protection, May 2004), in addition to the other environmental regulations. No basements should be allowed in the Partington Creek fan area because deep building footing drains may drain the groundwater table level and effect baseflow in the creek. This strategy can be accommodated through design guidelines in the PCNP process

Section 11

Summary and Recommendations

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11. SUMMARY AND RECOMMENDATIONS

11.1 SUMMARY

INTRODUCTION

- The Partington Creek IWMP employed a multi-disciplinary approach including stormwater engineering, land use planning and environmental protection.

- The study was guided by a City Steering Committee, an Advisory Committee with interested stakeholders, City Council and the public. This study is also integrated with *Partington Creek Neighbourhood Plan* study.

- Two watershed goals direct the IWMP: strive for no-net-loss of ecological health for the watershed as a whole and provide a net environmental benefit to fish habitat on the value lower main-stem channel.

- Applicable stormwater criteria includes the City's 10-year minor and 100-year major conveyance standards, DFO's 6-month volume reduction, 6-month to 5-year detention, and water quality treatment of 90% of annual runoff, and the Riparian Area Regulation for riparian protection.

OVERVIEW OF PARTINGTON CREEK WATERSHED

- The Partington Creek watershed is 625 ha and drains to DeBoville Slough to the Pitt River. There are three significant tributaries: Star Creek, Fox Creek and Dairy Creek.

- The existing land use is predominantly second growth forest with sporadic rural development.

- Future development proposes a Village Core surrounded by high, medium, and low density residential lands. Existing total impervious area within the watershed is expected to increase from 3% to 22%. The headwaters in Pinecone Burke Provincial Park will remain undeveloped.

- There is an existing sedimentation and flooding problem in lower Partington Main-stem. There is considerable sediment deposition in the lower flat channel and annual flood flows overtop Cedar Drive into lowland agricultural lands.

- The Partington IWMP needs to incorporate provision for conveyance of flood flows from upper Hyde Creek Development Reserve as well as the Partington Creek Development Reserve and the Dairy Creek and upper Partington catchments.

WATERSHED INVENTORIES

- A drainage inventory noted the size and type of all hydraulic structures on the creek channels. Minimal erosion was noted under existing conditions.

- Partington Creek supports a diverse fish community with at least 14 fish species including floodplain, anadromous and resident fish communities. There is excellent chum salmon spawning habitat on lower Partington Creek and its tributaries. Three fish species which are species at risk occur or may occur in the watershed.

- Water quality is considered unimpaired and similar to undeveloped, forested watersheds in coastal B.C.

- Partington Creek has excellent ecological health reflected in the 2005 B-IBI score of 31 and a mean taxa richness of 28.5. This is the fourth highest B-IBI score and third highest mean taxa richness out of 34 measured streams in Metro Vancouver.

- Over 90% of the watershed is forest. Invasive plants were common along lower Partington Creek.

- Wildlife use in the watershed is diverse including species of conservation significance. Pacific water shrew, a species at risk, was recently found west of the Partington watershed and is suspected within the high quality riparian habitat areas around Partington Creek, Star Creek, and Fox Creek.

- The hydrogeology inventory revealed steeply sloping lands with shallow soil cover. The underlying silt, till and bedrock has low permeability and severely limits infiltration.

HYDROLOGIC AND HYDRAULIC MODELLING

- The City started collecting flow monitoring data on Partington Creek at the Victoria Drive bridge in 2005 and continues to monitor.

- An XP-SWMM model was developed and calibrated.

- Rainfall data and IDF curves were obtained from Metro Vancouver climate stations, *Port Coquitlam City Yard* for the lower subcatchments and *Burke Mountain Firehall* for the mid elevation subcatchments and factored up by 125% and 160% for the higher elevation areas.

- The volume reduction target for the lower Partington proposed development area is 63 mm (6-month 24-hour event).

- Peak flows were estimated at strategic locations within the watershed for both existing and future conditions.

- Development areas can increase peak flow estimates two to three times higher than existing forested conditions. Changes in peak flows are less pronounced in the Partington and Fox Creeks because of different timing of the hydrograph peaks – developed areas peak with short duration events (1 hour) while forested catchments peak during longer duration events (4 to 12 hours). The 100-year unmitigated flows at the mouth of Partington increase by 14%. Wear and tear on the watercourse is significantly increased with increased flows and frequency of flows and volumes.

DRAINAGE SYSTEM ASSESSMENT

- Debris floods may pose a moderate risk to development in the lower reaches of the creek where the channel is not well confined.

- There are a number of structures on the Partington Creek fan which are currently at risk to flood and channel avulsion.

- Sediment deposition in the lower channel is causing flooding, overtopping Cedar Drive and subsequent flooding in the lowlands, during larger events.

- Modelling shows that 10 culverts are undersized for the existing land use flows and 4 additional culverts are undersized for unmitigated future land use flows.

- Two bridges were found collapsed and should be removed immediately.

- Ten bridges over the Partington Creek main stem along Cedar Drive would be overtopped during the design flow and are overtopped nearly annually.

- All erosion sites noted during the field inventory would be considered minor and no works are proposed to address them at this time.

- The development of Partington Creek is predicted to have little effect on the Deboville Slough water levels and flow velocities during a 100-year event:

  - 0.04 m maximum water level increase during low Pitt River conditions; and
  - 0.2 m/s maximum velocity increase during low Pitt River conditions.

  The combined impacts of development within both Hyde and Partington Creeks, including the development of both Hyde and Partington Development Reserves (see Figure 2-3), is also predicted to have little effect during a 100-year event:

  - 0.27 m maximum water level increase during low Pitt River conditions; and
  - 0.27 m/s maximum velocity increase during low Pitt River conditions.

During frequently occurring, average storms with average or higher Pitt River water level conditions, the incremental changes would be even less evident.

The effects of increased urban stormwater drainage on fish habitat and other environmental values in DeBoville Slough are predicted to be minor.

ENVIRONMENTAL ASSESSMENT

- The Watershed Health Tracking System was used to estimate existing and future watershed health. If left unmitigated, the proposed development in Partington Creek is estimated to result in the B-IBI health indicator decreasing from a value of 35 to 19 which represents a significant impact to the watercourse.

- Stormwater source controls and riparian preservation and restoration can be used to limit the impact of future development.

- Fifteen potential aquatic restoration and nine riparian restoration/enhancement projects were identified. The primary terrestrial habitat restoration/enhancement opportunity is to begin to reduce the amount of red alder forest in the mid-portion of the Partington watershed by under-planting of shade-tolerant conifers.

DEVELOP AND EVALUATE ALTERNATIVES

- Three alternatives were developed for mitigating the proposed development focussing on land use planning, engineering, and environmental issues.

- A multi-account system was set-up for the technical evaluation of the alternatives. Members of the Steering and Advisory Committees and Public were asked to select their preferences from each component.

DIRECTION FOR IWMP STRATEGY

- The new *Rainwater Management – Source Controls Design Requirements and Guidelines 2009* replaced the *Low Impact Development Policy and Procedures Manual 2005.*

- Goals and criteria used in development of the IWMP:

  - strive for a no-net-loss of ecological health for Partington Creek watershed;

  - provide a Net Environmental Benefit for Fish Habitat by enhancing aquatic habitat along the Partington Main-stem where there is high fish spawning use;

  - apply DFO’s *Urban Stormwater Guidelines for the Protection of Fish and Fish Habitat*;

  - apply the *Riparian Area Regulation* (RAR) requirements to aquatically significant watercourses; and

  - apply the City's flood conveyance criteria of 100-year major drainage system and suitable flood protection within the floodplain.

- The items that were strongly preferred by the Advisory Committee and the public are summarized as follows:

  - environmental protection;
  - increased riparian setbacks for all streams;
  - maximized forest cover;
  - widened corridors for wildlife migration to prevent conflicts with humans and improved wind firmness & community amenity;
  - maximize green space and conservation areas;
  - full hydrologic mitigation through source controls, diversion, and ponds;
  - widening Partington Main-stem and relocating Cedar Drive;
  - regular sediment removal;
  - re-instating flows to Irvine Creek;
  - avoid use of large ponds; and
  - long term strategy to protect farmland from the Fraser River freshet.

PROPOSED PARTINGTON CREEK IWMP STRATEGY

- The City advised that the servicing for the Dairy Creek catchment should not be included in the IWMP strategy because it is outside the PCNP and development would be more than 20 years away. Servicing can be reviewed in detail in the future when development is more imminent.

- The Hydrotechnical Upgrade Plan included the following:

  - sediment management plan including a sand trap, sediment removal basin and designated removals;

  - acquire land to relocate and raise Cedar Drive on the southeast side of the creek;

  - acquire land on the north side of the creek to widen channel and enhance riparian area;

  - ensure that any development within the Partington Creek fan be in conformance with the *Flood Hazard Area Land Use Management Guidelines* (Ministry of water, Land and Air Protection, May 2004), in addition to the other environmental regulations;

  - removal two collapsed bridges immediately to prevent blockage and flooding;
  - upgrade six high priority culverts in the short term;
  - upgrade low priority bridge and ten culverts over the long term at time of development;
  - remove ten bridges along Cedar Drive and five culverts in the development area during development;
  - construct a diversion pipe to drain the major flows from a majority of the PCNP development area and from the Hyde Creek Development Reserve area into the DeBoville Slough. The diversion will also mitigate the peak flow increases to Fox Creek and its tributaries, Star Creek, and the tributaries in Freemont Park; and
  - construct cut-off ditches above development areas to intercept shallow interflow and any surface runoff from undeveloped upslope areas.

- The Hydrologic Environmental Protection Plan included the following:

  - implement source controls to achieve stormwater volume reduction target of 63 mm for roads and all land uses except for single family. Implement source control measures on single family lots that include a minimum 300 mm of absorbent topsoil on all pervious areas, grading impervious surfaces to pervious areas, and encouraging the use of rain barrels and pervious paving materials;
  - supplement source controls with underground baseflow augmentation facilities (to mitigate runoff volumes) and baseflow release facilities (to sustain baseflows) downstream of single family areas;
  - implement source controls for roadways to replace the hydrologic function of existing roadside ditches;
  - address water quality treatment with source controls and/or ponds/wetlands;
  - design specialized flow splitters to maintain baseflows and reduce post-development flow rates to pre-development levels in the creeks and convey excess flows away through proposed diversion; and
  - size and widen a portion of the main stem channel to accommodate additional flows from one unmitigated development area – alternatively divert more flow away from Star Creek to compensate for this area.

- The Ecological Protection Plan included the following:

  - implement RAR setbacks on aquatically significant watercourses (excluding manmade ditches with minimal habitat value) in the development areas and maintain full riparian outside of the development areas;

  - replant trees within the RAR setbacks for high quality riparian forest integrity;

  - investigate enhanced riparian widths beyond RAR on Fox and Star Creeks during PCNP study;

  - underplant red alder areas with native, shade-tolerant conifer species;

  - add complexing to Lower Fox Creek and Partington Creek south of Victoria Drive;

  - restore instream complexity, floodplain wetlands and riparian forest along lower Partington Creek within Cedar Drive setback area and additional setback on the north side of the creek; and

  - remove fish passage barriers.

- The Watershed Health Tracking System was used to predict the gains and losses in the developing watershed. With the proposed mitigative and enhancement measures, the tracking system indicates that no-net-loss would be achieved in the long term watershed wide. The individual subwatersheds showed the following change in B-IBI points.

  - Star Creek would be the most impacted with a reduction of roughly 11 B-IBI points;
  - Fox Creek would be slightly impacted – 4 B-IBI point reduction;
  - Partington Creek upstream of Fox Creek confluence – no B-IBI reduction; and
  - Partington Creek overall – no B-IBI reduction in the long term.

- Additional mitigative measures can be sought through:

  - additional riparian widths through the PCNP for protection and connectivity of wildlife habitat, Pacific Water Shrew, trails and recreation and wind firmness; and

  - larger volume reduction facilities to further reduce EIA.

- A Net Environmental Benefit for Fish Habitat will be achieved through Mainstem instream complexing, floodplain and wetland creation, and enhanced riparian areas. Fish habitat improvements in this reach are intended to mitigate some of the direct and indirect effects of urbanization on fish habitat in Partington Creek and its tributaries.

- Costs were estimated for the proposed IWMP components. In total, the Class ‘D’ cost of servicing the Partington Creek Neighbourhood Plan development is estimated at approximately $31 million.

IWMP IMPLEMENTATION STRATEGY

- To measure the success of stormwater management and other mitigation measures, a monitoring and adaptive management plan is proposed. Instream flows, baseflows, and water quality should be measured prior to, during, and post build-out.

- The City’s long term strategy is to relocate and raise Cedar Drive to act as a dyke to protect the agricultural areas from the Partington Creek and Pitt River/Fraser River flood levels.

- The sediment and water quality management for DeBoville Slough is proposed to include the following components:

    - upland source controls including onsite and regional water quality treatment;

    - short term sediment removals from the lower section of Partington Creek and ongoing removals of gravels and sands at two sediment traps;

    - diversion of erosive high flows away from Partington tributaries to reduce sediment transport;

    - sediment and erosion control during construction;

    - spill control and emergency response plans to clean up pollutants; and

    - monitoring aggradation at the Pitt River Boat Club marina and targeted removals in the slough.

- A number of issues have been identified in the IWMP that will impact the PCNP planning process. These include opportunities for increased riparian protection, wildlife corridors, wildlife habitat and watershed forest, addressing the Pacific Water Shrew habitat requirements, land use requirement south of Victoria west of Star Creek, and development on the Partington Creek fan.

11.2 RECOMMENDATIONS

Based on the foregoing, it is recommended that the City of Coquitlam:

INCREASE FLOOD CONVEYANCE

1. Remove existing bridges BRG002 and BRG022 that are collapsed at the earliest opportunity. These two bridges are a hazard and may trap debris that could result in channel blockage and exacerbate flooding.

2. Upgrade high priority culverts and bridges.

SEDIMENT MANAGEMENT

3. Resurvey the lower Partington Creek channel and estimate a sediment budget for the watershed by comparing to previous survey accounting for any sediment removed between the two surveys.

4. Initiate removal of 500 m^3 of sediment from identified in-stream locations and at proposed sand trap and sediment basin locations at the earliest opportunity. Construct permanent flow diversion in area of sediment basin.

CREEK HAZARDS

5. Quantify the risk due to debris flood and develop a risk map for the lower unconfined reaches of the Partington Creek Main-stem prior to development.

6. Ensure that any future development or redevelopment within the creek fan area be in conformance with the *Flood Hazard Area Land Use Management Guidelines* (Ministry of water, Land and Air Protection, May 2004), in addition to the other environmental regulations. A detailed hazard assessment of the fan area could be required prior to redevelopment.

MITIGATE IMPACTS OF DEVELOPMENT

7. Continue to liaise with the PCNP process to ensure that objectives of the IWMP are integrated into the Neighbourhood Plan.

8. Pursue a formal application with the Agricultural Land Commission Act to relocate Cedar Drive onto farm land.

9. Obtain a specialist consultant to ensure proper analysis and design for the following:

    - lower Partington channel sizing to mitigate erosion especially for the unmitigated development area not serviced by the proposed diversion;

- specialized flow control structures to make certain intended flow interactions between the water quality ponds, baseflow augmentation/release facilities, diversion and creeks are met; and

- design event and continuous simulation modelling to validate intended operation of flow control structures and Partington Creek Main Stem channel widening to ensure both flood and environmental protection.

The creek receiving environment is one of few high fish use left in the Lower Mainland and is highly sensitive; the proper sizing and design of these elements area critical to protecting existing values.

10. Begin replanting new riparian area in vicinity of the proposed relocated road as soon as possible as plants and trees will take a number of years to mature to provide full benefits to Partington Creek. The riparian should be well established prior to commencing development in the watershed.

11. Implement environmental protection measures and enhancements prior to commencing development to keep watershed health indicators positive before declining.

MONITORING

12. Download and quality check flow monitoring data on Partington Creek at Victoria Drive. Because of the active debris movement within the channel, the flow monitoring cross section should be surveyed twice annually and the flow rating curve updated. Data should be quality controlled and checked on a regular basis to ensure accurate flow monitoring results. Existing condition flow monitoring is very important to firmly establish the pre-development flow regime in order to use as a health indicator as the watershed develops.

13. Quantify the existing conditions summer and winter baseflows near the mouth of Partington Creek.

14. Initiate the recommended monitoring program in 2011.

IMPLEMENTATION

15. Enforce Sediment and Erosion Control and Spill Control plans and measures to protect water quality in Partington Creek and tributaries and DeBoville Slough.

16. Enforce impervious area limits over time, not just at development permit stage to ensure source controls are not being replaced with hard surfaces.

17. Enforce Stormwater Source Controls to meet the stormwater targets established.

11.3 REPORT SUBMISSION

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