FINAL REPORT

City of Campbell River

Integrated Stormwater Management Plan

Campbell River / Quinsam River Area

1479.0009.01 / December 2006

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Integrated Stormwater Management Plan
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Final Report

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ABBREVIATIONS AND ACRONYMS

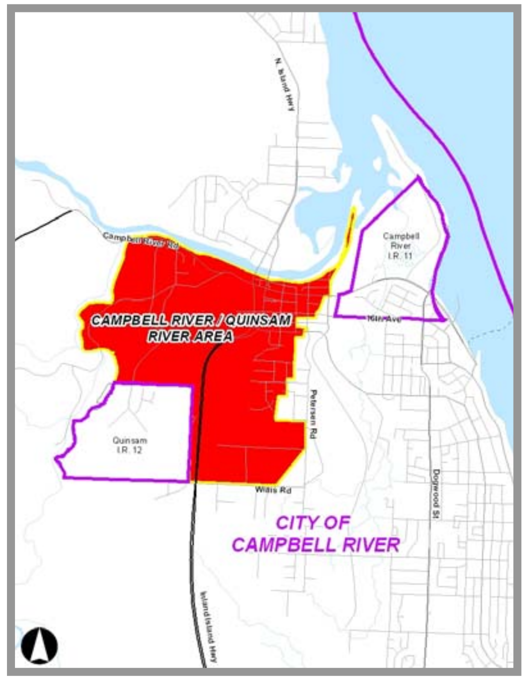
ALR	Agricultural Land Reserve
BMP	Best Management Practices
CMP	Corrugated metal pipe
DFO	Fisheries and Oceans Canada
ESC	Erosion and sediment control
ha	hectare
hr	hour
ISMP	Integrated Stormwater Management Plan
LID	Low Impact Development
L/s	liters per second
LWD	Large woody debris
m	meters
mg/L	milligrams per liter
mm	millimetres
m/m	meter per meter
m/s	meters per second
m^3/s	cubic meters per second
MoE	BC Ministry of Environment (formerly MWLAP)
MWLAP	BC Ministry of Water, Land and Air Protection
O&M	Operation and Maintenance
RAR	Riparian Area Regulations
TOR	Terms of Reference
yr	year

EXECUTIVE SUMMARY

The City of Campbell River has embarked on a process to address stormwater issues within the City, which is consistent with current guidelines published by the Province for integrated stormwater management planning (ISMP). This effort encompasses the entire City, though the current study addresses the City's **Campbell River/Quinsam River Area** only. The area covers about 420 hectares along the Quinsam and Campbell Rivers and west of the downtown area (see map below). The City is responsible for the construction, operation, maintenance and enhancement of stormwater systems in the Campbell River/Quinsam River Area which includes ten storm sewer outfalls.

The goals of the City-wide stormwater management planning effort are:

- Develop stormwater management solutions and policies that maintain, restore and enhance the watershed and meet engineering, environmental and land use needs
- Protect the community from flooding, erosion and destruction of private and public property
- Promote community development while recognizing neighbourhood values and unique characteristics of the area
- Integrate engineering, planning and environmental solutions for the benefit of the Campbell River



The Project Team for this ISMP included engineers, planners, biologists and hydrogeologists. The process included technical assessments by the Project Team as well as direct consultation with local stakeholders and First Nations. A Working Group met three times to discuss the issues facing the Campbell River/Quinsam River Area, review options presented by the Project Team and provide input to the plan. Two Open Houses were held during the project to provide for general public consultation as well.

Six main tasks or objectives were addressed in this plan:

- Document existing stormwater, biophysical and land use conditions
- Identify required stormwater infrastructure and land use policies to ensure protection of the residents and property as well as protection of aquatic habitat

- Ensure that stakeholder interests and senior environmental agency support for recommendations is balanced with social and economic interests of the community
- Develop decision matrices that allow the City to analyze and evaluate options
- Recommend an integrated approach to achieving cost effective solutions
- Provide the City with evaluation and recommendations that will lead to the development of sustainable financial tools for implementation

The Quinsam River / Campbell River Area encompasses both highly urbanized areas that exhibit the distresses to the watershed that inevitably accompany development and natural areas that provide significant habitat for fish and wildlife. Healthy watersheds in southwestern British Columbia, including Vancouver Island, are typified by having greater than 65% forested land and less than 10% impervious surfaces (buildings, roads, parking lots and other hard, non-porous surfaces associated with urbanization). Overall, the Study Area is about 39% forested and 26% impervious surface; these levels highlight the twin challenges for the Study Area of mitigating the negative impacts of past development while avoiding such impacts in the future.

A hydrologic and hydraulic model was developed to assist with the evaluation of the existing storm sewer system. Using this model, several existing storm drains were identified for improvement to alleviate nuisance flooding. The model was also used to test alternative stormwater management approaches, including the use of regional detention ponds and implementation of various low impact, sustainable stormwater controls. In addition the model has been configured to include the two watersheds comprising the bulk of the study area land, Detweiler and Haig Brown's Kingfisher Creeks. With minimal additional effort in the future the model can be used to further assess environmental and flood flow conditions within the creeks themselves.

Other specific issues that were identified for the Study Area are:

- Runoff quality and attendant impacts to local and regional fisheries
- Poor or degraded fish habitat in a number of reaches of Detweiler and Haig Brown's Kingfisher Creeks
- Low base flows in Detweiler and Haig Brown's Kingfisher Creeks
- Potential continued degradation of habitat due to long-term loss of forest and wetlands within currently undeveloped areas
- Future potential increased flooding and erosion from new development in currently undeveloped areas of the watersheds

To address these issues, a set of guiding principles was formulated:

- Minimize impact of new development on runoff
  - Maintain base flows to streams
  - Maintain water quality in streams
  - Apply sustainable stormwater controls to new development
  - Meet specific runoff performance targets for peak, volume and quality
  - Encourage use of sustainable stormwater controls to for infill and redevelopment
- Improve water quality when feasible
  - Establish an environmental monitoring program
  - Apply retrofit runoff treatment controls in some developed areas

The overall intent is to preserve and enhance the creek resources, accommodate the demand for growth in the area and preserve the generally low density residential character of the currently undeveloped parts of the Study Area.

A wide range of recommendations are made to further the guiding principles. The table on the next page lists the recommendations, grouped as follows:

- Municipal drainage infrastructure
- Environmental
- Data Management and System Analysis
- Policy
- Public Education and Outreach

We recommend that the City take an adaptive approach to stormwater management. This includes:

- Regular updates of the plan, at 5-year intervals
- Use of pilot projects to test and provide a basis for design of new sustainable stormwater control methods
- Allowing flexibility on the part of developers to prepare plans that meet the basic performance targets for stormwater volume, peak and water quality control

The estimated capital cost for recommended infrastructure improvements is $12.6 million with annual maintenance costs of approximately $424,000. These improvements are for storm drains, detention ponds and stormwater treatment systems.

Financing for these improvements can be through DCCs, however we strongly recommend that the City establish a community-wide stormwater utility that can collect user fees and charges. Such a utility can provide a long-term, sustainable and dedicated source of funds for both capital improvements as well as for on-going operation and maintenance of the City's stormwater system.

Table E.1
Summary of Recommendations for Campbell River / Quinsam River Area Stormwater Management

Category	Recommendation	Priority Level		
		1	2	3
Municipal Infrastructure	Upgrade deficient municipal drainage infrastructure (storm drains; 7 segments)			X
	Construct detention ponds for future developments (7 sites)		X	
	Construct runoff water quality treatment facilities (9 locations)	X		
	Upgrade existing catch basins with deeper sumps and trapping hoods			X
	Enhance street cleaning program		X	
	Prepare operations and maintenance schedule for stormwater system, incl street cleaning	X		
Environmental	Prepare inventory of existing commercial/industrial "hot spots"	X		
	Develop spill containment procedures		X	
	Install manual ditch level gages to determine base flows		X	
	Establish long-term outfall water and sediment quality monitoring program	X		
	Establish long-term biophyscial monitoring program at 2 or more sites	X		
	Initiate soils property verfication program		X	
	Re-establish digital recording of continuous rainfall measurements at the airport		X	
	Enhance key habitat sites in conjunction with other City initiatives (5 key, potential sites)	X		
Data Management and System Analysis	Obtain updated, detailed aerial contour mapping of area (supplemented by ground survey)		X	
	Compile manhole rim, outfall invert and related infrastructure data throughout the area		X	
	Refine the current XP-SWMM model to perform extended period (continuous) simulations		X	
	Perform assessment of environmental flows using upgraded XP-SWMM model		X	
	Update GIS database		X	
Policy	Adopt performance targets for stormwater volume, peak and quality	X		
	Adopt a single, consistent 5-year level of service for minor conveyance systems		X	
	Require the use of LID techniques (where appropriate and feasible) for new development	X		
	Require specific stormwater quality treatment for all new commercial and industrial sites	X		
	Develop and adopt an Erosion and Sediment Control Bylaw		X	
	Develop and adopt a Tree Retention Bylaw		X	
	Develop and adopt a Pesticide Use Bylaw		X	
	Adopt measureable targets in OCP for preserving tree cover and limiting impervious area	X		
	Introduce Development Permit Area guidelines for vegetation retention and native plant use	X		
	Update zoning bylaw for maximum parking / impervious surfaces and encourage cluster devpmt		X	
	Update engineering design standards per City's "alternate design standards" initiative	X		
	Require use of deep sump catch basins with trapping hoods			X
	Develop and adopt a stormwater utility to finance all aspects of the stormwater system		X	
Public Education and Outreach	Initiate a long term public eduation and outreach program	X		
	Prepare and distribute to builders an Erosion and Sediment Control Brochure	X		
	Publicize stormwater pilot projects	X		
	Develop a stewardship award for the development community		X	

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1.0 INTRODUCTION

1.1 Stormwater Management Vision for Campbell River

Over the past forty years, approaches to managing stormwater in urban and urbanizing communities have undergone a significant and rapid evolution. Increasingly more than just basic engineering perspectives on flood control are guiding communities as they attend to the impacts of urban development on streams, soils and local environments. Concerns for fish habitat and water quality are now at the fore for some communities, and stormwater runoff is coming to be seen as a resource to manage and protect rather a nuisance to avoid or correct.

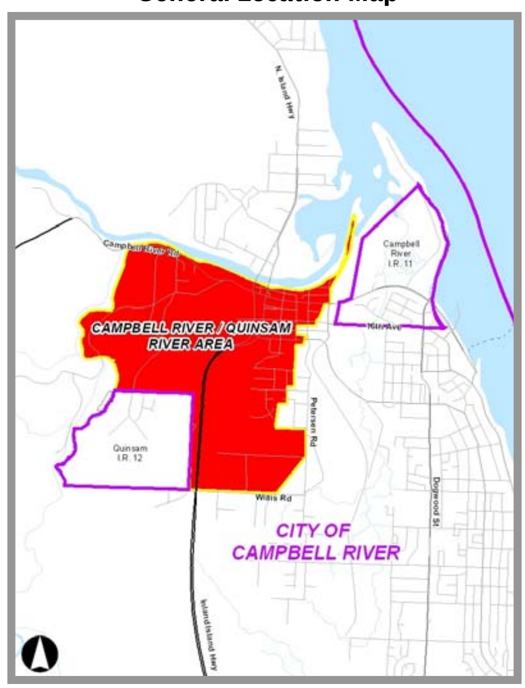
It is within this context that the City of Campbell River embarked on a five-year program to develop integrated stormwater management plans (ISMP's) for all areas of the City. This program reflects the City's desire to review and update stormwater controls within in its jurisdiction, to better emphasize an integrated approach that applies current understandings of urban hydrologic processes. In particular, the City wishes to incorporate policies and practices that emphasize sustainability with community acceptance and that harmonize environmental stewardship with traditional flood control and erosion protection.

The focus of this current ISMP is the **Campbell River/Quinsam River Area** of the City (see Figure 1.1); it is the last in the series comprising the overall five-year stormwater program. Previous ISMP's have been completed and approved for these drainages and watersheds:

- Holly Hills drainage (approved April 2004)
- Perkins Road drainage (approved April 2004)
- Nunns Creek watershed (approved June 2005)
- Simms Creek watershed (approved June 2005)
- Willow Creek watershed (approved June 2005)
- Foreshore Area (approved November 2005)

It is the City's vision, which the Project Team shares, to create living documents for each watershed, which recommend stormwater management strategies that are *long-term*, *proactive* and *adaptable*.

Figure 1.1
General Location Map



1.2 Goals and Objectives of the ISMP Studies

The Terms of Reference issued by the City for the Campbell River/Quinsam River Area ISMP identified four main goals:

- To establish an achievable and supportable vision for each watershed that will result in the development of stormwater management solutions and policies that maintain, restore and enhance the natural watershed characteristics while meeting engineering, environmental and land use needs.
- To protect the community from flooding, erosion and destruction of private and public property.
- To promote community development while recognizing neighbourhood values and unique characteristics of the area.
- To integrate engineering, planning and environmental solutions to the benefit of each watershed.

To achieve these goals, the City outlined seven main objectives, or tasks, to be undertaken as part of the ISMP study:

- To document the existing condition of each watershed including the stormwater infrastructure, biophysical inventory, and existing and future land use patterns.
- Recommend alternatives to reduce maintenance costs and increase habitat values through retrofitting, amalgamating or removing existing infrastructure.
- To identify the required stormwater management infrastructure and land use policies necessary to ensure the protection of residents and property with protection of the aquatic habitat.
- To ensure that stakeholder interests and senior environmental agency support for the study recommendations is balanced with the social and economic interests of the community.
- To develop decision matrices that will allow the City to analyze and evaluate options that meet the multiple needs of the community.
- To recommend an integrated approach to achieving cost effective solutions which will assist the City and its partners in establishing watershed based stormwater policies, a stormwater infrastructure program.
- To provide the City with an evaluation and recommendation(s) that will lead to the development of sustainable financial tools that support the City's land use plan and capital works program, including but not limited to the establishment of a stormwater

1.3 Communications Strategy

To ensure that the ISMP process is a successful one, involvement and support from a variety of interested parties are essential. Over the course of the project, the following groups were consulted.

1.3.1 City of Campbell River

A series of meetings were held with City staff over the project duration to define and address issues such as the scope of work, schedule and associated milestone dates, review of submissions, public and stakeholder consultation, etc. City staff from the Engineering, Planning and Public Works departments participated in the meetings. The project team worked closely with City staff throughout the project to ensure that the ISMP study ultimately reflected the vision that the City has for its watersheds.

Council was kept informed on the status of the project via discussions with City staff, announcements in the Council's newsletter and a project summary statement, which will be presented to Council at the conclusion of the project.

1.3.2 Working Group

One of the objectives of the ISMP study was the formation of a working group. This group included representatives from a variety of interested parties, including senior environmental agencies, local environmental groups and the development community. Other interested organizations and local First Nations were also invited and kept informed of the Working Group's proceedings. The main purpose of the group was to provide background information on the Campbell River/Quinsam River area, as well as to review and comment on recommendations from the ISMP study. The group met three times over the course of the project. Table 1.1 lists the members of the working group. Additional information related to the group can be found in Appendix E.

Working Group Meeting

Table 1.1
Working Group Participants

Attendees	
Name	**Organization**
Barry Peters	Campbell River Stewardship Advisory Council
Kathy Campbell	City of Campbell River
Ron Neufeld	City of Campbell River
Gary Giese	Development Liaison Group (Bonaventure Development Corp)
Rick Senger	DFO, Area Habitat Technologist
Shannon Anderson	DFO, Habitat Biologist
Lesley Fell	Discovery Coast Greenways Land Trust
Luisa Richardson	Coast Greenways Land Trust
Leona Adams	Estuary Protection Group
Tim Ennis	Nature Conservancy of British Columbia
Dave Ewart	Quinsam Hatchery
Tony Roberts Jr.	The Campbell River Indian Band
Other Invitees	
Name	**Organization**
Ron Burrell	Advisory Planning Commission
Allistair McLean	BC Hydro
Mike Gage	Campbell River Gravel Committee
Brian Kelly	Cape Mudge Indian Band
Jim Van Tine	Haig-Brown Kingfisher Creek
Peter Law	MWLAP / Urban Biologist & Provincial Ministry of Environment
Bob Hall	Ministry of Transportation and Highways
Hubert Bunce	Q Coal Environmental Technical Review Committee
Dave Selent	Quinsam Coal Corporation

1.3.3 General Public

Contact with the general public was primarily made through media releases and public open houses. Four separate media releases were published in the local newspapers as well as posted on the City's website over the project duration. These media releases provided updates on the project status, contact information for City staff and the project team, and dates and times for upcoming public open houses. Media releases can be found in Appendix F.

Two public open houses were hosted by the City to summarize the progress to date on the ISMP and to allow the general public an opportunity to comment and provide input into the study. The public open houses were held on Tuesday, September 12, 2006, and Wednesday, November 15, 2006. Each open house included a brief formal presentation as well as time for open discussion and questions. Presentation materials, sign-in sheets and feedback forms for both open houses are located in Appendix F.

CR/QR ISMP's Second Open House

1.4 Background Studies and Reports

Background studies and documents were provided to the project team at the project initiation meeting with City staff. Additional reports and anecdotal information were also obtained from the working group members and the public. A comprehensive list of the documents which were reviewed by the project team is attached in Section 12.0 (List of References).

1.5 Project Team

An interdisciplinary project team was assembled for this ISMP study, including representatives with engineering, planning and environmental perspectives. Each team member has extensive experience in their related field, has prior experience in developing ISMPs and was familiar within the Campbell River area. Team members and contact information are provided in Table 1.2.

Table 1.2
ISMP Project Team Members

Area of Expertise	Company	Contacts	Phone Number
Stormwater Management	Urban Systems	Jeffrey Rice, P.Eng., Project Manager Samantha Ward, P.Eng. Melanie Ross, Project Coordinator	604-273-8700
GIS	Urban Systems	Mercedes Braun, GIS Specialist	250-374-8311
Planning / Land Use	Urban Systems	Sara Stevens, M.Pl.	604-273-8700
Habitat Biology	Komori Wong Ltd.	Violet Komori, M.R.M.	250-339-7613
Hydrogeology	Piteau Associates	Andy Holmes, P.Eng. Arnd Burgert, GIT	604-986-8551

2.0 STORMWATER

There was a time when people tended to think publicly about water only during two periods: When there was too little of it (drought) or when there was too much of it (flood). When it came to drinking water, the former was most on people's minds, but when it came to urban drainage, the latter tended to rule. Since the focus was on preventing flooding and thus protecting people and their property, efficiency in removal was the goal. The faster water could be moved away from flood-threatened areas, the sooner people could forget about it.

For centuries, with respect to water supply, water has been treated as a resource, that is, as something to protect and maintain. But in the latter part of the 20th century, many people began to recognize that stormwater represents a resource as well. If treated wisely, stormwater contributes to the well-being of the natural environment, including fish-bearing water-bodies and groundwater resources. But if treated unwisely, stormwater can become a nuisance at best or a serious factor in environmental degradation at worst.

The first step in accepting that stormwater is a resource is to understand the hydrologic cycle and the implications of disrupting that cycle by urban development practices. The next few paragraphs provide a primer on the hydrologic cycle, characteristics of a healthy watershed and the stormwater impacts associated with urban development. A final section describes integrated stormwater management.

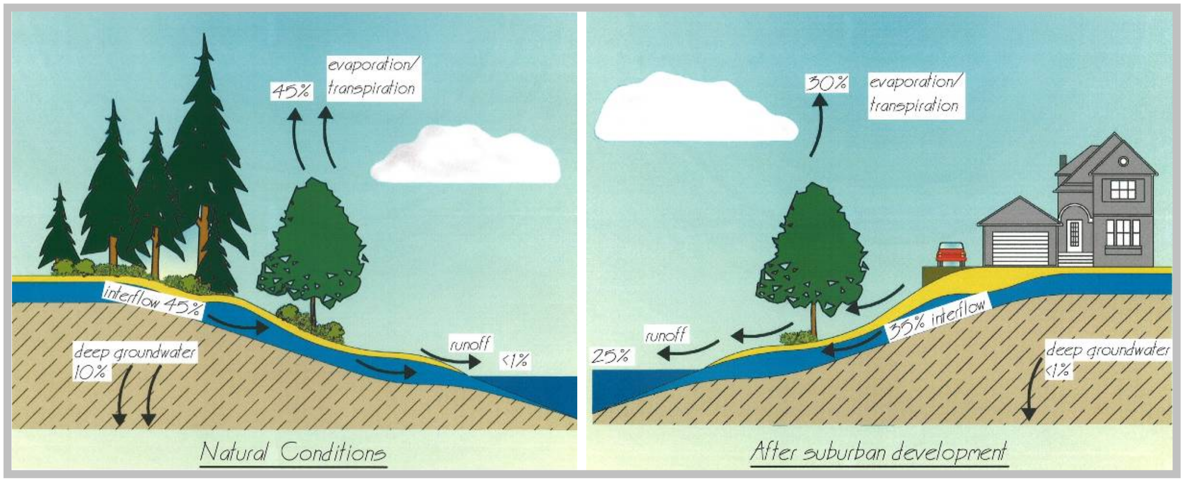
2.1 The Hydrologic Cycle

Rain that falls on any piece of land, whether natural or built, can basically move in only four directions:

- Back into the air via evaporation from surfaces and transpiration from leaves (evapotranspiration)
- Into the surface soils via soaking where it can move slowly to streams (interflow)
- Into deep groundwater aquifers via seepage (groundwater recharge)
- Directly into streams via the land surface or built structures (surface runoff, or stormwater)

Surface runoff from a forested or naturally vegetated watershed is very small, representing 10% or less of rainfall volume in many cases. Except during occasional extreme rainfall events, the flow that is observed in streams (commonly called *base flow*) is actually a product of *interflow,* the slow movement of water through soils into streams. Land development alters this natural water balance. When natural vegetation and soils are replaced with roads and buildings, less rainfall infiltrates into the ground, less is taken up by vegetation and more becomes direct surface runoff. Runoff volumes increase in direct proportion to impervious area – land uses with extensive roof and paved area create more runoff than land uses with extensive areas of absorbent soils and forest cover (see Figure 2.1).

Figure 2.1
Typical Annual Water Balance for the Lower Mainland British Columbia
Pre- and Post-Development Conditions



2.2 Land Use Characteristics of a Healthy Watershed

From a stormwater management perspective, two of the most significant land use factors to consider in defining a healthy watershed are wooded (forest) area and impervious area. Recent studies consistently show that healthy watersheds in this region of North America are characterized by high percentages of forest area (generally >65%) and low percentages of impervious area (generally <10-15%). Outside these ranges, streams tend to exhibit a host of "unhealthy" conditions that are attributable to the process of urbanization, as described in the next section.

2.3 Impacts of Urban Development

Work at the Center for Urban Water Resources (University of Washington) (Booth and Jackson, 1997) clearly demonstrates that the most important impacts of development (urbanization) on streams, in order of importance, are:

- Changes in hydrology
- Disturbance of the riparian corridor
- Deterioration of water quality
- Disturbance of the physical habitat within the stream

In addition, if these impacts are not avoided, there can also be serious legal, financial and political implications. These impacts are discussed in more detail in the paragraphs that follow.

2.3.1 Hydrology

One of the major impacts of urbanization on streams is its effect on stream hydrology. Hydrology is defined as the study of the movement (or flow) of water in all its phases. Understanding the water balance is essential to understanding the impact of development on the hydrology of streams.

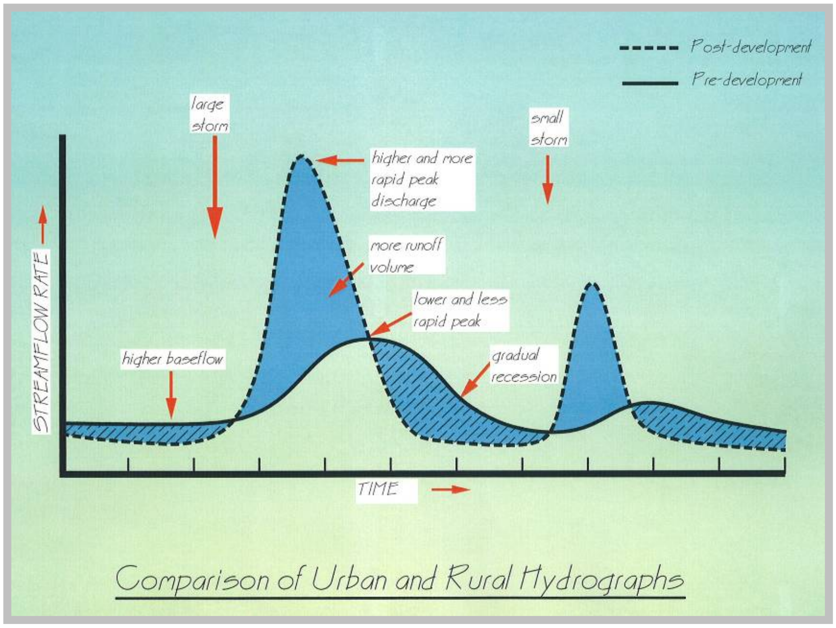
The water balance, as shown in Figure 2.1, is the concept that the sum total of rainfall is equal to the amount of rain infiltrated (interflow), absorbed (deep groundwater), and evapotranspired, plus the volume of runoff generated from the watershed. In a pre-developed setting, much of the rainfall is absorbed by the surrounding vegetation, soil and ground cover. In a developed setting, the water balance changes and a disproportionate amount of rainfall becomes surface runoff.

Changes in the water balance in urban streams are exemplified by increased flood peaks, increased frequency of bankfull flows, widening of the floodplain and decreased dry weather flows (see Figure 2.2). Bankfull flows are simply runoff events that fill the normal channel of a stream to the top of the banks. Bankfull flows are significant because they are the channel forming flow condition in a stream and they are highly erosive, turbid ("cloudy") and damaging to the natural morphology of the stream.

Further, traditional pipe and ditch systems were designed to remove runoff from impervious surfaces as quickly as possible and deliver it to receiving waters. With increased land development, stormwater arrives at the receiving waters much faster, which in turn increases the peak rate of flow.

By the time a watershed is fully developed with buildings, roads and parking lots, 15 to 20 times more runoff can occur as compared to conditions prior to development.

Figure 2.2
Change in Streamflow Response with Urban Development



2.3.2 Disturbance of Riparian Corridor

Generally, most streams begin to enlarge as impervious cover exceeds 10-15% in the watershed. The enlargement process may take up to 50 years to fully occur, but urban streams in watersheds with more than about 10-15% impervious cover are characterized by various degrees of stream enlargement and widening, erosion, downcutting, decreased channel stability and embeddedness. An undeveloped watershed with less than about 5% impervious cover is characterized by excellent stream conditions— good riparian cover, high quality substrate (stream bottom) and wetted perimeter during low flow conditions.

Even though a developed area does not entirely encompass a watershed, the sections of a stream that are located downstream are likely to experience these changing conditions.

2.3.3 Deterioration of Water Quality

In addition to hydrologic changes and changes to the riparian corridor of the stream, urbanization directly impacts the quality of the receiving water. Some of the indicators of the impact of urbanization on water quality include increased stream temperature and pollutants.

Stream temperature is a very important habitat parameter for fish and insects, and temperature variability can dictate the growth of aquatic insects and timing of migration and molts. Impervious cover increases air and soil water temperatures and can create an increase of 3-6°C in urban streams.

In addition to increased stream temperature, urbanization can increase the amount of pollutants entering water bodies, such as sediment, nutrients, organic matter, trace metals (copper, cadmium, lead), pesticides, herbicides and hydrocarbons, and others. During storm events, the quality of urban stormwater declines sharply which adversely affects human and aquatic uses of downstream waters.

The sources of pollutants in stormwater are predominately associated with impervious areas. Impervious areas act as a collector and conveyor for pollutants that arrive from many pathways. Pollutants can fall out of the sky during dryfall. They may also arrive in rain or snow as wetfall. Automobiles are also sources of pollutants. Wear of tires (a known source of zinc), deteriorating brake pads, or just leaks, drips and spills of oil and other pollutants from the car can accumulate on impervious surfaces. Pollutants can also be blown in from adjacent pervious areas. Pollutants land on the street where they often stay in curbs, cracks and other areas until the next rain storm where they are washed off the surface and into the storm drain system and ultimately to receiving streams.

Excess nutrients (such as nitrogen and phosphorous) can create eutrophic conditions that can lead to uncontrolled algal growth that consumes oxygen in shallow, slow-moving waters and may create fish kills, odours and other problems.

Another common pollutant in urban stormwater is sediment. Sediment can smother bottom organisms and it can clog gills of fish and aquatic insects when it is in the water column. Sources of sediment include streambank erosion, construction sites and the wash off from paved surfaces.

Fecal coliform levels in urban stormwater runoff are typically 15 to 50 times the standard set for water contact recreation. Fecal coliform can be derived from human and nonhuman sources. In fact, research indicates that much of the fecal coliform in urban runoff is from nonhuman sources such as dogs, cats, cattle, horses, squirrels, geese, pigeons and ducks. However, very high levels of bacteria may also be due to leaks of human sewage from sanitary sewer overflows, leaking septic systems, combined sewers or illicit discharge of sewage.

Stormwater hotspots are areas that produce higher concentrations of pollutants than normally found in urban runoff. Certain areas of the urban landscape are known to be hotspots of stormwater pollution. Examples include gas stations, parking lots and auto recycling facilities. Generally, stormwater hotspots contribute 5 to 10 times higher concentrations of trace metals and hydrocarbons in stormwater runoff. These hotspots merit special management and pollution prevention activities.

Trace metals are frequently found in urban stormwater and sometimes at concentrations that can be acutely toxic to aquatic life. In nearly every stormwater sample, one generally will find zinc, copper and lead. Hydrocarbons, zinc, copper, cadmium, and lead are known to accumulate in the tissue of fish. In some cases, this may make the fish unsuitable for human consumption.

2.3.4 Disturbance of the Physical Habitat within a Stream

Along with changes in hydrology, riparian corridor and water quality, the habitat value of urban streams diminishes with increased impervious cover. There are numerous impacts to the aquatic habitat as well as the riparian corridor, particularly along the stream side zone.

The creation of fish barriers is another impact of urban development. Barriers can prevent the movement of fish. In some cases, the fish barriers are created by culverts that are put in stream crossings for roads and other urban infrastructure. As the stream erodes down with increasing urban development, vertical barriers to fish movement are created that cut off spawning areas. Fish that are trying to move up stream to spawn in spring will likely encounter fish barriers that they cannot surmount.

Pipes such as culverts and storm sewers are typically much smoother than a natural stream. Thus, they tend to produce higher velocities of water flowing through them. Further, long culverts and storm sewers do not provide natural resting areas and cut off access to natural light. All of these effects tend to act as barriers or restrictions to fish movement.

2.4 Integrated Stormwater Management

Integrated stormwater management is comprehensive and ecosystem-based; it attempts to take into account the scientific and technical knowledge that has been gained over the last 40 years concerning the impacts of land development on watersheds. As a result, stormwater management has undergone evolutionary growth in its scope and in its perspectives. At first focusing almost exclusively on removing runoff from developed areas quickly and efficiently, we are now coming to know the importance of considering all aspects of the hydrologic cycle, including understanding how land use development decisions can lead to disruption of that cycle. Further, we are beginning to see the value of eliminating causes of stormwater problems, rather than dealing only with the consequences of our land use decisions.

The recently released provincial guidelines for stormwater control represent one approach to integrated stormwater management planning. The guidelines are consistent with recent thinking across North America about urban drainage. As noted in Section 1, the City views the current planning for the Campbell River/Quinsam River Area in the context of these provincial guidelines, which begin with the premise that stormwater (or more precisely rainwater) is a resource to be managed.

Regardless of how "pristine" or how "degraded" a watershed may be initially, steps can be taken to improve the conditions resulting from urbanization by treating stormwater as a resource. However, communities can choose when it is best to take these steps, what level of commitment to make towards protecting, enhancing or restoring a watershed, and how to use the various management tools that are available.

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3.0 CAMPBELL RIVER/QUINSAM RIVER AREA DESCRIPTION

3.1 Available Information

The City provided the project team with GIS and AutoCAD data for relevant features in the watershed, including study area boundaries, contour information, elevation points within developed areas, some storm sewer and culvert locations / properties, watercourse locations, wetland and ditch locations, OCP and zoning designations, legal boundaries, street configurations and aerial photography. Much of this information was used to complete hydrologic / hydraulic modeling for the watershed, as discussed in Section 7. The Public Works department also forwarded flooding complaint summary spreadsheets, which summarized resident drainage complaints between the years 2000 to 2004. The drainage complaint summary spreadsheets are attached in Appendix G.

Only limited background studies and documents were available for the study area. Anecdotal information on fish habitat along the shoreline was provided by members of Working Groups.

Sources of information for the hydrogeological investigations included reports on surface drainage, stereo aerial photography, the regional soils map, logs of drilled wells and reports on conditions in other City watersheds and other hydrogeologically similar areas in Southwestern BC.

As with all previous ISMPs, rainfall information was obtained for the Campbell River Airport and Campbell River Sewage Treatment Plant stations, both of which are located within the overall study area and are the closest complete meteorological stations. While the Campbell River Airport rain gauge station is still active, the Sewage Treatment Plant rain gauge station was shut down several years ago. All of the above information was reviewed and incorporated, where relevant, into the context of this report. A summary of the documents reviewed can be found in Appendix A.

Existing conditions for this study are based on 2006 aerial photography or GIS information, except where more current as-built drawings were available.

3.2 Field Verification and Reconnaissance

Reconnaissance and field verification formed a significant aspect of background development for the planning process. The work consisted of a targeted habitat survey by a fisheries biologist, general site visit by a hydrogeologist and field verification of infrastructure data by a stormwater engineer. These are briefly described in the next few paragraphs.

Site reconnaissance and survey were undertaken in early August 2006, to verify conflicting or missing information in the City's existing GIS database and to supplement general knowledge of the study area. Several tasks were completed during the visit, including:

- Verifying pipe sizes
- Surveying manhole rims at critical locations
- Measuring roadside ditch cross sections and surveying invert elevations at various locations
- Obtaining photos of the area
- Obtaining a general overview of land use in the area
- Gaining an understanding of the overall configuration of the Campbell River/Quinsam River Area and how runoff is conveyed within it

Fisheries biologists undertook field reconnaissance on August 18, 2006 and again on September 11, 2006. Most of the existing storm drain outfalls were visited and a general assessment of habitat conditions was made. As well, preliminary assessments were made of many of the streams and wetlands in the Study Area; this included taking photographs, estimating base flow rates and, in some cases, obtaining in-field measurements of water temperature and dissolved oxygen (D.O.) levels. Appendix B contains a complete report.

The project team's hydrogeologist visited the study area on June 21, 2006, to confirm lithology and hydrogeological interpretations from other reports and sources and to groundtruth the locations of lithologic units that may present infiltration potential. Photographs were also used to document conditions around the study area. Appendix C contains a complete report.

3.3 Catchment Area and Composition

For purposes of this ISMP, the Study Area comprises four catchments or subareas (see Figure 3.1, in Appendix A):

- Detweiler Creek Watershed – lying on the west edge of the Study Area and extending south into the Quinsam IR # 2 (Cape Mudge Band); the creek discharges to the Campbell River.
- Haig Brown's Kingfisher Creek Watershed – in the center of the Study Area; the creek discharges to the Campbell River.
- Campbellton Catchment – drains the most highly developed lands of the Study Area, including the historic settlement areas along the Campbell River that now include commercial and light industrial land use activities along with residences; nine (9) outfalls discharge runoff directly to the Campbell River.

- River Bank Drainages – land, generally undeveloped, or only minimally developed, that lies along and up from the east bank of the Quinsam and the south bank of the Campbell, and that drains directly into the two rivers

The upper reaches of Haig Brown's Kingfisher Creek extend into Quinsam IR #12, although the bulk of this watershed lies within the Study Area. One particularly interesting feature in the watershed is a diversion (or "bifurcation") structure constructed on Kingfisher Creek. Located just west of the highway, the structure retains low flow in the creek but diverts high flows out of the Kingfisher Creek and into the Campbellton storm drain system. The structure was constructed as part of a habitat compensation package for the Inland Island Highway in about 1997 along with channel improvements downstream to enhance salmon spawning habitat.

The Campbellton catchment covers some of the oldest parts of the City. The area consists of both single family residential areas, primarily located in the catchment's uplands but also along the River itself, and commercial / light industrial land use activities in and adjacent to the Campbell River floodplain. The catchment is served by an extensive system of storm drains that discharge into the River via one of nine (9) outfalls. Some portions of the catchment have open ditch systems.

Both Detweiler and Kingfisher Creek watersheds contain significant patches of forested land and wetlands, along with some low density, single family residential development. Runoff is conveyed from the watersheds via open ditch systems and culverts discharging into the creeks. The central part of Kingfisher watershed, between the highway and older residential development, is currently being developed as bare land strata.

Both the Quinsam and Campbell River watersheds extend far beyond the Study Area boundary and thus hydrologic and hydraulic analysis for these areas were beyond the scope of this ISMP.

The overall Study Area boundary was initially established by the City in the study's Terms of Reference (Appendix K), and subsequently revised early in the project. The most significant revision was the deletion of Baikie Island and adjacent areas of the Campbell River Estuary, as these were previously included in the City's first ISMP for the Holly Hills/Perkins Road Drainages in North Campbell River. The specific catchment and subcatchment boundaries were added during the study as well. The boundaries were set using existing contour mapping (5-m contour intervals) and storm sewer information provided by the City. The existing contour mapping was supplemented by 20-meter Provincial Terrain Resource Information Management (TRIM) mapping where necessary (see Figure 3.3 in Appendix A). The resultant catchment boundaries are slightly different than originally provided by the City and also reflect the watershed boundaries established for as apart of previous ISMPs. The Study Area, as set forth in the project Terms of Reference, totaled 534.4 hectares (ha); this was reduced to 415.8 ha after adjustments, as noted.

Table 3.1 summarizes several basic parameters which are useful in measuring the extent of urban disturbance within an area. The parameters were calculated based on the 2006 aerial photography supplied by the City (Figure 3.2, in Appendix A). The basis for delineating the areas is:

Drainage Area – Land that was included in the hydrologic model developed for the study. For hydrologic and hydraulic modeling purposes the "drainage area" is different than the "study area" for two reasons. First, Haign Brown's Kingfisher Creek watershed extends beyond the Study Area, into IR #12. Second, since the Quinsam and Campbell Rivers were not modeled, the River Bank Drainages were not modeled either.

Impervious Area – Representative "blocks" of properties were randomly chosen within the developed portion of the watershed for each land use type (residential, commercial, industrial, etc). The total impervious area was calculated for each representative block (impervious area included roofs, driveways, roads, sidewalks, etc). These impervious values were extrapolated for each land use type over the entire developed area and then added together to calculate the total impervious area for the watershed.

Wooded Area – Based on interpretation of 2006 aerial photography, blocks of contiguous tree cover larger than 0.25 ha are included in this total. Linear stands of trees, for example along a road, were not included.

Riparian Area – Includes all areas along watercourse corridors where the corridor appeared to be extensively vegetated (based on the 2006 aerial photography). Limits of the riparian areas were set based on a noticeable change in vegetation type.

Table 3.1
Hydrologically Significant Existing Land Use Features[1]

Parameter	Catchment				Total
	Detweiler Creek	Kingfisher Creek	Campbellton Area	River Bank Drainages	
Study Area (ha)	73.8	208.6	93.0	40.5	415.8
Drainage Area (ha) *	47.5	318.5	99.5	n/a	465.5
Impervious Area (ha)	6.4	47.5	56.2	n/a	110.1
Impervious Area (%) **	8.7%	22.8%	60.4%	n/a	26.5%
Wooded Area (ha) ***	43.1	94.1	3.6	22.7	162.3
Wooded Area (%)	58.4%	45.1%	3.8%	55.9%	39.0%
Stream Length (km) ****	2.54	7.38	0	0	9.92
Riparian Area (ha) *****	18.8	54.3	0	0	73.1
Riparian Area (%)	25.5%	26.0%	0	0	17.6%
Open Channel (ditch) Length (km)	1.15	3.02	2.81	0.77	7.75
Closed Pipe (Storm Sewer) Length (km)	0	0	7.48	0	7.48
Main River Bank Length (km) ****	0.62	0.20	1.12	1.13	3.07

* As modeled (see Section 5.2); may differ significantly from "Study Area" figures
** All percentages are based on the Study Area total, not the Drainage Area as modeled; the Quinsam/Campbell catchment was not modeled and the Kingfisher Creek watershed extends significantly beyond the Study Area boundaries
*** Covers significant contiguous areas of forest only
**** Not including Quinsam and Campbell Rivers, which are listed under "Main River Bank Length"
***** Based on 60m corridor along identified streams (but not ditches)

As discussed in Section 2.2, healthy watersheds are typically characterised as having less than 10-15% impervious area and greater than 65% forested area. Clearly, the Campbellton Area is severely altered by urban development and can not be considered a healthy watershed; indeed except for ditches there are no open channel water features in this area. Stream flooding, stream erosion and "stream health" in general are thus not issues for the Campbellton Area. However, because of the extensive development, stormwater quality may be, particularly at outfall locations where fish habitat may be present. These issues will be discussed further in Section 5.9.

Even Detweiler and Kingfisher Creeks show signs of significant alteration. Flooding is generally not an issue in these watersheds, though low base flows, erosion and water quality are. And with increasing pressure to develop, new problems will undoubtedly arise.

1. These parameter values were prepared for the purpose of this planning study and re provided for general reference only. Site specific information must be obtained and provided to the City to confirm the actual site conditions at any location.

3.4 Historical Background

European settlements in the Campbell River area began more than 120 years ago, although the First Nations people had been present in the area for a significant time beforehand. The first European settlements were located near the mouth of the Campbell River and over time development extended south along the shoreline as well as along the ridge between the shore and Nunns and Simms Creeks.

3.5 Watercourse Characteristics

Figure 3.3 (in Appendix A) presents an overview of all open channel watercourses and closed pipe systems in the Study Area.

As noted, there are two primary natural open channel watercourses within the Study Area, Detweiler Creek and Haig Brown's Kingfisher Creek. These are both small streams that, with their respective watersheds, provide significant habitat for fish and wildlife. The streams vary in elevation from near sea level at the outlets to 70 and 78 m for Detweiler Creek and Kingfisher Creek, respectively.

Significant wetlands along the west branch of Detweiler Creek, along with smaller wetlands on the east branch, provide habitat (especially for amphibians) and naturally stabilize flows in the creek. Low summer base flows limit the fish values of the stream. According to the biophysical review report (see Appendix B), fine sediments have accumulated in the lower portions of the creek; these may inhibit fish spawning habitat.

Haig Brown's Kingfisher Creek has been severely manipulated by human development beginning with railway construction and logging activity at the turn of the last century which altered the location as well as the outlet of the lower West Branch. Since that time, infilling, ditching, relocations and rerouting within drain pipes have continued a legacy of human alterations. Efforts have been applied to several areas to provide access and spawning and rearing habitat for fish.

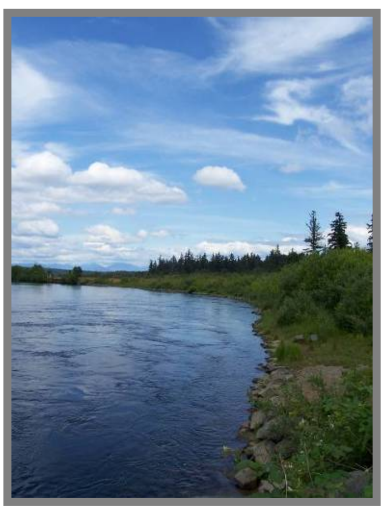
Historically, the headwater area of the West Branch was once characterized by having extensive bog habitat and the middle and headwater areas of the East Branch were dominated by wetland habitat. In particular, the East Branch had a good year-round supply of flow and a natural floodplain area where the Campbellton light industrial zone now exists. The "Pease Swamp," located along the west boundary of the Campbellton School playgrounds continues to provide water retention for the East Branch. Flooding in the area of the school and the light industrial zone led to the construction of the diversion structure, to retain some flow in the Creek as well as divert it from the flooding areas.

Both branches of Kingfisher Creek support significant fish habitat, though with a number of stream characteristics that can either add or detract from that habitat, including:

- Poor instream and riparian cover in upper East Branch (through the Sequoia Springs Golf Course)
- Beaver activity in the middle area of the East Branch
- Perched culverts at some locations
- Limited summer base flows (observed in late August 2006)
- Numerous in-stream channel improvements to enhance habitat in some locations, including channel construction, stream complexing, provision for off-channel ponds, riparian plantings, and construction of flow control weirs

Additional comments can be found in Section 3.8.

The Campbell River is a hydro-managed system, having three dams along its lower reaches. Base flows are maintained in the lower River to meet fisheries' rearing and life cycle requirements for anadromous and non-anadromous fish. The total watershed area is nearly 1,500 km^2, encompassing numerous lakes and tributary streams, including the Quinsam River. It is the source of drinking water for the City. Average monthly flows vary from a low of about 67 m^3/s in August and September to a high of around 130 m^3/s in November and December.



Located roughly 4 km upstream of Discovery Passage, the Quinsam River is a significant tributary of the Campbell River. With a watershed of about 280 m^3, the river delivers average monthly flows of just over 2 m^3/s in August to near 17 m^3/s in December. Water quality is becoming an issue along the Quinsam River. As reported in the Campbell River Watershed Management Plan (2001), the Quinsam River is beginning to show signs of environmental stress as indicated by water quality changes. While water quality apparently still exceeds current guidelines for all water uses, sulphate is of some concern, particularly in the upper reaches below the Quinsam Coal mining operations.

The DFO Quinsam River Fish Hatchery is located on the west bank of the Quinsam River about 3 km upstream of the confluence with the Campbell River and just upstream of the Study Area. The operation counts on Quinsam River's continued good health to support significant fish releases.

3.6 Hydrologic Conditions

There is no known data on stream flows in Detweiler and Kingfisher Creeks. Flow data is however available for the two large rivers, Campbell and Quinsam. The Campbell River is a highly managed water system and thus not a reliable source for estimating either low flow or flood conditions. Small late summer base flows, sufficient in some areas to sustain fisheries, were observed in Detweiler and Kingfisher Creeks during the field reconnaissance work (see Appendix B). Similarly, storm sewers in the Campbellton area exhibited small flows even in late summer when the field reconnaissance was completed.

The two Study Area rivers are large enough that flood plain mapping has been completed for them (Klohn Leonoff, 1989). As part of the floodplain mapping exercise flood discharges for the Campbell and Quinsam were determined. Table 3.2 shows these estimates. Using backwater hydraulic computations, these flows were translated into flood elevations along the rivers, as shown in Figure 3.4 (Appendix A); the 200-year recurrence flood elevations assume a downstream starting tidal condition of 1.9 m geodetic (Higher High Water Large Tide, see section 3.7); this includes a 600mm freeboard allowance. Although the likelihood is not great, these flood conditions would not normally be expected to coincide with local flooding conditions on Detweiler and Kingfisher Creeks. This is a result of the differing times for the arrival of peak flows on small streams as compared to large river systems. As well, flows in the Campbell River are managed for multiple purposes, including water supply, electrical generation, fish maintenance and flood control.

Table 3.2
Estimated Flood Discharges for the Campbell and Quinsam Rivers

Location	20-year Recurrence Flood (m^3/s)	200-year Recurrence Flood (m^3/s)
Quinsam River	136	233
Campbell River below Quinsam River	1,220	1,573

3.7 Tidal Conditions

Tides in Discovery Passage extend into the Study Area along the Campbell River upstream to just beyond the Tamarac Street/Island Highway Bridge. Generally only extreme high tides would be expected to significantly impact the functioning of storm drains in the Campbellton Area. Table 3.3 shows data previously gathered for the Nunns Creek ISMP.

Table 3.3
Tidal Heights, Extremes and Mean Water Level for Campbell River

DATUM	HEIGHTS (m)				RECORDED EXTREMES (m)		MEAN WATER LEVEL (m)
	Higher High Water		Lower Low Water		Highest High Water	Lowest Low Water	
	Mean Tide	Large Tide	Mean Tide	Large Tide			
Hydrographic Datum	4.0	4.8	1.3	0.2	5.4	-0.2	2.9
Geodetic Datum	1.1	1.9	-1.6	-2.7	2.5	-3.1	0.0

(Source: McElhanney, 2004)

3.8 Biophysical Inventory

Appendix B contains a complete report on the biophysical conditions of the Study Area. These findings are summarized in the paragraphs that follow. [2]

3.8.1 Lower Campbell River

The Campbell River is 90 km in length with anadromous habitat available within the lowermost 5 kilometers. Significant runs of pink, chum, chinook, coho, a small run of sockeye as well as summer and winter run steelhead trout, anadromous cutthroat trout and Pacific Lamprey are produced in the Campbell River. As well, notably large chinook salmon that has generated a prized fishery for tyee.

The reach of the river within the Study Area provides critical spawning habitat primarily for chum and chinook salmon as well as a small run of pinks. The right (south) bank is utilized as an important migration corridor with deep pools providing adult holding habitat for coho, pink, steelhead and chinook salmon as well as high quality rearing habitat for juvenile salmonids. The Campbell River is tidal to approximately 100m upstream of Highway 19 Bridge with estuarine conditions providing high quality nursery habitat for juvenile salmonids and invertebrates.

The Campbell River estuary supports a large number of resident and migratory birds including passerines, waterfowl, raptors, shorebirds and gulls as well as upland birds including trumpeter swans, bald eagles and great blue herons. A study in the early 1980's observed 125 bird species utilizing the estuary and determined that the estuary supported a minimum of 5,689 birds in at least one stage of their life history during the study period and includes Great Blue Heron nesting sites. However, bird use is thought to be lower in the estuary relative to other systems of equivalent size or smaller on the east coast of Vancouver Island, possibly limited by urban disturbances including industrial and commercial users as well as high levels of recreational

2 References have been omitted in the text, but can be found in the full report (Appendix B).

activity. The estuary also supports invertebrate species with a small amount of crab and clams harvested in the estuary.

Rare and unique plants can be found in the sparsely vegetated sand and gravel upland habitat of Tyee spit that occurs infrequently on the east coast of Vancouver Island. Undeveloped uplands near Westmin facility support the only known occurrence of balsamroot on the east coast of Vancouver Island. The lower river also supports marine and terrestrial mammals, amphibians, reptiles including historical documentation of river otters, beaver, mink, wolves, harbour seals, black bears, black tailed deer, Roosevelt elk and cougar.

Sediment delivery to the mainstem has been significantly modified over the past 50 years due to construction of the hydroelectric dams that regulate water and sediment discharge. As a result, the lower river is sediment starved. Within the study area, restoration in the Campbell River mainstem has occurred since the late 1990's and has included restoration of spawning and rearing habitat through construction of the Raven spawning and rearing channel as well as spawning platforms to offset to lack of natural gravel recruitment. Restoration works in the Campbell River estuary have included marsh and intertidal benching, bank stabilization, marsh and riparian planting, creation of low marsh habitat and soil remediation.

The Campbell River provides a diverse array of recreational activities and is estimated to support the second largest sports fishery in B.C. In 1975/76 steelhead catches in the river ranked 12th highest in B.C. On average, the Campbell River provides approximately 8-10,000 angler days annually.

The Campbell River also provides high value kayaking, snorkeling and swimming opportunities in addition to a network of hiking trails throughout. The Campbell River fish stocks also make an important contribution to the commercial fishery. As well, associated fish and wildlife populations also hold cultural and economic importance to First Nations people of the area.

3.8.2 Lower Quinsam River

The Quinsam River is a major tributary to the Campbell River and enters the mainstem river approximately 3.4 km upstream from the mouth. Relative to the Campbell River, the Quinsam River is smaller with more diverse hydraulic conditions. The Quinsam River is 45 km in length and drains an area of 283 square kilometers. The lower 25.7 kilometers is accessible by steelhead and coho, whereas pink and chum typically remain downstream of the rock cascade at 21.7 km. The lowermost 2.2 kilometers of the river defines the western boundary of the Study Area. The lower 10 km has an average bankfull width of 20 m and a gradient of 0.7% with substrates dominated by gravel and cobble. This reach has the highest concentration of spawning habitat between the river mouth up to Quinsam Lake.

Quinsam River supports steelhead and 5 species of salmon and provides critical spawning habitat for coho and pink salmon where as chinook and chum generally prefer to spawn in the mainstem Campbell River. However, chinook and chum spawners also utilize the lower 3.6 km of the river while coho salmon spawn throughout the mainstem to km 41.5. Sockeye spawning distribution is poorly understood but thought to occur primarily upstream of the Study Area. Other fish species in the lower Quinsam River within the Study Area include cutthroat trout, rainbow trout, Dolly Varden, char and Pacific lamprey. The entire lower reach is utilized by all anadromous species for rearing.

The Quinsam River hatchery was constructed in 1974 in order to enhance chinook, coho, pink, steelhead and sea run cutthroat trout stocks returning to the Quinsam River and adjacent systems. Then enhancement programs release hatchery-cultured fish for emigration to salt water as well as a juvenile outplanting program in the upper watershed.

Unstable silt banks in the lower reaches contribute fines to the channel that have been accumulating and degrading gravel quality. Habitat restoration activities have included construction of a dyke below the hatchery to reduce channel braiding and impingement on Cold Creek, anchoring larger woody debris (LWD) downstream of the dyke as well as riparian planting to stabilize an eroding bank 1 km upstream of the hatchery.

Intact forested habitat in the lower Quinsam River also provides an important wildlife migration corridor as well as providing residence to a number of species as listed for the lower Campbell River. There are high recreational values including hiking trails from the Elk Falls park trails between the hatchery and the confluence area. Quinsam fish stocks make an important contribution to the commercial marine fishery as well as both marine and freshwater sports fisheries

3.8.3 Detweiler Creek

Detweiler Creek produces coho salmon and cutthroat trout with an average of less than 12 coho spawners annually. Known distribution for coho extends up the east branch for approximately 800-1000m to the ponds immediately upstream of the Quinsam Road crossing. Further distribution of coho and trout in Detweiler Creek as well as location of spawning habitat is currently unknown. In general, fish production is thought to be limited by summer low flows and corresponding suitable summer rearing habitat.

One of the most valuable ecological features of the Detweiler watershed is the presence of wetland habitat that has provides high quality habitat for amphibian species with the potential to provide rearing habitat for salmonids. Wetlands also provide water storage opportunities and naturally stabilize the effects of high flows, particularly to low gradient reaches downstream. In 1991, the provincial Sensitive Ecosystems Inventory group identified a unique 2.1 ha wetland (S0342) in the Detweiler Creek West branch immediately downstream of Quinsam Road (Figure 3.5 in Appendix A). The location and extent of additional wetlands was interpreted from 1995 aerial mosaics but should be considered a starting point.

Another important ecological feature of Detweiler Creek is the presence of undisturbed forested land that provides one of the few remaining migration corridor for wildlife species. In 1991 the Sensitive Ecosystem Inventory group identified an ecologically sensitive, 6.1 ha high value riparian forest between the lower Detweiler Creek and the Quinsam (S0347D). Recreational values are also notable in the area and include hiking and fishing opportunities.

Overtime, sediment has naturally accumulated in the lower gradient reaches with restoration opportunities to include channel complexing and addition of spawning gravels. At this time, access by coho adults is limited to higher fall flows.

3.8.4 Haig Brown's Kingfisher Creek

Haig Brown Kingfisher Creek (HBKC) is a physically diverse system encompassing 281 ha with 2 main drainages referred to as the East and West Fork in this report. Due to significant historical and environmental values, there has been land set aside in the lower creek for ecological significance. In 1975, the Roderick Haig Brown property along Highway 28 became a Provincial Greenbelt Reserve with the 7.7 ha riverside property set aside to be managed for public education and fisheries enhancement.

The stream channel has been severely manipulated by human development since the 1890's when railway construction and logging activity altered the location as well as the outlet of the lower West Branch. Later, streams flows from the upper East Branch were rerouted down a storm drain pipe for approximately 400 m and entered the Campbell River between the Island Highway bridges at outfall CR 7 (Figure 3.5 in Appendix A). Sections of the original channel were infilled starting in 1957 and the East and West Branches separated into 2 systems and their confluence with the Campbell River relocated at least twice more. Access to a portion of the west tributary was eliminated by fish screen. The middle branch of Haig Brown Creek was groundwater fed but destroyed by infilling and ditching. In 1984, the west branch was diverted down a new channel with coho using the channel the first fall it was open but summer low flows limited suitable rearing habitat for coho within the West Branch.

However, much of the watershed remains forested though 23% of the watershed is currently considered to have an impervious surface. The majority of streams and wetlands have naturally vegetated riparian habitat. The most significant degree of development to date includes the light industrial zone in the lower East fork as well as development of low density rural residential in the upper East fork. The west fork had undergone a lower degree of development with single family residential development in the lower river and the Quinsam Crossings development within IR #12 in the headwater area. Urban development is increasing in Haig Brown Kingfisher watershed with an established storm drain system and commercial development in the lower reaches as well as proposed urban residential development north of the Sequoia Springs golf course.

The headwater area of the West Branch was once characterized by having extensive bog habitat while the middle and upper reaches of the East Branch were once dominated by wetland habitat . Historically, the East Branch of Kingfisher Creek had a good year round supply of stream flows with a natural floodplain area where the Campbellton light industrial zone now exists (Stearns 1996). Water continues to be retained year round in the 26 acre wetland known as "Pease swamp" located along the west boundary of the Campbellton School playground. The wetland and riparian area provide ideal wildlife habitat with extensive mud bottom ponds, seasonal channels with an abundance of overhead shrubs intermixed among deciduous trees. In 1991, a 1.4 ha wetland (S0341-R) located in the West Branch was identified as having ecologically significant value.

Coho and trout production in HBKC is thought to be limited by summer low flows and corresponding availability of summer rearing habitat. Historically, the E branch was reported to have a good year round water supply. During late August 2006, after a period of extended dry weather, seepage flows in both E and W branches were sustaining a very limited amount of summer rearing habitat, inferring that limited groundwater seepage flows continue to feed both E and W branches. Salmonid fry were observed in pool habitat fed by subsurface seepage flows with suitable water quality measured in the lower reaches of the West Branch as well as upper and lower reaches of the East Branch.

Historical flooding issues in lower HB Creek within the natural floodplain area into Campbellton Elementary school and the Campbellton light industrial zone have been documented since 1974. Flooding issues precipitated restoration works in 1998 that involved construction of a bifurcation structures that re-routed flows from a storm drain pipe into almost a kilometer of an excavated stream channel connecting the East Fork with the west fork (see photo).

Bifurcation (diversion) structure in Kingfisher Creek

At the same time, the 300 m of the lower West fork was restored with improvements to fish access as well as to increase spawning and rearing habitat through LWD and boulder complexing, riffle construction and gravel placements, off channel ponds, flow control weirs for flood control and riparian planting undertaken in both forks. In 1995, a groundwater fed settling/rearing channel was constructed in an East Branch tributary immediately downstream of the Island Highway ROW as part of the habitat compensation requirement for highway construction. Monitoring results in 1999-2001 confirmed high fish use by coho and trout juveniles as well as good riparian recovery.

Kingfisher Creek typically supports 200-300 coho spawners on average annually as well as a few chum spawners downstream of the Highway 28 crossing. Cutthroat trout are produced in the upper reaches of both the east and west branches. Known distribution of coho spawners in the East fork extends 500 m upstream of the Inland Island Hwy after which, the East fork is incised into a steep ravine (Fig 3.5 in Appendix A). In 2001, coho fry were captured 50 m upstream of the Inland Island Highway culvert. Cutthroat trout are distributed through the Sequoia Spring golf course with potential residence further upstream during seasonal higher flows.

The main branch of the West fork originates in IR#12 and ascends down a moderately sloped sidehill through private land. In 1995, as part of the Vancouver Island Highway Project (VIHP), coho and cutthroat fry were captured at the toe of the slope in groundwater fed ponds, approximately 25 m downstream of the ROW. The extent of known coho distribution coincides with the ISMP study boundary. Known fish distribution in the west branch of the West fork includes the reach that runs parallel to Nursery Road. Cutthroat trout are thought to be distributed upstream of anadromous reaches throughout the headwater area of HBKF Creek. The low gradient marsh habitat throughout the middle reaches provide good potential summer rearing habitat with coho spawners sighted in gravel reach adjacent to hatchery road.

Beaver dams in the middle watershed area may limit coho distribution in HBKC. However, adult access through the dams is annually facilitated by a crew who partially breaches the dam features during periods of anadromous fish migration. Fish access issues in HBKC east also includes stranding at culvert at Stat 1+850 (culvert at forestry road is impassable as u/s end is stranded at moderate flows, with majority of flow running through fill surrounding the culvert.

HB Greenways Property has historically provided habitat for cougars, black bear, blacktail deer, mink, raccoon as well as many bird species. The property continues to provide an important migration corridor for these species with critical wetland habitat also providing habitat for amphibian species (likely presence of red tailed frogs) as well as foraging habitat for bears and various bird species.

Through the Sequoia Springs Golf Course, the East Branch has poor instream and riparian cover. Three water storage ponds were excavated for irrigation purposes but also function as runoff detention features. There are cutthroat trout in the channel downstream of the detention ponds, and likely rainbow trout as well.

3.8.5 Campbellton Light Industrial Area

The Campbellton Light Industrial Zone represents approximately 25% of the Study Area. Surface waters are conveyed through a well established storm drain system with no natural streams present anywhere in the area. Within the central core of the light industrial area is a modest residential neighborhood where the stormwater flows through a series of culverts with intermittent open vegetated ditches (Appendix B).

Historical flooding issues in lower HB Creek within the natural floodplain area into Campbellton Elementary school and the Campbellton light industrial zone have been documented since 1974. Streams flows from the upper East Branch were rerouted down a storm drain pipe for approximately 400 m and entered the Campbell River between the Island Highway bridges at the Enns property (Outfall CR7). In 1996, post diversion and channel construction in the East Fork, adult coho continue to migrate up the Campbellton storm drain (Outfall CR 7). Flooding issues precipitated restoration works in 1998 that involved construction of a bifurcation structure that re-routed flows from a storm drain pipe into almost a kilometer of an excavated stream channel connecting the East Fork with the west fork.

Table 3.3
Summary of Campbell River / Quinsam River Reconnaissance Study Results

Site (Outfall #)	Site Characteristics	Ground Water Flow (Est)	Photos	Photos
CR1 Maple St	Open cement culvert, perched at low tide, amongst rip-rap along RB outside bend pool. Adjacent to Myrt Thompson Trail	None		
CR2 Petersen Rd	Staff gauge and tide gate over outlet. Potential rearing habitat at confluence with river, shallow shelf that would provide refuge habitat between two wharves	None		
CR3 CR Lodge	New 16" outfall pipe with outlet cover recently installed, old one still in place with metal cover and staff gauge. Good rearing adjacent to outfall area and good off channel rearing habitat observed at these flows.	None		
CR4/5 Redwood St	Outfall not observed from foreshore area, commercial building no manhole or obvious access observed from road.	Unknown		

Site (Outfall #)	Site Characteristics	Ground Water Flow (Est)	Photos	Photos
CR6 Spruce St	Heavy brush, outfall not observed would require clearing riparian shrubs to access or water access	Unknown		
CR 6.5 Downstream side of H19 north bound (Tamarac Street) bridge.	Fish access possible at very high tide and high river flows i.e. 2 m higher than today's level at 3:50 pm Sept 2, 06	1L/sec		
CR7 Between H19 bridges	2133 mm CMP with cement outfall curtain constructed under house, low gradient outfall, concrete box culvert. Reported access by adult and juvenile salmonids into storm drain system. Old creek location.	2L/sec year round flows		
CR8 Upstream side of H19 southbound bridge Willow St bridge	Perched twin 12" CMP, > 3 m above existing water level, likely no fish access or utilization along shoreline			

3.9 Geology

From regional surficial geology maps, the upland portions of the CR/QR study area are underlain primarily by glaciomarine deposits consisting of mainly silts and clays. Based on field evidence, layers of silty till-like deposits were noted within a sequence of fine marine sediments. In the lower eastern terraces, materials are variable, with silty, till-like deposits interspersed with sand gravel. The northern lowland, along the Campbell River, is covered by recent alluvial deposits.

The marine deposits may be 16-65 m in thickness, depending on location, and are further underlain by either sedimentary bedrock or more likely glacial outwash sand (called Quadra Sand). The marine deposits can be considered to have low permeability while Quadra Sand unit is moderately permeable.

There are very few shallow dug wells within the study area and only one deep drilled well from which to develop a more complete picture of the area's geology. The single drilled well, at the Quinsam Seed Orchard, was about 115 m deep. Depth to water in this well was 35 m and the reported yield was only 0.75 L/s (12 GPM).

A fuller discussion of general geologic conditions in the Study Area is included with the hydrogeological report which is reproduced in Appendix C. Figure 3 (Appendix C) in the report shows a typical geological cross section through the Quinsam River extending northeast to the Campbell River.

3.10 Surficial Soils

The dominant soils type of the CR/QR area, covering roughly 75% of the Study Area, is the Fairbridge soil. Fairbridge consists of silty loam to silty clay materials, with relatively low long term saturated flow potential of only about 3 mm/hr. Cassidy sandy loam soils, which predominate in the lowland areas along the Campbell and Quinsam Rivers, have a somewhat higher infiltration potential (on the order of 6 mm/hr), but seasonal high water tables in the low lying areas may limit use for stormwater infiltration. A very limited area of Dashwood soil (marine sand and gravel) is found in the eastern part of the Study Area; this soil is associated with marine sands and gravels and thus with very rapid infiltration rates of about 250 mm/hr.

Figure 2 in the hydrogeological report (Appendix C) delineates the soils limits; Figure 3.6 (Appendix A) reinterprets the data with respect to areas of higher or lower long term potential infiltration rates.

3.11 Groundwater Conditions

Some of the precipitation falling on areas outside the Study Area, to the south and west, seeps into the ground and likely flows along the top of the restrictive layers of marine clay or bedrock. This subsurface flow will either find a place where it can seep through the restrictive layers into deeper permeable layers of material (such as the Quadra Sand), or discharge to the surface at springs and seeps or directly into local streams, where it supports base flows. Precipitation falling within the Study Area similarly contributes to recharge of shallow sediments, and can discharge to the surface at springs, seeps and streams as base flow.

The Study Area presents potential for infiltration of stormwater in certain areas (see Figure 3.5). Areas with Dashwood and Cassidy soils offer the best potential, but careful use of other areas may allow infiltration practices to be returned to the local hydrologic cycle (as it was before development occurred). The low long-term potential infiltration rates certainly restrict the use of large scale, concentrated (i.e., centralized) infiltration of stormwater, for example, through neighbourhood infiltration basins. However, with proper design precautions, even soils with low infiltration rates can often support more diffuse infiltration practices. Significant design issues that must be considered for each application include slope stability, especially along scarps (for example, immediately south of Spruce Street), depth to local water table, need for perforated underdrains, and provision for proper pre-treatment before infiltrating the stormwater. Swales, rain gardens, soak-away systems and shallow infiltration trenches are example source control systems that are available for use. Other options include "leaky" (perforated) storm sewers and deep well vertical infiltration systems.

3.12 Baseflow Conditions

No firm data was available to quantify base flow conditions for Detweiler and Kingfisher Creeks, however, the hydrogeological report prepared for the Nunns, Simms and Willow Creek watersheds (Piteau, 2005) may offer some insight into local conditions. For those three creeks, base flows were estimated to be between 0.2 and 4.0 L/s/km^2, depending on location within the watershed. The report noted that this range is generally lower than that found on other Vancouver Island streams, and attributed this to the effects of urban / suburban development in the City. During the biophysical field reconnaissance, base flow was observed at several locations, including the East Branch of Kingfisher Creek just below the diversion / bifurcation structure and at two outfalls. The estimated low flows at CR6.5 and CR7 yield about 0.9 L/s/km^2, within the range found for the other watersheds in Campbell River. In the absence of other data, Detweiler and Kingfisher Creeks can be assumed to exhibit similar base flow conditions.

The base flow for Quinsam River was listed as 11.3 L/s/ km^2 (Piteau, 2005), which is much more consistent with other largely undeveloped watersheds in the area.

Undoubtedly, groundwater discharging as springs and seeps north of the highway play a role in supporting the sizable wetland and pond complex of the middle parts of Kingfisher Creek. Development upstream of here, to the extent that it relies on interception of stormwater into closed conduits, will likely reduce the volume of infiltration which now flows as groundwater months later.

3.13 Municipal Drainage Infrastructure

Much of the Study Area is low density residential or rural in character, being served by roadside ditches and culverts, as needed. The exception is the Campbellton catchment which is heavily storm sewered (see Figure 3.7 in Appendix A). Here there are eight (8) storm drain networks, with nine (9) outfalls, partially interconnected as will be discussed below, serving the lower lying areas along and just up from the Campbell River (Campbellton area). These networks include storm sewers constructed as part of the Island Highway project as well as older systems of unknown age.

The outfalls for these networks vary in size from 300mm diameter to a 2100 X 2100mm box conduit that discharges underneath a private home on Enns Road. At least two of the outfalls (CR2 and CR3) were observed to have flap gates. It is assumed that CR4 through CR6 also do, although they could not be accessed during field reconnaissance. A separate storm drain network serves a portion of the development on top of the hill, near the Sequoia Springs Golf Course, although much of the area has ditches and culverts. Runoff from the entire upper terrace area is conveyed down the hill and into the sewer networks serving Campbellton proper.

According to the City's GIS database there are no stormwater detention ponds in the Study Area. All piped stormwater is discharged directly to the Campbell River with no attenuation or treatment, except as will be described in the next section. According to City Staff, a pond to serve parts of new development between the highway and Treelane Road will serve to reduce peak flows from the bare land strata development currently underway; this area is in the Kingfisher Creek watershed.

Outfall #CR 7

3.14 Stormwater Treatment

Minimal stormwater treatment is currently provided within the four catchments. Current City standards for catch basins require that a 600 mm sump be provided, to catch gross solids (coarse sand and larger), but does not include a hood on the outlet to skim oil and grease. All catch basins constructed within the last 20 years or so should meet this standard, but earlier construction may not have. If not frequently cleaned, solids that collect in catch basins are easily washed out in heavy rains.

City GIS records show two oil/water separators[3] installed on storm sewer mains in the Campbellton area, while a third was recently installed near 19th and Tamarack (see Figure 3.6). The systems have been installed "on-line," that is, all runoff that enters the sewers must pass through the separators. Unfortunately, one difficultly often encountered with on-line treatment systems is that high intensity rainfalls washout the sediments, oils and greases that have been trapped previously.

Undoubtedly some commercial enterprises have stormwater treatment systems for their private sites; for example, most gas stations have systems to capture spills. The extent or prevalence of such treatment systems is unknown.

Ditches that are well maintained are grassed and have reasonably shallow profile slopes (such as the east/west ditches in the residential areas in the upper, southerly areas of Campbellton catchment) will provide some runoff treatment by allowing solids to settle and enhancing contact between soil and runoff.

Water Quality Pond at 14th Ave. & Willow St

A water quality pond was constructed as part of the Island Highway project in the late 1990's; it is located in the median as the highway splits towards northbound Tamarac Street and southbound Willow Street, near 14th Avenue. This pond is intended to treat runoff from the highway only, however no design computations were available to verify this nor were computations available to establish the design parameters for the pond. From the available construction drawings, the pond has a surface area of about 630 m^2 with permanent and high water pool depths of 1.0 and 1.9 m, respectively.

The City also has an irregular street cleaning program, which utilizes a 10-year-old Model 605 Vacuum Sweeper by Johnston Sweepers. This cleaner will remove trash, leaves and gross solids from City streets. This is good, but likely does not remove the smallest particles which are generally associated with most harmful pollutants, for example, heavy metals.

On balance, highly developed areas such as the Campbellton Area are unlikely to be receiving any significant treatment of the runoff generated within its subcatchments. The pollutants generated in the area are conveyed by the runoff into the Campbell River and Estuary.

3 Underground tanks or vaults, generally constructed with baffles or other passive means for capturing free oil and grease, which floats on top of the stormwater. The structures will also trap coarse sediments, to which oil and grease have attached. On-line systems may be subject to wash-out during high intensity rainfalls.

3.15 Land Use

3.15.1 Existing Land Use Pattern

The existing land use pattern within the Campbell River/Quinsam River catchment is largely determined by the City of Campbell River's Zoning Bylaw No. 2700, which regulates land use within the City (see Figure 3.8 in Appendix A). As shown on Figure 3.8 most of the existing development is residential or commercial.

Existing commercial development is limited to the north-eastern portion of the study area, in the Campbellton neighbourhood. Most of the existing commercial area falls within the **Commercial Three (C-3) Zone**, which provides for service uses (including service stations) and warehousing uses. The C-3 Zone requires a minimum lot area of 750 m^2 for new commercial lots, and 400 m^2 for existing residential lots, and imposes a maximum lot coverage restriction only for motels (maximum lot coverage of 65%). This area of the study area also includes light industrial uses such as heavy equipment service and repairs, and warehousing.

Most of the existing residential development falls within the **Residential One (R-1) Zone**, which permits one single-family residence per lot. The minimum lot size in the R-1 Zone is 450 m^2, and the maximum lot coverage of all buildings, including driveways and parking areas, is 35%. Aerial photographs show that all of the land zoned for this use in the study area has already been developed.

As shown on Figure 3.9, (Appendix A) a significant portion of the study area (39%) is forested. Much of this area falls within the **Rural One (Ru-1) Zone**, which permits residential and rural uses on one hectare lots, or the **Rural Two (RU-2) Zone**, which allows residential uses and uses requiring large parcels on four hectare lots.

The southernmost portion of the study area is zoned for **Residential Infill One (R1-1)**, which allows residential uses up to 5 units per hectare, and **Residential Infill Three (RI-3)**, which allows medium density residential uses up to 60 units per hectare. While both of these zones allow for urban residential development, the current land use is rural.

While residential and commercial uses are the predominant land uses, the study area also includes a variety of other land uses, including light industrial uses, the Sequoia Springs Golf Course (located east of the Inland Island Highway near the southern boundary of the watershed), public assembly uses, and greenways, including the Haig Brown Conservation Area.

3.15.2 Future Land Use Pattern

The area's future land use pattern is primarily determined by the City's Official Community Plan (OCP), which provides the overall direction for future development in the City. The future land use designations within the OCP are shown on the Official Community Plan map (see Figure 3.10 in Appendix A). The most significant future land uses within the study area are:

- **Residential**

  The Residential OCP designation encourages residential infill, and supports cluster housing near Environmentally Sensitive Areas. Most of the residential development is expected to be low density (up to 30 dwelling units per hectare); however, the Campbellton area and the southeastern corner of the study area are designated for future medium density residential development (31 to 65 dwelling units per hectare).

- **Commercial**

  The Campbellton area is designated for future commercial development. This commercial designation promotes existing highway commercial, service commercial, and tourist commercial uses.

- **Park/Natural Areas**

  The OCP also designates a significant area of the study area near Kingfisher Creek as a Park/Natural Area. This designation supports the establishment of a system of linked parks, natural areas, and greenways, and protects environmentally sensitive areas.

- **Rural**

  A sizeable portion of the Campbell River/Quinsam River study area is designated for future Rural uses. The Rural OCP designation encourages the preservation of larger lot sizes, supports the conservation of lands in the Agricultural Land Reserve, promotes preservation of forested lands, and allows outdoor recreational uses such as golf courses.

The Campbell River/Quinsam River study area also includes land use designations to provide for institutional uses and water uses.

Sequioa Springs/Kingfisher Conceptual Development Plan – The OCP contains the Sequioa Springs/Kingfisher Conceptual Development Plan, which outlines a more detailed development plan for approximately 80 hectares of land through the middle of the study area straddling the Inland Island Highway. The plan calls for the development of between 600 and 800 low to medium density residential dwelling units over at least 10 years. Approximately 40% of the plan area is designated for greenways, including parks areas and proposed expansion of the golf course, as well setbacks along Kingfisher Creek to protect environmentally sensitive areas.

Urban Residential Containment Boundary – The OCP contains an Urban Residential Containment Boundary (URCB) to control residential development and prevent urban sprawl. With the exception of the ALR land immediately north of Quinsam IR No. 12, the Study Area falls within the URCB, which means the City plans to direct future residential development to this area.

Environmentally Sensitive Areas – The OCP includes a chapter on Environmentally Sensitive Areas (ESAs), which puts forward policies to protect the environment, minimize pollution, and conserve the quality and quantity of groundwater and surface water. ESAs are defined as "any parcel of land, large or small, under public or private control, that provides, contains, or includes productive, rare or sensitive habitat, ecosystems or landforms," which includes watersheds, watercourses and their associated aquatic habitats. To control development in these areas, the OCP designates these areas as Environmental Development Permit Areas. All lands within the Riparian Assessment Area falls within the Environmental Development Permit Area.

The development permit guidelines for streamside areas protect waterways, drainage areas, and wetlands through a variety of policies, including:

- Requiring development setbacks from watercourses (as identified in the Zoning Bylaw)
- Encouraging the planting of appropriate vegetation to restore riparian areas
- Encouraging the registration of covenants to protect streamside areas
- Requiring (in some cases) the provision of works (e.g. fencing) to protect or enhance environmentally sensitive areas
- Requiring that the discharge of stormwater not negatively impact adjacent water quality

Environmentally sensitive areas within the Campbell River Estuary are further protected by the Campbell River Estuary Management Plan, which contains policies to guide land development adjacent to the Estuary Plan Area and supports the restoration of aquatic, riparian, and upland areas to improve fish and wildlife habitat. The Estuary Management Plan was developed to be consistent with the policies contained in the City's OCP regarding Environmentally Sensitive Areas.

3.15.3 Short Term Development Potential

The study area is expected to experience significant residential development in the short term. Over the next ten years, up to 800 low-to medium density units are expected to be developed in the Kingfisher Creek catchment as per the Sequia Springs /Kingfisher Conceptual Development Plan. A 60 to 70 unit townhouse development on Charleville Road near the northern border of the study area is also anticipated, and there may be potential for the development of a mobile home park at the old Rod & Gun site, though plans have not yet been developed. A 119-unit bareland strata development is currently under construction just north of the Sequoia Springs Golf Course, and a further 200 patio homes are slated for development in this area.

In terms of commercial development, the Campbell School site (the school is currently closed) on Campbell River Road will likely be redeveloped for service commercial uses. As well, residential uses in the historic town centre are expected to convert to commercial uses over time.

3.15.4 Special Land Use Designations

In general, local governments have the authority to regulate land use through their Official Community Plan and Zoning Bylaw. However, local governments must respect special land use designations imposed by the provincial and federal governments. As such, the City cannot regulate development (or in some cases has only limited ability to do so) on land within these special land use designations. Identification of these special types of land use is important because each designation has a different impact on stormwater management. The Campbell River/Quinsam River catchment includes the following special land use designations:

- **Agricultural Land Reserve** – the Agricultural Land Reserve (ALR) is a provincial land use designation that protects agricultural land and encourages agricultural activity. Only very limited development is permitted on land within the ALR. Local governments are able to apply OCP designations and zoning on ALR land, but the Agricultural Land Commission Act supersedes any local government policy. Agricultural land can be removed from the ALR if the Agricultural Land Commission (ALC) approves the exclusion. However, since the ALC's mandate is to protect agricultural land, it is generally difficult to exclude land from the ALR.

  The Campbell River/Quinsam River study area contains 44.4 ha of ALR lands, constituting 10.7% of the land within the watershed (see Figure 3.9). Since the ALR designation protects agricultural land and limits development, the ALR designation generally has a positive impact on stormwater management as long as logging or other activities are properly managed. For example, replanting of logged areas usually results in a positive impact on stormwater management; however, ditching associated with access road building tends to be detrimental as it often short-circuits interflow from reaching the creek.

- **Haig-Brown Conservation Area** – The Campbell River/Quinsam River catchment also includes the Haig-Brown Conservation Area, which is owned by the Province. The City leases the heritage properties within the Conservation Area and is currently negotiating a second lease arrangement jointly with the Greenways Land Trust and the Province for the other parcels within the Haig-Brown Conservation Area. In addition to the heritage properties, the Conservation Area also contains a forest trail system. Land uses within the Haig-Brown Conservation Area are restricted to fish and wildlife uses and conservation uses.

4.0 CURRENT STORMWATER MANAGEMENT TOOLS

The City currently has a number of policy, management and regulatory "tools" available to address stormwater issues in the Campbell River/Quinsam River Area. These include the broad principles adopted in the Official Community Plan (OCP), as well as the City's various land use and development bylaws and engineering standards. In addition, management of stormwater is also addressed in and through provincial and federal laws and guidelines. In the following paragraphs, some of these tools are briefly discussed, highlighting potential avenues for better stormwater resource management. Of particular interest in this regard is the provincial "Environmental Best Management Practices" document described in Section 4.2.4; this document provides a much fuller and more complete discussion than can be provided in this brief chapter.

4.1 Municipal Level

4.1.1 Bylaws

Through its authority under the *Local Government Act* (see next section), the City has adopted a number of bylaws which have a direct impact on stormwater. While the OCP provides a framework for some aspects of stormwater management within the City, these bylaws regulate implementation on a routine basis. Critical bylaws include:

- **Building Bylaw** – regulates design and construction of structures within the City
- **Subdivision Bylaw** – regulates development within the City
- **Zoning Bylaw** – regulates the use of land and structures within the City
- **Frontage Improvement Bylaw** – Requires certain improvements to serve developments
- **Storm Drain System Connections Bylaw** – requires connection to storm drains, where available

The financing of stormwater improvements such as storm drains and regional detention ponds is also addressed in several City bylaws:

- Development Cost Charges Bylaw
- Frontage Improvement Bylaw
- Stormwater Management Parcel Tax Bylaw
- Local Improvement Charges Bylaw

The Stormwater Management Parcel Tax is an especially important tool for the City as it generates revenue that is designated exclusively for use in stormwater management. The tax is $12 per non-exempt parcel and was initially assessed for only a period of five years (2001-2005), but has since been extended through the year 2010. The tax was renewed for an additional five years in September 2005. With approximately 10,000 parcels in the City, the tax generates about $120,000 per year for stormwater management purposes.

4.1.2 Land Use Policies

The previous section of this report discussed the OCP in detail. One basic environmental principle is that in order for the "natural life support systems to remain healthy [the City] must reduce [its] negative impact on them." Several guiding principles for general community decision-making and governance outlined in the OCP may impact the way stormwater planning is approached:

- Balance between development and conservation
- cooperation between public and private sectors
- Proactive management of change
- Involved citizenship

4.1.3 Design Standards and Specifications

The City's Engineering Design Standards and Specifications are appendices to the Subdivision and the Frontage Improvement Bylaws. Together, they set standards for design and construction of infrastructure including roads and storm drains. For example, new roads in residential areas must have minimum pavement widths of 9.0 metres.

In addition, the City maintains a list of "approved products," such as manholes, catch basins and pipe that can be used to meet storm drainage needs of the area.

The City is in the process of developing "alternate" subdivision design standards. The alternate standards are a way of addressing the environmental impacts of urbanization by requiring development that is customized to site and land use conditions. The Phase 1 report (Lanarc, 2005) on use of alternate design standards include the use of narrower road pavements, pervious pavement, bio-swales and other low impact stormwater BMP's; a draft set of alternate design standards is currently under review by the City. The recommendations of the Campbell River/Quinsam River Area ISMP and the alternate design standards project should be mutually compatible, with a focus on long-term sustainability.

4.2 Provincial Level

4.2.1 Riparian Areas Regulation

The Provincial Riparian Areas Regulation (RAR), enacted in July 2004, calls for local governments to protect riparian areas during urban development by ensuring that proposed activities are subject to a science-based assessment. The assessment is to be conducted by a Qualified Environmental Professional (QEP), serving as the consultant for the land developer. RAR is managed by the Ministry of Water, Land and Air Protection (MWLAP).

The RAR is intended to provide protection for the features, functions and conditions that are vital to the natural maintenance of stream health and productivity. This includes such things as:

- Large organic debris (fallen trees and tree roots)
- Areas for stream channel migration
- Vegetative cover to moderate stream temperature
- Provision of food, nutrients and organic matter to the stream
- Stream bank stabilization
- Buffers to prevent excessive introduction of silt and runoff pollution

The assessment methodology for streamside protection and enhancement areas are set forth in the RAR. The RAR does not apply to agriculture, mining or forestry-related land uses and saltwater areas. Riparian protection for these activities is under separate initiatives.

The previous Memorandum of Understanding (MOU) among the City, MWLAP, and Fisheries and Oceans Canada (DFO) dealing with activities in the riparian area has recently expired. The City now protects riparian areas through the RAR, which has been implemented though the City's Official Community Plan.

4.2.2 Stormwater Guidelines

The Province recently released guidelines for stormwater control that encourages the use of an integrated approach to management planning. The guidelines are consistent with recent thinking and practice across North America about urban drainage. The guiding principles for integrated stormwater management, as set forth in the document "Stormwater Planning: A Guidebook for British Columbia" (May 2002), are:

- Agree that stormwater is a resource

- Design for the complete spectrum of rainfall events
- Act on a priority basis in at-risk drainage catchments
- Plan at multiple scales – regional, watershed, neighbourhood and site
- Test solutions and reduce costs by adaptive management

With respect to the second principle, the general approach advocated by the Guidelines is to:

- Capture rainfall from small storms on site for surface runoff volume reduction and water quality control
- Control runoff from larger storms to provide surface runoff rate reduction
- Manage flood risk from extreme storm events by providing peak flow conveyance

In the past stormwater management has focused almost exclusively on this final item, extreme event risk management. But from the standpoint of fisheries, for example, it is the small, frequent storms and water quality that are of much more interest.

One of the tools subsequently developed by the province (in partnership with the Fisheries and Oceans Canada and private sector participants) to assist with implementation of the guidelines is the so-called "Water Balance Model," or WBM. The WBM is a planning tool that can show the impacts on runoff of unmanaged development. It allows various on-site controls to be tested based on site conditions such as soils type.

4.2.3 Local Government Act and Community Charter

In British Columbia, local governments acquire their powers from two pieces of provincial legislation: the *Local Government Act* and the recently introduced *Community Charter*. The *Community Charter*, which came into force on January 1, 2004, is intended to eventually replace the *Local Government Act*. However, at this time, the *Community Charter* contains only the core municipal provisions, while other provisions such as those related to planning and land use remain within the *Local Government Act*.

The *Local Government Act* and *Community Charter* allow local governments to enact various bylaws and policies that can affect stormwater management. Under the *Local Government Act* and *Community Charter,* municipalities have the power to enact the following types of policies:

- Regional growth strategies
- Official Community Plans
- Policies to prohibit pollution

- Soil deposit and removal controls (erosion control)
- Zoning
- Environmental policies
- Runoff controls
- Landscaping requirements
- Development permit area policies
- Subdivision servicing requirements

The *Local Government Act* and *Community Charter* also gives municipalities a number of other powers to manage stormwater less directly, through a variety of regulatory tools and policies such as building standards, development cost charges, development works agreements and tree protection bylaws.

4.2.4 Environmental Best Management Practices

In June 2004, MWLAP published a comprehensive guide to environmental practices for land development in British Columbia. The document, "Environmental Best Management Practices for Urban and Rural Land Development," is intended to provide guidance for sustaining environmental values during the land development process throughout the province. In overview, it discusses and provides links to the full range of provincial resource and environmental laws, regulations and guidelines for planning, implementing, reviewing and approving land development in BC. In addition, it also cross references many related federal level laws, regulations and guidelines.

Taking both a community and site level perspective, "Environmental Best Management Practices" describes objectives, requirements and best management practices for development with respect to such topics as:

- Environmentally sensitive areas
- Special wildlife and species at risk
- Aquatic and riparian ecosystems
- Pollution prevention

The section on pollution prevention includes discussions of water quality, spill containment and reporting, liquid waste, pesticides and groundwater, all of which have application to stormwater management.

Special areas of land development – mining, forestry and commercial agriculture in Agricultural Land Reserves – are specifically not covered, although many of the BMP's discussed in the document can also apply in these areas.

4.3 Federal Level

4.3.1 Land Development Guidelines

Fisheries and Oceans Canada (DFO) has recently updated their previous "Land Development Guidelines for the Protection of Aquatic Habitat" (originally issued in 1992 jointly with the BC Ministry of Environment, Lands and Parks, now MWLAP), with a guidelines document entitled "Urban Stormwater Guidelines and Best Management Practices for Protection of Fish and Fish Habitat" (draft, October 2004). Issued within DFO's broader mandate under the Federal *Fisheries Act*, these guidelines emphasize the critical role of source control and runoff reduction on protecting fish and fish habitat. It specifically notes the roles of several mechanisms for reducing the impact of urban runoff:

- Minimizing impervious areas
- Retaining runoff by infiltration (or long-term storage)
- Encouraging evapotranspiration through vegetation

It also notes the importance of minimizing or removing contaminants and pollutants from runoff.

To this end the DFO recommends a hierarchy of three site-based BMPs:

- *Reduce the volume of runoff* – Impervious area runoff from the 6 month 24-hour post-development storm event is not to be discharged; can be accomplished by:
  - Minimizing impervious area
  - Infiltration to ground
  - Evapotranspiration via vegetation, and/or
  - Long-term storage
- *Improve water quality of runoff* – Collect and treat the volume of the 24-hour precipitation equalling 90% of the total rainfall runoff from impervious areas; can be accomplished by:
  - Infiltration to ground, and/or
  - Treatment in constructed wetlands
- *Control runoff from larger storm events* – Restrict runoff from developed areas to match the volume, shape, and peak instantaneous rates of pre-development runoff for the 6-

month, 2-year and 5-year 24-hour recurrence storm events; can be accomplished through detention and controlled release

Though site-based, DFO recognizes that all site-based BMP implementation must be placed in the context of watershed-wide planning in order to maintain and enhance overall watershed health.

4.3.2 Fisheries Act

The *Federal Fisheries Act* provides the basis for Fisheries and Oceans Canada (DFO) to carry out protection of fish and fish habitat. The *Act* itself addresses three primary areas of concern:

- Management and control of fisheries
- Conservation and protection of fish and protection of fish habitat
- Prevention of pollution

The *Act* applies to all fisheries waters throughout Canada, including private property in every province and territory. The *Act* applies both to waters with fish present as well as those that provide food and nutrients to fish-bearing streams. Specifically, Section 34 defines fish habitat as "spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly to carry out their life processes."

The key habitat protection provision of the *Act* (Section 35) states that "[n]o person shall carry on any work or undertaking that results in the harmful alteration, disruption or destruction of fish habitat" without proper authorization. Authorization can be given by the Minister or through regulations under the *Act*.

Clearly, urban development that impacts streams by, for example, altering flow regimes, introducing pollutants to streams or causing significant stream siltation fall could generate concern from the perspective of the *Fisheries Act*. For that reason alone, stormwater management takes on a critical function within local development process. The BMP guidelines described in Section 4.3.1 were developed as part of DFO's mandate under the *Act*.

4.4 Jurisdictional Issues

The Federal and Provincial governments share jurisdiction over activities in harbours and marinas. The Federal government, through the *Federal Fisheries Act*, has the power to prohibit the deposit of deleterious substances to waters frequented by fish, while the Provincial government, through the Provincial *Environmental Management Act*, has jurisdiction over pollution abatement and prevention (but not restricted to pollution having an adverse impact on fish).

The Federal responsibilities for enforcing those provisions of the *Fisheries Act* related to pollution prevention have been delegated to Environment Canada. Environment Canada has two main programs to fulfill its mandate: the Environmental Emergencies Program (to respond to spills of a deleterious substance) and the Environmental Protection and Enforcement Program (to conduct inspections and investigations to ensure compliance). On the provincial level, the Provincial Ministry of Environment develops regulations and guidelines for industrial and municipal operations regarding discharges, hazardous waste, pesticides and other pollutants. The Ministry of Environment also develops pollution-prevention programs.

4.5 Land Use Policy Gaps

To be most effective, stormwater management policies should be implemented at the regional (watershed), neighbourhood, and site planning scales. Land use policies contained within the Official Community Plan and Zoning Bylaw have the most direct impact on stormwater management. The Official Community Plan controls development at the regional and neighbourhood and at times, even watershed levels, while the Zoning Bylaw controls development at the site level.

To support an Integrated Stormwater Management Plan, municipal bylaws, regulations, and policies should include provisions to:

- Limit sprawl
- Protect natural areas
- Reduce and/or disconnect impervious area
- Protect environmentally sensitive areas

This section reviews the City's OCP and Zoning Bylaw to identify land use policy gaps relevant to stormwater management within the Campbell River/Quinsam River study area.

4.5.1 Official Community Plan

In general, the City's OCP policies reflect integrated stormwater management principles. Most importantly, the City has imposed an Urban Residential Containment Boundary (URCB) to limit sprawl and concentrate residential development in areas that are in close proximity to public services. While the URCB supports integrated stormwater management city-wide, because the Campbell River/Quinsam River study area falls entirely within the boundary, the Study Area will not derive any of the environmental benefits of being outside it.

The OCP also includes provisions to protect Environmentally Sensitive Areas by requiring Development Permits in specified Environmental Development Permit Areas, which encompasses watersheds, watercourses and their associated aquatic habitats. These provisions help ensure that inappropriate development does not encroach upon sensitive environmental areas, thereby supporting and promoting integrated stormwater management principles. Furthermore, the OCP protects natural areas by supporting residential infill, and encouraging cluster development near Environmentally Sensitive Areas.

While the OCP is, in general, supportive of integrated stormwater management practices, the document fails to include measurable targets for preserving open space or limiting impervious area. The introduction of well defined measures (e.g. percentage of impervious area targets) could promote better stormwater management practices within the Campbell River/Quinsam River study area. The OCP could also include more detailed landscaping guidelines (as Development Permit Area guidelines) that would more specifically support stormwater management principles. For example, a guideline could be included to require the preservation of natural vegetation within commercial, industrial, and residential Development Permit Areas.

4.5.2 Zoning Bylaw

Like the OCP, in general, the City's Zoning Bylaw supports integrated stormwater management principles. The Zoning Bylaw helps limit impervious area by setting maximums for lot coverage and, in some zones, requiring a minimum amount of open space (which must be pervious). In terms of parking requirements, the City requires only one off-street parking space for single-family residences, which is a relatively low requirement and should help minimize impervious area. In addition, the Zoning Bylaw protects ESAs by prohibiting development within any streamside protection or enhancement area.

While the Zoning Bylaw includes several provisions that support integrated stormwater management, the City may consider improving its Zoning Bylaw by imposing more specific requirements to limit impervious area and protect open space. For example, the City could set maximums as well as minimum parking standards to limit the amount of impervious area, or require the use of pervious materials for off-street parking. The Zoning Bylaw could also extend impervious area limitations to all zones by including impervious areas in the calculation of lot coverage.[4] For example, the Rural One Zone could include a maximum impervious area provision (currently this zone does not include such a requirement). Notably, the residential infill zones include a requirement for a minimum amount of open space, which cannot be impervious. The Zoning Bylaw could also specify density averaging options within select zones to promote cluster development.

Table 4.1 provides a summary of the City's OCP and Zoning Bylaw and identified gaps related to stormwater management within the Campbell River/Quinsam River study area.

4.5.3 Strata Developments

The new bareland strata subdivision in the Kingfisher area just north of the golf course raises an interesting issue for the City regarding the applicability of its Subdivision Bylaw. Section 938 (3) of the *Local Government Act* specifically excludes strata development from the requirements in the Subdivision Bylaw. Consequently, it may be difficult to require the installation of specific stormwater management facilities within strata developments. In certain instances, the City may be able to obtain an agreement with the developer to abide by the Subdivision Bylaw. It may also be possible for the City to set performance standards related to the connection of private systems to the public system. It is recommended that the City consult its solicitor to confirm the legality of such requirements.

4.5.4 Other Bylaws

As permitted by the *Community Charter*, municipalities have the power to adopt a bylaw to regulate, prohibit and impose requirements in relation to trees. While these powers are subject to certain limitations, a tree protection bylaw can be an effective component of an integrated stormwater management plan. Protecting trees can prevent increases in stormwater flow, flooding, and erosion due to development. In general, a tree protection bylaw specifies

4 In the District's Zoning Bylaw, "lot coverage" is defined as the area of a lot covered by buildings and structures, dirveways and parking areas, expressed as a percentage. However, most zones include a provision that reads: " The maximum lot coverage of all buildings is x%". Where "buildings" is defined as any structure intended to support any use including the shelter of people, animals, or property. Given the definitions of "lot coverage" and "building", it appears that the provision regulating lot coverage within each zone contains a redundancy, or the term "lot coverage" is not strictly interpreted as per its definition in the Zoning Bylaw. Notably, the District does have zones that explicitly regulate the lot coverage of buildings as well as impervious surfaces.

circumstances in which trees may not be removed, and typically sets out requirements for obtaining a tree cutting permit. The City may consider adopting a tree protection bylaw to support their integrated stormwater management plan. Examples of tree protection bylaws are:

- the City of Nanaimo's Tree Protection Bylaw, No. 4695, which can be found at: http://www.nanaimo.ca/uploadedfiles/Bylaws/4695.pdf

- the City of Kelowna's Tree Protection Bylaw, No. 8041, which can be found at: http://www.kelowna.ca/CityPage/Docs/PDFs%5CBylaws%5CTree%20Protection%20Bylaw%20No%2E%208041.pdf

Municipalities also have the power to make regulations in relation to the protection of the natural environment. To promote water quality, the City may consider adopting a bylaw that limits the private and public use of pesticides for "cosmetic purposes." According to the Coalition for a Healthy Ottawa, 124 municipalities across Canada currently regulate the use of pesticides on private property. Examples of bylaws that prohibit the use of certain types of pesticides are:

- The City of Port Moody's Pesticide Use Control Bylaw No. 2575, which can be found at: http://www.cityofportmoody.com/NR/rdonlyres/9802B0F9-7420-424F-A0F1-837BD12D2C5B/46882/PesticideUseControlBylaw.pdf

- The District West Vancouver's Pesticide Use Control Bylaw No. 4377, which can be found at: http://www.westvancouver.ca/article.asp?a=3831&c=692

In addition to a bylaw controlling pesticides, the City may also consider adopting regulations to prevent pollutants generated by commercial or industrial activities from entering the stormwater system. For example, the City of Victoria recently adopted Codes of Practice under their Stormwater Bylaw to regulate pollutants generated by certain specific commercial activities such as construction and development, automotive and parking lot operations, recreation facilities, and outdoor storage yard and recycling operations. The Codes of Practice regulate what is permitted to enter the system and the type of controls and monitoring that is required at each location.

The City may also consider adopting an erosion and sediment control bylaw to further protect its watercourses. These bylaws typically contain sediment and erosion control guidelines (for use during construction), set specific criteria for excessive solids discharge, and impose fines of up to $10,000 for offences. Examples of such bylaws are:

- The District of West Vancouver's Watercourse Protection Bylaw No. 4364, which can be found at: http://www.westvancouver.ca/article.asp?a=4051&c=692

- The City of North Vancouver's Stream and Drainage System Protection Bylaw No. 7541, which can be found at: http://www.cnv.org/bylaws/bylaws/7541.doc

- The Township of Langley's Erosion and Sediment Control Bylaw, No. 4381 (not available online)

Table 4.1
Study Area Watershed – Gaps in Land Use / Development Policies

Bylaw	Purpose	Provisions Supportive of Stormwater Management (applied within the Campbell River/Quinsam River Study Area)	Identified Policy Gaps (recommended improvements)
Official Community Plan	To direct future development in the watershed.	• Designation of residential densities discourages intense residential development in forested areas • Designation of Development Permit Areas for streamside areas protects ESAs – development permits require setbacks, planting of vegetation, registration of restrictive covenants, provision of works to protect ESAs, and requirement that discharge of stormwater not negatively impact adjacent water quality • Residential land use designation supports cluster development • The residential land use designation permits some medium density development and infill development	• OCP does not include measurable targets for preserving open space or limiting impervious area • Landscaping specifications (as Development Permit Area guidelines) could more specifically support stormwater management principles. For example, a guideline could be included to require the preservation of natural vegetation within commercial, industrial, and residential Development Permit Areas
Zoning Bylaw	To regulate the current use of land, at the site level, within the watershed.	• Most zones set maximums for lot coverage of all buildings • Some zones include minimum requirements for usable open space • Parking requirements – one off-site space for each single-family residence (low requirement decreases impervious area) • Development within any streamside protection and enhancement area requires compliance with BC Riparian Areas Regulation.	• No maximums on parking requirements • Impervious area measures should extend to all zones (e.g., lot coverage should include impervious area) • Landscaping specifications could be more specific to support stormwater management principles • Not all zones directly encourage cluster development
Tree Protection Bylaw	To retain trees	n/a (no such bylaw currently adopted)	• A bylaw to protect trees should be adopted.
Pesticide Use Control Bylaw	To control the use of pesticides	n/a (no such bylaw currently adopted)	• A bylaw to control pesticide use on public and private property should be adopted.
Codes of Practice to Regulate Pollution	To prevent pollutants from entering the drainage system from specific land use activities	n/a (no such bylaw currently adopted)	• Codes of practice to regulate pollution should consider developing guidelines.
Erosion and Sediment Control Bylaw	To prevent the discharge of solids into the drainage system	n/a (no such bylaw currently adopted)	• A bylaw to control erosion and sediment should be adopted.

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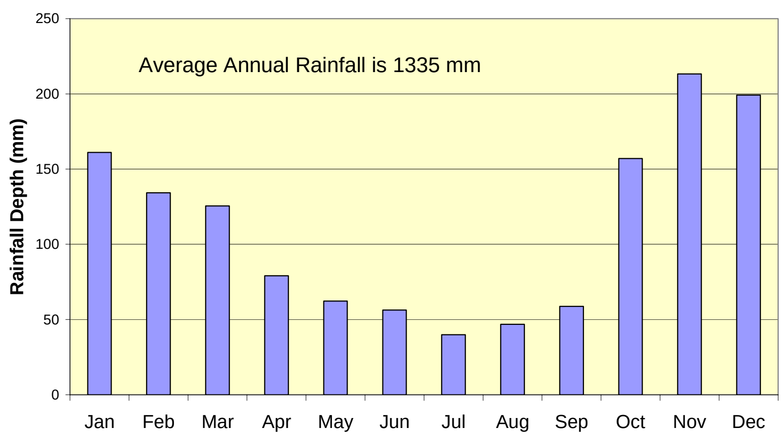
5.0 HYDROLOGIC / HYDRAULIC MODELING AND ANALYSIS

5.1 Rainfall Analysis

Precipitation in Campbell River is typical of Vancouver Island and the Lower Mainland, with most falling in the form of rain. The average annual rainfall is 1335 mm per year, with snowfall averaging only about 110 mm/year. The monthly distribution of this rainfall over the course of a year is shown below in Figure 5.1. From 36 years of record at the Campbell River Airport (1965 through 2000), the Mean Annual Rainfall (MAR) storm event is 55 mm per day. Rainfall events tend to be of long duration but relatively low intensity. Over the period of record, about 95% of all rainfall events in the City yielded total rain amounts of less than half the MAR, or 27.5 mm, while only 0.4% exceeded the MAR (See Figures 5.2 and 5.3). This is not unusual for areas within coastal British Columbia.

Figure 5.1
Typical Annual Rainfall Pattern – Campbell River



The rainfall record is of insufficient length to firmly estimate the most extreme storm event conditions, such as the 100-year recurrence storm[5]. However, based on the records at the airport, Table 5.1 shows the estimated peak 1-hour, 12-hour and 24-hour rainfall depths for various recurrences.

5 The 100-year recurrence event is a storm anticipated to occur on average once in 100 years or, put another way, it is a storm with a 1% chance of occurring in any year. Similarly the 2-, 5- 10- and 25-year recurrence events have 50%, 20%, 10% and 4% chances, respectively, of occurring in any year.

Figure 5.2
Typical Annual Volume Distribution of Rainfall

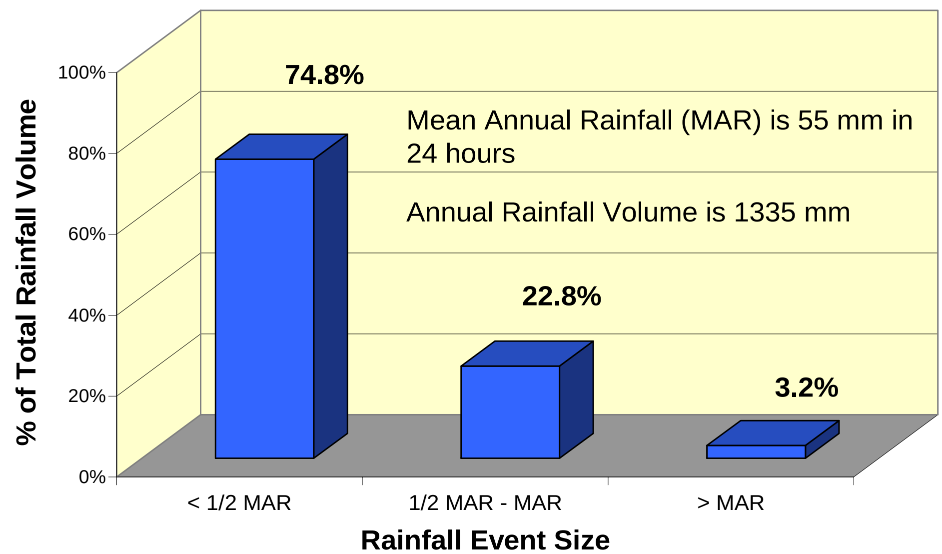


Figure 5.3
Typical Annual Frequency Distribution of Rainfall

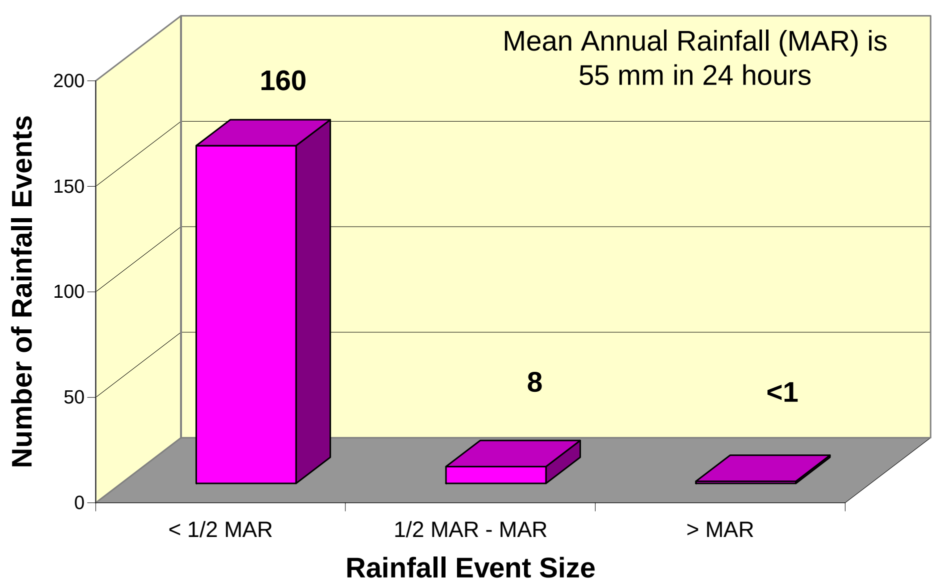


Table 5.1
Design Storm Rainfall Depths for Campbell River Airport

Recurrence (Year)	1-Hour Rainfall Depth (mm)	12-Hour Rainfall Depth (mm)	24-Hour Rainfall Depth (mm)
2	11.5	41.5	59.3
5	15.0	49.7	69.4
10	17.2	54.8	75.6
25	20.1	61.5	84.0
50	22.3	66.6	90.3
100	24.4	71.4	96.3

5.2 Model Development

As in previous ISMP Studies, the hydrologic and hydraulic modeling for this study was done using the XPSWMM software package[6]. This package is able to model the multiple outfalls and backwater conditions present in the Campbell River/Quinsam River study area. It can be calibrated to available pipe and stream flow data (flowrate and depths) and used to simulate both "event storm" and "extended period simulation" conditions. At this time, event storm simulations were performed on most of the Study Area. While extended period simulation modelling is within the capabilities of the software package, the lack of continuous synoptic rainfall and flow data limits the value of such simulations.

Base hydrologic parameters such as sub-catchment area, impervious levels, widths, and slopes were calculated using the following information provided by the City:

- Contour and supplementary elevation information
- TRIM Mapping
- 2002 aerial photography

Impervious levels were calculated for representative "blocks" of each land use which were then extrapolated to cover the entire study area.

Infiltration parameters were based on either a well drained clay loam or poorly drained silty clay soil type. The locations of both types of soils in the watershed were based on the hydrogeological results from this IMSP study. A nearly saturated soil state was entered as the initial condition in the model to simulate winter conditions. The groundwater module in XPSWMM

6 XPSWMM" is XP Software's version of the U.S. Environmental Protection Agency's "Stormwater Management Model," a well documented and commonly used (in North America) hydrologic and hydraulic model

was not used in the simulation, as there are several parameters in the groundwater module which require extensive monitoring and testing to ascertain.

The following Municipal drainage infrastructure information was provided by the City:

- Sizes, slopes, lengths, invert elevations, material types and locations for most existing storm sewers
- Locations and some invert elevations of manholes
- Locations of culverts
- Locations of roadside ditches
- Locations of watercourses and tributaries

The following information was missing from data provided by the City:

- As-built information for some storm sewers (size, inverts, grade)
- Manhole rim elevations
- Inverts of all culverts, and some sizes
- Geometric data for all open channel watercourses.

A skeletonized, or simplified model was developed for the Campbell River/Quinsam River catchments. This process simplifies the system by eliminating smaller pipes but does not compromise the quality of the overall results. The main criteria used when skeltonizing the model are summarized below:

- storm sewers 300 mm ø and smaller were not modelled
- where there are limited runs of conveyance (pipe, ditch) or only a single catch basin to one outfall, they were not modelled
- where a culvert serviced a relatively small portion of highway runoff, it was not modelled

As a result of this skeltonization process, 8 outfalls have been included in the model. A model schematic can be found in Appendix D.

The river bank areas draining directly into the Quinsam and Campbell Rivers were not modeled at this time.

5.3 Model Assumptions

A number of assumptions were made in the development of the XPSWMM model, including the following key assumptions:

- Manhole rim elevations were either measured directly, estimated from contour data, field survey, or were assumed to be 1.5 metres above the storm sewer invert at the manhole junction
- In the absence of other data, Highway 19A cross culverts were assumed to be at 1% grade with outfall inverts at 0.0 m geodetic
- In the absence of other data, Highway 19A cross culvert sizes were estimated on the capacity of the immediate upstream pipe size
- Manning's roughness factors for pipes were widely using literature values of:
    - 0.014 – concrete
    - 0.011 – PVC
    - 0.024 – CSP
- Sub-catchment boundaries were based on available contour information, the configuration of the storm sewer network, and lot boundaries
- While there are commercial and industrial land uses dotting the shoreline, the detail required to model these single lot uses was not available nor was it believed essential to an evaluation of the entire system as a whole.

5.4 Sensitivity Analysis

The sensitivity analysis is a tool used to understand the reliability of the model output and to identify those parameters most critical to the modeling process. The former is especially important since at this time we are not building calibrated models and are only using "event storm" simulations, not "continuous" modeling.

For the sensitivity analysis, both hydrologic and hydraulic parameters were varied by plus and minus 20%. Each parameter was varied in isolation (i.e. all of the other parameters were kept constant) so that the true sensitivity to each individual parameter could be determined. The hydrologic parameters were run under a "winter" regime, assuming that the soils were essentially saturated under winter conditions.

The base conditions values, where applicable, for some of the hydrologic and hydraulic parameters are summarized in Table 5.2. The sensitivity analysis for hydrologic parameters is shown in Table 5.3 for winter conditions. Tables 5.4 and 5.5 summarize the sensitivity analysis for hydraulic parameters for residential areas and for the downtown business district, respectively.

Table 5.2
Base Condition Values of Hydrologic / Hydraulic Parameters

Hydrologic Parameter	Base Value	Hydraulic Parameter	Base Value
Impervious Depression Storage (mm)	0.5	Pipe Roughness Coefficient (Concrete)	0.014
Pervious Depression Storage (mm)	2.0	Pipe Roughness Coefficient (PVC)	0.011
Impervious Manning's "n"	0.011	Pipe Roughness Coefficient (CMP)	0.024
Pervious Manning's "n"	0.2	Open Channel Roughness Coefficient	0.045
Average Capillary Suction (mm)	200	Contraction / Expansion Loss Coefficient	0.2
Initial Moisture Deficit (m/m)	0.050	Entrance / Exit Loss Coefficient	0.5 / 1.0
Saturated Hydraulic Conductivity (Cassidy Soils) (mm/hr)	6.0	Boundary Water Surface Condition at Discovery Passage (m)	1.4
Saturated Hydraulic Conductivity (Dashwood Soils) (mm/hr)	250	-	-
Saturated Hydraulic Conductivity (Fairbridge Soils) (mm/hr)	3.0	-	-
Saturated Hydraulic Conductivity (Tolmie Soils) (mm/hr)	1.0	-	-

Table 5.3
Sensitivity Analysis on Hydrologic Parameters (Winter Condition)

Parameter	Total Flow		Peak Flow		Degree of Sensitivity
	+20%	-20%	+20%	-20%	
Total Area (ha)	21.0%	-20.7%	22.3%	-21.9%	High
Impervious Area (%)	18.8%	-18.9%	17.0%	-17.4%	High
Catchment Width (m)	0.8%	-0.9%	1.9%	-2.3%	Low
Catchment Slope (m/m)	0.4%	-0.5%	1.0%	-1.2%	Low
Impervious Depression Storage (mm)	-0.7%	0.7%	0.0%	0.0%	Low
Pervious Depression Storage (mm)	-2.5%	3.4%	-3.9%	4.3%	Medium
Impervious Manning's "n"	-0.1%	0.1%	-0.7%	0.7%	Low
Pervious Manning's "n"	-0.6%	0.9%	-1.2%	1.6%	Low
Average Capillary Suction (mm)	-3.3%	5.6%	-5.7%	8.0%	Medium
Initial Moisture Deficit (m/m)	-4.4%	11.3%	-8.2%	15.1%	Medium
Saturated Hydraulic Conductivity (mm/hr)	-3.3%	5.6%	-5.7%	8.0%	Medium

Table 5.4
Sensitivity Analysis on Hydraulic Parameters for Residential Area

Parameter	Change to Peak Flow		Degree of Sensitivity
	+20%	-20%	
Pipe Roughness Coefficient	-4.8%	+2.8%	Medium
Contraction / Expansion Loss Coefficient	0.0%	+0.7%	Low
Entrance / Exit Loss Coefficient	0.0%	+0.7%	Low
Boundary Water Surface Condition (m)	+0.3%	+0.4%	Low

Table 5.5
Sensitivity Analysis on Hydraulic Parameters for Business District

Parameter	Change to Peak Flow		Degree of Sensitivity
	+20%	-20%	
Pipe Roughness Coefficient	-13.28%	+17.6%	High
Contraction / Expansion Loss Coefficient	-0.2%	+0.4%	Low
Entrance / Exit Loss Coefficient	-1.4%	+1.4%	Medium
Boundary Water Surface Condition (m)	-14.8%	+15.6%	High

A winter condition analysis is generally useful for sizing drainage infrastructure because the most intense storms in the area occur in the winter. A summer analysis was not run because there are no streams in the study area, only storm sewer systems. Further monitoring and analysis on hydrologic parameters that exhibit a medium or high degree of sensitivity should be undertaken in the future as they could have an appreciable impact on the overall model results.

The hydraulic sensitivity analysis was run in two different areas. One area represented a typical large residential catchment and the second represented the business district of the Downtown Catchment. The results from this analysis show that the residential area is insensitive to hydraulic parameters, while the Downtown area is comparatively more sensitive. The downtown area, as will be discussed in a following section, is subject to complex backwater and tidal conditions and therefore requires a higher degree of detail in study. Unfortunately, this area of the Downtown Catchment was also the area with the least available information on the existing storm drain system.

5.5 Existing Conditions Hydrology

Using the "base condition" hydrologic and hydraulic parameters, the XPSWMM model was run with a variety of storm events. Table 5.6 presents aggregate runoff volumes and peak flows for each catchment area. As a comparison, the same data is listed for Willow, Simms and Nunns Creek. Due to the large number of outfalls, more detailed results of the model runs are presented in Appendix D rather than here.

Table 5.6
Aggregate Peak Flow for Each Catchment Area (Existing Conditions)

Catchment		Discharge Volume		Unit Discharge Volume (m^3/ha)		Flowrate (m^3/s)		Unit Discharge Flowrate (L/s/ha)	
	Size (ha)	2-Year	5-Year	2-Year	5-Year	2-Year	5-Year	2-Year	5-Year
Outfall									
1 (Maple Street)	2.6	900	1,100	346	423	0.027	0.032	10.4	12.3
2 (Petersen Street)	7.3	2,600	3,100	356	425	0.079	0.093	10.8	12.7
3 (19th Avenue)	0.5	200	200	400	400	0.005	0.006	10.0	12.0
4 (Redwood Street)	52.4	14,700	17,700	281	338	0.458	0.554	8.7	10.6
5 (Redwood Street)	2.5	1,000	1,100	400	440	0.028	0.033	11.2	13.2
6 (Spruce Street)	1.3	600	700	462	539	0.016	0.019	12.3	14.6
7 (Enns Road)	33.2	15,700	20,000	473	603	0.617	0.756	18.6	22.8
8 (Willow Street)	0.5	300	300	600	600	0.007	0.008	14.0	16.0
9 (Kingfisher Creek)	318.5	23,100	26,400	73	83	0.512	0.577	1.6	1.8
10 (Detweiler Creek)	47.5	3,600	4,200	76	89	0.107	0.126	2.3	2.7

Note: Duration for all storms is 24 hours.

The hydrologic impacts of urban development are well illustrated in Table 5.6. For example, the high volumetric unit discharges for the storm sewered areas (1-8), as compared to the two relatively undeveloped watersheds, reveal the impact of significant tree cover losses accompanied by significant areas of impervious surface coverage. Similarly, higher unit discharge rates, 4 to 8 times those found in the two undeveloped watersheds, are also seen for the storm sewered catchments. Again, this is a result of high impervious surface coverage in watersheds, which delivers more runoff more quickly (and thus at higher rates) to outfalls.

5.6 Performance of Existing System

After reviewing the results of the existing conditions simulation, storm drain systems were systematically upsized as required to meet City level of service standards. The level of service for the municipal drainage system is currently set by one of two design criteria. The service level for residential areas is the 5-year recurrence rainfall event, while for commercial and industrial areas it is the 10-year recurrence rainfall event.

Tables 5.7 and 5.8 list the pipes and locations that were determined to be undersized (i.e., surcharging). As shown on the tables, in cases where a surcharging pipe was also found to be causing surface flooding, an upgraded pipe size was determined to meet current City design criteria. In some cases, upsizing one pipe merely causes the flooding location to relocate within the storm drain system. Thus, on the tables, downstream pipes are also shown as upsized in some cases.

Table 5.7
Undersized Pipes and Locations – Commercial and Industrial Areas
(10-year Level of Service)

Surcharged Pipe #	Location	Ex. Size	Length	Flooded ?	Upgrade Pipe #	Recc. Size
1691*	Petersen Street and 16 Avenue	450	95.2			
1692*	Petersen Street	610	50.7			
1693*	Petersen Street	610	48.5			
1694*	Petersen Street and Island Highway 19A	610	36.4			
1695*	Petersen Street (Outfall CR2)	610	109.2			
1696	Redwood Street and 14 Avenue	685	86.5	√	1696	900
1697	Redwood Street and 15 Avenue	760	102.0	√	1697	1050
1698*	Redwood Street and 16 Avenue	760	129.7	√	1698	1050
1699*	Redwood Street and Island Highway 19A	915	110.8	√	1699	1200
1700*	Redwood Street and 19 Avenue (Outfall CR4)	850	86.7		1700	1200
1701*	Redwood Street and Island Highway 19A	600	71.1			
1702*	Redwood Street and Island Highway 19A	600	57.9			
1704	Spruce Street and Pease Road	610	82.0			
1705	Spruce Street and 14 Avenue	610	88.6			
1709	14 Avenue and Marwalk Crescent	380	15.9			
1726	16 Avenue and Spruce Street	380	86.6			
1727	16 Avenue and Redwood Street	380	85.7			
1746	14 Avenue and Spruce Street	610	99.9	√	1746	675
1747	14 Avenue and Redwood Street	610	65.4	√	1747	750

Surcharged Pipe #	Location	Ex. Size	Length	Flooded ?	Upgrade Pipe #	Recc. Size
1793	Tamarac Street and Island Highway 19A	610	39.9			
1795	Island Highway 19A and Willow Street	525	80.3			
1796	Island Highway 19A and Willow Street	375	147.5			
5005*	19 Avenue and Petersen Street (Outfall CR3)	300	85.0			
5006*	Redwood Street and 19 Avenue (Outfall CR5)	600	52.3			
5009*	Redwood Street and 17 Avenue	600	78.3			
5010	Spruce Street and Pease Road	450	16.5			
5011	Spruce Street and Pease Road	600	17.3			
5024	Tamarac Street and Island Highway 19A	610	5.6			

* Surcharged due to high tidal conditions

Table 5.8
Undersized Pipes and Locations – Residential Areas
(5-year Level of Service)

Surcharged Pipe #	Location	Ex. Size	Length	Flooded ?	Upgrade Pipe #	Recc. Size
1686*	Maple Street	525	89.4			
1687*	Maple Street (Outfall CR1)	610	101.5			
1767	Fairway Drive	375	86.9			
1768	Fairway Drive	375	89.6			
1772	Cheviot Road	450	118.4			
1773	Cheviot Road	450	54.9			
1774	Easement between Cheviot Road and Bear Place	450	111.8			
1775	Bear Place	525	8.7			
1776	Bear Place	525	56.7			
LINK 236*	Detweiler Road (Outfall CR10)	700	100			

* Surcharged due to high tidal conditions

5.7 Future Development Hydrology

As discussed in the land use section of this report, the Study Area is likely to undergo significant changes of the type and intensity of land use activities that will in turn affect stormwater runoff. Pressure to develop the "Sequoia Springs" area west of the highway in Kingfisher Creek watershed could produce significant residential development in and around what is now wetlands and forest.

The Campbellton Catchment will be affected the least over time since it is largely developed already. However, potential redevelopment from single family residential to commercial or light industrial could change the character of contaminants that may be washed off during storms. This is discussed further in Section 5.9, below.

Table 5.10 shows the overall impact of the anticipated land use changes and growth, assuming that no stormwater controls other than traditional collection and conveyance are applied.

Table 5.9
Aggregate Peak Flow for Each Catchment Area (Future Conditions - Unmanaged)

Catchment		Discharge Volume		Unit Discharge Volume (m^3/ha)		Flowrate (m^3/s)		Unit Discharge Flowrate (L/s/ha)	
	Size (ha)	2-Year	5-Year	2-Year	5-Year	2-Year	5-Year	2-Year	5-Year
Outfall									
1 (Maple Street)	2.6	900	1,100	346	423	0.027	0.032	10.4	12.3
2 (Petersen Street)	7.3	3,100	3,700	425	507	0.093	0.109	12.7	14.9
3 (19th Avenue)	0.5	200	200	400	400	0.005	0.006	10.0	12.0
4 (Redwood Street)	52.4	16,100	19,400	308	371	0.499	0.603	9.5	11.5
5 (Redwood Street)	2.5	1,000	1,100	400	440	0.028	0.033	11.2	13.2
6 (Spruce Street)	1.3	600	700	462	539	0.016	0.019	12.3	14.6
7 (Enns Road)	33.2	20,600	25,900	621	781	0.820	0.997	24.7	30.0
8 (Willow Street)	0.5	300	300	600	600	0.007	0.008	14.0	16.0
9 (Kingfisher Creek)	318.5	33,300	38,000	105	120	0.760	0.867	2.4	2.7
10 (Detweiler Creek)	47.5	8,000	9,500	169	200	0.243	0.285	5.1	6.0

Note: Duration for all storms is 24 hours.

5.8 Impacts of Management Strategies

5.8.1 Municipal Sewer Upgrades under Future Conditions (Unmanaged)

No additional pipes are surcharged in residential areas under future conditions beyond those shown on Table 5.8. Five additional pipes surcharged in commercial / industrial areas under future conditions beyond those shown on Table 5.7; these are shown on Table 5.11 below. No additional pipes changed from surcharged to flooding under future conditions beyond those shown on Table 5.7, however pipes 1699 and 1700 had to be upsized from 1200 (as recommended in Table 5.7) to 1350 to eliminate flooding under future condition scenario.

Table 5.10
Undersized Pipes and Locations – Commercial and Industrial Areas
(10-year Level of Service, Future Unmanaged Conditions)

Surcharged Pipe #	Location	Ex. Size	Length	Flooded ?	Upgrade Pipe #	Recc. Size
1699*	Redwood Street and Island Highway 19A	915	110.8	√	1699	1350
1700*	Redwood Street and 19 Avenue (Outfall CR4)	850	86.7		1700	1350
1718	Tamarac Street and Island Highway 19A	900	46.3			
1793	Tamarac Street and Island Highway 19A	610	40.0			
5024	Tamarac Street and Island Highway 19A	610	5.6			
5030	Island Highway 19A and Enns Road	525	48.6			
5031	Island Highway 19A and Enns Road	600	12.3			

* Surcharged due to high tidal conditions

5.8.2 Detention Facilities

To assess potential stormwater management features that could be used to mitigate the effects of future development, detention storage requirements were estimated for areas in Kingfisher and Detweiler Creeks. Detention targets were set to reduce the 2-year recurrence event to 50% of pre-development conditions and reduce the 5-year recurrence event to the pre-development flow rate. The storage results, shown in Table 5.12, vary from about 120 m3/ha of contributing area to around 330 m3/ha. The major disadvantage of using detention ponds without other stormwater source controls is that only the peak flow, and not the volume of runoff, is reduced.

The result is generally that erosion in downstream receiving channels can still worsen, even though flooding may be controlled. Creek erosion can not only cause property losses but can yield fish habitat losses.

Table 5.11
Target Release Rates and Required Storage Volumes for Proposed Detention Facilities (Future Conditions)

Development	Catchment	Area (ha)	Target Release Rates (m^3/s)		Required Active Storage Volume (m^3)
			50% of 2 Year Flow Rate	5 Year Flow Rate	
Kingfisher Creek					
1	Upper Reach	42.8	0.306	0.491	5,100
2	Middle Reach	6.2	0.008	0.019	1,300
3	Middle Reach	12.4	0.005	0.014	4,000
4	Lower Reach	6.9	0.003	0.008	2,200
5	Lower Reach	5.2	0.002	0.006	1,700
Detweiler Creek					
6	Upper Reach	12.2	0.020	0.033	3,000
7	Lower Reach	7.7	0.020	0.046	1,200

5.8.3 Low Impact Development

As an alternative to the use of conventional detention ponds to reduce post-development peak runoff, the use of low impact development methods was also evaluated. When compared to detention ponds, LID can reduce runoff volumes as well as contribute to reduced peak flows. Table 5.13 shows the results, which assume full application of LID to retain[7] on site all runoff from storms up to and including one half the Mean Annual Rainfall amount (the results can be compared with those listed in Table 5.6). For this assessment, the use of LID was applied only to areas where significant "green field" development could potentially occur; LID can be used whenever new or re-development occurs though the benefits may be greatest in newly developing areas.

7 In this context, "retain" means to capture rainfall on site for infiltration, evaporation and transpiration, rather than being allowed to runoff as surface flow.

Table 5.12
Peak Flows under Future Conditions using an LID Approach

Catchment	Peak Flow (m^3/s)			
	2 Year		5 Year	
	Unmanaged	LID	Unmanaged	LID
7 (Enns Road)	0.820	0.506	0.997	0.743
9 (Kingfisher Creek)	0.760	0.612	0.867	0.773
10 (Detweiler Creek)	0.248	0.208	0.285	0.275

Note: LID approach applied to new development in Kingfisher Creek and Detweiler Creek catchments only; Duration for all storms is 24 hours.

5.9 Land Uses and Runoff Pollutants

In order to assess the potential pollutant loads associated with stormwater runoff and identify potentially significant land uses for runoff contamination in the Campbell River/Quinsam River Area, a preliminary computation was performed using a method developed by the Center for Watershed Protection (CWP) (Center for Watershed Protection, 2003). The method requires minimal input:

- Drainage area
- Impervious cover
- Annual precipitation
- Pollutant concentrations

The first three items were already determined as part of the modeling process. Pollutant concentrations are based on extensive data gathered across the U.S. in the 1980's as part of the "National Urban Runoff Pollution Program", and summarized in the CWP's pollutant load computation method.

The method uses four basic land use categories for which typical pollutant concentrations are presented. For purposes of this analysis, local land use was placed in four broad categories:

- **Category 1 – Open Spaces and Public Uses**
  Category 1 land uses, by definition, generate smaller amounts of runoff pollutants than any other land use category. Land uses included in this category typically have minimal impervious area and relate to activities that generate relatively few pollutants (i.e., pollutant

exposure is relatively low). Land uses in this category include open space, park space, greenways, and rural recreation.

- **Category 2 – Low Density Residential**
  Category 2 includes land uses that generate more runoff pollutants than those in Category 1, but compared to Category 3 and 4, still generate relatively low runoff pollutant loads. This category includes single-family residential and duplex developments, which are both estimated to have lots with roughly 40% impervious area, but are not associated with activities that generate much in the way of point or non-point source pollution. (However, lawn fertilization and household-pesticide use can be a concern.)

- **Category 3 – High Density Residential and Commercial**
  Category 3 includes multiple-family developments – typically ground-oriented townhouses and mid-rise apartments – which generally have higher site coverage both in building footprint and paved area relative to those residential uses in Category 2. This category also includes retail and office development, which are both likely to have substantial land area used for parking, and therefore, a relatively high percentage of impervious area (approximately 90%). While these uses are not typically associated with "hot spot" polluting activities, the substantial impervious area contributes to increases in runoff pollutant loads over Categories 1 and 2.

- **Category 4 – "High Risk" Commercial and Industrial**
  This category includes a range of uses that generally have a greater impact on runoff quantity and quality. In general, these uses cover large portions of their sites with buildings or impermeable surfaces, and are likely to exhibit greater exposure to activities or materials that generate pollutants.

Roads are also included under each of the four categories. While roads are estimated to have relatively high pollutant loads, the scale and scope of this analysis does not permit a detailed investigation of roads as a separate land use; however, the runoff coefficients used in the analysis do account for the existence of roads.

In general, the categories for use in the analysis of existing conditions were developed as per the zones listed in Table 5.14. However, all undeveloped areas were designated as Category 1 regardless of zoning, and certain residential developments were classified according to density rather than zone. Figure 5.5 (Appendix A) shows the distribution of these hydrologically-significant land uses within the Study Area for existing conditions.

Table 5.13
Hydrologically Significant Land Uses – Existing

	Category 1	Category 2	Category 3	Category 4
Zones/ Land Use	• Greenways • All undeveloped land	• Rural Two • Low density residential development	• Residential One • Residential Multiple 1 • Commercial Three • Mobile Home Two • Golf course • Schools	• Industrial One • Industrial Three • Roads

In general, the categories for use in the analysis of future conditions were developed as per the OCP designations listed in Table 5.15. However, residential developments were classified according to anticipated future residential density rather than OCP designation as the Residential OCP designation encompasses a wide range of densities. Figure 5.6 (Appendix A) shows the distribution of these hydrologically-significant land uses within the Study Area for future conditions.

Table 5.14
Hydrologically Significant Land Uses – Future

	Category 1	Category 2	Category 3	Category 4
OCP Designation/ Land Use	• Park/Natural Areas • ALR land	• Low density residential (<30 upha)	• Medium / High density residential (>30 upha) • Commercial • Schools • Golf course	• Industrial • Roads

While the above categories are helpful for understanding the overall relationship between land use and pollutant loads, it should be noted that this analysis is developed using zoning and OCP as a proxies for land use. Of course, the actual land use may vary somewhat from that defined in the Applicable Bylaws.

Using the Center for Watershed Protection's (CWP) suggested typical pollutant concentrations, annual loadings for the following pollutants were estimated:

- Total Suspended Solids (TSS)
- Nitrogen
- Phosphorous
- Zinc
- Copper
- Lead

The results, by catchment, are shown in Tables 5.15 and 5.16, for existing and future conditions respectively.

Quinsam IR #12 contributes runoff, and any pollutants conveyed by the runoff, to Haig Brown's Kingfisher Creek. Development is currently mostly residential with some new commercial and institutional development on about 24 hectares of land just west of the Willis Road and Island Highway intersection. Future growth will primarily be in the same categories, with particular emphasis on additional commercial development to supplement what has already been constructed (Anderson, 2003, and Anderson Civil, 2006). The loading values shown in Tables 5.15 and 5.16 do not include contributions from IR #12. The loads could be expected to be roughly 20-30% higher if the reserve's contributions were included. As with the areas within Campbell River, to the extent that stormwater controls are applied to runoff from IR #12, the impacts of future growth can be minimized.

Stormwater quality is a highly variable subject to a myriad of factors including time since last rainfall, duration and intensity of rainfall, site specific land uses, layout of storm network, presence of water quality structures, etc. As such, without local data, this analysis should be viewed as an order of magnitude estimate of the potential pollutant loading from Campbell River/Quinsam River lands.

While the quantity of pollutant is directly related to the land area in question, such that the predominant land use (residential) is responsible for the greatest quantity of pollutant, the pollutant per unit area (kg/Ha), is greatest in the two highest pollutant load category land uses.

As shown in Table 5.15, low density residential areas (Category 2) contribute the greatest total pollutant loads (in kilograms). This is not surprising given that Category 2 represents over 50% of the land in the Campbell River/Quinsam River catchments. What is equally interesting are the pollutant loading rates (in kilograms per hectare), by category. Again as shown in Table 5.15, in all cases except for phosphorus (P), Category 4 has the greatest loading rates. This suggests that, if runoff water quality treatment is desired in the Campbell River/Quinsam River Area, a cost effective approach will likely focus first on commercial areas with high potential for runoff contamination.

Two sets of pollutants are notably absent from the analysis presented here. First, pesticides and herbicides have not been included, due to the large number of potential contaminants and the general lack of data to support inclusion at this time. In qualitative terms, these pollutants can, however, exhibit loading rates by land use category that are contrary to the others listed in Table 5.15 and 5.16. Areas with large open space and lawns, such as low density residential, golf courses and other public and institutional open spaces, may actually yield very high loadings in runoff. This is due to their often heavy use to maintain thick, green lawn areas.

Bacteriological indicators, specifically fecal coliforms, are also not included in Tables 5.15 and 5.16. Coliform levels in runoff are notoriously variable and can be due to both anthropogenic and "natural" causes. In areas with significant human contact with open water, such as at public beaches, it is important to monitor fecal coliform levels from a public health standpoint. But predicting the actual loading or contaminant level is beyond the preliminary nature of the current analysis.

It is instructive to compare these pollutant loading results with those that occur with municipal wastewater, which the City fully treats at its wastewater treatment facility in North Campbell River. Thus, for example, in the year 2001 the Study Area contributed an estimated 71,500 Kg of Total Suspended Solids (TSS) to the City's sanitary sewer system; this load was reduced by about 95% at the City's wastewater treatment plant so that only 3,220 Kg was discharged to Discovery Passage over the course of the year[8].

8 Based on information provided in "District of Campbell River, Long Term Sewage Treatment Study, Final Report," Stantec, October 26, 2004.

Table 5.15
Runoff Pollutants by Major Land Use Categories (Existing Conditions)

Total Quinsam River/Campbell River - Potential Runoff Pollutant Loading Estimate (Existing)		Pollutant											
		TSS		P		N		Zinc		Lead		Copper	
Land Use	**Area (Ha)**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**
Open and Park Space	201.1	22892	114	92	0.5	504	2.5	57	0.3	60	0.3	17	0.1
Low Density Residential	46.9	23041	491	92	2.0	507	10.8	57	1.2	60	1.3	18	0.4
High Density Residential / Non-Polluting Retail	92.6	65466	707	262	2.8	1440	15.6	162	1.8	171	1.8	50	0.5
Commercial / Industrial	75.2	58120	773	155	2.1	1550	20.6	192	2.6	203	2.7	59	0.8
Total Area	415.8	169520	408	601	1.4	4001	9.6	468	1.1	494	1.2	144	0.3

Breakdown by Watershed

Detweiler Creek Watershed Only		Pollutant											
		TSS		P		N		Zinc		Lead		Copper	
Land Use	**Area (Ha)**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**
Open and Park Space	51.1	5817	114	23	0.5	128	2.5	14	0.3	15	0.3	4	0.1
Low Density Residential	7.0	3439	491	14	2.0	76	10.8	9	1.2	9	1.3	3	0.4
High Density Residential / Non-Polluting Retail	7.2	5090	707	20	2.8	112	15.6	13	1.8	13	1.8	4	0.5
Commercial / Industrial	8.5	6569	773	18	2.1	175	20.6	22	2.6	23	2.7	7	0.8
Total Area	73.8	20916	283	75	1.0	491	6.7	57	0.8	60	0.8	18	0.2

Haig Brown's Kingfisher Creek Watershed Only		Pollutant											
		TSS		P		N		Zinc		Lead		Copper	
Land Use	**Area (Ha)**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**
Open and Park Space	120.2	13683	114	55	0.5	301	2.5	34	0.3	36	0.3	10	0.1
Low Density Residential	30.1	14788	491	59	2.0	325	10.8	37	1.2	39	1.3	11	0.4
High Density Residential / Non-Polluting Retail	29.3	20714	707	83	2.8	456	15.6	51	1.8	54	1.8	16	0.5
Commercial / Industrial	29.0	22413	773	60	2.1	598	20.6	74	2.6	78	2.7	23	0.8
Total Area	208.6	71598	343	257	1.2	1680	8.1	196	0.9	207	1.0	60	0.3

Campbellton Drainage Only		Pollutant											
		TSS		P		N		Zinc		Lead		Copper	
Land Use	**Area (Ha)**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**
Open and Park Space	8.4	956	114	4	0.5	21	2.5	2	0.3	2	0.3	1	0.1
Low Density Residential	1.8	884	491	4	2.0	19	10.8	2	1.2	2	1.3	1	0.4
High Density Residential / Non-Polluting Retail	49.1	34712	707	139	2.8	764	15.6	86	1.8	91	1.8	26	0.5
Commercial / Industrial	33.7	26046	773	69	2.1	695	20.6	86	2.6	91	2.7	26	0.8
Total Area	93.0	62599	673	216	2.3	1499	16.1	177	1.9	186	2.0	54	0.6

River Bank Drainages Only		Pollutant											
		TSS		P		N		Zinc		Lead		Copper	
Land Use	**Area (Ha)**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**
Open and Park Space	21.4	2436	114	10	0.5	54	2.5	6	0.3	6	0.3	2	0.1
Low Density Residential	8.0	3930	491	16	2.0	86	10.8	10	1.2	10	1.3	3	0.4
High Density Residential / Non-Polluting Retail	7.0	4949	707	20	2.8	109	15.6	12	1.8	13	1.8	4	0.5
Commercial / Industrial	4.0	3092	773	8	2.1	82	20.6	10	2.6	11	2.7	3	0.8
Total Area	40.4	14407	357	54	1.3	331	8.2	38	0.9	40	1.0	12	0.3

Table 5.16

Runoff Pollutants by Major Land Use Categories (Future Conditions)

Total Quinsam River/Campbell River - Potential Runoff Pollutant Loading Estimate (Future w/o Controls)		Pollutant											
		TSS		P		N		Zinc		Lead		Copper	
Land Use	**Area (Ha)**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**
Open and Park Space	98.1	11167	114	45	0.5	246	2.5	28	0.3	29	0.3	8	0.1
Low Density Residential	130.6	64162	491	257	2.0	1412	10.8	159	1.2	168	1.3	49	0.4
High Density Residential / Non-Polluting Retail	115.6	81726	707	327	2.8	1798	15.6	203	1.8	214	1.8	62	0.5
Commercial / Industrial	71.5	55261	773	147	2.1	1474	20.6	183	2.6	193	2.7	56	0.8
Total Area	415.8	212316	511	776	1.9	4929	11.9	572	1.4	603	1.5	175	0.4

Breakdown by Watershed

Detweiler Creek Watershed Only		Pollutant											
		TSS		P		N		Zinc		Lead		Copper	
Land Use	**Area (Ha)**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**
Open and Park Space	18.7	2129	114	9	0.5	47	2.5	5	0.3	6	0.3	2	0.1
Low Density Residential	42.3	20781	491	83	2.0	457	10.8	52	1.2	54	1.3	16	0.4
High Density Residential / Non-Polluting Retail	4.4	3111	707	12	2.8	68	15.6	8	1.8	8	1.8	2	0.5
Commercial / Industrial	8.4	6492	773	17	2.1	173	20.6	21	2.6	23	2.7	7	0.8
Total Area	73.8	32513	441	121	1.6	746	10.1	86	1.2	91	1.2	26	0.4

Haig Brown's Kingfisher Creek Watershed Only		Pollutant											
		TSS		P		N		Zinc		Lead		Copper	
Land Use	**Area (Ha)**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**
Open and Park Space	66.9	7616	114	30	0.5	168	2.5	19	0.3	20	0.3	6	0.1
Low Density Residential	62.5	30705	491	123	2.0	676	10.8	76	1.2	80	1.3	23	0.4
High Density Residential / Non-Polluting Retail	52.3	36975	707	148	2.8	813	15.6	92	1.8	97	1.8	28	0.5
Commercial / Industrial	26.9	20790	773	55	2.1	554	20.6	69	2.6	72	2.7	21	0.8
Total Area	208.6	96086	461	357	1.7	2211	10.6	255	1.2	269	1.3	78	0.4

Campbellton Drainage Only		Pollutant											
		TSS		P		N		Zinc		Lead		Copper	
Land Use	**Area (Ha)**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**
Open and Park Space	3.1	353	114	1	0.5	8	2.5	1	0.3	1	0.3	0	0.1
Low Density Residential	6.0	2948	491	12	2.0	65	10.8	7	1.2	8	1.3	2	0.4
High Density Residential / Non-Polluting Retail	52.8	37328	707	149	2.8	821	15.6	93	1.8	98	1.8	28	0.5
Commercial / Industrial	31.1	24036	773	64	2.1	641	20.6	79	2.6	84	2.7	24	0.8
Total Area	93.0	64665	695	227	2.4	1535	16.5	180	1.9	190	2.0	55	0.6

River Bank Drainages Only		Pollutant											
		TSS		P		N		Zinc		Lead		Copper	
Land Use	**Area (Ha)**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**	**Kg**	**Kg/Ha**
Open and Park Space	9.4	1070	114	4	0.5	24	2.5	3	0.3	3	0.3	1	0.1
Low Density Residential	19.8	9727	491	39	2.0	214	10.8	24	1.2	25	1.3	7	0.4
High Density Residential / Non-Polluting Retail	6.1	4313	707	17	2.8	95	15.6	11	1.8	11	1.8	3	0.5
Commercial / Industrial	5.1	3942	773	11	2.1	105	20.6	13	2.6	14	2.7	4	0.8
Total Area	40.4	19052	472	71	1.8	438	10.8	51	1.3	53	1.3	15	0.4

6.0 ISSUES AND CHALLENGES

As a result of the field reconnaissance, review of existing background material, analysis of land use issues and the modeling efforts, a number of issues and challenges to integrated stormwater management in the Campbell River/Quinsam River Area can be named. Some of these are also issues and concerns raised by residents at the open houses and by members of the Working Group.

6.1 Issues from Consultation Process

A significant issue for the Campbell River / Quinsam River Study Area is the lack of public participation in the process. Attendance at the open houses for the City's previous ISMPs to date has been spotty, sometimes generating significant interest and other times very little. The first open house for this current ISMP was attended by only two residents. A challenge for the City as it completes this ISMP and moves into the implementation phase for all the City's ISMPs is to develop a program of public information that adequately prepares people (including developers, designers and contractors) and generates their support for the changes in stormwater management that will be taking place in the City over time.

As might be expected from a largely technical group, the Working Group suggested a number of specific and general issues that could be addressed within the context of the ISMP. Focusing on the four main streams included in the Study Area, the group identified these issues:

- Detweiler Creek
  - Heavily impacted by development already
  - Creek has limited habitat value
  - Limited opportunities for restoration
  - Need for a wildlife corridor
  - Desire for access for enjoyment and recreation
  - Fish-bearing stream, which needs to be protected
- Haig Brown's Kingfisher Creek
  - Heavy development pressure in the upper watershed, including in and around the golf course
  - High erosion potential in some areas
  - Low summer base flows
  - Need for wildlife corridor
  - Desire for access for enjoyment and recreation
  - Fish-bearing stream, which needs to be protected

- Quinsam River
    - Erosion and bank stability
    - Development pressure
    - Fish-bearing stream, which needs to be protected
    - Size of river – much can happen outside the jurisdiction of the City
- Campbell River
    - Erosion and bank stability
    - Property acquisition and protection
    - Fish-bearing stream, which needs to be protected
    - Nutrient-rich runoff
    - Invasive aquatics
    - Development pressure
    - Acts as a wildlife corridor

Some more specific suggestions included:

- Maintain year round flow in Haig Brown Kingfisher Creek
- Maintain +30m minimum of natural vegetation surrounding streams
- Investigate greater use of swales and ditches (including retaining existing ditches in the area) instead of storm sewers
- Require catch basins to keep polluted runoff out of streams (but only if can be sure they don't become mosquito breeding areas)
- Provide oil/water separation before discharge of runoff to streams
- Monitor water quality
- Require use of stormwater infiltration where feasible
- Require use of alternate design standards to reduce effective impervious surface to < 10%.
- Undertake effective impervious surface mapping
- Maintain the natural flow regimes and water quality in the streams
- Restore riparian areas for all streams in the area
- Ban use of pesticides
- Adopt better development controls on private lands
- Develop further improvements to logging practices to protect streams
- Change homeowners/business owner's attitudes towards their contributions to runoff pollution
- Provide improvements to flood-prone areas
- Replace culverts with bridges

The Working Group identified two primary obstacles to implementing a more sustainable stormwater management approach in Campbell River. The first is cost, both initial and long-term operation and maintenance. The second is really a cluster of issues around developing knowledgeable public support for stormwater management that allows people to set aside narrowly focused attitudes and interests in favor of long-term sustainability.

6.2 Primary Issues and Challenges

Through consultation with the City, and accounting for input from the working group and the open houses, the following key issues were carried forward:

a) Maintaining in-stream water quality through runoff treatment
b) Establishing/maintaining year-round baseflows in outfalls and streams
c) Need for stormwater controls in new developments
d) Need to address impacts of redevelopment, especially in Campbellton
e) Determining adequacy of existing drainage systems
f) Protecting and maintaining riparian corridors.
g) Requiring erosion and sediment controls during construction
h) Enhancing public education and outreach
i) Identifying tools for predicting and mitigating impacts of future development on runoff and for monitoring the progress of stormwater management in the Study Area
j) Adopting a sustainable means for funding stormwater management

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7.0 SUSTAINABLE STORMWATER CONTROLS

Communities and regions around North America have increasingly applied stormwater "best management practices" (BMP's) to mitigate the effects of land development on watersheds. Initially this was primarily done to reduce stormwater runoff peak rates, generally to a level occurring prior to development. More recently, broader objectives have been assigned to BMP's. Specifically, the current ideal is to fully mimic the natural hydrology of an area and protect water quality as well. Thus BMP's may serve to reduce the peak rate of stormwater runoff, reduce the total volume of stormwater runoff, improve the water quality of the stormwater runoff or, typically, meet more than one of these objectives.

The realization among stormwater practitioners that it is important to control runoff at its source as well as deal with consequences of runoff has led to the development of a philosophy called Low Impact Development (LID). Although sometimes used nearly interchangeably, LID and BMP are not quite the same thing. They can, however, be complementary ways to address stormwater management. Some BMP's fit well within an LID approach and use of LID can reduce the size or need for large, often public, BMP's such as regional detention ponds. For purposes of this discussion, LID methods are included within the list of BMP's discussed below.

In this chapter an overview of BMP's is provided, followed by discussion of significant issues for BMP use in the Campbell River/Quinsam River Area.

7.1 Best Management Practices

A large body of best management practices has been developed over the last several decades, covering a variety of application scales and complexities. Various schema have been proposed to provide categories for the various BMP's. For the purposes of this ISMP, BMP's can generally be grouped into four broad categories:

- Site adaptive planning
- Source controls
- Structural controls
- Non-structural practices

Site adaptive planning includes a variety of site design practices that can be used to reduce the impervious surface coverage on a wide range of land uses. These practices include reducing roadway widths, reducing building footprints, reducing parking standards (number of parking spaces provided per dwelling unit), limiting amount of surface parking, building compact communities and preserving natural features such as wetlands, forests and soils.

Source controls are those practices intended to reduce runoff volume by retaining or enhancing infiltration and evapotranspiration; these practices supplement the site adaptive planning BMP's that directly reduce impervious surfaces in a watershed. These source controls are typically applied to an individual building site, such as a single house, apartment complex or shopping mall. Examples of source controls include absorbent landscaping (amended soils), surface ("rain gardens") and subsurface (such as soak-away pits) infiltration facilities, pervious paving (pavers, concrete and asphalt), pervious decks, green roofs ("eco-roofs"), rain barrels and disconnected roof leaders. Detailed discussions of these source controls is presented in a recent GVRD publication entitled, "Stormwater Source Control Design Guidelines 2005."

Structural controls are probably the most well-known type of stormwater treatment practices. About 40 years ago, a number of communities began constructing detention ponds to attenuate the affects of peak runoff from developments. Other structural BMP's include underground oil and grease traps, constructed wetlands and sand filters. A properly designed and constructed roadside ditch, called a vegetated or bio-filter swale, is another structural BMP[9]. The City's oil/water separators in the Campbellton Catchment and the water quality pond along the Island Highway are examples of structural controls.

Finally, *non-structural practices* focus both on maintaining the long-term usefulness of structural BMP's and source controls, as well as reducing the likelihood of stormwater causing problems in the first place. In this category are street cleaning, detection and containment of contaminant spills, maintenance of vegetation in rain gardens and bio-swales, catch basin cleaning, public education programs and best practices for handling potential pollutant-generating materials. This latter example of a non-structural BMP is particularly critical at hot spots where commercial or industrial activities may expose harmful materials to rainfall for potential pickup in runoff.

BMP's can also be considered either *temporary* or *permanent*. Temporary BMP's are used during construction to control the acute conditions that occur when vegetative cover is removed and large areas of soil are directly exposed to rainfall. These BMP's generally focus on controlling soil erosion at the site and preventing subsequent downstream deposition of the sediments. Permanent BMP's are intended to remain in working condition for extended periods of time (i.e., years). They can fulfill multiple functions including reducing the rate and volume of runoff as well as improving the quality of the runoff.

7.2 Application for the Campbell River / Quinsam River Area

The City's current engineering design standards indicate a preference for the use of neighbourhood or regional wet detention ponds, designed in accordance with stormwater

9 In an example of the fluidity of the BMP categories, bio-filter swales could also be considered a source control since they are primarily intended to reduce the total volume of runoff from a site, in this case a roadway.

management plans. Where such facilities (existing or proposed) are unavailable, dry detention ponds, pipe-based detention or parking area and roof-top detention may be used. As an alternative to, or in conjunction with, these traditional types of facilities, various other BMP's could be used. Table 7.1 provides a lengthy list of potential BMP's for use in Campbell River. The paragraphs that follow provide discussion of several aspects of BMP implementation unique or especially applicable to the Study Area.

7.2.1 Alternative Road Design Standards

The City's current practice for roadway urbanization is to infill the existing roadside ditches and install a storm sewer system. Runoff generated on the road surface is directed to the curb and gutter, where it then flows into a catch basin which is connected to the new storm sewer. The underlying intent of a "traditional" urbanized roadway design is to convey runoff away from the road as soon as possible. This efficient method of drainage capture and conveyance has a detrimental impact on downstream watercourses, as both peak flows and volumes of runoff are significantly increased over the un-urbanized condition, where runoff had an opportunity to infiltrate or be attenuated in the roadside ditches. Stormwater quality also suffers as plants and soil no longer have an opportunity to filter out contaminants prior to discharge of runoff offsite.

Most of the roads in the Campbellton Catchment have already been constructed with standard urbanized cross section. However, there are opportunities to convert existing urbanized roads to a road using alternative standards and to incorporate an alternative road design in future developments. In general, it is preferable to use ditches than to use storm drains to convey roadway runoff. And, further, it is preferable to use properly designed swales than to use simple ditches to convey roadway runoff. The former (swales, also called infiltration swales, bio-swales, dry or wet swales, etc.) provide opportunities for runoff attenuation and treatment that are not provided by standard ditches and enclosed pipes.

Table 7.1
Potential Stormwater Issues and BMP Options for Various Land Uses

Best Management Practice	Scale				Primary Issue(s) Addressed			
	Site Level	Neighbour-hood Level	Watershed Level	Regional Level	Volume Control	WQ Control	Peak Control	Erosion Control
Adaptive Site Planning								
Disconnect Impervious Areas	X	X			X			
Narrow Pavement Street		X			X		X	
Maintain Riparian Corridors			X	X		X		X
Preserve Natural Drainage Features	X	X	X		X	X	X	X
Protect/ Retain Wetlands		X	X		X	X	X	
Retain Trees at Building Sites	X				X		X	
Source Controls								
Biofiltration Swale (Bioswale)		X			X	X		
Downspout Splashpads	X				X			
Amended Soils (w/min. depth)	X				X	X		
Grass Swale		X			X	X		
Green Roof	X				X	X	X	
Infiltration Trench	X	X			X	X		
Infiltration Basin	X	X			X	X		
Planter Boxes	X				X			
Porous Pavement	X	X			X			
Rain Barrel	X				X			
Rain Garden	X				X	X		
Rock / Soakaway Pit	X				X	X		
Underground Infiltration System	X	X			X	X		
Structural Controls								
Bioengineering Techniques	X							X
Biofiltration Swale (Bioswale)		X			X	X		
Constructed Wetlands		X	X		X	X		
Dry Detention Pond		X	X			X	X	
Green Street		X			X	X		
Infiltration Trench	X	X			X	X		
Infiltration Basin	X	X			X	X		
Oil / Grit Separator	X					X		
Perforated Storm Sewer		X			X		X	
Rip Rap	X							X
Sand Filters	X				X			
Turf Reinforcement Mats	X							X
Underground Infiltration System	X				X			
Underground Tank / Vault	X						X	
Vegetative Filters		X	X			X	X	
Non-Structural Practices								
Early Revegetation of Cleared Sites	X							X
Minimize Soil Compaction	X				X			X
Public Education Programs			X	X	X	X	X	X
Street Sweeping			X	X		X		

7.2.2 Roof Leader Disconnection

The soils mapping provided by the hydrogeological report indicates that infiltration of stormwater runoff may be possible in some parts of the Campbell River/Quinsam River Area. However the specific applicability must be established on a localized or site level. Modeling efforts in previous ISMP's indicated that a peak flow reduction on the order of 33% is possible within catchments where all or most of the properties can disconnect roof leaders. Moreover, this practice would provide a modest level of preliminary treatment of runoff. For example, roof downspouts from individual homes would be discharged onto splash pads and grassed areas rather than be connected directly to the municipal storm sewer system, which is the City's current standard.

Table 7.2 provides the results of modeling done for a 70 ha future development in the southern part of the City.[10] Similar results can be expected for any development in Campbell River, if properly designed and maintained. The table shows the impact of both disconnecting roof leaders and placing 300 mm of amended soils in yards before they are seeded or sodded (see Section 7.2.3 for discussion).

Table 7.2
Stormwater Management Alternatives for Future Ocean Grove Development

	Existing Conditions	Unmanaged Future Conditions	Roof Leader Disconnected	Amended Soils	Roof Leader Disconnection and Amended Soils
	Flow (m^3/s)	Flow (m^3/s)	Flow (m^3/s)	Flow (m^3/s)	Flow (m^3/s)
2-year	0.40	0.82	0.63	0.76	0.49
5-year	0.64	1.1	0.91	0.92	0.56

7.2.3 Absorbent Landscaping

Absorbent landscaping may offer some of the most cost effective BMP's for use in both retrofit and new development applications. In urbanizing areas, it is common practice to strip a site of all topsoils and replace them with only a thin layer (often 50 mm or less) of imported topsoil. During the time between the stripping and the replacement, the underlying soils are often severely compacted by building activities. This process yields lawns that are nearly as impervious as some asphalt surfaces.

This situation can be easily mitigated by careful construction practices that avoid soils compaction (or mitigate what does occur) and by providing 300 mm or more of landscaped absorbent (or

10 Computations were done for the Foreshore Area ISMP (2005)

"amended") soils[11]. This thick layer of amended soil, especially when coupled with on-site tree retention (or replacement), can virtually eliminate runoff from lawns, even for very wet winter conditions with low hydraulic conductivities for underlying soils. Another significant benefit of deeper organic soils on lots is healthier stands of grass with deeper roots that are more resilient to drought conditions.

Enhancing lawns with additional absorbent soils and fuller tree canopies can do the same thing for lawns in existing developments. Requiring this is difficult, but encouraging residents to upgrade their lots could be done.

As discussed previously, Table 7.2 shows one potential beneficial impact of the use of amended soils in developments.

7.2.4 Infiltration / Recharge Potential

Design Concepts and Justification

In many parts of the study area, ground infiltration systems could be incorporated into landscaping and engineering plans, to direct water towards points where ground infiltration is feasible. Areas with the highest potential for infiltration were shown previously on Figure 3.6.

Systems that collect stormwater runoff for infiltration need to include landscaping to channel water to the infiltration system, adequate storage to allow slow infiltration after the rainfall event, and a clarification system to eliminate suspended sediments and floating detritus. A regular (annual or 10-year) clean out of some structures should be anticipated.

It is better to have a wide distribution of infiltration systems introducing the water into different areas and strata, rather than a few concentrated areas discharging into one strata. This will reduce the potential for water table mounding, and in some areas, the potential for slope instability.

It is important to appreciate that all ground infiltration systems will not be effective for very long if suspended solids and bacteria are not adequately removed from surface runoff, prior to discharge into the ground. This can be accomplished with properly designed, constructed and maintained vegetated swales or other similar BMP's.

Shallow Infiltration Systems

Shallow infiltration systems could be designed to infiltrate runoff into many areas within the well drained units, such as the Dashwood and Qualicum soils. These soils cover extensive areas in

11 To optimize infiltration, the absorbent soils should have high (10 to 25%) organic content and otherwise meet the requirements of BC Landscape Standard for medium or better landscape soil.

the catchments and have potential infiltration rates of 250 mm/hr and 10 mm/hr respectively. Examples of shallow infiltration enhancement systems include: soak-a-way pits, seepage basins, shallow infiltration wells and seepage trenches.

The hydraulic conductivity of the subsurface soils in the study area is likely quite variable, due to the presence of localized permeable sand and/or gravel seams, or interbeds, in the middle of relatively low permeability loamy soils. For this reason performing infiltration tests in linear trenches in representative areas will be required, prior to development of more detailed plans for stormwater infiltration. For example, infiltration tests performed in soils similar to Dashwood indicated infiltration rates to a 0.6m wide trench in the range from about 2 to 4 L/s/m length of trench.

Vertical Infiltration Wells

Clean stormwater that cannot infiltrate into shallow soils in the upland areas could be discharged into the Quadra Sand Unit below the low permeability till-like unit. The concept for this method is illustrated in Figures 4 and 5 of the hydrogeology report (see Appendix C). While no tests have been conducted in the study area, the results of tests run in hydrogeologically similar areas suggest that short term inflow rates of between 0.5 to 2 L/s per well may be feasible in the upland parts of the study area. The actual infiltration rate for an individual well will depend on a number of factors including: well depth, depth to static water level, formation permeability and continuity of the aquifer.

7.2.5 Peak and Volume Controls

Two unique characteristics of the Campbellton area may strongly influence the recommended approach to controlling runoff volumes and peaks there. First, Campbellton is largely developed and already has an extensive storm drain system with capacity to safely convey storm flows[12]. In fact, as noted in Section 5.7, this existing system generally can also handle future increases in runoff due to infill and redevelopment. From this perspective, there may be no need for new detention to manage either existing or future runoff.

Secondly, the current storm sewer systems discharge directly to the Campbell River via numerous outfalls that do not, by definition, cause flooding and erosion in the receiving water as might be experienced in a small, natural stream receiving stormwater runoff[13]. This is so due to the sheer size of the river compared to the outfalls as well as to the significant river velocities that can carry runoff away quickly. Again, from this perspective, there may be no need for new detention to handle either existing or future runoff.

12 With some exceptions, as noted in the evaluation of the existing municipal conveyance infrastructure (Section 5.6).

13 Some of the outfalls do exhibit scour holes at the outlet. As long as this scour doesn't threaten adjacent property or the outfall itself, it can be considered relatively minor.

As noted previously, earlier approaches to stormwater control often emphasized the reduction or attenuation of peak runoff rates as a way to minimize flooding of property. On balance, this seems unnecessary for the developed portions of Campbellton and thus, barring significant deviations in future land uses from the OCP, BMP's for reduction in peak runoff are not required.

The situation is entirely different for the remaining developable "green field" areas in Detwieler and Kingfisher Creek watersheds. To avoid future degradation of the stream systems, runoff peak and volume controls are essential. In their absence erosion and sedimentation will be significant. (Obviously subject to the extent of development that actually occurs.) This in turn will lead to reduction in ecological value of the systems.

7.2.6 Stormwater Quality

As previously discussed, urban runoff typically can carry a variety of potentially harmful pollutants. The biophysical inventory identified the variety of fish and wildlife that depend on the presence of healthy streams and rivers, specifically on high quality water, in the Study Area. While anecdotally there have been episodes of runoff contamination in the Campbellton Area (specifically discharging through Outfall CR7), at this time, there is no specific runoff, receiving water or ambient sediment quality data that suggests there is a problem in the Study Area. However, it seems prudent to confirm the findings of this study's preliminary pollutant loading analysis by determining the extent of runoff contamination and subsequently applying water quality treatment BMP's as appropriate.

If water quality improvement becomes a primary stormwater management objective, additional work will be required to determine the extent of the problem and provide a basis for treatment controls. This additional work should include a sampling and testing program to determine pollutant characteristics of runoff, receiving water and sediments at and near outfalls.

Table 7.3 (Appendix A) provides a list of the most common structural stormwater treatment systems in use today. The table also provides a general evaluation of the capabilities of these systems.

7.3 Public Versus Private Facilities

Some BMP's are best owned and maintained by the public, that is, the City. This can guarantee that the facility is properly maintained, repaired or upgraded as needed. Detention ponds serving large tracts of land are an example of a publicly-owned stormwater facility. Similarly, street sweeping is an activity generally suited for handling by a public agency (e.g. public works department).

Other BMP's are better suited for private construction and ownership, often because they are located on private property or are designed to serve only a small land area. Examples include roof-top gardens and bioretention areas. Sometimes a combination works, for example, a pond may be built by a private developer, but later maintained by the City.

7.4 Erosion and Sediment Control Practices

The current state of erosion and sediment control (ESC) practices on construction sites has been a recurring topic mentioned by the City, the stakeholders and the public. While, in general, developers are fairly diligent about implementing and operating ESC works, the function of these facilities tends to diminish once the land has been transferred to individual builders. The City has some grounds to enforce ESC on the developer through the maintenance period in their contract, however, it is often difficult to enforce to the same standard on the builders themselves. Long-term maintenance of ESC works, restoration of disturbed areas and lack of enforcement appear to be the main issues and minimization of cleared areas, source control measures and timing of implementation of ESC works within the construction framework could be stressed by the City.

7.5 Operation and Maintenance

BMP's will fail to meet runoff flow and water quality objectives unless they are maintained. Once incorporated into a community's budget and departmental work loads, public facilities can be regularly inspected and maintained as needed. On the other hand, privately-owned source controls may not necessarily receive the same attention, thus risking failure. For example, a buyer of a home may not even be aware that a subsurface infiltration system is already present on the lot and that it may need attention. Or the soils in the rain garden intended to provide a location for infiltration may become plugged, yielding merely a standing pool of water rather than a stormwater benefit. Fortunately, because on-site controls are diffuse, failure of a few will not seriously impact the overall stormwater control provided by the BMP's. Nonetheless, it will be important for the City to adopt a program for suggesting, encouraging or requiring maintenance of on-site BMP's.

The City currently cleans catch basins, ditches and pipes periodically. As well it provides street cleaning. These practices could be reviewed and enhanced as necessary to improve their contribution to overall stormwater management in the City.

7.6 Retrofitting Existing Neighborhoods with BMP's

It can be challenging to retrofit on-site control BMP's in existing highly developed areas. For example, within commercial districts and urban residential areas street widths are already set, with curb, gutter and storm drains in place. Replacing these with narrow streets, bio-swales and other similar low impact BMP's can be expensive and some or many residents can be resistant to losing what is perceived as chief amenities of an urban environment, namely curb, gutter and storm drains. Urban and suburban dwellers have also often come to view removing rainfall from their lots as quickly as possible as an important aspect of development. Despite its benefits, absorbent landscaping that retains rainfall on site can be viewed as a negative by some residents, especially if the lawn is "soggy" in more then just the winter.

As a result, retrofitting BMP's in existing areas may only be feasible on a neighborhood level, using publicly owned and maintained systems. These include systems such as extended detention ponds (for flow and quality treatment), engineered underground sediment removal structures and sand filters. Availability of land (space) for large, surface BMP's such as ponds and wetlands may also be limited in developed areas. Thus flow control may be nearly impossible to achieve in developed areas, although as noted previously water quality is likely the overriding stormwater concern in areas such as Campbellton.

One particularly promising non-structural practice for use in existing urban areas is street cleaning, which can pick up solids-based pollutants even before they become a combination of suspended solids and dissolved contaminants in runoff. In fact, Minton and Sutherland (1998) have argued that in many cases street cleaning is the most cost effective long-term solution to urban stormwater quality issues. They also point out that most current street cleaning programs are inadequate to provide any meaningful water quality benefit. Specifically, their concerns are the frequency of cleaning (not often enough) and the efficiency of the equipment (too low, leaving behind the smallest sediment particles that in fact may be associated with most contaminants). They strongly suggest the use of high efficiency vacuum cleaners to obtain the full benefit of a street cleaning program. Frequency of sweeping should be determined by an analysis of the sediments being produced in a neighborhood or at a site.

8.0 ALTERNATIVE STORMWATER MANAGEMENT STRATEGIES

8.1 General

Within the direction provided by the City's ISMP goals and objectives (see Section 1), the City may approach the unique stormwater issues of the Campbell River/Quinsam River Area a number of different ways. These range from an essentially "leave it alone" approach for some existing low density developed areas to full application of on-site controls throughout the Campbell River/Quinsam River Area. Some of the questions to be considered are:

- Should the use of stormwater BMP's be voluntary or required? If voluntary, should the City encourage their use or merely provide "educational" materials to developers?
- Should performance targets be set for runoff peak flows and volumes? Should these be applied to all areas or only new developments?
- What conditions should trigger the requirement for stormwater quality treatment? Should specific receiving water quality targets be set? For which pollutants?
- Should performance targets be set for stormwater quality? For which pollutants?
- Should residents and businesses in existing developed areas be expected or required to retrofit for runoff quality treatment? If not, should publicly owned neighborhood-based systems by installed instead?
- Should the City differentiate between new development and infill/redevelopment with respect to stormwater control requirements?
- It is known that stormwater "hot spots" can generate significant or even toxic runoff pollution. How should the City determine which businesses or industries fall into this category? Should the City require hot spot operations to install and maintain treatment systems?

The recommendations of earlier ISMP's in Campbell River have generally done the following:

- Set performance targets for stormwater flows (peak and volume)
- Set minimal performance targets for stormwater quality
- Allowed developers to choose which BMP's best meet the performance targets and are suited to the site
- Required all new development as well as commercial/industrial redevelopment to meet the targets, while simply encouraging residential infill development to do so
- Used a mix of on-site controls and public infrastructure improvements (detention ponds) to control stormwater in new development areas

8.2 Runoff Peak and Volume

Traditional stormwater management, at least since around 1970, has focused on detention of runoff in order to attenuate, or reduce, *peak* runoff flows into streams. This has had the effects of reducing storm drain trunk pipe sizes and, depending on the downstream conditions, perhaps alleviating flooding in some cases. However, the lack of specific runoff volume controls has generally contributed to erosion in receiving streams and consequent reduction in habitat values. This is due to a shift in the flow-duration relationship in streams that leaves them carrying elevated (though not necessarily extreme) flows for longer periods of time which in turn triggers stream bed degradation and bank erosion. Thus it is important to address post-development reductions in both runoff peaks and volumes.

In areas that are currently serviced by storm drain systems and for which there are no other apparent downstream flooding or erosion issues, reductions in runoff volumes and peaks are unnecessary. This is the case of the Campbellton area. With only modest upgrades of the existing storm drains, the existing system can adequately handle runoff without any significant loss of instream values. However, in areas that are currently undeveloped, stream health will be greatly enhanced by applying controls to limit both runoff peaks and volumes, especially for the high frequency storm events (such as those less than or equal to the MAR). The less frequent, but larger, storm events may still require reductions in their peaks to avoid flooding or other downstream impacts and the full arsenal of peak and volume strategies should be considered to reduce these impacts. These strategies include low impact stormwater sources controls, but also neighbourhood or regional based detention and retention ponds, as required.

For extreme storm events (those exceeding the 5-year recurrence event, for example), generally the best option is to provide safe passage of flood flows. Attempts to provide control facilities, for example, detention ponds, can become quite expensive as the facilities become increasingly larger to accommodate the last increment of runoff associated with extreme flood events.

8.3 Water Quality

The City's Foreshore Area ISMP report (2005) offered a rationale for providing stormwater quality treatment, but not control of stormwater peak and volume, for highly urbanized areas situated along large water bodies. That plan focused on the City's main downtown area, but the same reasoning essentially applies to the Campbellton Area. First, to reiterate the Foreshore rationale, there are no freshwater stream systems to protect from high volumes of Campbellton runoff. The corollary is that the Campbell River which is a large river (when compared to the stormwater discharges) does not require protection from flooding or stream bed and bank erosion resulting from Campbellton runoff. Thus, in general, stormwater detention to attenuate peak flows is unnecessary in the Campbellton Area.

Second, highly urbanized areas such as Campbellton tend to generate significant volumes and concentrations of pollutants in runoff, the more so when an area has heavy commercial and/or light industrial land uses present. While there are no local streams to protect, there may be concern for receiving water quality and sediment contamination at and below the outlets to the nine storm drain outfalls that line the river. Given the high value of the Campbell River (fisheries, etc.) and the role it plays in the community's identity, it stands to reason that its protection and enhancement is critical. Thus, in general, stormwater quality issues are of greater concern in the Campbellton Area than stormwater volume and peak issues.

Retrofitting site adaptive planning and on-site controls in highly urbanized areas can be very challenging. In particular proactive methods such as limiting the footprint of buildings and parking areas can be difficult to implement in the Campbellton's commercial core. Among other things, this is due both to resident and business community resistance, as well to technical challenges and costs of replacing existing infrastructure. Thus, publicly-owned and maintained neighborhood or watershed level systems (i.e. "end of pipe" systems) may be the preferred, or in some cases the only, option for meeting stormwater objectives. Since it has already been suggested that runoff peak and volume need not be the primary focus for stormwater management throughout the Campbellton Area, this applies primarily to runoff quality treatment.

When developing initiatives for water quality treatment in Campbellton, a cost-benefit analysis should be employed such that the greatest benefit to the receiving waters is derived for the money spent. The application of a specific treatment measure must be carefully evaluated to ensure the greatest benefit. The variety of available techniques will permit the selection of the most appropriate for the funds available, pollutant target, and other dependent constraints; there is not any single treatment technique that is a best-fit for all areas. Some techniques are applicable across a wide-ranging area (a street-sweeping program), while others are very site specific (oil-grit separator).

Basic stormwater quality treatment systems could be constructed at the end of every outfall along the Campbell River. Assuming these were all underground treatment systems, the construction cost for providing this treatment would be on the order of $1.3 million (see Appendix H). Enhanced treatment that specifically targets metals and/or other pollutants will cost significantly more, the cost being a function of the target pollutants and the level of treatment desired.

As noted in Section 7.6, an alternative approach to runoff water quality control in highly urban areas is the application of high performance street cleaning. This requires purchasing expensive equipment (approximately $340,000[14]) and performing the cleaning on a very frequent basis, up to weekly or more often in some areas. Annual O&M costs are variable, depending in part on frequency of use, but may run $30,000 to $40,000. (See Appendix H for cost estimate.) Over a 30-year analysis period, this amounts to a present worth investment of about $1.1 million dollars[15] for the downtown core area only, compared to the $1.5 million noted above. As noted previously, high performance cleaning is likely to be more efficient at picking up the smaller, more contaminating particles than the sediment removal structures discussed above. To get comparable results from an engineered treatment system requires the addition of filtration or other advanced treatment processes to the basic sediment removal structure. Of course, street cleaning by the City does not remove pollutants from private property, only that which is lying on City streets and parking lots.

While this section has focused on the already developed Campbellton area, attention to stormwater quality in other parts of the Study Area is critical to improvement and maintenance of water quality in both the Detweiler and Kingfisher Creek systems. Most of the future development envisioned for these watersheds is residential, which readily allows the application of low impact stormwater sources controls to address runoff quality issues. Non-residential developments should be required to address stormwater quality on-site.

8.4 Fish Habitat Enhancements

As a result of the biophysical review, a number of potential stormwater and habitat protection/improvement opportunities were identified. Some of these reinforce the various points made in the previous paragraphs. The selection of opportunities took into account factors such as:

- Presence (or absence) of base flow
- Presence of existing habitat features, e.g., pools and channels
- Presence of fish, e.g., salmonids

The in-stream and riparian enhancement opportunities include planting native vegetation, stream complexing, application of bioengineered bank protection, creation of spawning and rearing habitat, improving fish passage, and preservation of existing high quality habitat for fish and other wildlife. Table 8.1 (Appendix A) provides information on these sites.

14 A top-of-the-line high performance street cleaner costs approximately US$280,000, or about CND $340,000, depending on exchange rates, but not including shipping the vehicle to Campbell River.

15 The Foreshore ISMP also included a recommendation that the City consider use of street cleaning in lieu of sediment removal systems. The capital cost for purchasing a high performance system should be compared against passive treatment systems as described both here and in the Foreshore report.

With respect to these fish habitat enhancement opportunities, these could be done as "stand alone" projects, however, the City has in the past indicated a preference for linking such projects to other efforts. Some on-going City programs that could be used as a trigger for an associated shoreline fish habitat enhancement are:

- Construction of "end-of-pipe" stormwater quality treatment facilities resulting from ISMP recommendations
- Park purchase or set aside

8.5 Monitoring

There are a number of reasons to perform environmental monitoring within the Campbell River/Quinsam River Area:

- To provide data to calibrate and verify the hydrologic / hydraulic model (base and storm flows)
- To obtain data to identify areas that likely contain stormwater "hot spots"
- To establish background conditions at storm drain outfalls (flow and quality), in the associated outlet channels and pools (water and sediment quality), and in Detweiler and Kingfisher Creeks (flow; water and sediment quality)
- To determine performance of overall stormwater management strategy once implementation

If the City were interested, runoff quality data can also be used as the basis for a water quality model that would update the preliminary pollutant load computations performed for this ISMP. Specifically, the data could be used to add a water quality component to an extended period ("continuous") simulation model in XP-SWMM.

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9.0 RECOMMENDATIONS

9.1 Guiding Principles

It is the vision of both the City and the project team to ultimately create a living document for the Campbell River/Quinsam River Area, which is expected to be updated and revised, as necessary, as the recommendations described below are implemented and monitored. The primary goal is to recommend stormwater management solutions for the Study Area which are realistic and practical to achieve, and which are adaptable should conditions change as future information on the watershed is obtained.

While a significant portion of the Study Area is essentially fully developed, other parts will increasingly feel development pressure. Redevelopment potential in the Campbellton Area will present opportunities to redress past inattention to stormwater quality, while new development in both the Detweiler and Haig Brown's Kingfisher Creek watersheds has the potential to negate or undo past attempts to protect the fish and wildlife values of these areas.

As a filter for formulating, evaluating and implementing stormwater management options within the Campbell River/Quinsam River Area, we have used the following guiding principles:

- Minimize impact of new development on runoff
    - Maintain base flows to streams
    - Maintain water quality in streams
    - Apply sustainable stormwater management controls on new development, including minimizing vegetation removal and minimizing effective impervious area
    - Meet performance targets
    - Encourage use of sustainable stormwater management controls for infill and redevelopment
- Improve water quality when feasible
    - Establish an environmental monitoring program
    - Apply retrofit runoff water quality treatment controls

Table 9.1 (Appendix A) provides a summary list of the recommendations that are discussed in the paragraphs that follow. Figure 9.1 shows the general locations for various infrastructure and in-stream improvements.

9.2 Performance Targets

We recommend that the City adopt stormwater performance targets for runoff volume, quality and peak that are generally consistent with Provincial and Federal guidelines and that will support the City's desire to continue to provide a consistently high level of service throughout the community. We recommend the following specific, post-construction performance targets:

- **Small Storm Goal:** No discharge from impervious surface areas for storm events with rainfall depths up to one half the 24-hour Mean Annual Rainfall (MAR)[16]
- **Large Storm Goal:** The post-development runoff for the 2-year recurrence 24-hour storm shall be 50% of the pre-development runoff and the post-development runoff of the 5-year recurrence 24-hour storm shall not exceed the pre-development runoff
- **Extreme Storm Goal:** For storm events exceeding the 5-year recurrence, safe conveyance of runoff
- **Water Quality Goal:** Treat runoff from impervious surface areas for all storm events less than or equal to the MAR, with a minimum 80% annual average removal of Total Suspended Solids (TSS) for particles greater in size than 50 microns; for commercial and industrial developments, oil and grease shall also be removed in order to limit discharge to concentrations less than 10 mg/L.

While these targets will be generally applicable to individual residential sites, in some or even many cases it will not be feasible to meet them. Thus the targets should be applied more strictly to entire new developments (or phases of development) with developers and builders given the option of finding an appropriate mix of onsite and neighbourhood best management practices for each development. The targets should however be applied to all commercial and industrial development.

In conjunction with this, we recommend the City revise its current design frequency for minor storm conveyance systems to provide the same level of service to all areas, regardless of land use. We recommend that the level of service be the 5-year recurrence runoff event, after taking account of the on-site performance targets noted above, if applicable. The major storm conveyance system level of service should remain the same, namely the 100-year recurrence runoff event.

With respect to stormwater quality, as listed above, we recommend that the City require removal of 80% of the annual average Total Suspended Solids (TSS) load (for particles ≥ 50 microns)

16 The Mean Annual Rainfall (MAR) is 55 mm in 24 hours.

conveyed by runoff from all new development.[17] (This standard would be supplemented during construction by application of an approved ESC plan; see Recommendation 9.11). Further, properly installed and maintained BMP's or the use of low impact development methods could be presumed to satisfy this target when approved as part of a development application / building permit process. For commercial and industrial developments, we also recommend specifically requiring removal of oil and grease before discharge to storm systems or the creek.

With respect to infill development and redevelopment, we recommend that the City consider each development application on a case by case basis to determine the need for rigid application of these performance targets. At the least, residential in-fill development should attempt to include on-site BMP's or low impact methods and commercial / industrial redevelopment must incorporate measures to control runoff water quality.

In all cases, private landowners should be responsible for maintaining on-site BMPs, including oil/water separators. We recommend that the City consider establishing enforcement mechanisms (such as fines) for those who do not maintain their stormwater systems; this could be done as part of a stormwater utility (see Section 9.16).

The current, draft version of the City's new "alternate design standards"[18] (Lanarc, 2006), proposes the use of *performance* and *prescriptive* stormwater standards. The former would be applied to large or complex developments and would allow the developer to determine the appropriate mix of BMPs to meet specified performance targets (as listed above). For smaller projects, the standards prescribe the use of specified BMPs, thus reducing the engineering effort needed to design stormwater controls. The use of performance and prescriptive standards is fully compatible with the recommendations made in this section.

9.3 Municipal System Upgrades

As described in Section 5, some storm drains were identified as having insufficient capacity to meet existing servicing criteria. In some cases, upsizing these pipes results in the problem being transferred to another part of the storm drain system. Therefore, we recommend upgrades to seven (7) pipe segments, as listed in Tables 5.7 and 5.10. The total estimated construction cost for these upgrades is $1.2 million (see Section 10; full details in Appendix H).

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17 Provision for skimming of oil and grease should always be part of sediment removal systems, whether an aboveground pond or an underground manufactured unit. However, in most cases, oil and grease in urban runoff is in fact typically at or below the level that can be achieved by most treatment systems ("oil/water separators"). Commerical parking lots, industrial sites and other potential hot spots should specifically target oil and grease for removal, as noted in the proposed water quality goal.

18 Consistent with the other recommendations of this ISMP, we urge the City to consider using "alternate" design standards for all new (re)development; thus, perhaps a more appropriate name for these new standards would simply be "sustainable design standards" or "low impact design standards."

As discussed in Section 5, it appears that, except as noted in the previous section, the existing drainage infrastructure has sufficient capacity to maintain level of service for "full build-out" of the Campbell River/Quinsam River Area, as delineated in the draft OCP. Therefore no new trunk storm sewers are recommended at this time.

Detention ponds, to provide additional stormwater control for large storms (see Section 9.2), are recommended for seven (7) areas slated for future development in Detweiler and Haig Brown's Kingfisher Creek watersheds (see Figure 9.1 for general locations). The total estimated construction cost for these ponds is $10.1 million (see Section 10; full details in Appendix H).

We recommend upgrading the current City design standard for catch basins to include a deeper sump sized (with a recommended 1200 mm minimum depth compared to the current 300 mm minimum) and a trapping hood to retain floatables and some oil and grease. As existing storm drains are replaced, the associated catch basins should all be upgraded to this new standard at the same time.

Water quality treatment facilities are discussed in Section 9.4.

9.4 Stormwater Quality Treatment Facilities

It is clear that significant runoff pollution potential is present in the Campbellton Area. The area is highly developed, and includes land uses with high risk of runoff contamination (commercial and light industrial land). Further, the areas is likely to undergo redevelopment that will convert the existing residential area to commercial or light industrial as well. The City has installed three (3) oil/water separators in the area (outfalls CR3, 5 and 7). The oil/water separators have been installed "on-line," that is, all flow in the storm sewers must flow through the units. As previously noted, this may be problematic, yielding poor treatment performance due to washout of pollutants. The Ministry of Transportation included a permanent water quality control pond in its construction of the Inland Island Highway, however neither the design criteria nor the performance of this facility is known. Thus we recommend that the City construct new stormwater treatment facilities on all Campbellton storm sewer outfalls. These facilities would be designed to meet or exceed the water quality performance target set forth in Section 9.2, namely, average annual removal of 80% of the total suspended solids (TSS) load from runoff, down to the 50 micron particle size, as well as oil and grease capture capacities. In order to minimize the loss of open space to treatment facilities, these treatment systems could be constructed underground, using one of several available proprietary technologies for the removal of sediment solids. As a basis for preliminary assessment, construction of nine (9) vortex-based sediment removal systems can meet the performance target for an estimated cost of about $1.3 million; estimated annual O&M is about $47,000. Sizing is based on the 2-year recurrence storm event, which varies from 6 L/s to 617 L/s for the outfalls. The treatment systems can be expected to remove about 40% of the annual average heavy metal contaminant load along with the suspended solids that are removed.

Prior to proceeding with implementation, we recommend that the City undertake a more thorough assessment of the existing treatment systems and an evaluation of the use of high performance street cleaning in lieu of structural BMPs. Specifically, for the former, we recommend the City undertake a performance review (including runoff quality field sampling) of the existing oil/water separators and the highway water quality pond. The protocols for sampling and analysis can be developed at the time the study is ordered, but should follow guidelines prepared for inclusion in the "International Stormwater Best Management Practices (BMP) Database," which is sponsored by a coalition of U.S.-based federal agencies such as EPA and private industry groups (http://www.bmpdatabase.org/).

The latter assessment should include comparing life cycle costs for street cleaning versus those for the water quality treatment facilities recommended here and in the Foreshore Area ISMP. The assessment should also consider the purchase of a high performance vacuum street cleaner for use in highly commercialized areas such as the downtown core. This street cleaner would supplement the use of the City's current sweeper. A top-of-the-line high performance street cleaner will cost approximately $340,000.

Assuming that the Campbellton water quality treatment facilities proceed (rather than purchase of the high-end street cleaner), it should be accompanied by:

- An environmental monitoring program (see Section 9.5)
- An enhanced program of street cleaning using existing City-owned equipment
- Program to identify specific hot spot commercial or industrial enterprises
- Spill containment procedures

A first step towards identifying stormwater hot spots is to simply generate an inventory of commercial and industrial enterprises, based on field reconnaissance and keyed to lot locations (in order to allow coupling to the City's GIS database). A preliminary list of potential "pollutants of concern" can be developed for each enterprise based on the stormwater quality literature. After this first step, the City may wish to perform water quality testing at individual hot spots to determine more accurately the pollutant contributions of a specific land use activity. Longer term, the City may wish to adopt "codes of practice" for specific commercial and industrial activities.

9.5 Environmental Monitoring Program

Previous ISMP's have recommended continuous flow monitoring to develop (among other things) the data necessary for extended period simulation modeling. The previous ISMP's have also recommended concurrently establishing a network of manually read ditch water level staff gages to monitor base flow conditions in watersheds. The latter could certainly be implemented in the Study Area, however the former (automated continuous stream flow metering) should be coordinated throughout the City's watersheds in order to optimize useful and meaningful data collection.

A primary purpose of flow monitoring is to provide data to calibrate and verify the hydrologic modeling completed in this ISMP. This will allow upgrading the models to perform "continuous," extended period simulations which can be used to assess environmental stream flows and to more accurately predict system behavior with stormwater source controls in place.

We recommend establishing a two-pronged environmental monitoring program. One prong focuses on water and sediment pollution, while the other focuses on the actual biophysical characteristics of representative areas within the area. A water quality and sediment quality testing program at storm drain outfalls, similar to the Capital Regional District's testing program, should be implemented. Testing should focus on total suspended solids, fecal coliforms, metals and polycyclic aromatic hydrocarbons (PAH's), along with standard parameters such as temperature, salinity, conductivity, dissolved oxygen and pH.

As a minimum, sampling frequency and locations should be:

- First year, sample each major outfall (CR4, CR6.5 and CR7) twice
- Second and subsequent years, sample on a semi-annual basis the major outfalls

Sampling locations and frequencies should be coordinated with that being implemented under the City's other ISMPs.

In preparation for design of the proposed stormwater treatment facilities (or implementation of a program of high performance street cleaning in the downtown core), we recommend performing particle size and chemical analysis on street sediments in the Campbellton area.

The second prong of the environmental monitoring program is to establish periodic biotic inventories of several areas in Detweiler and Kingfisher Creeks and at the major Campbellton outfalls. This could be done by the City alone or in conjunction with a local organization such as the Greenways Land Trust, if properly trained and funded.

There is a rain gauge currently in operation at the Campbell River Airport, however, Environment Canada (EC) apparently records only daily precipitation amounts. Upon request from the City, EC could reactivate recording the continuous data. This in turn can be used to update the City's IDF curve at regular intervals, say every five years. The Quinsam River Fish Hatchery also has a rain gauge which could perhaps be upgraded to a full recording station, if the City desired. In this case, the City would need to work cooperatively with DFO to fund and operate the weather station.

9.6 Field Verification of Soil Infiltration Properties

Consistent with previous ISMP's, we recommend that the City develop a soils database to update the general information gathered at this time. The soils infiltration properties of the database can be used in upgrading the hydrologic modeling in the City and in further identifying potential areas for infiltration-based BMP's.

The City should require a soils report be submitted with a development application that discusses in-situ testing undertaken at the site to establish infiltration rates. This report would assist both the developer and the City in selecting and evaluating different types of best management practices which may be appropriate for that particular site to mitigate the impacts of the development. Over time, the City should also use this information to build a database of soil infiltration properties for the area.

Alternatively, if the rate of future development applications is slow, we recommend that the City implement a test pit program in the watershed to obtain the necessary soils information for the model. A total of three to six test pits could be dug at various around the Study Area to confirm soil infiltration properties. Preliminary costs for infiltration tests and test pitting are included in Section 10.

9.7 Topographic Database Updates

Previous ISMP's have recommended the City update its overall contour mapping throughout the City, especially since some areas only have 20-m contour information available. We continue to commend this to the City. To supplement this, we recommend ground survey of the Campbellton core which can be integrated with the aerial mapping. To keep the cost reasonable, aerial mapping only needs 1- to 2-m resolution contouring. However, this is insufficient for use in the flat downtown core area, thus the need for additional detailed, ground survey.

Finally, we recommend that the City conduct a long-term program to review storm sewer as-built information and compile manhole rim and outfall invert elevation data. Elevation data found to be missing should then be surveyed in the field and elevation data should be updated accordingly in the model and in the City's GIS database.

9.8 Continuous Modeling

We understand that it is the City's intent to use the XPSWMM model prepared for this study as a base model, which will be developed and refined over time as additional information on the catchments become available. We recommend that the City implement the recommendations listed in Sections 9.5 to 9.7 above so that the XPSWMM model can be expanded from an event based model to a continuous simulation model.

There are several benefits for the City in moving from an event based model to a continuous simulation, besides sizing municipal drainage infrastructure and determining detention requirements. A continuous simulation provides an indication of the magnitude of base flows which can then be correlated to fish habitat. Continuous simulations also allow the City to model infiltration, evapotranspiration and groundwater recharge processes more accurately, so that their benefits can be accounted for when designing BMP / LID facilities.

A model which is calibrated based on actual data can be used to more accurately understand the response of the watershed to rainfall and interstorm events, as well as to evaluate the impact of potential development proposals. This type of analysis will assist the City when providing direction to developers on the stormwater management requirements for their site, as well as the types of features that would be well suited to the individual characteristics of their site.

Finally, the XP-SWMM model can be enhanced by adding a pollutant washoff component to it. When used with a continuous simulation, annual loadings for TSS or other pollutants can be refined from the preliminary estimates developed for this ISMP.

9.9 Operations and Maintenance Schedule

The City's council policy manual has a chapter which outlines the Public Works department's operation and maintenance schedule. The manual outlines a timeline for inspection and maintenance, as well as recording and action procedures to rectify inadequacies, for several types of drainage facilities in the City including roadside ditches, catch basins and storm sewers.

We recommend that the City include street cleaning in its O&M schedule, setting frequency has high as possible in Campbellton and other areas with high potential for runoff contamination. Generally to gain full benefit of the cleaning, it should be at least 25-30 times per year (see further discussion in Section 9.4). Similarly, we recommend that detention ponds also be added to the O&M schedule.

9.10 Habitat Protection, Restoration and Enhancement Opportunities

We recommend that opportunities for habitat protection, restoration and enhancement be coupled with other on-going initiatives within Campbell River. The priority opportunities listed previously in Table 8.1 can be used as a screen to determine locations where funds and effort may be best utilized. The sites are also shown on Figure 9.1 (Appendix A).

To supplement the projects the City may undertake over time, we recommend that the City explore use of an incentive program for preserving environmental values on developing properties. This could be coupled with the tree protection bylaw recommended in Section 9.14.3, as well as with the stormwater utility recommended in Section 9.16.

9.11 Erosion and Sediment Control Practices on Construction Sites

We recommend that the City adopt a new Erosion and Sediment Control Bylaw. This bylaw would clearly outline the City's requirements for ESC practices on construction sites and would also state the penalties and/or fines for not meeting the requirements of the bylaw. A comprehensive ESC bylaw may require that the applicant do one or more of the following:

- Prepare and submit an ESC plan for the site prior to the start of construction, which would indicate the location and function of all proposed ESC facilities, as well as the location of any nearby watercourses or other sensitive areas
- Designate an ESC supervisor for the site, who would be responsible for the construction, operation and maintenance of onsite ESC facilities
- Outline a reporting structure for the ESC supervisor on their inspection of ESC facilities, where the reports may or may not need to be submitted to the City
- Outline a timeline for inspections by the ESC supervisor, which may be weather dependent
- Establish the City's right to enter the site at any time to inspect ESC facilities and issue warnings / fines for non-compliance as necessary
- Allow the City to undertake any remedial works necessary to correct non-compliance issues and bill the applicant
- Limit the times of year when certain construction activities could take place, or require more stringent controls during the winter season
- Limit the amount of area that can be cleared at any one time

The performance targets, as specified by the BC Ministry of Environment, for construction-related ESC should be:

- **During dry conditions:** runoff TSS shall not exceed 25 mg/L above receiving stream levels
- **During wet conditions:** runoff TSS shall not exceed 75 mg/L above receiving stream levels
- **In spawning areas:** runoff TSS shall not exceed the receiving stream levels

If the City chooses to implement a new ESC bylaw, it should be recognized that additional staff and or re-training of existing staff may be necessary to ensure that the bylaw is properly enforced. It will also be important to develop public (i.e., contractor) education and information opportunities, such as ESC workshops or pamphlets. It is our understanding that the Environmental Advisory Commission plans to discuss the implementation of an ESC bylaw in 2008.

The City's draft "alternate design standards" includes erosion and sediment controls. The draft standards should be reviewed in light of these recommendations.

9.12 Public Outreach and Education Initiatives

Recent studies and reports consistently note the necessity of strong public education and outreach initiatives for successful stormwater management plan acceptance and implementation. Consistent with previous ISMP's we continue to recommend that the City develop and implement such a program for Campbell River. This program can include public recognition of positive stewardship, clean-up days, tree planting programs, storm inlet labeling, additional open houses and other opportunities for face-to-face conversation about stormwater issues, brochures, and public service announcements. One innovative example of public outreach is the web-based videos developed for the Perkiomen Creek Watershed in Montgomery County, Pennsylvania (http://www.greenworks.tv/stormwater/index.htm). The videos cover a variety of stormwater-related topics, such as riparian buffers and vegetated bio-swales.

Public outreach should also include consultation with and education of the development community, including developers, contractors, building material suppliers and design professionals.

Pilot projects (see Section 9.13) can be excellent opportunities for publicizing stormwater issues. For example, Seattle, Washington, uses its website, local media and signs at the sites to keep the public informed about its "Street Edge Alternative" (SEA) pilot project in Northwest Seattle (http://www.seattle.gov/util/About_SPU/Drainage_&_Sewer_System/Natural_Drainage_Systems/Street_Edge_Alternatives/index.asp).

9.13 GIS Database

Several new GIS layers were created during the ISMP study to assist the project team in their analysis of the watershed. We recommend that the City incorporate the following new layers into their GIS database:

- Revised catchment boundaries
- Sub-catchment boundaries (used for model development)
- 5m contours for partial project area

We also recommend that the City continue to expand and supplement their GIS database as more information becomes available. Other parameters that would also be useful to reference in the GIS database include:

1. **Outfall Attributes** – each outfall could have attributes associated with it, such as invert elevation, size, material, data on outlet structures (if present), photos of each outfall and surrounding area, any related erosional or fisheries habitat improvement works present or scheduled for the future, and environmental monitoring results (see Section 9.5).
2. **Soils Attributes** – a new soils layer could be developed based on the hydrogeological information from this ISMP study, which could then be refined in the future as additional in-situ and drill testing is conducted and as new development provides additional data.
3. **Rainfall Data** – the Campbell River Airport rain gauge location and associated rainfall data (including the IDF curve) could be added to the GIS database.

9.14 City Bylaw and Policy Revisions

As noted in Section 4.5 on Land Use Policy Gaps, the City's land use bylaws (the Official Community Plan and Zoning Bylaw) are, in general, supportive of integrated stormwater management. However, as outlined in Table 4.1, a number of land use policy gaps remain. The City may wish to consider the following revisions to ensure its land use policies fully promote integrated stormwater management within the Campbell River/Quinsam River Area.

9.14.1 Official Community Plan

The OCP could be revised to include measurable targets for preserving open space or limiting impervious area. While the OCP already includes provisions to encourage the preservation of open space, setting well-defined targets would help the community more accurately determine whether broader goals are actually being met. For instance, the City may consider setting a goal to preserve a certain percentage of the City for open space. The OCP could also support policies to obtain open space (e.g. policies to support reclaiming brownfield lots for greenspace). This would allow the City to consider the cumulative impact of all types of development as opposed to the impact of each type of development separately, which is addressed in the Zoning Bylaw.

The OCP could also be modified to include more detailed landscaping policies (as Development Permit Area guidelines) that more specifically support stormwater management principles. For example, a guideline could be included to require the preservation of natural vegetation within commercial, industrial, and residential Development Permit Areas. The City could also choose to supplement these Development Permit Area guidelines by adopting a separate bylaw that deals exclusively with landscaping requirements. Section 909 of the *Local Government Act* enables local governments to require, set standards for, and regulate the provision of landscaping for screening purposes, preventing hazardous conditions, and to protect the environment. With these powers, the City could adopt a separate bylaw to encourage the use of native species of vegetation and relevant Best Management Practices (e.g. preservation of natural landscaping at the time of development) where appropriate, to support integrated stormwater management.

9.14.2 Zoning Bylaw

The City could make its Zoning Bylaw more supportive of integrated stormwater management principles by:

- Introducing maximum parking requirements (in addition to the existing minimum requirements)
- Extending maximum impervious area limitations to all zones
- Directly encouraging cluster development by allowing density averaging in all residential zones
- Including impervious areas such as driveways, sidewalks, and any other hard surfaces in the calculation of lot coverage to limit impervious area

9.14.3 Tree Protection Bylaw

We recommend that the City should consider adopting a tree protection bylaw, which could specify retention and planting requirements for both new development and re-development of existing parcels in the City. It is our understanding that the Environmental Advisory Commission will be discussing the implementation of a tree protection bylaw in the near future.

9.14.4 Pesticide Use Bylaw

A recently released study by the U.S. Geological Survey points to the challenges of pesticide and herbicide use. The study found widespread and persistent presence of pesticides (and degradates resulting from transformation of pesticides in the environment) in streams and aquifers. More than 90% of the time, water samples from streams with agricultural, urban or mixed land-use watersheds contained two or more pesticides or degradates, and about 20% of the time, they had ten (10) or more. Given the risks associated with pesticides, it is prudent to consider managing them better, especially in urban environments.

We recommend that the City adopt a bylaw to limit the use of pesticides and herbicides, and it is our understanding that the Environmental Advisory Commission will be addressing this issue in 2008.

9.15 Updates to City Engineering Standards and Specifications

We recommend that the City revise its Engineering Design Standards and Specifications to include sustainable best management practices, including LID practices that are consistent with the goals, objectives and guiding principles of this ISMP. The City's alternate design standards, which are currently in a draft form, will satisfy this recommendation.

The updated standards should include a provision for deeper sumps and trapping hoods on catch basins (see Section 9.3). They should also encourage the use of bioswales, in place of standard ditches, whenever possible.

9.16 Funding Mechanisms

We recommend that the City establish a stormwater utility as a mechanism to generate dedicated funds for construction, operation, maintenance and administration of all publicly-controlled components of the stormwater system. The stormwater system would likely include:

- Streams and ditches
- Culverts
- Storm sewers and appurtenances
- Regional detention ponds, wetlands and infiltration facilities
- Regional "engineered" water quality structures (such as oil / sediment removal systems)

The utility would have enforcement authority to require, for example, stormwater management plans from new development. Further, the utility would be able to collect stormwater user charge fees on a common and fair basis.

While there are many methods of determining user charge rates, we recommend adoption of the fairly simple approach of basing rates on either land use classes or on actual impervious area on each property. The latter is preferred, as it is the single most important determinant of runoff peak and volume from any developed property in an urban area. However, establishing actual impervious area is not always straightforward or easy. In any case, the basis must be fair and must be based on the actual service provided, in this case stormwater removal and treatment and environmental protection[19]. Credit could be given for the upkeep and use of approved runoff reduction methods (BMP's / LID methods) on existing properties. Consideration may also be required for new development which is required to meet the recommended performance targets for stormwater control. There were more than 40 stormwater utilities operating in the Pacific Coast states of the U.S. as of the year 2001 (NRDC, 2001); these and other examples can be reviewed as the user charge system is developed.

19 The concept is similar to water and sanitary sewer utilities, which charge user fees for services provided, namely delivering clean drinking water and treating sanitary wastes, respectively.

Table 9.1
Summary of Recommendations for Campbell River / Quinsam River Area Stormwater Management

Category	Recommendation	Priority Level		
		1	2	3
Municipal Infrastructure	Upgrade deficient municipal drainage infrastructure (storm drains; 7 segments)			X
	Construct detention ponds for future developments (7 sites)		X	
	Construct runoff water quality treatment facilities (9 locations)	X		
	Upgrade existing catch basins with deeper sumps and trapping hoods			X
	Enhance street cleaning program		X	
	Prepare operations and maintenance schedule for stormwater system, incl street cleaning	X		
Environmental	Prepare inventory of existing commercial/industrial "hot spots"	X		
	Develop spill containment procedures		X	
	Install manual ditch level gages to determine base flows		X	
	Establish long-term outfall water and sediment quality monitoring program	X		
	Establish long-term biophyscial monitoring program at 2 or more sites	X		
	Initiate soils property verfication program		X	
	Re-establish digital recording of continuous rainfall measurements at the airport		X	
	Enhance key habitat sites in conjunction with other City initiatives (5 key, potential sites)	X		
Data Management and System Analysis	Obtain updated, detailed aerial contour mapping of area (supplemented by ground survey)		X	
	Compile manhole rim, outfall invert and related infrastructure data throughout the area		X	
	Refine the current XP-SWMM model to perform extended period (continuous) simulations		X	
	Perform assessment of environmental flows using upgraded XP-SWMM model		X	
	Update GIS database		X	
Policy	Adopt performance targets for stormwater volume, peak and quality	X		
	Adopt a single, consistent 5-year level of service for minor conveyance systems		X	
	Require the use of LID techniques (where appropriate and feasible) for new development	X		
	Require specific stormwater quality treatment for all new commercial and industrial sites	X		
	Develop and adopt an Erosion and Sediment Control Bylaw		X	
	Develop and adopt a Tree Retention Bylaw		X	
	Develop and adopt a Pesticide Use Bylaw		X	
	Adopt measureable targets in OCP for preserving tree cover and limiting impervious area	X		
	Introduce Development Permit Area guidelines for vegetation retention and native plant use	X		
	Update zoning bylaw for maximum parking / impervious surfaces and encourage cluster devpmt		X	
	Update engineering design standards per City's "alternate design standards" initiative	X		
	Require use of deep sump catch basins with trapping hoods			X
	Develop and adopt a stormwater utility to finance all aspects of the stormwater system		X	
Public Education and Outreach	Initiate a long term public eduation and outreach program	X		
	Prepare and distribute to builders an Erosion and Sediment Control Brochure	X		
	Publicize stormwater pilot projects	X		
	Develop a stewardship award for the development community		X	

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10.0 COST ESTIMATES

Several recommendations for the Study Area were presented in Section 9, however, some of these recommendations are policy related (e.g. bylaw amendments) or "soft" solutions (e.g. public outreach and education), therefore it is difficult to assign a cost to them. Thus, the costs outlined in this section are related to "well-defined" recommendations presented in the previous section, namely:

- Municipal storm sewer upgrades to service existing and future development conditions
- Stormwater quality treatment facilities
- Topographic mapping and aerial photography updates
- Flow monitoring program and water quality sampling
- Infiltration test pit program

Costs outlined in this section are representative of a Class D cost estimate and include a 35% contingency and 15% engineering allowance. Details on the cost estimates can be found in Appendix H. GST has not been included in these estimates.

10.1 Municipal Storm Sewer Upgrades

Municipal upgrade requirements to service existing and future development conditions were summarized in Section 9.3. Table 10.1 itemizes the costs associated with these upgrades (including capital costs and operations / maintenance costs). Costs assume that any existing manholes will not require replacement.

Table 10.1
Costs for Recommended Municipal Storm Sewer Upgrades

Model ID	Location	Proposed Pipe Size (mm dia.)	Pipe Cost ($/m) [1]	Length (m)	Capital Cost ($) [2]	O&M Cost ($/yr)	Present Worth of O&M Cost ($)[3]
1696	Redwood Street and 14 Avenue	900	885	86.5	$ 92,200	$ 1,000	$ 14,600
1697	Redwood Street and 15 Avenue	1050	1040	102	$ 124,500	$ 1,300	$ 18,900
1698	Redwood Street and 16 Avenue	1050	1040	129.7	$ 158,300	$ 1,600	$ 23,300
1699	Redwood Street and Island Hwy 19A	1350	1355	110.8	$ 170,100	$ 1,800	$ 26,200
1700	Redwood Street and 19 Avenue	1350	1355	86.7	$ 133,100	$ 1,400	$ 20,400
1746	14 Avenue and Spruce Street	675	665	99.9	$ 84,500	$ 900	$ 13,100
1747	14 Avenue and Redwood Street	750	745	65.4	$ 60,500	$ 700	$ 10,200
				Sub-Total	$ 823,200	$ 8,700	$ 126,700
				+35% Contingency	$ 288,200	$ 3,100	$ 44,400
				+15% Engineering	$ 123,500		
				Total	$ 1,234,900	$ 11,800	$ 171,100
						Grand Total (Capital + O&M)	**$ 1,406,000**

Notes:
1 Pipe cost includes manholes at 155 metre spacing.
2 Capital cost assumes road removal and restoration for top of trench width (width based on 1.5 m cover on sewer and 1.5:1 excavated side slopes on trench).
3 Present worth based on 30 year life with 5.5% interest rate

10.2 Detention Facilities

Stormwater detention ponds are recommended in seven locations to attenuate flows from large storm events; locations are shown on Figure 9.1. Table 10.2 summarizes the costs for these ponds, including capital costs and operations / maintenance costs.

10.3 Water Quality Treatment Facilities

Stormwater quality treatment facilities are recommended for the Campbellton Area. The estimated costs of these facilities are based on a review of manufacturer's prices for vortex-based sediment removal systems as well as final costs for two similar systems installed in the City of Victoria. Table 10.3 summarizes the capital and O&M costs for the facilities.

Table 10.2
Stormwater Detention Facility Costs

Development	Catchment	Area (ha)	Active Storage Volume (m^3)	Perimeter (m) [1]	Capital Cost ($) [2]	O&M Cost ($/yr)	Present Worth of O&M Cost ($)[3]
1	Kingfisher Creek (Upper Reach)	42.8	5,100	240	$ 1,854,000	$ 74,200	$ 1,078,500
2	Kingfisher Creek (Middle Reach)	6.2	1,300	120	$ 477,000	$ 19,100	$ 277,600
3	Kingfisher Creek (Middle Reach)	12.4	4,000	210	$ 1,455,750	$ 58,300	$ 847,400
4	Kingfisher Creek (Lower Reach)	6.9	2,200	160	$ 804,000	$ 32,200	$ 468,000
5	Kingfisher Creek (Lower Reach)	5.2	1,700	140	$ 622,500	$ 24,900	$ 361,900
6	Detweiler Creek (Upper Reach)	12.2	3,000	180	$ 1,093,500	$ 43,800	$ 636,600
7	Detweiler Creek (Lower Reach)	7.7	1,200	120	$ 441,000	$ 17,700	$ 257,300
				Sub-Total	$ 6,747,750	$ 270,200	$ 3,927,300
				+35% Contingency	$ 2,361,800	$ 94,600	$ 1,374,600
				+15% Engineering	$ 1,012,200		
				Total	$ 10,121,750	$ 364,800	$ 5,301,900
						Grand Total (Capital + O&M) [4]	**$ 15,424,000**

Notes:
1 Perimeter calculation assumes a square pond at 1.5 metre depth
2 Capital cost assumes a 3 metre wide riparian planting buffer around perimeter of pond.
3 Costs assume a dry pond, i.e. no additional storage volume for a permanent pool.
4 Present worth based on 30 year life with 5.5% interest rate

Table 10.3
Costs to Treat Runoff at Campbellton Outfalls

Outfall(s) Name	Capital Cost ($)	O&M Cost ($/yr)[1]	Present Worth of O&M Cost ($)[2]
CR1	$ 66,700	$ 2,700	$ 39,300
CR2	$ 80,000	$ 3,200	$ 46,600
CR3	$ 66,700	$ 2,700	$ 39,300
CR4	$ 193,300	$ 7,800	$ 113,400
CR5	$ 66,700	$ 2,700	$ 39,300
CR6	$ 66,700	$ 2,700	$ 39,300
CR6.5[3]	$ 130,000	$ 5,200	$ 75,600
CR7	$ 130,000	$ 5,200	$ 75,600
CR8	$ 66,700	$ 2,700	$ 39,300
Sub-Total	$ 866,800	$ 34,900	$ 507,700
+35% Contingency	$ 303,400	$ 12,300	$ 177,700
+15% Engineering	$ 130,100		
Total	$ 1,300,300	$ 47,200	$ 685,400
	Grand Total (Capital + O&M)		**$ 1,990,000**

Notes:
1. O&M Cost based on 4% of construction cost, to cover required sediment removals and cleanings
2. Present worth based on 30 year life with 5.5% interest rate
3. Total at CR7 has been split 50/50 with CR6.5

10.4 Topographic Update

As noted previously, topographic information in the Study Area (as throughout the City) consists of a mix of 5-metre contour intervals in some areas and 20-metre TRIM mapping for the others. Due to the nature of the terrain in the Campbell River, a refined contour interval would be desirable in order to verify the watershed boundaries. Contour intervals of 1 to 2 metres can be prepared through an aerial survey of the watershed.

For ease of discussion, costs to update topographic information and aerial photography were prepared assuming that this work would be undertaken in conjunction with mapping throughout the city.

Table 10.4
Topographic Information and Aerial Photography Costs

Item	Cost ($)
Topographic Mapping with 1 metre contours for select areas, including photo targeting and GPS control survey.	$30,000
Topographic Mapping with 1 metre contours, including photo targeting, GPS control survey, and colour air photo.	$65,000
Colour orthophoto with 20 cm pixel resolution for the entire city	$10,000
Additional ground survey in downtown core	$25,000

10.5 Environmental Monitoring Program

Table 10.5 provides preliminary costs to implement the recommended environmental monitoring program. Water quality sampling and staff gauges could be added as needed and as desired by the City. Note that these costs would be somewhat lower should a volunteer program be implemented to download data and maintain the equipment. As noted previously, the biotic inventories could be undertaken by local group(s), such as Greenways Land Trust. Also, the City can anticipate a 10-20% discount for large volumes of analytical testing.

Table 10.5
Environmental Monitoring Costs

Item	Cost ($) / year
Ditch Staff Gauges (4) ($500 each to install)	$2,000
Water & Sediment Quality Sampling and Analysis at Outfalls	$2,000 per site
Biotic Inventories	$5,000 per site

10.6 Infiltration Test Program

Conducting one infiltration test per soil type per 5 hectares could be used as a guide for preliminary planning. This program could be modified if the results show a relatively high degree of consistency. A typical cost for constructing a test trench, running an infiltration test, analyzing the results and preparing a report for ten pits typically costs between $400 and $600 per pit.

Two to three 30-metre deep test holes could also be drilled to assess the feasibility of the deep infiltration method. A well typically costs about $9,000 and an infiltration tests cost in the range $1,800 to $3,500 depending of the availability and cost of a water source, such as a fire hydrant or tanker truck. Engineering and interpretation costs would typically cost an additional $4,000 to $5,000 per well. These well should be located in areas where development is planned, and where there is not much data on deep drilled wells. Selected wells can also be used for long term monitoring of groundwater levels and water quality. Water level monitoring is best performed using an electronic data logger that can be set to record water levels at intervals such as 15 minutes and run off a battery for several months. A data logger costs about $1,000 and typically runs for about seven years on a non renewable battery.

11.0 IMPLEMENTATION

11.1 Enforcement of Policies and Standards

For the recommendations outlined in this report to be successful, three elements must be present:

- **Education** – For both the City and developers, so that the development process and expectations for stormwater management in the watershed are clearly defined and understood by all parties
- **Enforcement** – Of new policies and standards by the City, particularly in the area of erosion and sediment control
- **Dedication** – By the City, to be willing to test out innovative techniques which may not always be entirely successful

Most importantly, support from all parties (City and City staff, stewardship groups, development community, environmental agencies) is needed for the ISMP process and its outcomes to be a true success. The City has established an excellent basis for this to happen during this ISMP process, through the working group meetings and the open houses. The City may wish to undertake in-house training for those City staff that will be at the "front lines" of implementation, namely, staff involved in the various aspects of development, from the planning stage, through engineering and building permit approvals, to long-term maintenance of facilities.

11.2 Measuring Success

Measuring success can happen in a variety of ways, some based directly on scientific evidence, others based on general feedback from residents and others. Some of these are:

- Increasing biodiversity at monitored sites
- Improving water quality at monitored sites
- Evidence that new development(s) are meeting performance targets
- Increasing support from development community
- Participation of residents and local groups in public education events, the biotic surveys, etc.

The recommendations outlined in this report should provide an opportunity to determine changes to the above noted mechanisms, either anecdotally or through actual field measurements.

11.3 Integration with Other ISMP's

The recommendations of this ISMP must be integrated with those of the City's other ISMP's. In particular, the City will want to review all capital improvement recommendations and then set priorities among all the possibilities. Also, environmental monitoring can become expensive, thus the requirements for flow monitoring and water quality monitoring should be coordinated among the various watersheds.

11.4 Future Adaptation

As mentioned previously, it is the intent of both the City and the project team to ultimately create a living document for the Campbell River/Quinsam River Area, which is expected to be updated and revised, as necessary, as the recommendations described below are implemented and monitored. The primary goal is to recommend stormwater management solutions for the area that are realistic and practical to achieve, and that are adaptable as conditions change and as the City learns more over time.

With that said, the City will need to be diligent in monitoring the impacts of any implemented works so that the true effect of that improvement is known. The City may wish to pass monitoring duties to developers; however, the City must have the appropriate number of staff with adequate training to ensure that monitoring is in fact being done and that accurate results are being produced. The City should also review the environmental monitoring program on a frequent basis and ensure that the program is providing useful data.

Finally, as this ISMP study is meant to be a living document, the City should review and update it every five to seven years.

12.0 LIST OF REFERENCES

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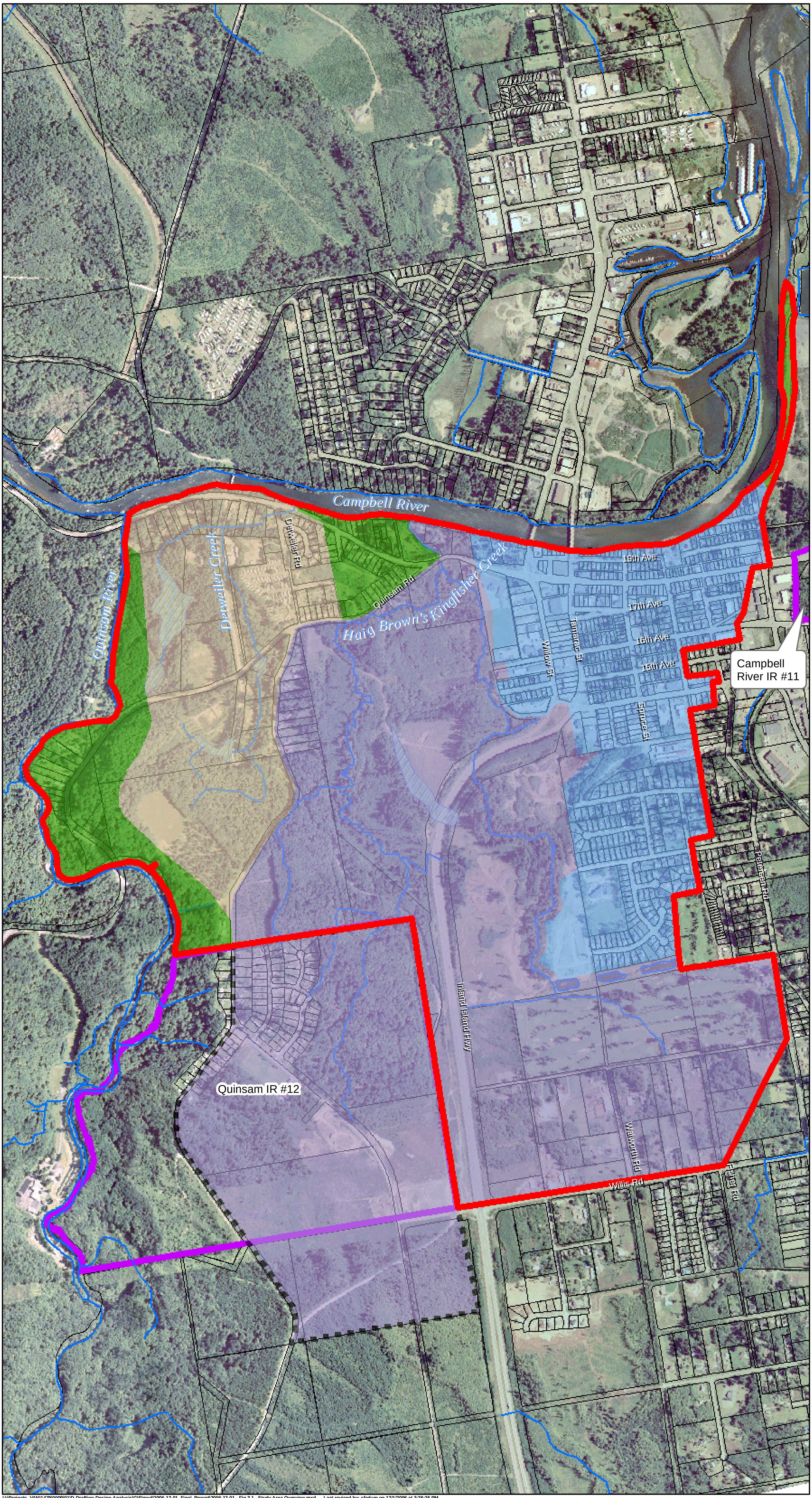
APPENDIX A

OVERSIZED TABLES AND FIGURES



City of Campbell River

Campbell River/ Quinsam River Integrated Stormwater Management Plan

Figure 3.1 Study Area Overview

- River/Stream
- Wetlands
- Study Area Boundary
- City of Campbell River Boundary

Catchment Areas

- Campbellton Drainage
- Detweiler Creek
- Kingfisher Creek
- River Bank Drainage

0 300
Metres

1:12,500

This map was prepared for the purposes of this planning study and are provided for general reference only. Site specific information must be obtained and provided to the City to confirm the actual site conditions at any location.

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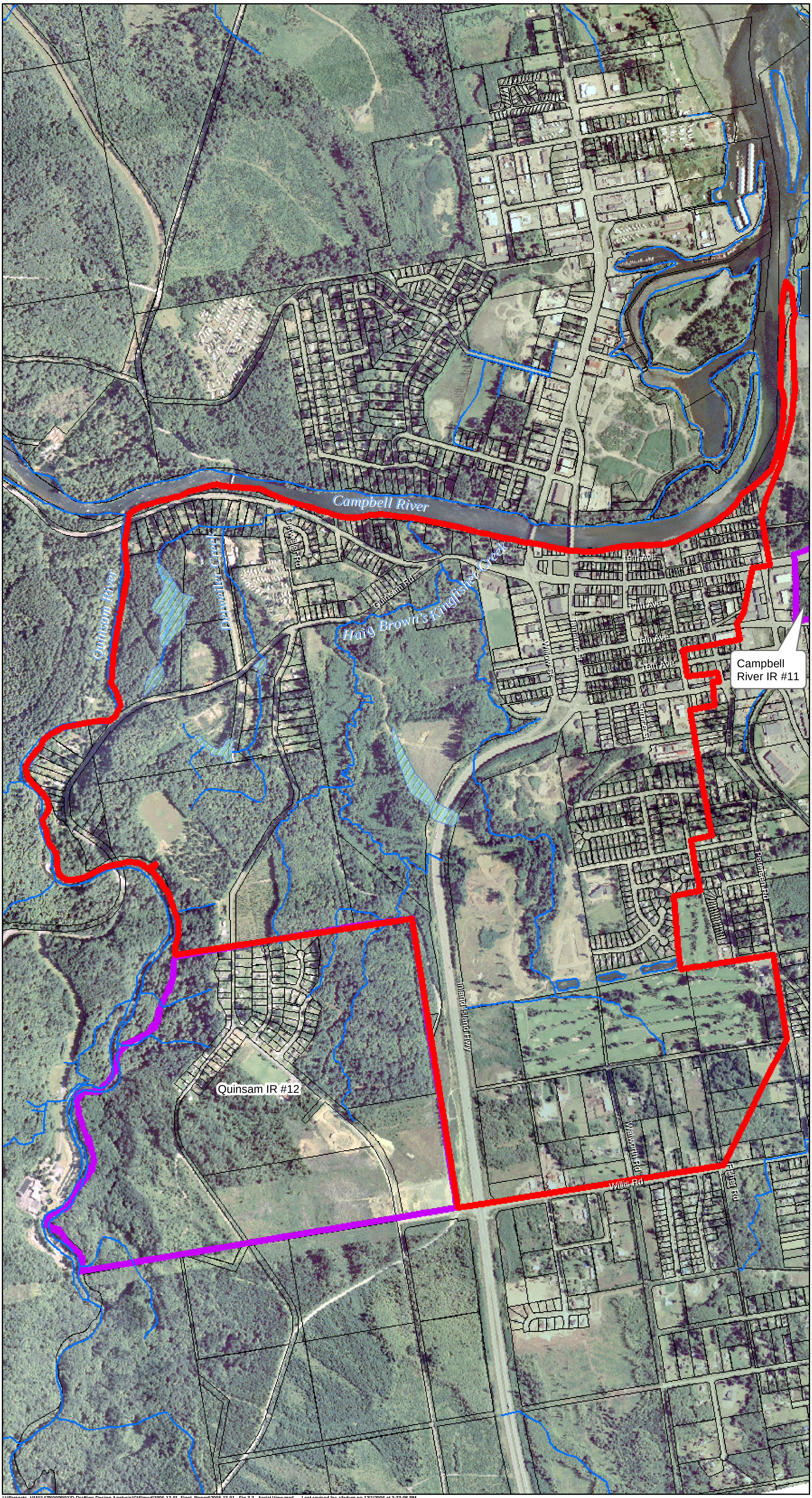

City of Campbell River

Campbell River/ Quinsam River Integrated Stormwater Management Plan

Figure 3.2 Aerial View

- River/Stream
- Wetlands
- Study Area Boundary
- City of Campbell River Boundary

0 150 300
Metres

1:12,500

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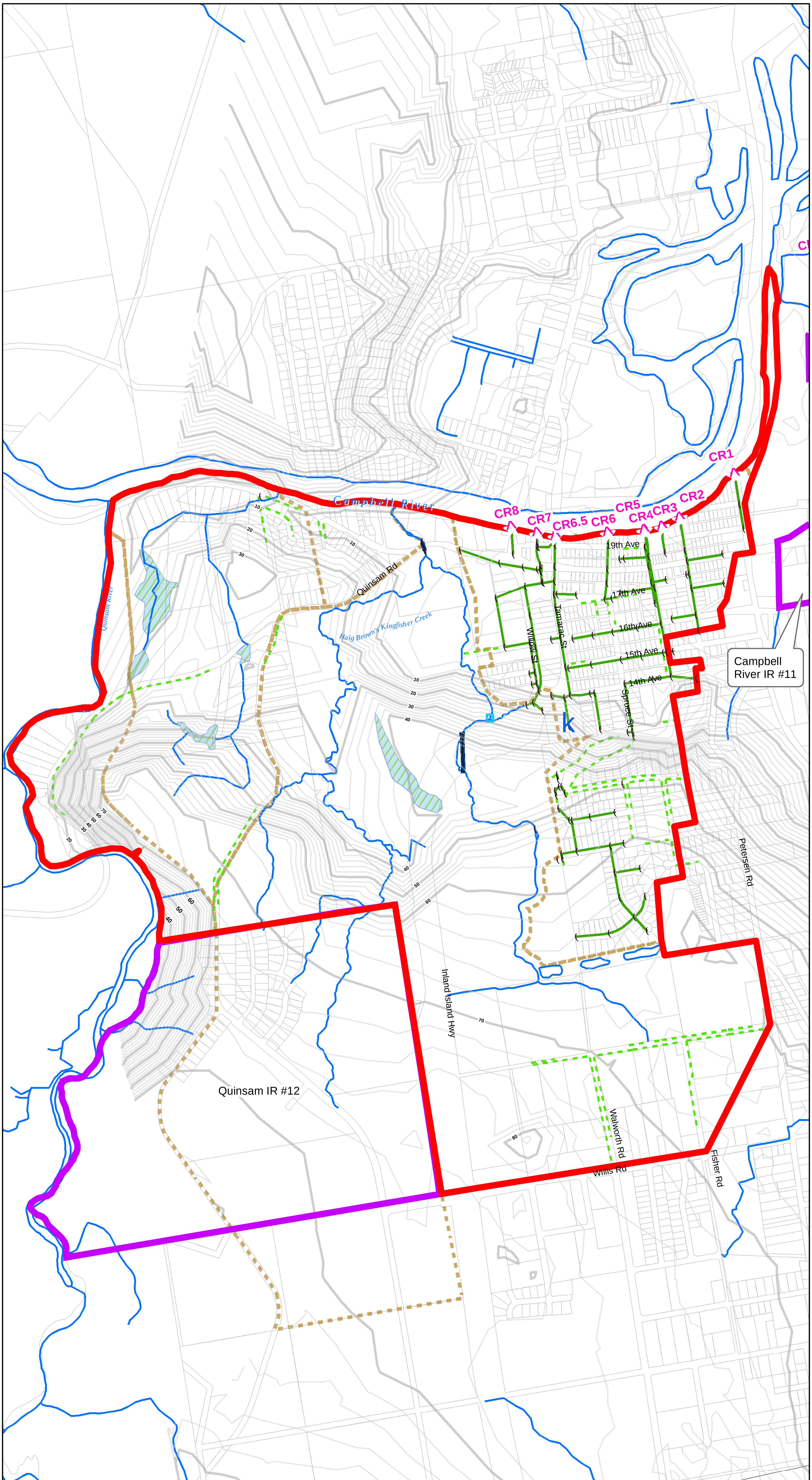

City of Campbell River

Campbell River/ Quinsam River Integrated Stormwater Management Plan

Figure 3.3 Topography

- Water Qulaity Pond
- Drainage Outfall
- Drainage Manhole
- Diversion Structure
- Drainage Ditch
- Drainage Main
- Contours (2m)
- Culvert
- River/Stream
- Wetlands
- Study Area Boundary
- City of Campbell River Boundary
- Catchment Area Boundary

0 145 290
Metres

1:12,500

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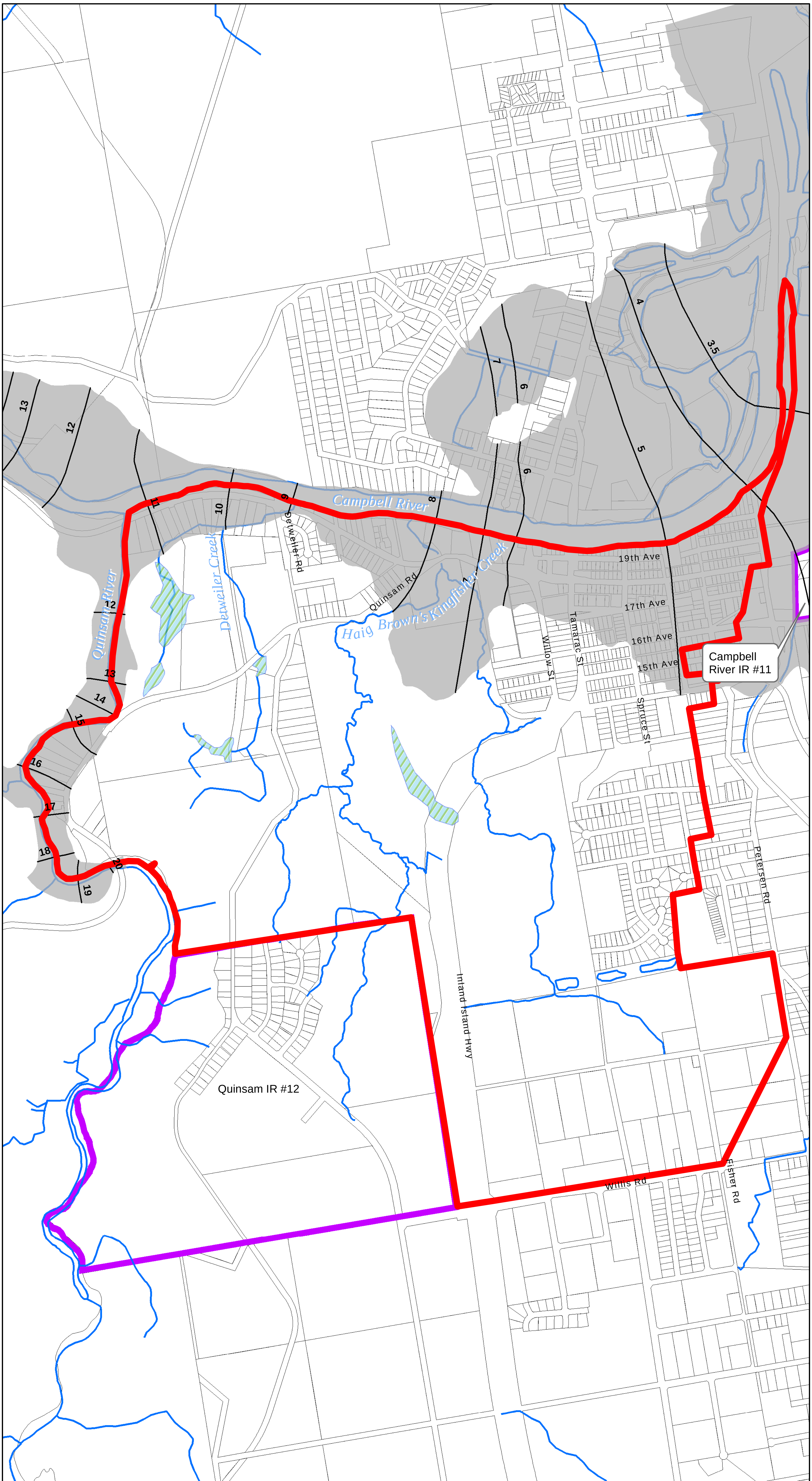

City of Campbell River

Campbell River/ Quinsam River Integrated Stormwater Management Plan

Figure 3.4 Floodplain

River/Stream

Wetlands

Study Area Boundary

City of Campbell River Boundary

200 yr Floodplain With Water Surface Elevation Contours

0 150 300

Metres

1:12,500

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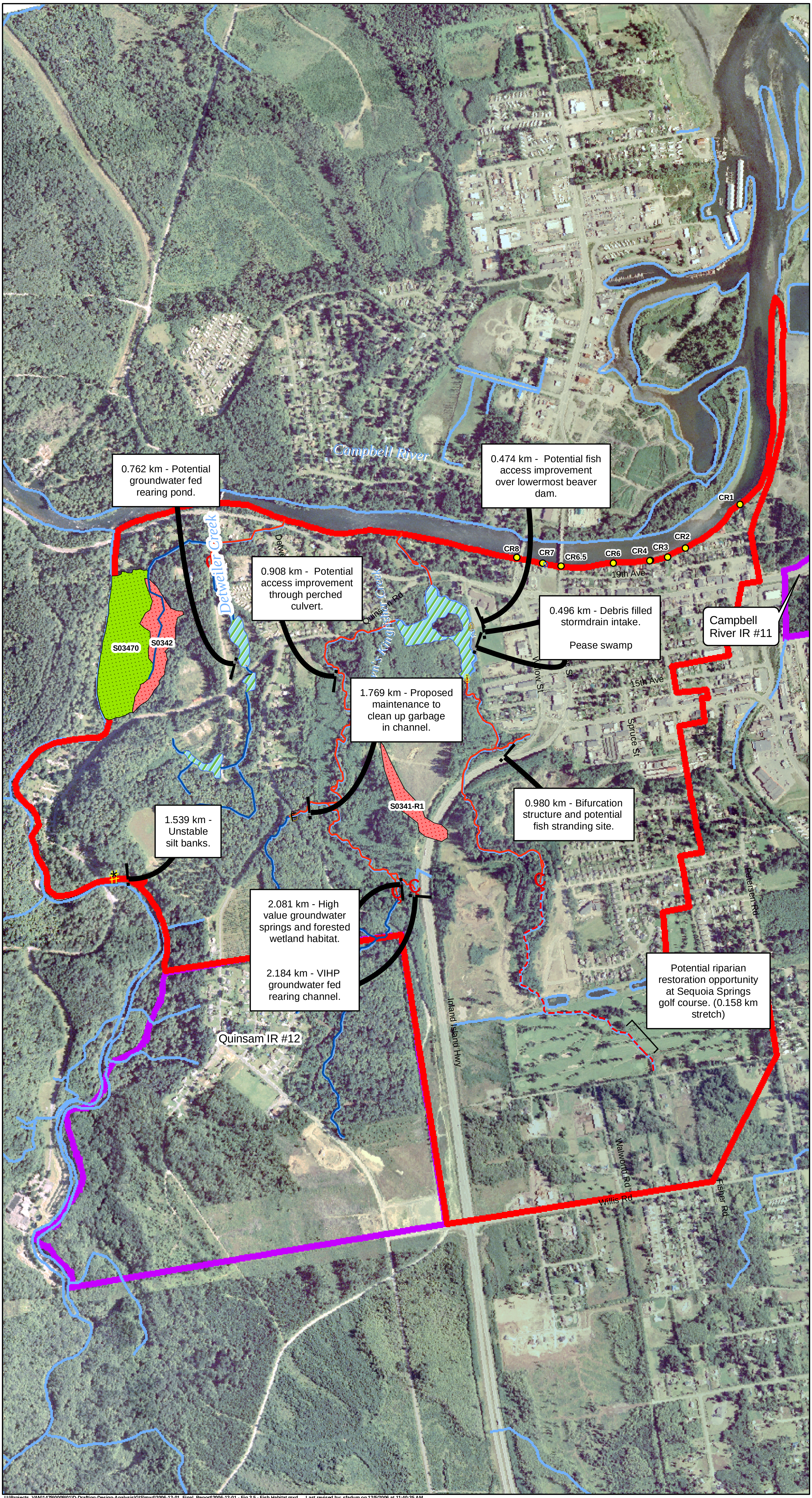

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City of Campbell River

Campbell River/ Quinsam River Integrated Stormwater Management Plan

Figure 3.5
Fish Habitat

Anadromous Distribution
- @ Beaver Dam
- Beaver Pond
- Bifurcation Structure
- Outfall
- Debris on High Flow Outlet Structure
- Ending Silt Bank
- Fish Accessible Outfall
- Habitat Restoration
- Mature Riparian Corridor
- Potential Rearing Channel
- End of Anadromous Distribution

Fish Distribution
- Known Anadromous Fish Distribution
- Known Resident Fish Distribution
- Unknown Fish Presence/Absence

Riparian Wetland
- Wetland
- SEI Designated Riparian Habitat
- SEI Designated Wetland Habitat
- River/Stream

- City of Campbell River Boundary
- Study Area Boudary

0 150 300
Metres

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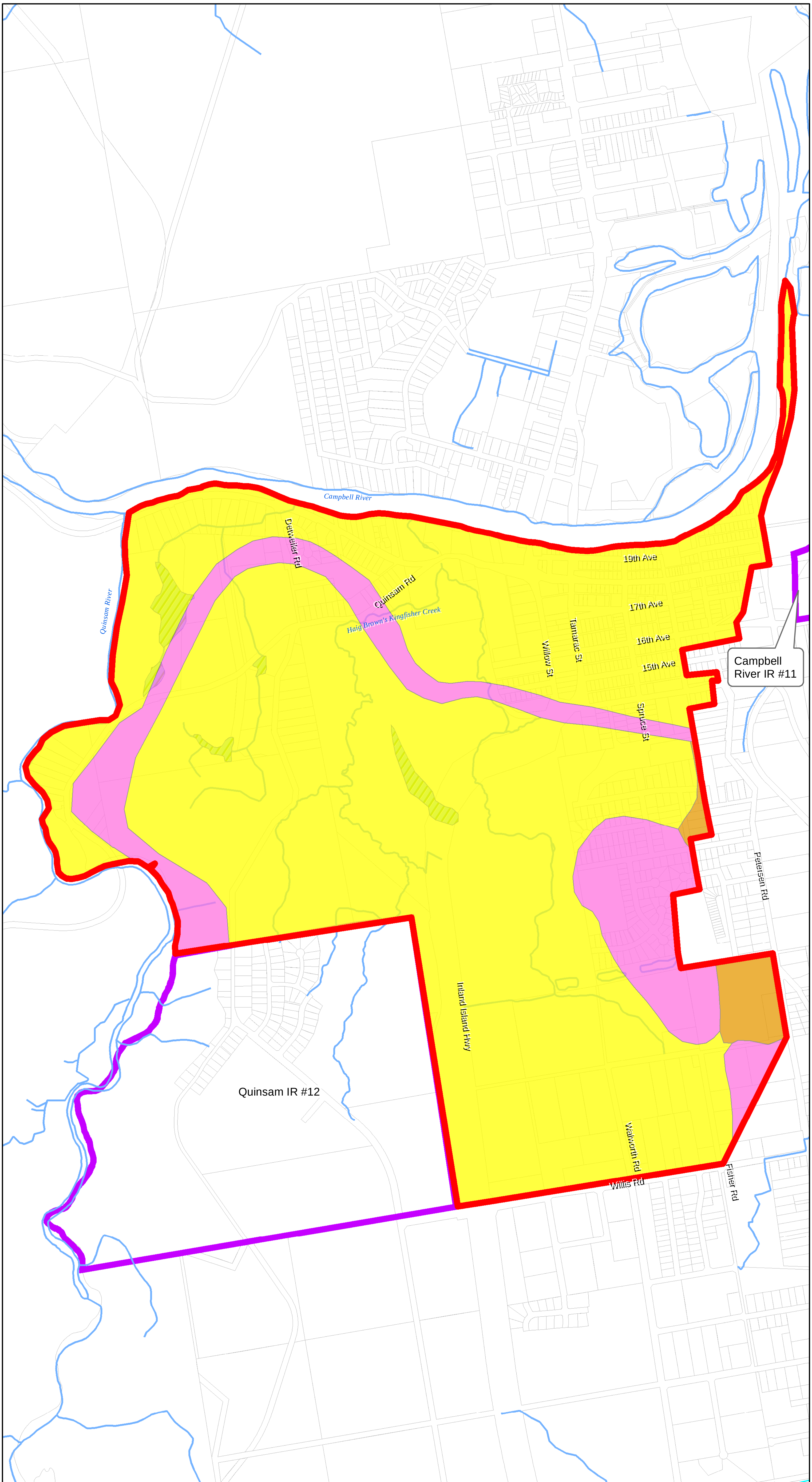

City of Campbell River

Campbell River/ Quinsam River Integrated Stormwater Management Plan

Figure 3.6 Long-Term Stormwater Infiltration Potential

High Potential (>25mm/hr)*
Medium (3-25mm/hr)*
Low (<3mm/hr)*
Wetlands
Study Area Boundary
City of Campbell River Boundary
River/Stream

*Long-term saturated hydraulic conductivity

0 150 300
Metres

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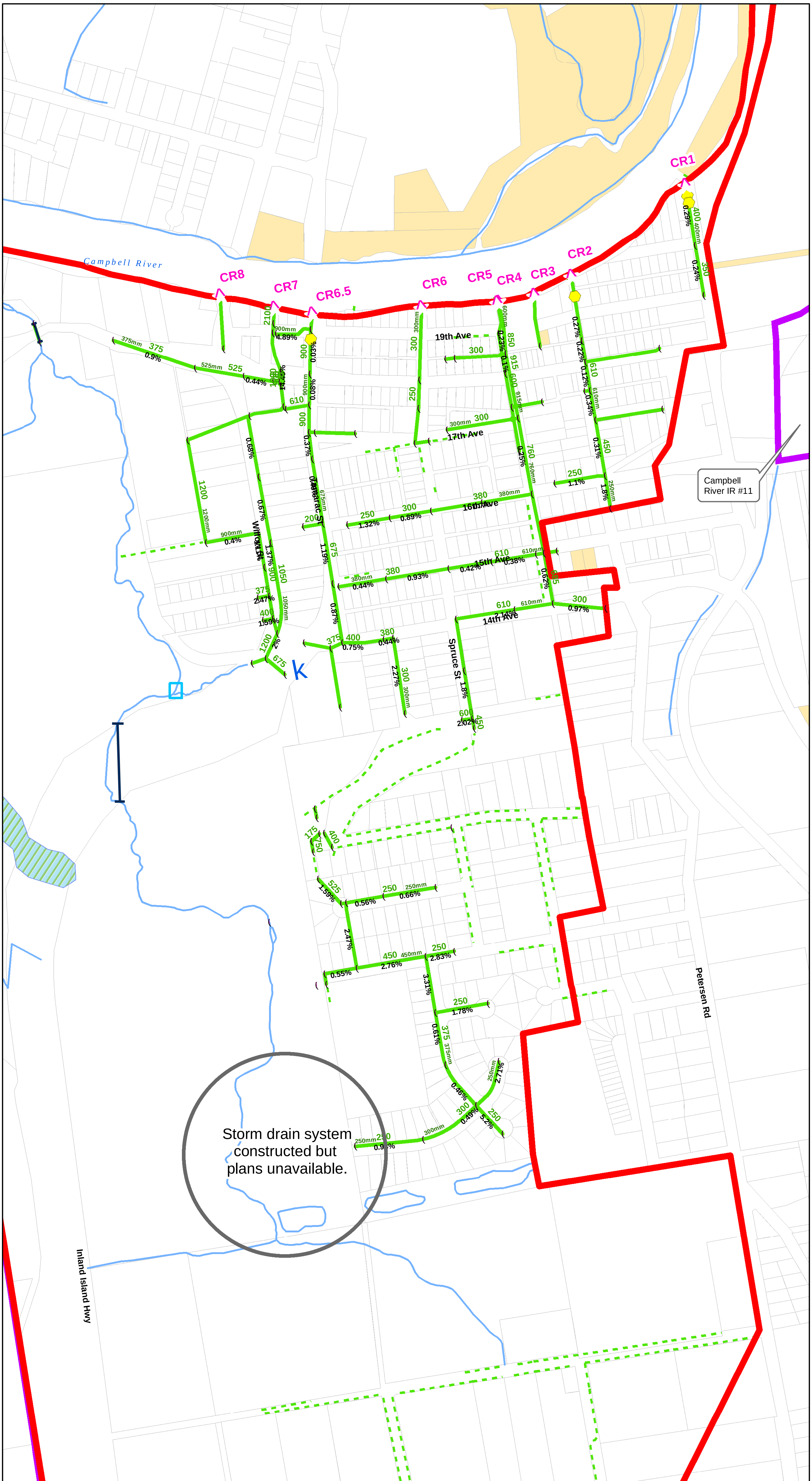

City of Campbell River

Campbell River/ Quinsam River Integrated Stormwater Management Plan

Figure 3.7 Municipal Drainage System

- Water Quality Pond
- Drainage Outfall
- Drainage Manhole
- Oil Separator
- Diversion Structure
- Drainage Main
- Drainage Ditch
- Culvert
- River/Stream
- City Owned Parcels
- Wetlands
- Study Area Boundary
- City of Campbell River Boundary

0 75 150
Metres

1:6,000

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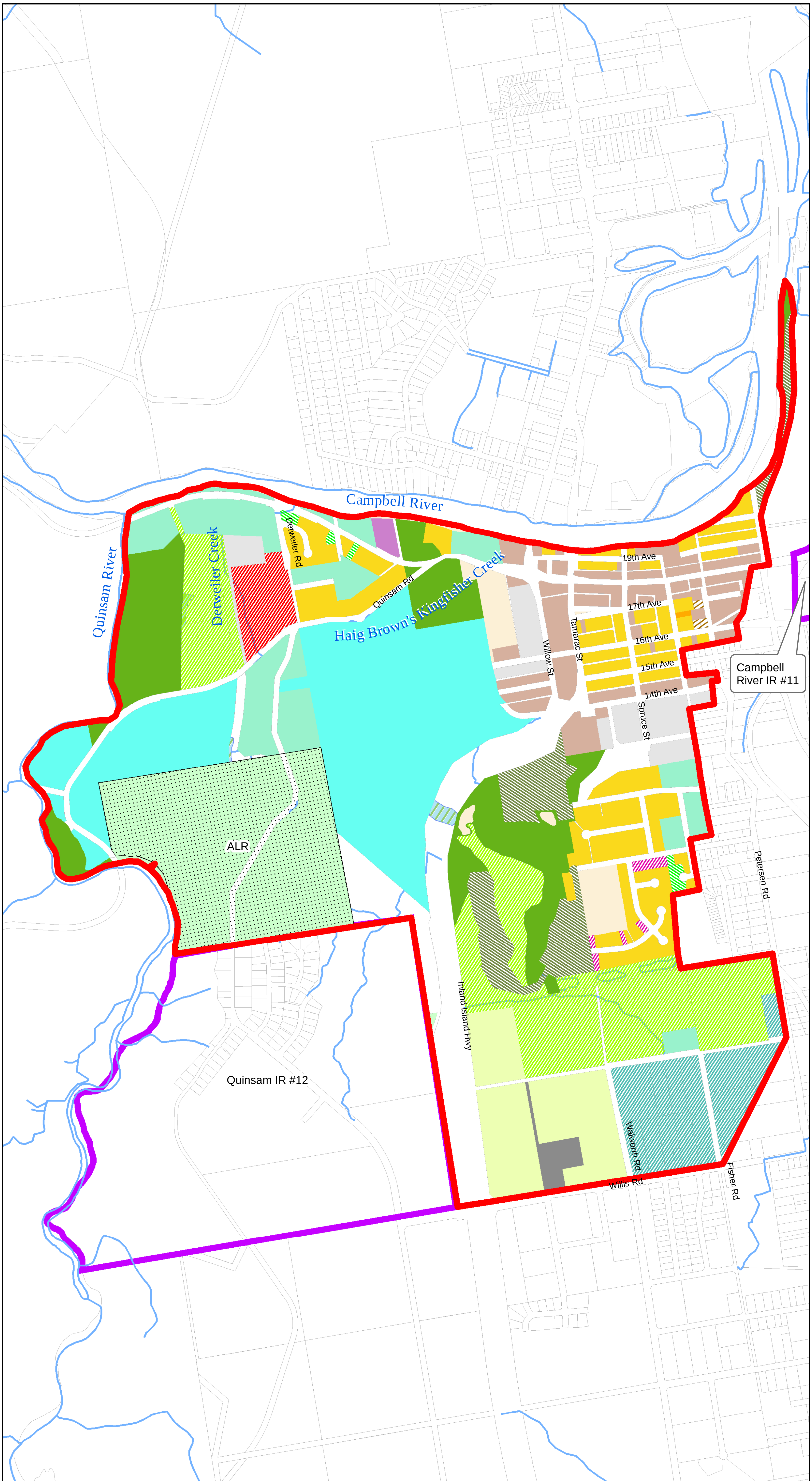

City of Campbell River

Campbell River/ Quinsam River Integrated Stormwater Management Plan

Figure 3.8 City of Campbell River Zoning Designations

- C-3 Commercial Three
- C-5 Commercial Five
- G-1 Greenways
- I-1 Industrial One
- I-3 Industrial Three
- MH-2 Mobile Home Two
- PA-1 Public Assembly
- R-1 Residential One
- R-1A Residential One A
- R-2 Residential Two
- RM-1 Residential Multiple 1
- RM-2 Residential Multiple 2
- RM-3 Residential Multiple 3
- RR-1 Rural Recreation
- RU-1 Rural One
- RU-2 Rural Two
- RI-1 Residential Infill One
- RI-2 Residential Infill Two
- RI-3 Residential Infill Three

- River/Stream
- Wetlands
- ALR
- Study Area Boundary
- City of Campbell River Boundary

0 150 300
Metres

1:12,500

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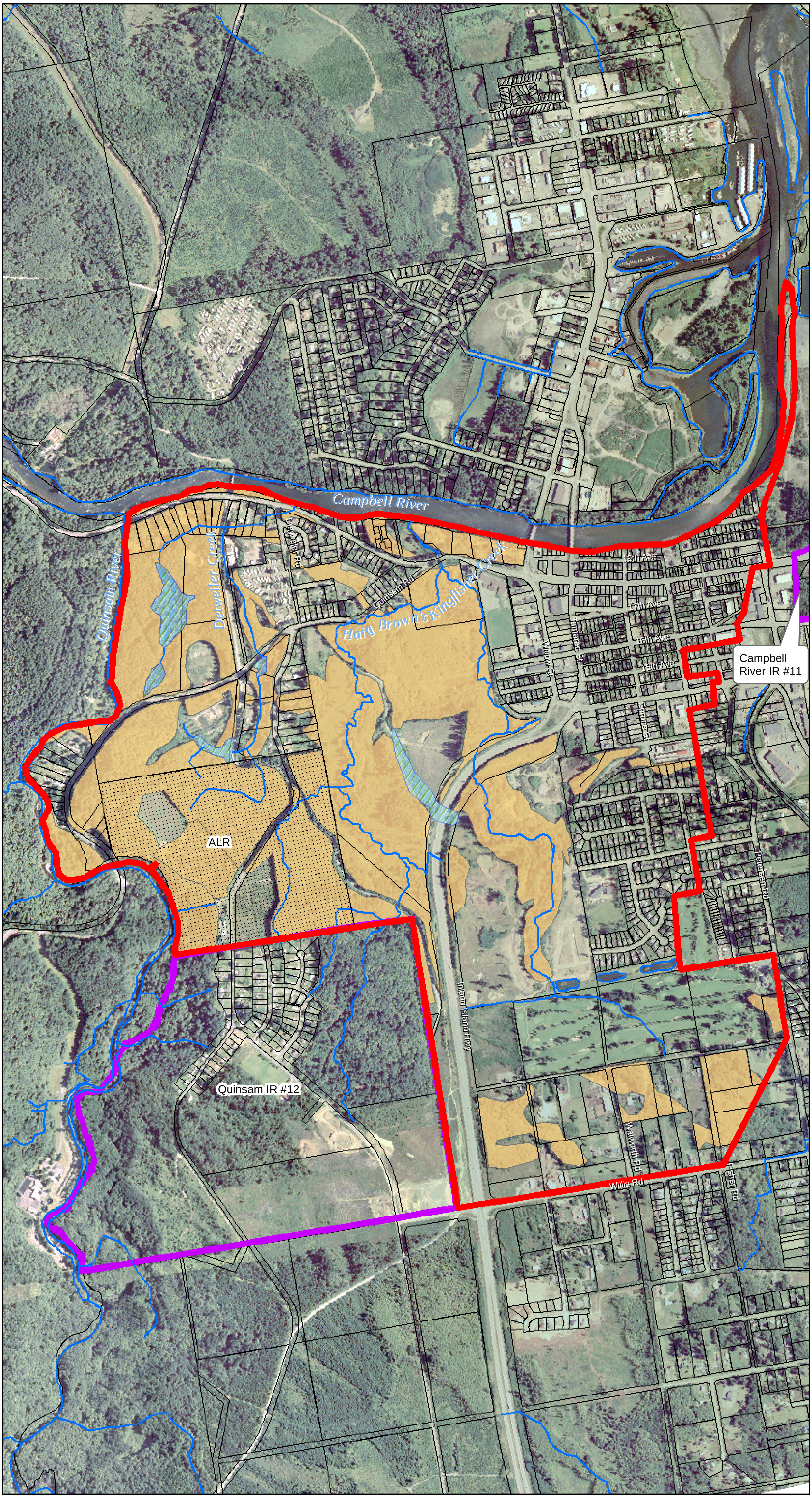

City of Campbell River

Campbell River/ Quinsam River Integrated Stormwater Management Plan

Figure 3.9 Wooded Areas

Wooded Area

River/Stream

Wetlands

ALR

Study Area Boundary

City of Campbell River Boundary

0 150 300

Metres

1:12,500

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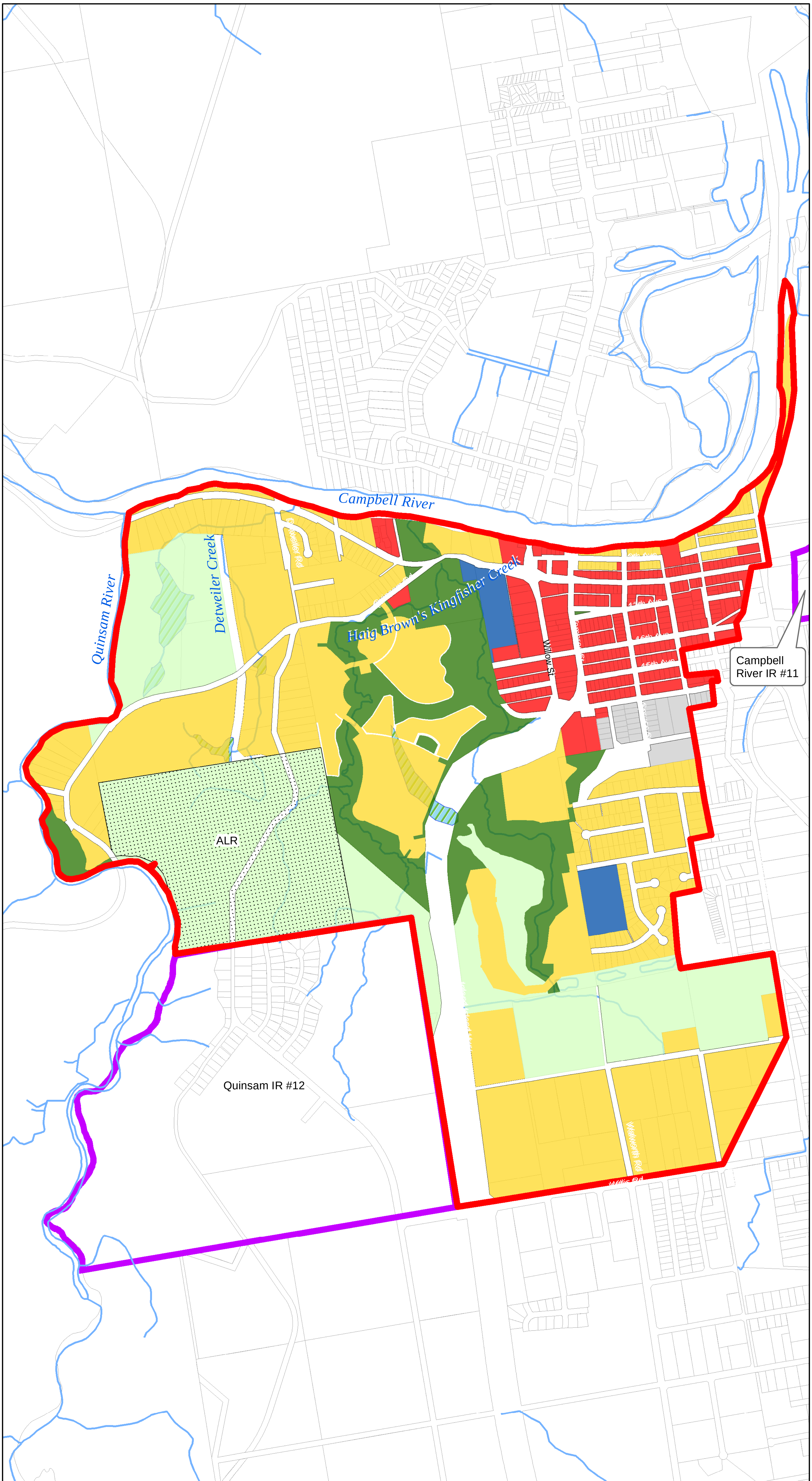

City of Campbell River

Campbell River/ Quinsam River Integrated Stormwater Management Plan

Figure 3.10 City of Campbell River Official Community Plan (OCP)

- Commercial
- Industrial
- Institutional
- Residential
- Park / Natural Areas
- Rural
- Water
- Road
- River/Stream
- Wetlands
- ALR
- Study Area Boundary
- City of Campbell River Boundary

0 150 300
Metres

1:12,500

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URBANSYSTEMS

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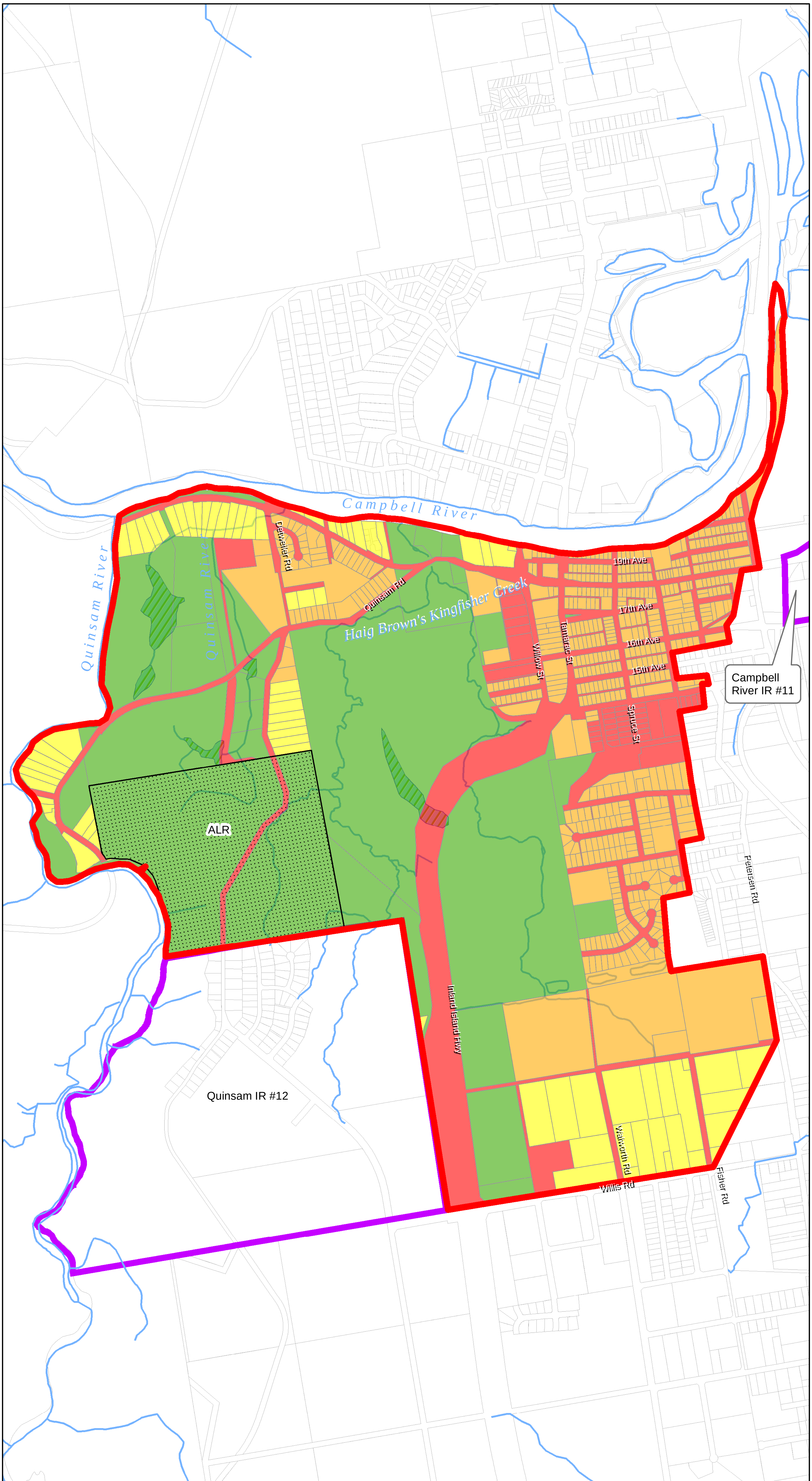
City of Campbell River

Campbell River Quinsam River Integrated Stormwater Management Plan

Figure 5.5 Hydrologically Significant Existing Land Uses



- 4 - Commercial and Industrial High Impervious area; High potential for pollutant load (includes streets and highways)
- 3 - High Density Residential and Non-polluting Commercial
- 2 - Low Density Residential
- 1 - Open and Park Space Low Impervious area; Low potential pollutant load
- River/Stream
- Wetlands
- ALR
- Study Area Boundary
- City of Campbell River Boundary

0 150 300
Metres

1:12,500

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URBANSYSTEMS.

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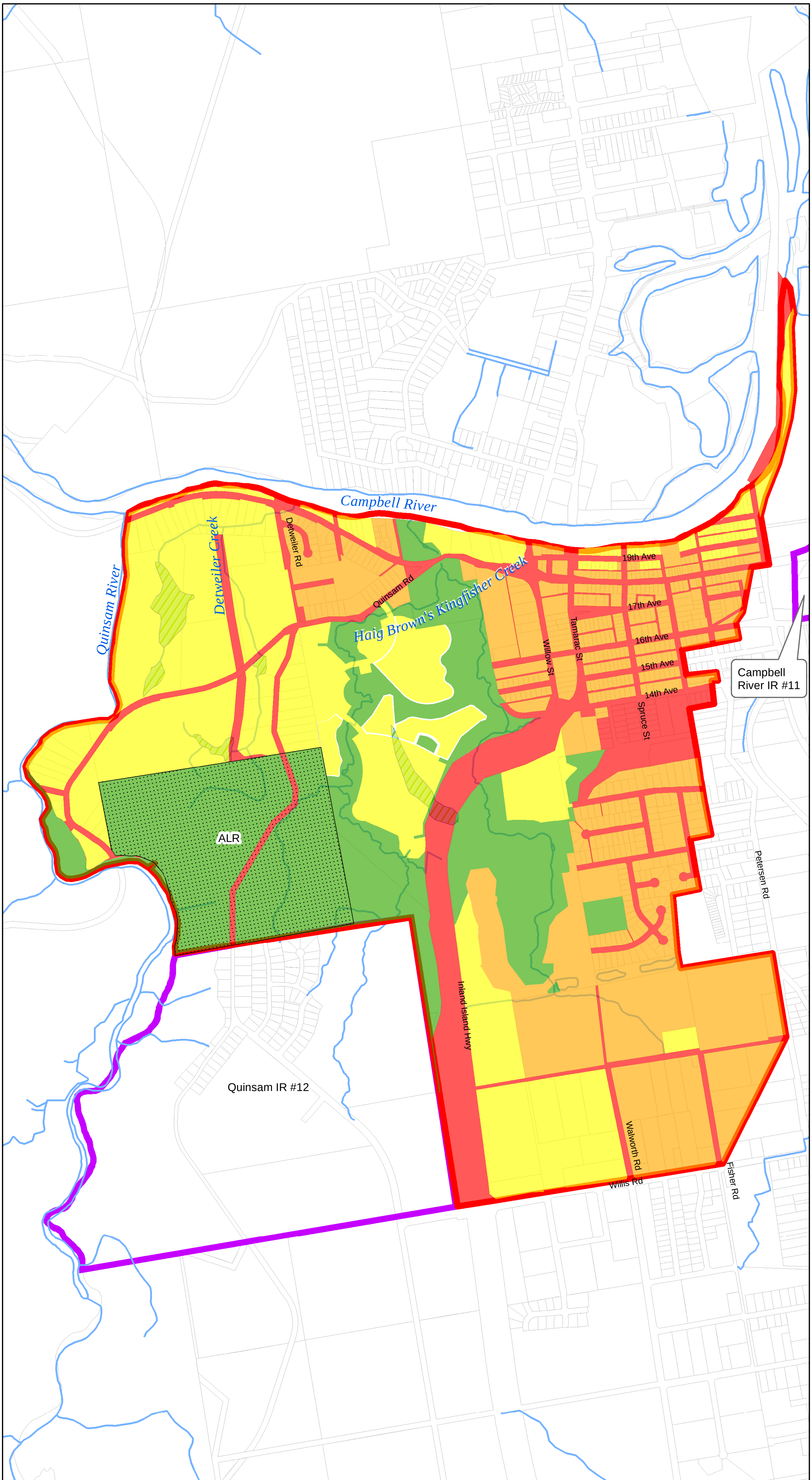

City of Campbell River

Campbell River/ Quinsam River Integrated Stormwater Management Plan

Figure 5.6 Hydrologically Significant Future Land Uses

- 4 - Commercial and Industrial High Impervious area; High potential for pollutant load (includes streets and highways)
- 3 - High Density Residential and Non-polluting Commercial
- 2 - Low Density Residential
- 1 - Open and Park Space Low Impervious area; Low potential pollutant load
- River/Stream
- Wetlands
- ALR
- Study Area Boundary
- City of Campbell River Boundary

0 150 300
Metres

1:12,500

This map was prepared for the purposes of this planning study and are provided for general reference only. Site specific information must be obtained and provided to the City to confirm the actual site conditions at any location.

URBANSYSTEMS.

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Table 7.3 - General Performance[1] of Common Best Management Practices (BMPs) Designed Per Typical Current Standards and Guidelines

BMP	TPH	Gross Sediments (litter)	Coarse Sediments (Sand)	Coarse & Fine Sediments (Silt/Clay)	Bacteria	Dissolved Pollutants					Pros	Cons	Limitations
						P	N	Zn	Other Metals	Pesticides[9]			
Screen		Good									Likely most cost-effective system for litter	Frequent[10] maintenance	Only removes litter
CB Insert		Good	Good	Low							Likely best for retrofit of sites with specific problems	Frequent[10] maintenance; performance is modest	Can not meet 80% TSS removal; for small catchments only in areas with high intensity rainfall
Small manufactured wet vault	Fair	Good	Good	Low	Low						Small space, underground; no landscaping maintenance	No infiltration; frequent[10] maintenance	Likely can not meet 80% TSS removal
Standard wet vault	Fair	Good	Good	Fair to good[8]	Fair						Underground; no landscaping maintenance	No infiltration; maintenance access required	
Oil-water separator	Good[2]	Good	Good	Fair	Low						Underground; no landscaping maintenance	No infiltration; frequent[10] maintenance	May not be able to meet 80% TSS removal using current typical sizing criteria
Swirl concentrator ("vortex-type" separator)	Fair	Good	Good	Fair	Low						Small space, underground; no landscaping maintenance	No infiltration; frequent[10] maintenance	Likely can not meet 80% TSS removal
Swale/strip[3]	Fair	Good	Good	Fair	Low	Low	Low	Low	Low	Low	Can integrate with landscaping; effective as strips along roads	Requires landscaping maintenance; can be a bacteria source; tends to be repository for litter (and dog poop) if near pedestrian traffic	May not be able to meet 80% TSS; for small catchments only in areas with high intensity rainfall
Sand filter	Good	Good	Good	Good	Fair			Fair[4]	Low[4]		Likely highest TSS performance	Takes up land; frequent[10] maintenance; no infiltration[13]	Requires elevation drop[11]
Amended sand filter[5]	Good	Good	Good	Good		Fair		Good	Fair	Fair	Likely highest TSS performance; can select media for target dissolved pollutants	Takes up land; frequent[10] maintenance; no infiltration[13]	Requires elevation drop[11]
Manufactured filter[6]	Fair to good	Good	Good	Fair to good		Fair[6]	Fair[6]	Fair[6]	Fair[6]	Fair[6]	Small space, underground, no landscaping maintenance; can select media for target dissolved pollutants	Frequent[10] maintenance; no infiltration	May not be able to meet 80% TSS removal; likely varies with product depending on design criteria
Dry extended detention basin		Good	Good	Good							Reduces mosquito potential when dry; can be integrated with flow control needs; some infiltration	High land requirement; landscaping maintenance[12]; potential for outlet clogging	Requires elevation drop[11]
Wet extended dentention basin	Fair to good	Good	Good	Good	Fair[8]	Fair	Fair	Fair	Fair	Fair	Provides some dissolved pollutant removal; can be integrated with flow control needs; some infiltration possible	High land requirement; landscaping maintenance[12]; potential for outlet clogging; possible mosquitoes; possible thermal effects; possible desorption of pollutants in base flow; can be a bacteria source	
Infiltration[7]	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Removes dissolved pollutants; helps hydrologic cycle; integrates with flow controls	Land area; landscaping maintenance unless subsurface system	Coarse soils (NRCS Type 'A') generally require treatment before infiltration can occur
Wet pond	Good	Good	Good	Good	Fair	Good	Good	Good	Fair	Good	Removes dissolved pollutants; integrates with flow controls; possible less area than extended detention basins; less area than wetlands; some infiltration if not lined	High land requirement; landscaping maintenance[12]; possible mosquitoes; possible thermal effects; possible desorption of pollutants in base flow; can be a bacteria source	
Wetland	Good	Good	Good	Good	Fair	Good	Good	Good	Fair	Good	Removes dissolved pollutants; aesthetic and wildlife benefits; integrates with flow controls; some infiltration if not lined	High land requirement; landscaping maintenance[12]; possible mosquitoes; possible thermal effects; possible desorption of pollutants in base flow; can be a bacteria source; some wetland residents may become pests	May need base flow to maintain plants, which may degrade performance

Notes:

1 "Good" >75%; "Fair" about 50%; "Low" <25% (Removal efficiencies are highly dependent on influent concentrations, decreasing as influent concentrations decrease.)

2 If designed specifically as an oil/water separator; not much data on performance of "true" oil/water separators.

3 Flow-through swale, not counting infiltration that may be significant at some sites; removal of dissolved pollutants higher when significant infiltration occurs.

4 Recent data indicate sand filters remove dissolved metals. Removal of zinc tends to be high compared to other metals due to high concentrations in runoff; removal of efficiencies of other metals such as copper limited by low influent concentrations.

5 Amended with various media or amended on sand surface to remove dissolved pollutants; pollutant removed varies with the amendment.

6 Dissolved pollutant removal depends on type of media; removal is limited to fair because media in manufactured filters is usually coarse unlike sand filters.

7 Includes bioretention, dry swales, and all forms of systems intended for infiltration. Performance assumes U.S. NRCS Type 'B' Soils, with performance reduced in coarser soils.

8 Performance level is conjectural; more data needed.

9 Very little data available.

10 At least once a year or more often.

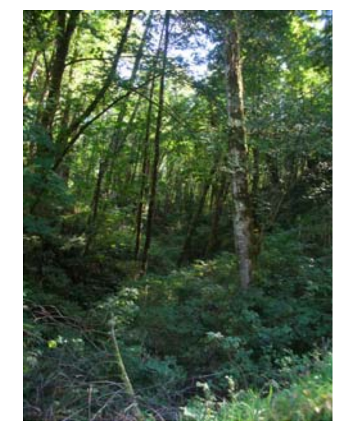
11 All BMPs require some drop in elevation, but sand filters can require 2-3 m.

12 Landscaping maintenance can be as frequent, if not more so, than for systems like sand filters, and may in fact require more time than maintenance of the treatment system itself.

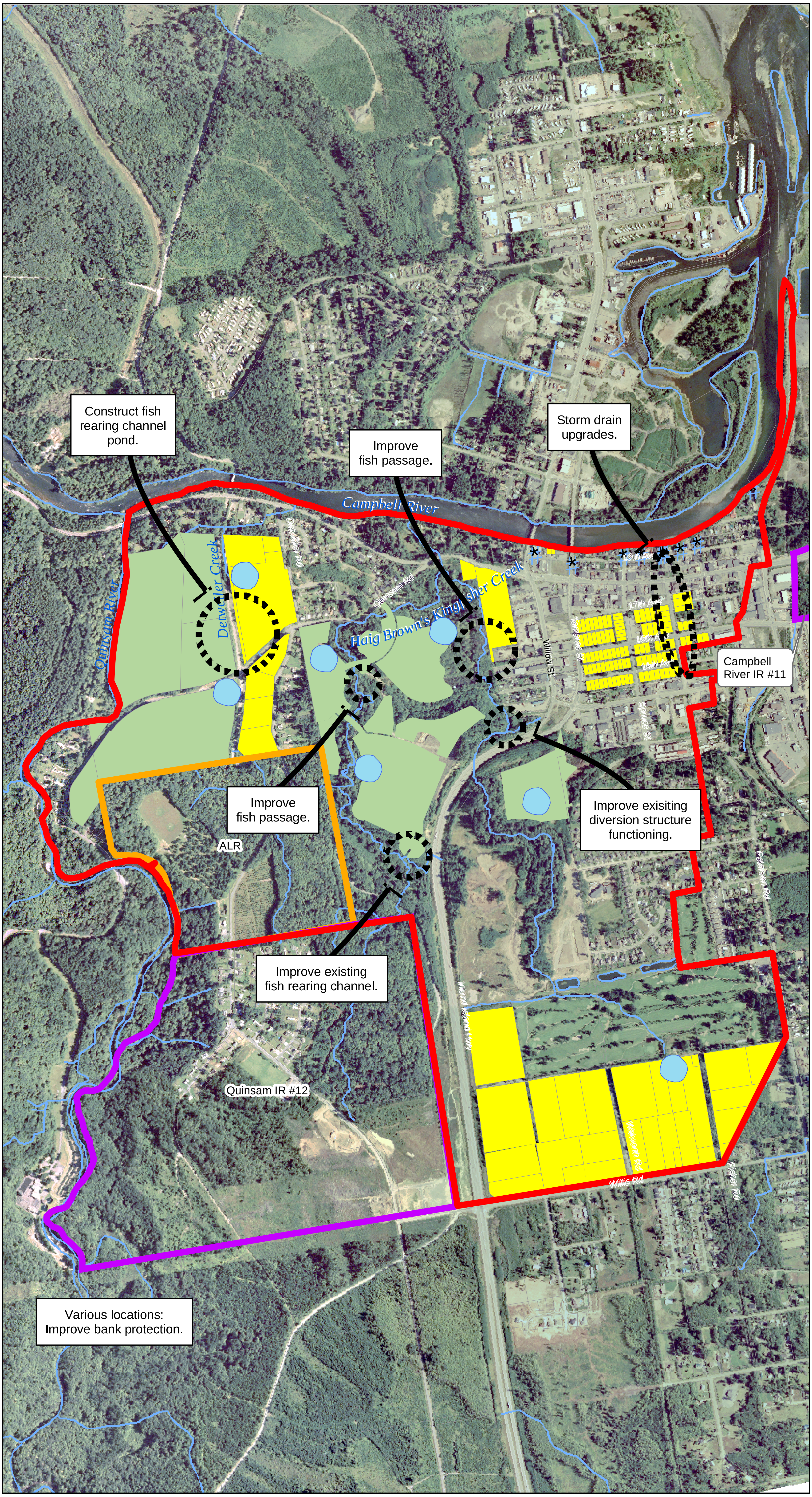
13 Infiltration can occur if bottom is not lined.

Table courtesy of Gary Minton, PhD, Resource Planning Associates, Seattle, Washington, February 2006

Key Habitat Issue	Stormwater Management Opportunities	Habitat Protection/Improvement Opportunities	Photos	Recommendations
1. Water quality concerns for stormwater effluent and lack of systematic water quality monitoring in the Campbellton industrial area.	1-1 Conduct Water Quality monitoring at priority sites as outlined in Table 1 that includes Outfall CR 6.5 and 7. 1-2 Based on WQ results modify and/or install additional or alternate oil/water separators or utilize other water treatment methods to reduce outflow of pollutants into the Campbell River mainstem. 1-3 Provide FOC information regarding Emergency Spill Response Procedures or current HASMAT procedures currently adopted by the City of Campbell River.	1-4 Minimize or eliminate pesticides use by the public for cosmetic purposes. 1-5 Increase awareness of residential and commercial sectors regarding release of deleterious substances into the storm drain system through a BMP handout. Educate the public, regarding the positive effects of low impact development and alternative stormwater strategies through outreach and support programs to foster compliance and cooperation.		
			Photo CRQ-1. Outfall CR-6.5 at Maple St where groundwater flows were observed in September 2006.	**Photo CRQ-2 . Typical view of Campbellton Light industrial area.**
2. Protection of groundwater flows and natural hydrologic regime	2-1. Promote source control treatment of stormwater runoff (bioswales, vegetated ditches, minimizing impervious surface area to <10% etc) strives to mimic natural runoff delivery rates 2-2. Ensure that development design plans sustain soil and water quality as well as maintenance of natural pre-development groundwater flows. 2-3. Initiate a flow study to include the determination of low flows, baseflows and peak flows as well as confirm all locations of groundwater supply sites within the Haig Brown Kingfisher Creek and Detweiler Creek drainages.	2-4. Investigate feasibility of securing flows from an old well on the original Ben Fellow's farm site (now Sequoia Spring) to supplement summer low flows in the East Fork of HBKF Creek (Stearns 1996). The well supplied an estimated 1500 gallons of water/day. 2-5. Investigate groundwater intake system of the VIHP rearing channel in Haig Brown KC west to determine the cause of poor water quality conditions in the channel while groundwater springs were visible 15 m west of the channel.		
			Photo CRQ-3. Groundwater rearing channel constructed as VIHP compensation works in HBKC East (1999).	**Photo CRQ-4. Downstream view of lower HBKC West illustrating groundwater fed rearing habitat observed in August 06.**
3. Conservation of High value wetlands and streams in Haig Brown and Detweiler Creeks	3-1. Promote sustenance of wetlands by implementation of alternate stormwater design standards for undeveloped land where new developments aim for source control and strive to mimic natural runoff rates.	3-2. Determine feasibility to construct a groundwater fed rearing channel/pond in Detweiler Creek east, immediately downstream of Quinsam Rd. 3-3. Establish conservation status for Pease swamp and the wetland adjacent to the VIHP rearing channel in HBKC as well as wetland habitat in Detweiler Creek. 3-4. Investigate drainage like ditch that has been excavated along the SEI Wetland #S0341-R1 in the middle reaches of HBKC.		
			Photo CRQ-5. Upstream view of marsh habitat and potential groundwater fed rearing channel in Detweiler Creek (Sept 06).	**Photo CRQ-6. Upstream view of upper constructed rearing pond within the middle reaches of HBKC East (Aug 06).**

Key Habitat Issue	Stormwater Treatment Opportunities	Habitat Protection/Improvement Opportunities	Photos	Recommendations
4. Fish Access and Flows through the E fork of Haig Brown Creek	4-1. Ensure regular maintenance of stormwater drainage structures including the high flow bifurcation structure and the overflow intake at the Campbellton elementary school field. 4-2. Determine whether flow diversion between the East Fork and the Tamarac St culvert is optimal during moderate and high flows.	4-3. Investigate the feasibility of hand excavating defined channels in the East fork of HBKC through Pease Swamp to facilitate fish access and ensure availability of groundwater flows to the lower reaches of Haig Brown Creek, particularly through summer low flow periods. 4-4. Investigate the feasibility of installing a steep pass fishway to facilitate juvenile access over the lowermost dam at the Campbellton elementary school field (Photo CRQ-8). 4-5. Improve fish passage in HBKC through logging road culvert 650 m upstream of the east/west split (CRQ-7). 4-6. Investigate fish stranding potential in the high flow channel downstream of the bifurcation structure.		
			Photo CRQ-7. Upstream view of 45 cm jump from a 25 cm deep plunge pool during low flows in HBKC.	**Photo CRQ-8. Lateral view of the lowermost beaver dam in Pease slough at the Campbellton school (Aug 06).**
5. Conservation of riparian habitat and wildlife migration corridors along Detweiler, HBKC and Quinsam River		5-1. Establish adequate leave strips along all stream banks to ensure ecological integrity of the riparian is maintained 5-2. Sustain or stabilize riparian corridors to increase channel and bank stability in steep ravines and gullies typical to Haig Brown Kingfisher Creek East upstream of the IIH as well as in the lower Quinsam River. 5-3. Increase riparian cover through the Sequoia Spring golf course by planting Native shrubs where possible to increase instream and riparian complexity. Determine acceptable species with the golf course owner Barrie Brown (HKCS 1996). 5-4. Investigate classification and potential for conservation status designation for groundwater fed wetland habitat in HBKC immediately downstream of the Inland Island highway.		
			Photo CRQ-9. Upstream view of mature riparian habitat in upper HBKC West Fork (Sept 06).	**Photo CRQ-10. Aerial photo illustrating riparian planting opportunities through the Sequoia Springs golf course.**
6. Potential fish presence and utilization of storm drains immediately East of the Haig Brown Kingfisher Creek system along Willow St and adjacent to the Campbellton Elementary School.		6-1. Undertake fish sampling to determine extent of fish distribution in upper HBKC and Detweiler Creek as well as in culverts between the bifurcation structure and Outfall at the Campbell River mainstem (CR#*) at the Enns property to determine utilization of culverts by rearing salmonids.		
			Photo CRQ-11. Overflow to stormdrain system at HBKC bifurcation structure (Oct 06).	**Photo CRQ-12. Lateral view of Outfall CR-7 with groundwater flows supporting salmonids in the outflow channel (Sept 06).**

Key Habitat Issue	Stormwater Treatment Opportunities	Habitat Protection/Improvement Opportunities	Photos	Recommendations
7. Quinsam River and Haig Brown East Fork bank instability	7-1. Ensure that future stormwater design sustains existing riparian vegetation and conveys stormwater away from steep erodable silt banks along the Quinsam River mainstem and tributaries.	7-2. Assess and determine feasibility of bioengineering options to assist in stabilization of eroding banks in the Quinsam River. 7-3. Assess bank instability issues documented in Haig Brown Creek at 150m, 650m, 966m and 1100 m upstream of the mouth and determine riparian treatment and bioengineering options if necessary.		
			Photo CRQ-13. Upstream view of eroding right bank in the lower Quinsam River at Argonaut Rd (Sept 06).	**Photo CRQ-14. Lateral view of silt bank erosion in the Quinsam River at Argonaut Rd (Sept 06).**
8. Maintenance activities in Kingfisher Creek East	8-1. Determine elevation of discharge from over the lowermost beaver dam, this outflow structure and any other discharge points from Pease swamp. 8-2. Clear debris from high flow intake at Campbellton Elementary school field to appropriate elevation according to Recommendation 8-1. If necessary, install beaver proof intake system at the appropriate water level where pond habitat is sustained and flood flow levels are controlled.	8-3. Clean up debris and garbage deposited into the channel at the Forestry Road in HBKC East.		
			Photo CRQ-15. Lateral view of debris plugged outflow structure in the Pease wetland (Aug 06).	**Photo CRQ-16. Upstream view of debris in the channel at the forestry road (Oct 06).**



City of Campbell River

Quinsam River/ Campbell River Integrated Stormwater Management Plan

Figure 9.1 Recommended Stormwater Infrastructure Improvements

- Future Greenfield Development Area
- Future Redevelopment Area
- Water
- Road
- River/Stream
- ALR
- Study Area Boundary
- City of Campbell River Boundary
- Recommended Water Quality Treatment Structures*
- Recommended Detention Pond*

- Sizes and locations are approximate. Current drawings are for display purposes.

0 150 300
Metres

1:12,500

This map was prepared for the purposes of this planning study and are provided for general reference only. Site specific information must be obtained and provided to the City to confirm the actual site conditions at any location.

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APPENDIX B

HABITAT / FISHERIES REPORT

KWE

Campbell River/Quinsam Integrated Stormwater Management Plan

Biophysical Review and Opportunities for Stormwater Treatment and Habitat Protection/Enhancements

November 30, 2006

Upstream view of the Campbell River mainstem at the Maple Street Outfall (CR#1) Sept 2006.

FINAL REPORT

Submitted to: Urban Systems Suite 2353-13353 Commerce Parkway, Richmond, B.C. V6V 3A1 (604) 273-8700

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1.0 INTRODUCTION

Since 2000, the City of Campbell River has been developing a City wide comprehensive Integrated Stormwater Management Plan (ISMP). The City of Campbell River has adopted a strategic planning level approach to stormwater management with a goal to minimize impacts of stormwater discharge on natural aquatic and terrestrial habitat values and when feasible, to pursue priority foreshore enhancement and restoration opportunities. In order to complete their integrated stormwater planning, one of the last areas for study includes the Quinsam/Campbell River ISMP area. The City's current practice for stormwater management includes an efficient method of rainfall capture and conveyance into watercourses that can result in increased peak flows and runoff volumes relative to natural conditions (Urban Systems 2005). Within the Quinsam Campbell River area, issues that support and promote development of an ISMP includes the reconstruction of H19a, upgrades to the sanitary sewer infrastructure, the ability of the existing stormwater infrastructure to meet future needs as well as to develop future long range stormwater management plans.

The purpose of this report is to summarize the existing biophysical features including unique or sensitive habitat types or sites with high ecological value, within the study area. This information has been collected from reference data in combination with interviews with key stakeholder groups within the study area. Based on this information, opportunities for stormwater treatment and aquatic/riparian habitat improvements are outlined.

This report is one component of an ongoing interdisciplinary Stormwater Management Strategy for Campbell River. In combination with stormwater flow modeling, hydrogeology and water quality studies, baseline biophysical reconnaissance data can provide information on sensitive environmental features that can be incorporated into engineering design and planning objectives. Collectively, proactive solutions can be developed to address the existing and potential impacts of stormwater discharge on natural ecological diversity, structure and function of instream and riparian habitat. As well in the future, decision makers can utilize key biophysical habitat attribute information to determine the environmental costs and benefits of various ISMP design alternatives.

1.1 Description of Study Area

The Campbell River/Quinsam ISMP study area includes a catchment area of 415.8 ha and includes a diverse combination of commercial, light industrial and residential development with approximately 39% of the study area remaining as contiguous forested land. The ISMP study area is bordered by the lower 2 km of the Quinsam River to the west, the Campbell River to the north, the Nunn's creek watershed to the east and IR#12/Willis Road to the south as outlined in Fig 1.

Within this catchment area, the most notable streams include the lower Campbell and Quinsam Rivers, Detweiler Creek and Haig Brown/Kingfisher Creek. The Campbell River is recognized as a Heritage River and along with the Quinsam River is highly valued for salmonid production. Natural flow regimes as well as sediment/debris transport in both of these systems have been manipulated by hydroelectric development initiated during the 1950's. Forested habitat within lower Quinsam River, Haig Brown and Detweiler Creek is recognized as an important migration corridor for wildlife species. As well, small but significant runs of coho, chum and trout species are produced in Haig Brown Kingfisher Creek and Detweiler Creek.

The highest degree of development within the study area has occurred in the Campbellton Industrial area where the total impervious area represents 60.4% of the landbase. Surface flows, stormwater drainage and groundwater flows are conveyed through a well-established storm drain system that discharges directly into the Campbell River. Conversely, the lowest amount of urban development has taken place within Detweiler Creek and Kingfisher Creek where wooded habitat represents approximately half of the landbase in each watershed. Therefore, opportunities to develop with alternative stormwater design standards in order to sustain a more natural runoff pattern still exist within part of the study area. The remainder of the plan area has been developed for residential and recreational (golf course) development.

1.2 Scope and Limitations

A very small (600 m x 120 m) residential/light industrial development in the vicinity of the Northmore and Treelane crossroads is included in the Quinsam Campbell River ISMP Plan Area. Although this area drains into Nunns Creek, a biophysical review of Nunns Creek watershed has not been included in the scope of this report. As directed by the City of Campbell River, this report does not include a review of biophysical features or an assessment of habitat restoration or stormwater design opportunities within IR #11 and #12. However, it is important to note that IR#12 is located in upper Haig Brown Kingfisher Creek and stormwater outflows from the Quinsam Crossings (IR#12) residential area as well as recent and future urban development has the potential to affect downstream values in Haig Brown Kingfisher Creek.

Wetland habitat has been identified according to the Sensitive Ecosystem Inventory Maps as well as photo interpretation and ground truthing where possible. The total area of wetlands should be a minimum estimate with a proper wetland assessment completed if more comprehensive information is needed.

The information in this report is based on a 2-day field study where a subsample of the sites were assessed to include a representative sample of habitat types and attributes. At these sites, consideration was given to identifying key habitat issues and corresponding opportunities for stormwater management and habitat improvement. The results of this assessment should not be considered a comprehensive evaluation as the remaining sites may provide additional opportunities. The recommendations and information associated with stormwater management and habitat improvement opportunities are intended for discussion at the conceptual level and/or for strategic planning level, rather than for prescriptive purposes.

1.3 Methodology

Significant biophysical features within the Quinsam Campbell River ISMP were researched through a background data review and interviews with senior environmental agencies including Fisheries and Oceans Canada (FOC), the City of Campbell River (CCR) environmental coordinator as well as contacts from the Haig Brown Kingfisher Creek Society and the Greenways Land Trust. Based on the background information, sensitive aquatic and terrestrial habitat values were identified and field investigated during a brief 2-day onsite review. Recommendations to address sensitive habitat features and opportunities for stormwater treatment and habitat improvements/ restoration were derived from the review and field reconnaissance.

There was limited documented fish distribution information for the Campbell River Quinsam ISMP study area. As such, "known fish distribution" as identified in Fig 1 is based on professional field knowledge of the interviewees. However, salmonid presence in other areas is possible and therefore, this distribution should be considered a starting point that will be updated with future fish inventory work. Wetland features were identified according to the Sensitive Ecosystem Inventory maps with additional wetlands and pond habitat identified through photo interpretation of 1:2000 aerial photography taken in 2005.

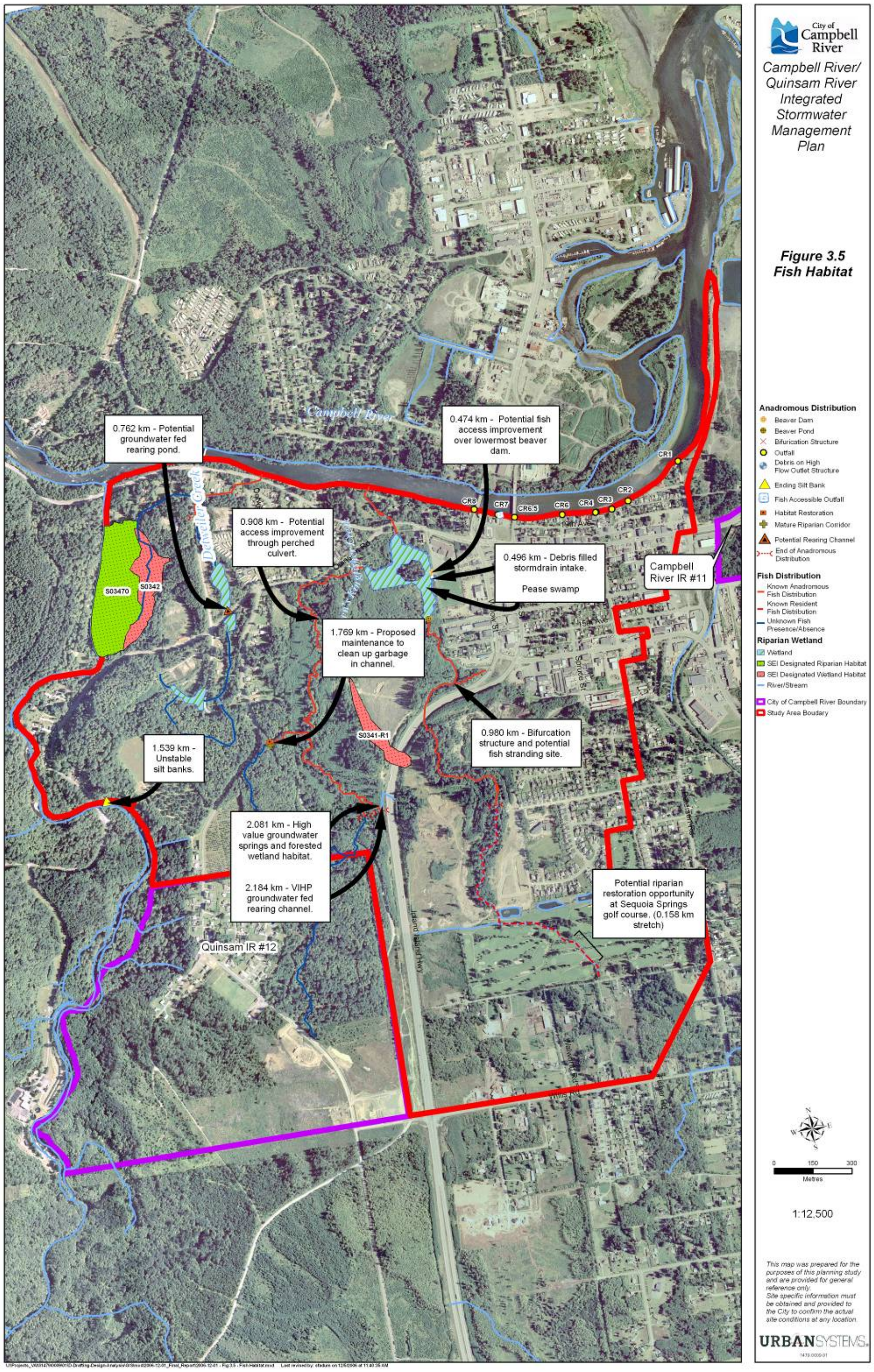


Figure 1. Overview map illustrating known fish distribution, wetlands and forested habitat as well as industrial and residential within the Campbell River Quinsam ISMP study area.

2.0 BIOPHYSICAL FEATURES

2.1 Lower Campbell River

Within the Quinsam Campbell River ISMP study area, there is a diverse assemblage of fish species and high value aquatic and riparian habitat. The lower 2.9 km of the mainstem Campbell River from the Quinsam River confluence down towards the estuary defines the northern boundary of the ISMP study area.

The Campbell River is a designated Heritage River and represents the third largest river on the east coast of VI based on flow delivery and drains an area of 1460 km^2 (Dawe et al 1995, Witty et al 1995). Most of Campbell River watershed was logged in early 20th century with 2 major fires destroying 39,100 ha of timber, leaving much of the present forest consequently as second growth timber. The lower river and estuary are surrounded by urban and industrial development (Bell and Thompson 1977). There has been major hydroelectric development activity within the Campbell River watershed with construction of the John hart dam and generating station in 1947. Within the watershed, there are 3 impoundments and a number of water diversions (Witty et al 1995).

The Campbell River is 90 km in length with anadromous habitat available within the lowermost 5 kilometers (Bell and Thom 1977). Significant runs of pink, chum, chinook, coho, a small run of sockeye as well as summer and winter run steelhead trout, anadromous cutthroat trout and Pacific Lamprey are produced in the Campbell River (Burt 2004). As well, notably large chinook salmon that has generated a prized fishery for "tyee". Tyee have been fished in the Campbell River since the late 1800's when records document chinook up to 67-70 pounds (Tyee Club of BC 1995). The reach within the ISMP study area provides critical spawning habitat primarily for chum and chinook salmon as well as a small run of pinks (Witty et al 1995, Burt 2004). The right bank is utilized as an important migration corridor with deep pools providing adult holding habitat for coho, pink, steelhead and chinook salmon as well as high quality rearing habitat for juvenile salmonids. The Campbell River is tidal to approximately 100 m u/s of H 19 bridge with estuarine conditions providing high quality nursery for juvenile salmonids and invertebrates.

Photo 1. Upstream view of the lower Campbell River at Outfall CR3 illustrating high value off channel habitat during low flows in Sept 2006.

The Campbell River estuary supports a large number of resident and migratory birds including passerines, waterfowl, raptors, shorebirds and gulls as well as upland birds including trumpeter swans, bald eagles and great blue herons. A study between the fall of 1982 and March 1984 observed 125 bird species utilizing the estuary and determined that the estuary supported a minimum of 5689 birds in at least one stage of their life history during the study period and includes Great Blue Heron nesting sites (Dawe et. al. 1995). However, bird use is thought to be lower in the CR estuary relative to other system of equivalent size or smaller on the east coast of VI, maybe use may be limited by disturbance including industrial and commercial users as well as high levels of commercial and recreational activity (Dawe et al. 1995). The estuary also supports invertebrate species with a small amount of crab and clams harvested in estuary (Bell and Thompson 1977).

Rare and unique plants can be found in the sparsely vegetated sand and gravel upland habitat of Tyee spit that occurs infrequently on the east coast of VI. Undeveloped uplands near Westmin facility support the only known occurrence of balsamroot (*Balsamorhiza deltoidea*) on the east coast of VI (Witty 1995). The lower river also supports marine and terrestrial mammals, amphibians, reptiles including historical documentation of river otters, beaver, mink, wolves harbour seals, black bears, black tailed deer, Roosevelt elk and cougar (Bell and Thompson 1977).

Sediment delivery to the mainstem has been significant modified over the past 50 years due to construction of the hydroelectric dams that regulate water and sediment discharge. As a result, the lower river is sediment starved (Burt 2004, Witty 1995). Within the study area, restoration in the CR mainstem has occurred since the late 1990's and has included restoration of spawning and rearing habitat through construction of the Raven spawning and rearing channel as well as spawning platforms to offset to lack of natural gravel recruitment (, S. Anderson, pers. comm.). Restoration works in the CR estuary has included the marsh and intertidal benching, bank stabilization, marsh and riparian planting, creation of low marsh habitat and soil remediation (Burt 2004).

The Campbell River provides a diverse array of recreational activities and is estimated to support the second largest sports fishery in B.C. In 1975/76 steelhead catches in the Campbell river ranked 12^{th} highest in B.C. and the sport fishery worth an estimated 5.5 million in 1972 (Bell and Thompson 1977). On average, the Campbell River provides approximately 8-10,000 angler days annually. The Campbell River also provides high value kayaking, snorkeling and swimming opportunities in addition to a network of hiking trails throughout. The Campbell River fish stocks also make an important contribution to the commercial fishery. As well, associated fish and wildlife populations also hold cultural and economic importance to First Nations people.

2.2 Lower Quinsam River

The Quinsam River is a major tributary to the Campbell River and enters the mainstem river approximately 3.4 km upstream from the mouth. Relative to the Campbell River, the Quinsam River is smaller with more diverse hydraulic conditions. The Quinsam River is 45 km in length and drains an area of 283 square kilometers (Burt 2003). The lower 25.7 kilometers is accessible by steelhead and coho, whereas pink and chum typically remain downstream of the rock cascade at 21.7 km. The lowermost 2.2 kilometers of the Quinsam River defines the western boundary of the Campbell River/Quinsam ISMP study area. The lower 10 km has an average bankfull width of 20 m and a gradient of 0.7% with substrates dominated by gravel and cobble (Burt 2003). This reach has the highest concentration of spawning habitat between the river mouth up to Quinsam Lake.

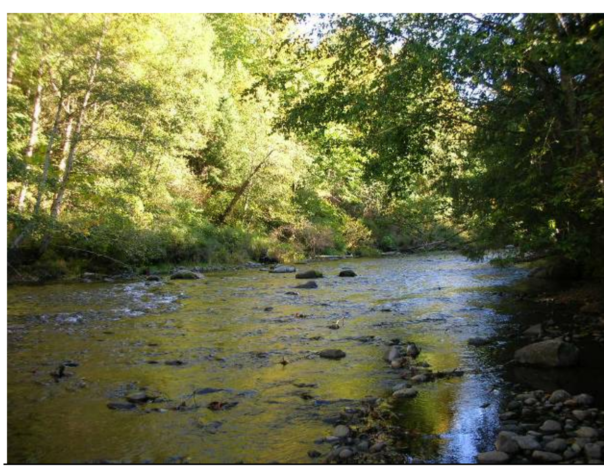


Photo 2. Upstream view of the lower Quinsam River in Elk Falls Park illustrating good quality spawning and rearing habitat Oct 2006.

Quinsam River supports steelhead and 5 species of salmon and provides critical spawning habitat for coho and pink salmon where as chinook and chum generally prefer to spawn in the mainstem Campbell River (Burt 2003). However, chinook and chum spawners also utilize the lower 3.6 km of the river while coho salmon spawn throughout the mainstem to km 41.5. Sockeye spawning distribution is poorly understood but thought to occur primarily upstream of the Quinsam Plan area (Burt 2003). Other fish species in the lower Quinsam River within the Plan Area include cutthroat trout, rainbow trout, Dolly Varden char and Pacific lamprey, (Solander et. al. 2004). The entire lower reach is utilized by all anadromous species for rearing.

The Quinsam River hatchery was constructed in 1974 at river km 3.3 in order to enhance chinook, coho, pink, steelhead and sea run cutthroat trout stocks returning to the Quinsam River and adjacent systems. Then enhancement programs release hatchery-cultured fish for emigration to salt water as well as a juvenile outplanting program in the upper watershed (Burt 2003).

Unstable silt banks in the lower reaches contribute fines to the channel that are accumulating and degrading spawning gravel quality (Lawseth 1979 in Burt 2003). Habitat restoration activities in the lower reaches to date have included construction of a dyke below the hatchery to reduce channel braiding and impingement on Cold Creek, anchoring LWD downstream of the dyke as well as riparian planting to stabilize an eroding bank 1 km u/s of the hatchery (Burt 2003).

Intact forested habitat in the lower Quinsam River also provides an important wildlife migration corridor as well as providing residence to a number of species as listed for the lower Campbell River. There are high recreational values including hiking trails from the Elk Falls park trails between the hatchery and the confluence area. Quinsam fish stocks make an important contribution to the commercial marine fishery as well as both marine and freshwater sports fisheries (Burt 2003).

2.3 Detweiler Creek

Detweiler Creek produces coho salmon and cutthroat trout with an average of less than 12 coho spawners annually. Known distribution for coho extends up the east branch for approximately 800-1000m to the ponds immediately upstream of the Quinsam Road crossing (Fig 1). Further distribution of coho and trout in Detweiler Creek as well as location of spawning habitat is currently unknown. Salmonid production is thought to be limited by summer low flows conditions and corresponding available summer rearing habitat. As well, overtime sediment has naturally accumulated in the lower gradient reaches and as a result, upstream access by coho spawners is limited to periods of higher flow levels. Restoration opportunities in lower Detweiler Creek include complexing the channel with LWD and the addition of spawning gravels (R. Senger, pers. comm.). A habitat assessment/fish inventory study would also assist with definition of aquatic and riparian values in this watershed.

Photo 3. Upstream view of lower Detweiler Creek at the Comox Logging Road illustrating mature riparian habitat and dry channel conditions during early October 2006.

One of the most valuable ecological features of the Detweiler watershed is the presence of wetland habitat that has provides high quality habitat for amphibian species with the potential to provide rearing habitat for salmonids. Wetlands also provide water storage opportunities and naturally stabilize the effects of high flows, particularly to low gradient reaches downstream (B. Peters, pers. comm.). In 1991, the provincial Sensitive Ecosystems Inventory group identified a unique 2.1 ha wetland (S0342) in the Detweiler Creek West branch immediately downstream of Quinsam Road (Fig 1). The location and extent of additional wetlands has been interpreted from 1995 aerial mosaics but should be considered a starting point. These wetlands should be assessed and more comprehensively mapped to provide base line information as future land development could threaten the long term presence of these marsh/wetland habitats.

Photo 4. Upstream view of high value wetland habitat in upper Detweiler East Branch. October 2006.

Another important ecological feature of Detweiler Creek is the presence of undisturbed forested land (58.4% of the watershed) that provides one of the few remaining migration corridor for wildlife species. In 1991 the Sensitive Ecosystem Inventory group identified an ecologically sensitive, 6.1 ha high value riparian forest between the lower Detweiler Creek and the Quinsam (S0347D). Recreational values are also notable in the area and include hiking and fishing opportunities.

2.4 Haig Brown Kingfisher Creek

Haig Brown Kingfisher Creek (HBKC) is a physically diverse system encompassing 281 ha with 2 main drainages referred to as the East and West Fork in this report. Within the HBKC watershed, existing development includes 2 major transportation corridors as well as a moderately low degree of residential, semi rural acreages, recreational (golf course) and industrial development (Fig 1). Due to significant historical and environmental values, there has been land set aside in the lower river for ecological significance. In 1975, the Roderick Haig Brown property along Highway 28 became a Provincial Greenbelt Reserve with the 19 acre riverside property set aside to be managed for public education and fisheries enhancement.

The stream channel has been severely manipulated by human development since the 1890’s when railway construction and logging activity altered the location as well as the outlet of the lower West Branch (Stearns 1996). Later, streams flows from the upper East Branch were rerouted down storm drain pipe for approximately 400 m and entered the Campbell River between the H19 bridges at CR 7 (Fig 1). Sections of the original channel were infilled starting in 1957 (Stearns 1996) and the East and West Branches separated into 2 systems and their confluence with the Campbell River relocated at least twice more. Access to a portion of the west tributary was eliminated by fish screen. The middle branch of Haig Brown Creek was groundwater fed but destroyed by infilling and ditching. In 1984, the west branch was diverted down a new channel with coho using the channel the first fall it was open but summer low flows limited suitable rearing habitat for coho within the West Branch (D. Hadden, pers. comm.).

However, the much of the watershed remains forested with only 22.8 % of the watershed is currently considered to have an impervious surface. The majority of streams and wetlands have naturally vegetated riparian habitat. The most significant degree of development to date includes the west portion of Campbellton in the lower East fork as well as low density rural residential development in the upper East fork (Fig 1). The west fork had undergone a lower degree of development with single family residential development in the lower river and the Quinsam Crossings development within IR #12 in the headwater area. Urban development is increasing in Haig Brown Kingfisher watershed with an established storm drain system and commercial development in the lower reaches (DFO 1982) as well as proposed urban residential development north of the Sequoia Springs golf course.

The headwater area of the West Branch was once characterized by having extensive bog habitat while the middle and upper reaches of the East Branch were once dominated by wetland habitat (Stephens, 1996, Stearns 1996). Historically, the E branch of Kingfisher creek had a good year round supply of stream flows with a natural floodplain area where the Campbellton light industrial zone now exists (Stearns 1996). Water continues to be retained year round in the 26 acre wetland known as "Pease swamp" located along the west boundary of the Campbellton School playground. The wetland and riparian area provide ideal wildlife habitat with extensive mud bottom ponds, seasonal channels with an abundance of overhead shrubs intermixed among deciduous trees. For more detailed reach descriptions, see Stearns 1996. In 1991, a 1.4 ha wetland (S0341-R) located in the West Branch was identified as having ecologically significant value.

Photo 5. Upstream view of excavated pond habitat with natural wetland habitat in the background at the Pease Swamp area of the East Fork of Haig Brown Kingfisher Creek October 2006.

Coho and trout production in HBKC is thought to be limited by summer low flows and corresponding availability of summer rearing habitat. Historically, the East branch was reported to have a good year round water supply (Stearns 1996). During late August 2006, after a period of extended dry weather, seepage flows in both E and W branches were sustaining a very limited amount of summer rearing habitat, inferring that limited groundwater seepage flows continue to feed both E and W branches. Salmonid fry were observed in pool habitat fed by subsurface seepage flows with suitable water quality measured in the lower reaches of the West Branch as well as upper and lower reaches of the East Branch. A follow up hydrology study to determine the status of summer low flow regimes would be valuable benchmark data as urban development increases within the watershed.

Historical flooding issues in lower HB Creek within the natural floodplain area into Campbellton Elementary school and the Campbellton light industrial zone have been documented since 1974 (Stearns 1996). Flooding issues precipitated restoration works in 1998 that involved construction of a bifurcation structures that re-routed flows from a storm drain pipe into almost a kilometer of an excavated stream channel connecting the East Fork with the west fork (Photo 1).

At the same time, the 300 m of the lower West fork was restored with improvements to fish access as well as to increase spawning and rearing habitat through LWD and boulder complexing, riffle construction and gravel placements, off channel ponds, flow control weirs for flood control and riparian planting undertaken in both forks (HBKC Society 1998a). In 1995, a groundwater fed settling/rearing channel (5m x 110 m) was constructed in an East Branch tributary immediately downstream of the VIHP ROW as part of the habitat compensation requirement for highway construction. Monitoring results in 1999-2001 confirmed high fish use by coho and trout juveniles as well as good riparian recovery (MOT 2003).

Photo 6. Downstream view of the bifurcation structure in HBKC East upstream of 14th Ave. Low flows proceed to top of picture and overflow to the right of the photo (August 06).

Kingfisher Creek typically supports 200-300 coho spawners on average annually as well as a few chum spawners downstream of the Highway 28 crossing (Ewert and Anderson, pers. comm.). Cutthroat trout are produced in the upper reaches of both the east and west branches. Known distribution of coho spawners in the East fork extends 500 m upstream of the Inland Island Hwy after which, the East fork is concised into a steep ravine (Fig 1). In 2001, coho fry were captured 50 m upstream of the Inland Island Highway culvert (MOT 2004). Cutthroat trout are distributed through the Sequoia Spring golf course with potential residence further upstream during seasonal higher flows (R. Senger and D. Hadden, pers. comm.). It is important to note that beaver dams in the middle watershed area may seasonally limit fish distribution in HBKC (Appendix B). However, a voluntary crew partially breaches the dam features to facilitate anadromous spawner access through the dams (B. Peters, pers. comm.).

The main branch of the West fork originates in IR#12 and descends down a moderately sloped sidehill through private land. In 1995, as part of the Vancouver Island Highway Project (VIHP), coho and cutthroat fry were captured at the toe of the slope in groundwater fed ponds, approximately 25 m downstream of the VIHP right of way (MOT 2004, Fig 1). The extent of known coho distribution coincides with the ISMP study boundary. Known fish distribution in the west branch of the West fork includes the reach that runs parallel to Nursery Road (Fig 1). Cutthroat trout are thought to be distributed upstream of anadromous reaches throughout the headwater area of HBKF Creek (D. Hadden, pers. comm. DFO 1982). The low gradient marsh habitat throughout the middle reaches provide good potential summer rearing habitat with coho spawners sighted in gravel reach adjacent to hatchery road (Erickson et al 1983).

HB Greenways Property has historically provided habitat for cougars, black bear, blacktail deer, mink, raccoon as well as many bird species. The property continues to provide an important migration corridor for these species with critical wetland habitat also providing habitat for amphibian species (likely presence of red tailed frogs) as well as foraging habitat for bears and various bird species.

Through the Sequoia Springs gold course, the East Branch has poor instream and riparian cover. Habitat restoration consisting of complexing the channel with rock and logs as well as planting Native shrub species in combination with taller species to increase instream and riparian complexity upon exchange of information for suitable species as acceptable with the golf course owner Barrie Brown (HKCS 1996). Three water storage ponds were excavated for irrigation purposes but also function as runoff retention features (R. Senger, pers. comm.). There are cutthroat trout and likely rainbow trout in the mainstem channel downstream of the ponds (R. Senger, pers. comm.).

2.5 Campbellton Light Industrial Area

The Campbellton Light Industrial Zone represents approximately 22.4% of the Quinsam Campbell River ISMP Plan Area. The area supports a significant proportion of the industrial and commercial development for the City of Campbell river and therefore dominated by heavy equipment sales/service outlets, gas stations, car dealerships, motels/fishing lodges, retail outlets, the bus depot, welding/fabrication/paint shops and other light industrial and commercial developments (Fig 1, Photo 7). This area also supports a lower income residential area as well as an important transportation corridor with both Highway 19A as well as the Inland Island Highway bisecting the ISMP Plan Area. Surface waters are conveyed through a well established storm drain system with no natural streams present throughout the area. Within the central core of the light industrial area is a modest residential neighborhood where intermittent open vegetated ditches convey stormwater flows through a series of culverts (Appendix B).

Photo 7. Typical view of the Campbellton area that is dominated by industrial and commercial development and 60.4% of the landbase is considered to be impervious (Oct 06).

Historical flooding issues in lower HB Creek within the natural floodplain area into Campbellton Elementary school and the Campbellton light industrial zone have been documented since 1974 (Stearns 1996). Streams flows from the upper East Branch were rerouted down storm drain pipe for approximately 400 m and entered the Campbell River between the H19 bridges at the Enns property (CR 7, Fig 1). In 1996, post diversion and channel construction in the East Fork, adult coho continue to migrate up the Campbellton storm drain (CR 7). Flooding issues precipitated restoration works in 1998 that involved construction of a bifurcation structure that re-routed flows from a storm drain pipe into almost a kilometer of an excavated stream channel connecting the East Fork with the west fork.

3.0 DISCUSSION

Existing biophysical features including unique or sensitive habitat types or sites with high ecological value have been identified for the Campbell River/Quinsam ISMP study area. The identification of sensitive environmental features for the study area is important to increase awareness as well as ensure appropriate management to sustain sensitive features are included in stormwater engineering design and planning objectives. Collectively, proactive solutions can be developed to address the existing and potential impacts of stormwater discharge on natural ecological diversity, structure and function of instream and riparian habitat. As well in the future, decision makers can utilize key biophysical habitat attribute information to determine the environmental costs and benefits of various ISMP design alternatives. A brief description of the environmental features are described in this section with recommendations for stormwater treatment or instream/riparian habitat improvements outlined in Section 4.

It is important to note that a significant portion of the Haig Brown (45.1%), Detweiler Creek (58.4%)and lower Quinsam River and Campbell River watersheds (55.9%) remain forested. That itself presents an opportunity for future alternative stormwater design or low impact development. Conversely, the Campbellton Industrial area is for the most part, fully developed and therefore in most cases, only “end of pipe” stormwater treatment options remain. Urban Systems has outlined options for alternative onsite stormwater treatment in a companion study to this report.

3.1 Water Quality and Water Quality Monitoring

Stormwater discharge has the potential to increase contaminant loadings into valuable foreshore and instream habitat, particularly from commercial and industrial sectors including the Campbellton Industrial Area. Primary concerns for water quality within the ISMP study area include contamination of stormwater effluent by metals, sediments, and oil/grease as well as elevated levels of phosphorous and nitrogen originating from residential areas, farms and golf courses. Increased nutrient levels can result in eutrophication of stream systems, particularly during low flow periods. Additional information on the water quality issues is presented and discussed in a companion report by Urban Systems.

For the Campbellton industrial area, there are also concerns for the accumulated effects of pollutants introduced into natural stream systems. The potential impacts of contaminants can be increased where a number of outfalls discharge into an ecological significant waterways such as the mainstem Campbell River. The effects of pollutants can be increased during periods of low flow and during low tide where there is limited exchange. An overview of the effects of reduced water quality on nearshore communities is discussed in http://www.stewardshipcentre.bc.ca/scbc/stewseries/pdf/Part1.pdf. The City of Campbell River has installed inline oil water separators at outfalls CR1 and CR2 with installation proposed for a 3rd system at outfall CR3 (G. Stewart, pers. comm.).

3.2 Protection of groundwater flows and natural hydrologic regime

The protection of groundwater flows and the natural hydrologic regime is another key fish and wildlife habitat issue within the Campbell River Quinsam ISMP plan area. Available groundwater flows often support high quality fish habitat and are often critical to sustain summer rearing habitat and overall fish production for resident salmonid species and anadromous species that require a freshwater rearing stage. Within the Plan Area, sustenance of groundwater flows in Haig Brown, Detweiler and the possible Lower Quinsam River should be a key objective for future stormwater management planning and design.

Historically, Haig Brown Kingfisher Creek (HBKC) had year round flows, with the lowest flow period typically observed in late August and September (B. Hurst pers. comm. in Stearns 1996). Coho and trout production in HBKC is thought to be limited by summer low flows and corresponding availability of summer rearing habitat. During late August 2006, after a period of extended dry weather, seepage flows in both the lower East and West branches immediately upstream of Highway 28 were sustaining a very limited amount of summer rearing habitat. As such, groundwater seepage flows continue to support year round fish habitat in both E and W branches. Salmonid fry were observed in pool habitat fed by subsurface seepage flows with suitable water quality measured in the lower reaches of the West Branch as well as upper and middle reaches of the East Branch.

There have been historical alterations to groundwater sources and flows to west branch of Haig Brown Creek along the east side of Duncan Bay Main. The creek originated in an extensive bog that no longer exists and was dry during field observations in October 2006. In the upper east tributary of the west branch (originates in IR#12), groundwater seepage flows and surface drainage collect into a wetland complex and then flows into lower HBKC Creek (Morely 1996). Construction of the VI Highway resulted in increased sedimentation to HB creek during the winter of 1995/96 as well as long term changes to surface flow patterns as well as potential interception of groundwater (Morley 1996). As part of the habitat compensation plan for the VIHP, a groundwater fed rearing channel was constructed and monitoring results in 1999-2001 confirmed high fish use by coho and trout juveniles as well as good riparian recovery (MOT 2003). During October 2006, adequate flows to support fish were observed in the west fork at Quinsam Road during a long period of dry weather that extended from late summer into early fall.

There is little historical information regarding the presence of groundwater flows in Detweiler Creek. However, wetted wetland habitat and standing shallow pools of cold water were observed in the East branch at Quinsam Road during the October 2006 field reconnaissance. As well, the pond immediately upstream of Quinsam Road is thought to support resident trout (B. Peters, pers. comm.).

3.3 Conservation of high value wetlands and riparian habitat

Wetlands are typically nodes of high biodiversity and support a high number of rare species or plant communities (MOE 2004). Sensitive wetlands are providing critical habitat within the Quinsam ISMP area for amphibian species (likely presence of red tailed frogs) as well as foraging habitat for bears, beavers, raccoons, deer and various bird species.

Valuable wetland habitat was observed in both Haig Brown Kingfisher Creek and Detweiler Creek (Fig 1). Wetland habitat throughout the middle reaches of HBKC consists of a several open ponds as well as marsh fringe and forested swamp habitat (Appendix B). The marsh also provides some degree of flood protection by acting similar to a constructed detention pond (http://www.env.gov.bc.ca/sei/van_gulf/results.html SEI conservation manual). Wetland and pond habitat in the Pease Marsh area of HBKC is increasing due to the increase in beaver population over the past 3-5 years. The area of wetland habitat, at minimum interpreted from 2005 aerial photography used for this study is _______. The total wetland area may be underestimated as a result of increased water retention due to higher flow periods and increased levels of recent beaver activity. However, beavers create water storage opportunities that outweigh any possible access issues and additional water storage development on Barrie Brown's development would be an asset (B. Peters, pers. comm.). A valuable forested wetland habitat is present in the upper West fork of HBKC adjacent to the Inland Island Highway with visible groundwater springs delivering flows to the alder dominated landscape (Appendix B).

A significant quantity of valuable wetland habitat exists in both East and West forks of Detweiler Creek and represents a total area of approximately ______ha as interpreted from 2005 aerial images. These wetlands likely provide good quality seasonal rearing habitat for salmonids as well as an important component of migration corridors for wildlife species. Combined wetland, riparian and forested habitat lower Quinsam, Detweiler and Haig Brown Kingfisher Creek collectively provides a migration corridor for cougars, black bear, black tailed deer, mink, raccoon as well as many bird species.

3.4 Fish Access in Haig Brown Creek

Coho production in Haig Brown Kingfisher Creek is affected by the availability of upstream spawner access through the beaver dams and resulting ponds located in the middle reaches of the E Fork at Pease Marsh (Fig 1, B. Peters, pers. comm.). Beaver dams also have the potential to limit both upstream and downstream migration of juvenile salmonids. However, spawner access through Haig Brown Creek has been facilitated annually by partial breaching of dam features during the fall inmigration period. As well, beaver pond complexes typically have several outflow areas with alternate access for fish depending on discharge levels.

Beaver dams can also benefit fish production by backwatering and increasing the amount of rearing habitat if suitable dissolved oxygen and water temperatures persist through the summer season. Good summer rearing habitat in small streams with summer low flow issues are typically fed by groundwater seepage flows. It is therefore imperative to sustain the supply of groundwater flows as well as transport of these flows through the beaver pond complex in order to maintain connectivity and access to suitable rearing conditions by salmonids.

The bifurcation structure allows fish access downstream to both the constructed fish restoration channel during low flows as well as to the storm drain system during moderate and higher flows. The plunge pool immediately downstream of the bifurcation structure leading to the storm drain system is a series of large cobble and boulders with no access to suitable habitat for emigrating juveniles. Flows then proceed downstream over a grassy knoll during high flows and appear to be subsurface through a gravel cobble layer during moderate flows. Therefore, there is potential for downstream migrants to be stranded prior to entry into the stormwater system.

Limited upstream fish access was also observed in HBKC West approximately 650 m upstream of the east/west fork junction. There is a perched culvert at the logging road with a 45 cm drop into a 25 cm deep plunge pool (2.5m x 3.5m) during low flows observed in October 2007. Upstream adult and juvenile fish passage was not possible during the flows observed, but during higher flows, the pool may likely backwater and facilitate limited passage for migrating spawners. However, access improvements could include construction of a series of rock riffles to decrease the free drop into the plunge pool or modifications to the culvert if further assessment can provide rationale to support improved fish access.

3.5 Potential fish presence and utilization of Campbellton storm drains

Historically, in order to address downstream flooding issues, the east branch of Haig Brown Creek was diverted into the stormwater system along 17th street and along Willow Street to outfall CR7 about 5 or 6 decades ago. Local residents report adult coho salmon migrating through the outfall at the Enn's property with presence of juvenile coho confirmed by F. Voysey, FOC in 1994. In 1998 a bifurcation structures was installed in the Haig Brown Kingfisher Creek East Fork upstream of the established storm drain system to re-reroute base flows down an excavated channel connecting the East Fork with the west fork. The bifurcation structure is adjustable to discharge flows to the stormwater system during periods of high flood flows only.

Downstream access is available through the bifurcation structure on Haig Brown East during high flows while upstream fish access is possible through the low gradient and backwatered 2133 mm CMP outfall pipe. Also accessible are the stormwater pipes located immediately east of the Campbellton Elementary School. Confirmation of fish absence/presence in accessible low gradient storm drains can determine typical utilization and direct further action towards water quality requirements and/or limiting fish access into the stormwater system.

3.6 Quinsam River and Haig Brown Creek Bank Instability

Unstable silt banks in the lower reaches of the Quinsam River mainstem are eroding and contributing fine sediments to the channel. There are at least 6 sites where large eroding clay banks identified in the lower Quinsam River with most sites upstream of Campbell River Quinsam ISMP Plan Area. However, one site is located immediately upstream of the Plan Area along the right bank at Argonaut Road. The fine sediments are transported downstream and are accumulating over valuable spawning habitat and thereby decreasing gravel quality in the lower river (Lawseth 1979 in Burt 2003).

As well, significant bank stability problems were identified in the east branch of Haig Brown Kingfisher Creek 150m, 650m, 966m and 1100 m upstream of the mouth that warrant further investigation to determine stability and erosion issues (HKCS 1996). Steep, erodable banks warrant special consideration for stormwater design and land development near these area due to environmental risk to valuable spawning habitat in the lower Quinsam River. These areas are also good candidate for bioengineering to increase bank and channel stability.

4.0 RECOMMENDATIONS FOR STORMWATER TREATMENT OR HABITAT PROTECTION/IMPROVEMENT OPPORTUNITIES.

There are 8 sensitive habitat issues identified for the Campbell River Quinsam ISMP study area with corresponding recommendations for stormwater management or habitat protection/improvement opportunities (Table 2). This list is based on a biophysical literature review and a 2 day field reconnaissance and should therefore be considered a starting point for identifying opportunities for stormwater treatment and habitat protection and/or improvement projects.

4.1 Water quality monitoring

Priority sites for water quality assessment/monitoring have been identified with recommendations for additional fish presence/absence sampling in Table 1. Outfall CR6.5 and 7 are a priority due to the presence of year round groundwater flows combined with existing or potential fish access. Recommendations for stormwater management opportunities relating to water quality also include an evaluation of the effectiveness of the existing inline oil/water separators to isolate deleterious substances. Additional recommendations include the review and discussion of emergency response procedures by the CCR with FOC. Recommendations for habitat protection include implementing a bylaw to minimize the cosmetic use of pesticides by the public as well as a BMP pamphlet to increase public awareness regarding the consequences of introducing deleterious substances into the storm drain system.

Table 1. List of priority sites for water quality assessment and fish sampling in the Campbellton Industrial area of the Campbell River/Quinsam ISMP.

Site	Location	Recommended sampling	Rationale
CR 6.5 outfall	D/s side of northbound H19 bridge	Water quality monitoring	Groundwater flows observed during early Sept 06. Unknown utilization by juvenile salmonids.
CR7 outfall 2133 mm CMP	Btwn 2 bridges at Enns property	Water quality monitoring and presence/absence fish sampling in open cement channel 20-25 m long between outfall and CR mainstem	Year round groundwater flows reported with verified historical use by adult and juvenile salmonids
Storm drain system from Willow St between 14th to outfall and west	Between bifurcation structure to outfall at Enns property as well as open ditches along 17th off Tamarack st (CR#7)	WQ and presence/absence fish sampling in low gradient stormwater pipes to determine seasonal utilization	Accessible by salmonids and presence of fish could be addressed by access modification and/or consideration to increase WQ and conserve habitat conditions within storm drain and open ditch system.

4.2 Protection of groundwater flows and natural hydrologic regime

The protection of groundwater flows and the natural hydrologic regime is imperative to sustaining wetland and instream values within the Plan Area. During a brief field reconnaissance, groundwater springs were observed discharging upstream of the IIH in Kingfisher Creek as well as at Quinsam Road in Detweiler Creek and other sources of groundwater could likely be observed with more detailed field surveys. Future land development has the potential to intercept or interrupt natural groundwater flows and convey them through a closed conduit system. Opportunities for stormwater management design to sustain groundwater flows include implementation of development policies that ensure maintenance of natural predevelopment groundwater flows as well as promoting source control treatment of stormwater runoff. Further assessment to determine baseflows and groundwater sources in HBKC and Detweiler Creek would also be beneficial and contribute important information towards the long term management of the study area.

A specific habitat improvement opportunity was observed in the VIHP rearing channel in upper Haig Brown Kingfisher Creek. In 1996, a 110 m x 5 m (550 m^2) groundwater fed rearing channel was constructed approximately 10 m west of the Inland Island Highway in the West Branch of Haig Brown Kingfisher Creek (Fig 1). Follow up sampling undertaken in 1999 confirmed good rearing conditions for salmonids and high utilization by coho fry in the constructed rearing channel. When constructed, the south end of the rearing pond received groundwater by way of a perforated pipe. During an onsite assessment on October 16, 06, water quality conditions were found to be unsuitable to support salmonids with dissolved oxygen levels were low and ranging from 0.8 to 2.9 mg/L while water temperatures ranged were 10.0 C. A series of groundwater springs were visible approximately 15 m west of the pond with good water quality conditions. At the source of the springs, dissolved oxygen levels were 5.5 mg/L with a water temperature of 10.2 C.

Rearing habitat quality in the pond has likely been compromised due to the lack of groundwater inflows. This may be the result of a blockage of the perforated inflow pipe installed in 1996 and efforts should be undertaken to investigate options to restore or increase the adjacent groundwater supply into the pond.

<Photo 8. Upstream view of the 550 m^2 groundwater fed rearing channel adjacent to the Inland Island Highway in upper Haig Brown Kingfisher Creek East fork (Oct 16, 06).

Photo 9>. Upstream view of groundwater springs approximately 15 m west of the rearing channel where good quality water was observed during October 2006.

4.3 Conservation or enhancement of wetland habitat

Implementation of alternative stormwater design standards to undeveloped land will assist in sustaining sensitive wetland habitat. Protection of wetland habitat also includes establishing conservation status for wetland habitat including the Pease Marsh and adjacent to the VIHP rearing channel in HBKC as well as wetland habitat within Detweiler Creek. Specific habitat enhancement opportunities within the Plan Area includes investigating the feasibility of constructing a groundwater fed rearing pond in Detweiler Creek East immediately upstream of Quinsam Road.

During the field reconnaissance on October 16, 2006, we observed an excavated ditch between the SEI designated wetland S03410R1 and the recently logged cutblock in the middle reaches of HBKC (Fig 1). The ditch was approximately 1.75 m wide and between 1.5 to 2 m deep and appeared to be draining moisture away from the wetland habitat.

Photo 10. Downstream view of the excavated ditch observed running the length of the SEI designated wetland (Oct 16, 06).

4.4 Improve fish passage and stream flows in Haig Brown Kingfisher Creek

There are several options that warrant further investigation in order to improve fish passage and stream flows through HBKC (Table 2). Opportunities range from hand excavating channel through Pease Swamp to installing a steep pass fishway at the likely largest and lowermost beaver dam at the Campbellton School field (Fig 1).

Limited upstream juvenile fish access was also observed along the logging road into a recently logged block in HBKC approximately 650 upstream of the east/west branch fork and approximately 200 m upstream of Quinsam Road. The outlet of the culvert is perched with a 45 cm drop into a 25 cm deep plunge pool (2.5m x 3.5m) during low flows observed in October 2007. Upstream adult passage may be possible during higher flows when the pool may likely backwater and facilitate limited passage for migrating spawners. Further investigation during higher flows is needed to assess upstream spawner access. Upstream juvenile passage could be improved through construction of a series of rock riffles through the low gradient channel downstream of the culvert. Backwatering the culvert outlet would decrease the free drop into the plunge pool and facilitate fish passage over a wider range of flows.

Photo 11. Upstream view of perched culvert at the forestry road crossing approximately 650 m upstream of the east/west fork junction (Oct 06).

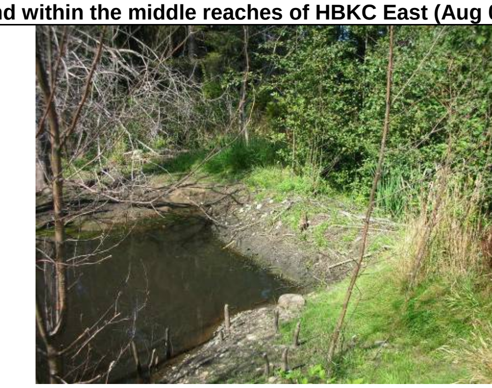
Photo 12. Downstream view of habitat downstream of the perched culvert in Haig Brown Kingfisher Creek where construction of rock riffles would assist passage over a wider range of stream flows (Oct 16 06).

Another opportunity to improve fish passage in HBKC is at the bifurcation structure that allows fish passage downstream to both the constructed fish restoration channel during low flows as well as to the storm drain system during moderate and higher flows. The plunge pool immediately downstream of the bifurcation structure leading to the storm drain system is a series of large cobble and boulders with no access to suitable habitat for emigrating juveniles (Photo 6). Flows then proceed downstream over a grassy knoll during high flows and flows appear to be subsurface through a gravel cobble layer during moderate flows. Therefore, there is potential for downstream migrants to be stranded prior to entry into the stormwater system.

In order to address the potential fish stranding issue, passage through the high flow channel should be modified to allow safe emigration for juvenile and/or adult salmonids. Options to facilitate passage should be investigated and include excavating the wood/boulder structure located in the channel approximately 3-4 m downstream of the bifurcation structure should be considered. Utilization of the channel by upstream spawners also needs to be determined as adults have historically been observed migrating through the CR7 outfall at the Enn's property. Alternately, the bifurcation structure could be modified to limit fish passage down the high flow channel.

Photo 13. Downstream view of the high flow channel immediately downstream of the bifurcation structure illustrating cobble/boulder lined plunge pool and grassy overland undefined channel section downstream that has potential to strand migrating salmonids (Oct 06).

Table 2. Summary of Key Fish and Wildlife Habitat Issues and Opportunities for Stormwater Management and Habitat Protection/Improvements in the Campbell River Quinsam ISMP study area.

Key Habitat Issue	Stormwater Management Opportunities	Habitat Protection/Improvement Opportunities	Photos	Recommendations
1. Water quality concerns for stormwater effluent and lack of systematic water quality monitoring in the Campbellton industrial area.	1-1 Conduct Water Quality monitoring at priority sites as outlined in Table 1 that includes Outfall CR 6.5 and 7. 1-2 Based on WQ results, modify and/or install additional or alternate oil/water separators or utilize other water treatment methods to reduce outflow of pollutants into the Campbell River mainstem. 1-3 Provide FOC information regarding Emergency Spill Response Procedures or current HASMAT procedures currently adopted by the City of Campbell River.	1-4 Minimize or eliminate pesticides use by the public for cosmetic purposes. 1-5 Increase awareness of residential and commercial sectors regarding release of deleterious substances into the storm drain system through a BMP handout. Educate the public, regarding the positive effects of low impact development and alternative stormwater strategies through outreach and support programs to foster compliance and cooperation.		
			Photo CRQ-1. Outfall CR-6.5 at Maple St where groundwater flows were observed in September 2006.	**Photo CRQ-2 . Typical view of Campbellton Light industrial area.**
2. Protection of groundwater flows and natural hydrologic regime	2-1. Promote source control treatment of stormwater runoff (bioswales, vegetated ditches, minimizing impervious surface area to <10% etc) strives to mimic natural runoff delivery rates 2-2. Ensure that development design plans sustain soil and water quality as well as maintenance of natural pre-development groundwater flows. 2-3. Initiate a flow study to include the determination of low flows, baseflows and peak flows as well as confirm all locations of groundwater supply sites within the Haig Brown Kingfisher Creek and Detweiler Creek drainages.	2-4. Investigate feasibility of securing flows from an old well on the original Ben Fellow's farm site (now Sequoia Spring) to supplement summer low flows in the East Fork of HBKF Creek (Stearns 1996). The well supplied an estimated 1500 gallons of water/day. 2-5. Investigate groundwater intake system of the VIHP rearing channel in Haig Brown KC west to determine the cause of poor water quality conditions in the channel while groundwater springs were visible 15 m west of the channel.		
			Photo CRQ-3. Groundwater rearing channel constructed as VIHP compensation works in HBKC East (1999).	**Photo CRQ-4. Downstream view of lower HBKC West illustrating groundwater fed rearing habitat observed in August 06.**
3. Conservation of High value wetlands and streams in Haig Brown and Detweiler Creeks	3-1. Promote sustenance of wetlands by implementation of alternate stormwater design standards for undeveloped land where new developments aim for source control and strive to mimic natural runoff rates.	3-2. Determine feasibility to construct a groundwater fed rearing channel/pond in Detweiler Creek east, immediately downstream of Quinsam Rd. 3-3. Establish conservation status for Pease swamp and the wetland adjacent to the VIHP rearing channel in HBKC as well as wetland habitat in Detweiler Creek. 3-4. Investigate drainage like ditch that has been excavated along the SEI Wetland #S0341-R1 in the middle reaches of HBKC.		
			Photo CRQ-5. Upstream view of marsh habitat and potential groundwater fed rearing channel in Detweiler Creek (Sept 06).	**Photo CRQ-6. Upstream view of upper constructed rearing pond within the middle reaches of HBKC East (Aug 06).**
4. Fish Access and Flows through the E fork of Haig Brown Creek	4-1. Ensure regular maintenance of stormwater drainage structures including the high flow bifurcation structure and the overflow intake at the Campbellton elementary school field. 4-2. Determine whether flow diversion between the East Fork and the Tamarac St culvert is optimal during moderate and high flows.	4-3. Investigate the feasibility of hand excavating defined channels in the East fork of HBKC through Pease Swamp to facilitate fish access and ensure availability of groundwater flows to the lower reaches of Haig Brown Creek, particularly through summer low flow periods. 4-4. Investigate the feasibility of installing a steep pass fishway to facilitate juvenile access over the lowermost dam at the Campbellton elementary school field (Photo CRQ-8). 4-5. Improve fish passage in HBKC through logging road culvert 650 m upstream of the east/west split (CRQ-7). 4-6. Investigate fish stranding potential in the high flow channel downstream of the bifurcation structure.		
			Photo CRQ-7. Upstream view of 45 cm jump from a 25 cm deep plunge pool during low flows in HBKC.	**Photo CRQ-8. Lateral view of the lowermost beaver dam in Pease slough at the Campbellton school (Aug 06).**

Key Habitat Issue	Stormwater Treatment Opportunities	Habitat Protection/Improvement Opportunities	Photos	Recommendations
5. Conservation of riparian habitat and wildlife migration corridors along Detweiler, HBKC and Quinsam River		5-1. Establish adequate leave strips along all stream banks to ensure ecological integrity of the riparian is maintained 5-2. Sustain or stabilize riparian corridors to increase channel and bank stability in steep ravines and gullies typical to Haig Brown Kingfisher Creek East upstream of the IIH as well as in the lower Quinsam River. 5-3. Increase riparian cover through the Sequoia Spring golf course by planting Native shrubs where possible to increase instream and riparian complexity. Determine acceptable species with the golf course owner Barrie Brown (HKCS 1996). 5-4. Investigate classification and potential for conservation status designation for groundwater fed wetland habitat in HBKC immediately downstream of the Inland Island highway.		
			Photo CRQ-9. Upstream view of mature riparian habitat in upper HBKC West Fork (Sept 06).	**Photo CRQ-10. Aerial photo illustrating riparian planting opportunities through the Sequoia Springs golf course.**
6. Potential fish presence and utilization of storm drains immediately East of the Haig Brown Kingfisher Creek system along Willow St and adjacent to the Campbellton Elementary School.		6-1. Undertake fish sampling to determine extent of fish distribution in upper HBKC and Detweiler Creek as well as in culverts between the bifurcation structure and Outfall at the Campbell River mainstem (CR#*) at the Enns property to determine utilization of culverts by rearing salmonids.		
			Photo CRQ-11. Overflow to stormdrain system at HBKC bifurcation structure (Oct 06).	**Photo CRQ-12. Lateral view of Outfall CR-7 with groundwater flows supporting salmonids in the outflow channel (Sept 06).**
7. Quinsam River and Haig Brown East Fork bank instability	7-1. Ensure that future stormwater design sustains existing riparian vegetation and conveys stormwater away from steep erodable silt banks along the Quinsam River mainstem and tributaries.	7-2. Assess and determine feasibility of bioengineering options to assist in stabilization of eroding banks in the Quinsam River. 7-3. Assess bank instability issues documented in Haig Brown Creek at 150m, 650m, 966m and 1100 m upstream of the mouth and determine riparian treatment and bioengineering options if necessary.		
			Photo CRQ-13. Upstream view of eroding right bank in the lower Quinsam River at Argonaut Rd (Sept 06).	**Photo CRQ-14. Lateral view of silt bank erosion in the Quinsam River at Argonaut Rd (Sept 06).**
8. Maintenance activities in Kingfisher Creek East	8-1. Determine elevation of discharge from over the lowermost beaver dam, this outflow structure and any other discharge points from Pease swamp. 8-2. Clear debris from high flow intake at Campbellton Elementary school field to appropriate elevation according to Recommendation 8-1. If necessary, install beaver proof intake system at the appropriate water level where pond habitat is sustained and flood flow levels are controlled.	8-3. Clean up debris and garbage deposited into the channel at the Forestry Road in HBKC East.		
			Photo CRQ-15. Lateral view of debris plugged outflow structure in the Pease wetland (Aug 06).	**Photo CRQ-16. Upstream view of debris in the channel at the forestry road (Oct 06).**

4.5 Conservation of Riparian habitat

Opportunities for protection and conservation of riparian habitat within the Quinsam Campbell River ISMP study area includes the establishment of adequate setback areas from stream and wetlands necessary to sustain riparian function, structure and diversity. Opportunities to restore riparian habitat exist through the Sequoia Spring golf course in upper HBKC (Table 2).

4.6 Determination of salmonid distribution

The distribution of salmonid species within the HBKC and Detweiler Creek watershed could be confirmed through additional fish sampling and include the storm drain system immediately East of the Haig Brown Kingfisher Creek system along Willow St and adjacent to the Campbellton Elementary School (Table 2).

4.7 Bank Instability in lower Quinsam River

There are several sites of bank instability along the lower Quinsam River that could benefit from an assessment for bioengineering restoration opportunities in order to reduce the input of fine sediments to spawning habitat in the lower river (Table 2).

4.8 Maintenance of storm drain intake structure and debris in HBKC

Maintenance opportunities include surveying the discharge elevations from Pease Swamp (outflow structure and the crest of the beaver dams) and corresponding maintenance activities. It would also be beneficial to remove the debris in the mainstem channel at the Forestry Road in upper HBKC east (Fig 1).

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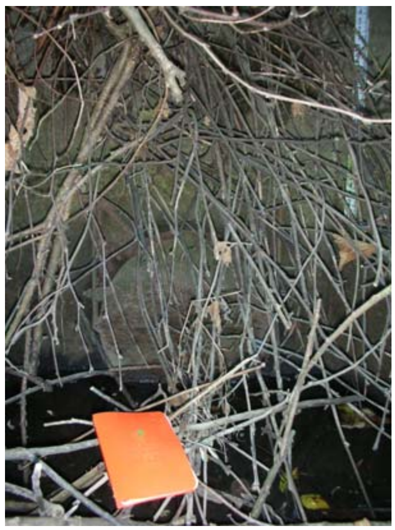
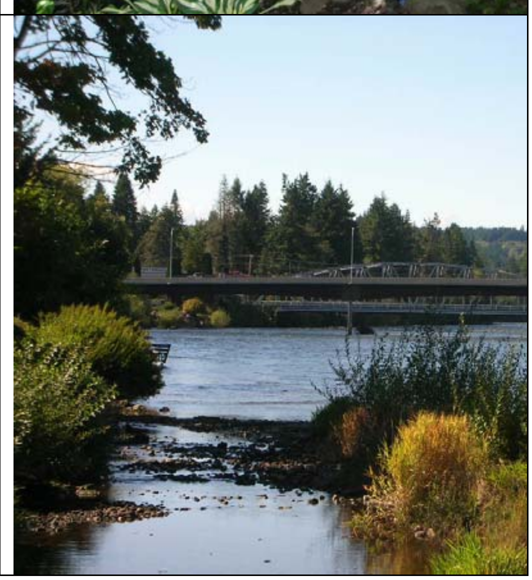
Appendix A. Reconnaissance of Campbell River Mainstem Outfalls with site characteristics and presence of groundwater during Sept 2006.

Site	Site Char	Gdwater Flow (Est)	Photos	Photos
CR1 Maple St	Open cement culvert, perched at low tide, grad .29% gradient, amongst riprap along RB outside bend pool. Adjacent to Murt Thompson Trail	None		
CR2 Petersen Rd	Staff gauge and pressure cover over outlet. Potential rearing habitat at confluence with river, shallow shelf that would provide refuge habitat between 2 wharfs	None		
CR3 CR Lodge	New 16" outfall pipe with outlet cover recently installed, old one still in place with metal cover and staff gauge. Good rearing adjacent to outfall area and good off channel rearing habitat obs at these flows.	None		
CR4/5 Redwood St	Outfall not observed from foreshore area, commercial building no manhole or obvious access observed from road.	Unknown		

Site	Site Char	Gdwater Flow (Est)	Photos	Photos
CR6 Spruce St	Heavy brush, outfall not observed would require clearing riparian shrubs to access or water access	Unknown		
CR 6.5 D/s side of north bound H19 bridge	Fish access possible at very high tide and high river flows ie 2 m higher than today's level at 3:50 pm Sept 2, 06	1L/sec		
CR7 Btwn 2 bridges at Enn's property	2133 mm CMP with cement outfall curtain constructed under house, low gradient outfall, concrete box culvert. Reported access by adult and juvenile salmonids into storm drain system – old creek location F. Voysey captured salmonids here in 1994.	2 L/sec year round flows		
CR8 Willow St bridge	Perched twin 12" CMP, > 3 m from existing water level, likely no fish access or utilization along shoreline			

Appendix B. Campbell River / Quinsam ISMP Site Photos – August to October 2006.

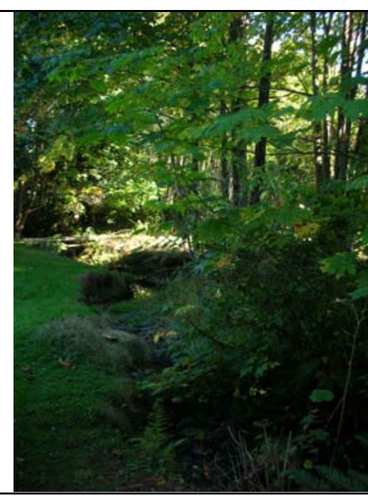
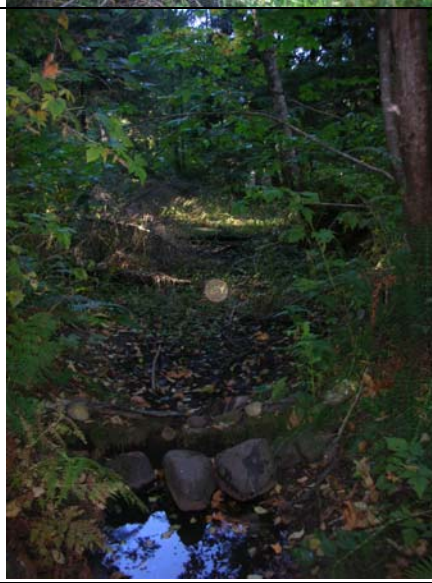
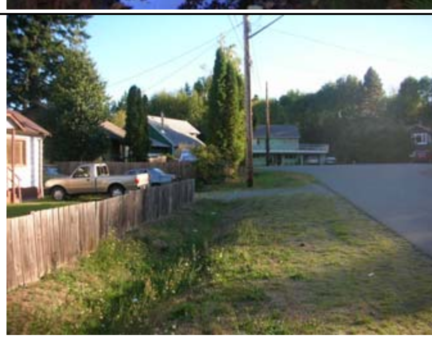
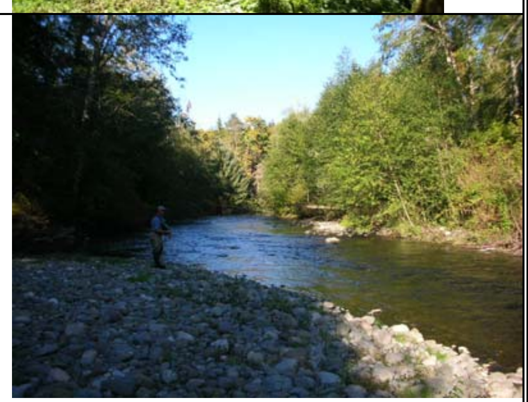
SITE/PHOTO NO.		SITE/PHOTO NO	PHOTO
Photo A-1. Lower Haig Brown Kingfisher Creek illustrating channel complexing at Haig Brown House property.		hoto A-2. aig Brown reek H28 lvert	
Photo A-3. HBKC West Branch lower illustrated 1998 habitat complexing works and good riparian recovery		Photo A-4. HBKC West branch lower illustrating groundwater flows that was supporting coho fry in early Sept 2006	
Photo A-5. HBKC East Rearing channel constructed immediately downstream of the VIHP crossing in the upper reaches (Oct 2006).		Photo A-6. Upstream view of groundwater fed fish habitat in the west fork of Kingfisher Creek at Quinsam Road during a period of extended dry weather in October 2006.	

Photo A-7. HBKC East Fork illustrating lowermost beaver dam at Campbelton elementary school field (Aug 06).		Photo A-8. HBKC East Fork Pease marsh (Aug 06).	
Photo A-9. HBKC East Fork wetlands upstream of Pease marsh (Aug 06).		Photo A-10. Upstream view of bifurcation structure in HBKC East illustrating pool habitat supporting salmonids during September 2006	
Photo A-11. Lateral view of the bifurcation structure where low flows travel under the metal plate and high flows travel over the cement sill in the foreground and into the storm drain system (Aug 06).		Photo A-12. Downstream view of the open fish accessible channel downstream of the bifurcation structure that flows into the Cambellton stormdrain system. Potential for fish stranding exists at collapsed mid channel wooden structure (Oct 06).	

Photo A-13. Upper Haig Brown West Fork, west Branch. Upstream view of dry channel conditions observed during October 2006.		Photo A-14. HBKC East Branch immediately upstream of Pease Marsh where open ditchline adjacent to 16th ave connects to the mainstem (Sept 06).	
Photo A-15. Typical open vegetated ditches in established neighbourhood at Westmore and Treelane in the residential area south of Campbelton (Aug 06).		Photo A-16. Typical curb, gutter and street light infrastructure in new subdivision at west end of Treeland Road (Aug 06).	
Photo A-17. Open vegetated ditch in the Campbelton light industrial area along 17th Ave (Sept 06).		Photo A-18. Example of typical light industrial development in the Cambellton area (Oct 06).	

Photo A-19. Mature riparian canopy in upper HBKC provides protection to instream values as well as important migration, foraging and nesting habitat for wildlife species (Oct 06).		Photo A-20. Upstream view of lower Detweiler C at Detweiler Rd illustrating good overhead cover and gravel/cobble substrates during dry channel conditions in early October 06.	
Photo A-21. Upstream view of Detweiler Creek at Duncan Bay Main where good riparian habitat and isolated pool habitat was observed during an extended period of dry weather (Oct 06).		Photo A-22. Detweiler Creek duck pond that likely supports trout species on private land immediately upstream of Quinsam Road (Oct 06).	
Photo A-23. Typical vegetated open ditches in lower Detweiler Creek (Oct 06).		Photo A-24. Downstream view of the lower Quinsam River mainstem in Elk Falls park illustrating good spawning and rearing habitat, mature riparian cover and recreational fisherman (Oct 06).	

APPENDIX C

HYDROGEOLOGICAL REPORT

PITEAU ASSOCIATES
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September 28, 2006

Urban Systems Ltd.
#2353 – 13353 Commerce Parkway
Richmond, B.C.
V6V 2L1

Attention: Mr. Jeff Rice, P.Eng.

Dear Sirs:

Re: Hydrogeological Assessment for Development of Integrated Stormwater Management Plan for Campbell/Quinsam Area, Campbell River

Piteau Associates Engineering Ltd. (Piteau) was retained by Urban Systems Ltd. (USL) to conduct a hydrogeological assessment of the Campbell/Quinsam Area in Campbell River. This assessment was designed to provide information to assist with the development of an Integrated Stormwater Management Plan (ISMP) for the area.

A series of district-wide ISMPs have been conducted, including the Foreshore, Nunns, Simms Creek and Willow Creek, and Holly Hills. The Campbell/Quinsam study area comprises a region roughly bounded by the Campbell and Quinsam rivers to the north and west, Quinsam I.R. 12 and Willis Road to the south, and Petersen Road to the east (Fig. 1).

This assessment was conducted with the knowledge that, in many areas of British Columbia, it has been found that ground infiltration of stormwater runoff has a number of benefits, which include:

1. helping to reduce peak runoff flow;

2. filtering out contaminants prior to discharge to stream and marine water; and

3. helping to sustain low flows in streams.

Much of the study area is currently undeveloped, but a series of residential developments currently underway indicate that land use is changing. This presents a potential opportunity to incorporate best management practices into stormwater management in new neighbourhoods.

WORK CONDUCTED

The study involved an office review of information on geology, surface soils, surface water drainage, logs of water wells, and vegetation types. Mr. Arnd Burgert, P.Geo., a Piteau hydrogeologist, made a site visit on June 21, 2006 to confirm lithology and hydrogeological interpretations made from aerial photos, and to ground-truth the locations of lithologic units that may present infiltration potential.

Sources of information included: reports on surface drainage, stereo air photos, a regional soils map, logs of drilled wells and interviews with individuals familiar with local area drainage patterns. The inferred groundwater conditions at the site were compared with hydrogeologically similar areas, such as Quadra Island (Piteau, December 1987), Point Grey, Vancouver (Piteau, December 2002), Holly Hills (Piteau, 2003), and Nunns, Simms, and Willow creeks (Piteau, 2005).

The existing data include several reports on surface water drainage, which are listed in the references. The reports with the most relevant information relating to the local area groundwater resource are those that included information on: soils, geology, stream low flows and water temperature and chemistry. However, information on land cover, land use and vegetation types was also useful for assessing past and present groundwater recharge and discharge areas. The water well database maintained by the Ministry of Environment was also reviewed for information on wells in the study region.

CLIMATE

Environment Canada's Campbell River Airport weather station is located at an elevation of about 105m above mean sea level (m-asl), and is 8.5 km south of the study area. Monthly and daily precipitation data are available from 1953. Based on the normalized record for the period 1971 to 2000, the station receives about 1,451.5mm of precipitation annually. The highest monthly average occurs in November (230.7mm), and the lowest in July (40.4mm).

The Campbell River Surfside station was located in southern downtown Campbell River at an elevation of 9 m-asl, about 10.5 km southeast of the study area. Monthly and daily precipitation data are available from 1981. The normalized record for the period 1981 to 2000 indicates that the station receives about 1,452.9mm of precipitation annually. While this total is almost identical to that recorded at the Airport station, a smaller proportion falls as snow.

The average annual temperature at the Airport station is 8.6°C. At 9.4°C, the average annual temperature at the Surfside station is nearly a degree warmer than that reported for the Airport station.

GEOMORPHOLOGY, SURFACE DRAINAGE AND LAND USE

The Campbell/Quinsam area includes the northern tip of a 33m high upland that extends southward beyond Campbell River Airport. The top of the upland is relatively flat (Photo 1), and in the study area, the western end of the upland is truncated by bluffs overlooking the Quinsam River. To the east of the upland lies a series of lower terraces having irregular topography. Stands of old growth Douglas Fir have been logged in the study area since the early 1900s, and second growth stands now cover much of the western portion.

Drainage in the westernmost portion of the study area is toward the Quinsam River. Along the bluffs overlooking the river, some gullying is evident. Drainage in the remainder of the study area is northward toward the Campbell River, along a series of small streams that are fish habitat (Photo 2).

Land use in the southeastern portion of the study area includes farms, wooded areas, and a golf course, while in the northeastern portion, established single-family residential development is prevalent. Some industrial and commercial use is also found in the southwest portion. New residential developments are currently underway in the area west of the west end of Cheviot Road (Photo 3).

GEOLOGY

Surficial deposits in the study area were deposited in glacial, fluvial, lacustrine, and marine environments during and immediately following the Late Wisconsin glaciation. After the glacial ice receded from the area some 10,000 years ago, most of the area was submerged by the ocean. Subsequent isostatic rebound caused a relative land surface rise of about 200m.

The regional surficial geology map (Fyles, 1959) shows that the upland area is underlain primarily by glaciomarine silt and clay. During the site visit, layers of dense, silty till-like deposits were noted within the sequence of fine clastic marine sediments. In the lower eastern terraces, lithology is variable, and silty, till-like units are interspersed with sand and gravel. The northern lowland near the Campbell River is covered by recent alluvial deposits.

The marine deposits are rarely thicker than 12m, and typically either overlie bedrock or a glacial outwash sand unit (Quadra Sand). Bedrock underlying the study area is divided by a northeast-trending nonconformity, with upper Cretaceous Nanaimo Group sandstone and conglomerate to the southeast, and middle to upper Triassic Vancouver Group volcanics to the northwest. The glaciomarine units typically have a relatively low permeability and the underlying Quadra Sand unit is moderately permeable.

The BC Ministry of Environment's records for deep water wells indicate only a single deep drilled borehole in the study area, located on Nursery Road (see location on Fig. 2). The lithology record from this well plus field observations were used to prepare the hydrogeological section presented on Fig. 3. Groundwater mapping by Halstead and Treichel (1966) suggests that groundwater can be obtained from unconfined aquifers in the upper part of the till unit, and from confined aquifers beneath the till.

While the Quadra Sand unit consists mainly of sand, in some areas it has beds of clay, silt and gravel present. These typically represent less than 10% of the unit thickness. According to Clague (1977), there is no systematic gradation in mean particle size either vertically through a section or areally along the length of the Georgia Depression where the Quadra Sand occurs. Most of the silt is present in the upper part of the unit, and gravel is most common in the lower part. For example, in the sea cliff exposures of Quadra Sand at the Point Grey Peninsula, where the University of British Columbia campus is located, the silt beds extend from about mean sea level to elevation 18 m-asl (Lopaschuk, 1976; Madsen, 1974). Below this unit (below sea level), there is a sand and gravel aquifer that sustains well yields in the 2 to 4 L/s range.

A similar situation is present in the Cape Mudge area on Quadra Island (Piteau, 1987), where an upper till unit is up to 35m thick and the underlying Quadra Sand unit extends to 40m below sea level.

SURFICIAL SOILS

The dominant soil type mapped in the Quinsam/Campbell area is Fairbridge soil consisting of silty loam to silty clay. According to Day, Farstad, and Liard (1959), the soil is derived from a fine clastic marine sediment parent material, but portions are probably also derived from glacial moraine. This soil presents relatively low potential for infiltration of stormwater. The estimated potential infiltration rate under long term (saturated) flow conditions is about 3mm per hour (mm/h).

The second most common soil occurrence is Cassidy sandy loam. These alluvial soils present moderate estimated long-term infiltration potential of about 6 mm/h. They are present in the northern portion of the study area, on the lowest terrace overlooking Campbell and Quinsam rivers. Silty sand and gravel are exposed along Detweiler Road.

A small occurrence of Dashwood soils is mapped in the easternmost portion of the study area. The parent material of these soils is sorted marine sand and gravel, such as raised beach deposits. Estimated long-term infiltration potential of these well-drained to excessively drained soils is about 250 mm/h.

Estimated infiltration capacities are based on the soil granular size descriptions, the depth of the soil horizon and experience with conducting percolation tests in similar types of soils. As such, these values should be used as a planning guide and not for detailed design of infiltration works.

TYPICAL SEDIMENT PROFILES

At a location on Nursery Road, about 650m north of the I.R. 12 boundary, an 11m thick section of dense silt is exposed in a road cut and creek bed (Photo 4). On Quinsam Road about 600m north of the Quinsam River bridge, a sequence of dense, laminated silt and clay are exposed (Photo 5). This lithology is interpreted as marine sediments, and water seeping from the top of this layer indicates that it acts as a groundwater flow barrier. Similar dense silt is exposed in a slide track about 200m south of the Quinsam River bridge (Photo 6), where the entire exposed section (about 30m thick) consists of dense silt. The upper portion contains boulders, indicating moraine, while the lower portion is stratified, indicating marine sediments.

Soils consisting of dense silt are also exposed in construction trenches in the southern portion of the study area, west of Cheviot Road (Photo 7); in a logging road cut about 500m northeast of Well 43118; and at a development site east of Hwy 19 and 700m north of Willis Road (Photo 8).

Sand and gravel units that appear to be very rapidly drained are exposed on a cleared terrace in the central portion of the study area (Photo 9), and along the Spruce Street roadcut in the eastern portion of the study area (Photo 10). The locations of these well-drained units are indicated on Fig. 2 by a red outline. While lithology and stratification of these sand and gravel units resembles Quadra Sand sediments, it appears to be of limited extent, suggesting that it is in fact a remnant of a younger post-glacial fluvial terrace deposit. The sand and gravel in the Spruce Street exposure has a vertical thickness exceeding about 15m, and underlying Nanaimo Group conglomerate bedrock is exposed in a valley north of Spruce Street (Photo 11).

STREAM BASE FLOW AND URBANIZATION

Poorly managed urban runoff can lead to unnatural increases in winter peak flows. This can result in scouring of channels and loss of aquatic habitat, as well as bank erosion and increased turbidity. Conversely, since groundwater seeps and springs contribute to summertime baseflows (low flows) in many streams, these can potentially be reduced because conventional urbanization results in a lower proportion of precipitation being absorbed into sediments. Baseflow reductions are associated with water temperature increases and reduced habitat.

Urban runoff also poses the hazard of contaminated water being discharged directly into an aquatic environment. As storm water flows through a storm sewer, it has virtually no opportunity for remediation of contaminants, reaching the outfall in a matter of minutes or hours. Before the onset of development, not only was runoff less likely to be contaminated by hydrocarbons and pathogenic micro-organisms in the first place, but the water encountered more opportunity for passive bacterial remediation and physical straining as it travelled through the shallow soil. Land use over much of the Quinsam-Campbell area is currently low-density, presenting an opportunity for the implementation of current best management practices (BMPs) as land use intensifies.

Quinsam and Campbell Rivers provide important fish habitat, including Steelhead and Salmon (Photo 12). Efforts to conserve both species are ongoing, and Fisheries and Oceans Canada operates the Quinsam River Hatchery 1 km southwest of the study area.

Deep groundwater from elevated regions to the west may pass beneath the Quinsam River, seeping toward Campbell River and Discovery Passage, but seepage observed from the top of a silt and clay unit on Quinsam Road confirms that shallow groundwater seepage probably contributes to local baseflows. Augmentation of recharge to shallow sediments in the Quinsam/Campbell area, if possible, would therefore likely help sustain baseflows.

Previous hydrogeology studies performed by Piteau in the Campbell River area have shown that historical baseflows in Simms and Willow creeks have been impacted by urbanization. The groundwater fluxes, or flows per unit catchment area, for Simms and Willow creeks were shown to be about 4 times lower than those in undeveloped areas. It was also shown that Simms Creek baseflow has a strong groundwater component. It is likely that small streams draining the study area are similarly fed by groundwater flow.

Historical Quinsam River mean monthly discharge for the month of August each year is presented on Fig. 4. The August discharge is probably roughly representative of baseflow for each year. Also presented on this figure are plots of the deviation from mean monthly precipitation (cusum) for Oyster River and Campbell River Airport weather stations. The cusum plots provide an indication of relative precipitation for a period, with a downward slope indicating a drying trend, and an upward slope indicating a wet period.

For the period prior to about 1983, there appears to be a correlation between the cusum trend and the Quinsam River baseflow. After 1983, the correlation is not clear, with the exception of a wet period between 1999 and 2000 during which the Quinsam River baseflow was unusually high. Quinsam River baseflows exhibited a general decline between 1993 and 2004. However, 2005 baseflow was within historic norms. Our interpretation of this data is that to date, urbanization has had no significant impact on Quinsam River baseflow. However, experience in other Campbell River watersheds indicates that as urbanization progresses, the potential for impact on baseflows increases, particularly among the smaller streams in the northern portion of the study area.

GROUNDWATER FLOW SYSTEMS

Some of the precipitation falling on the uplands to the south and west of the Campbell/Quinsam area seeps into the ground, and likely flows along the surface of restrictive layers such as marine clay or bedrock units. The flow will either find a place where it can seep through the cap into a permeable unit, or discharge back onto the ground surface as seeps or springs, or directly into streams. Precipitation falling within the study area likewise contributes to recharge of shallow sediments.

As groundwater temperatures are usually not more than about 1°C above or below the annual mean air temperature, it is expected that local area deep groundwater temperature will range between 7.5 and 9.5°C. As the average annual temperature at the Surfside weather station is 9.4°C, the temperature of shallow, rapidly cycling ground water may be in the range between 8.5 and 10.5°C.

GROUND INFILTRATION OF STORMWATER

The study area presents potential for infiltration of stormwater in certain areas. The regions with the greatest infiltration potential are the sand and gravel units located near the centre of the study area. These units are described under the heading "Typical Sediment Profiles", and their locations are depicted on Fig. 2 by a red outline. While the water infiltration rate for this unit is probably very high, its potential for stormwater infiltration is restricted by its limited areal extent. An exposure of the sand and gravel unit in the Spruce Street cutbank is greater than 15m thick. Immediately north of Spruce Street, a 30m deep valley has sideslopes of about 75%. Nanaimo Group conglomerate bedrock is exposed in the southern valley slope (Photo 11), but no seeps were noted from between the bedrock and the overlying sand and gravel, suggesting either that only a limited amount of water recharges into the sand and gravel, or the attitude of the bedrock surface deflects groundwater seepage away from the valley.

The texture of Cassidy sediments in the northern portion of the study area appears to be favourable for infiltration, but seasonal high water tables may limit potential for infiltration. Any infiltration works should be provided with overflow decants in case of backups during times of high precipitation. Because much of this northern area is built out with storm sewers in place, it may not be cost-effective to retrofit existing utilities for infiltration. However, certain infiltration mechanisms, such as "leaky" storm water pipes, can sometimes be substituted for conventional pipes relatively easily, and it may be worth considering a long-term plan to make such a substitution whenever portions of the system are due for upgrading. To confirm feasibility of stormwater infiltration in the northern part of the study area, groundwater levels should be monitored for at least a year to determine winter high water levels.

While sand and gravel exposed in a few areas provide potential for stormwater infiltration, dense silty and clay-rich sediments observed over much of the study area provide virtually no potential for infiltration. Site-by-site investigation may show that small, unmapped portions of permeable sediments are present locally. In some areas, ground infiltration systems could be incorporated into landscaping and engineering plans, to direct water towards points where ground infiltration is feasible. The infiltration ranking numbers presented on Fig. 2 are intended to indicate the relative capacities of soils to absorb storm water runoff. This indicates that, within the Quinsam Area, Dashwood soils (Rank 1) have the greatest potential and Tolmie soils have the lowest (Rank 5). While such localized units, if identified, could potentially provide temporal in-ground storage for small amounts of stormwater, they would probably not be suitable for disposing of sustained flows.

Little information is available on lithology at depth in the study area, but the Well 43118 log and observations made along the upland scarp indicate that conditions at depths shallower than about 55m result in limited potential for deep infiltration. While silty sand and gravel below this depth may present infiltration potential, such deep infiltration would have reduced benefit, since infiltrated water would likely seep toward Discovery Passage, rather than discharging into local streams.

Stormwater infiltration has the potential to decrease slope stability along scarps where infiltrated water might seep out. Slope instability can result in slope failures causing property damage and presenting a safety hazard. Lithologic units targeted for infiltration should be mapped and the hazard should be assessed as part of the design of any infiltration works.

Systems that collect stormwater runoff need to incorporate a number of design considerations, including: landscaping to channel water to the infiltration system, a properly sized storage compartment to detain water for slow infiltration after a rainfall event, and a clarification system to eliminate suspended sediments and floating detritus. Regular cleaning of some structures should be anticipated. Designs for all systems should incorporate overflow outlets to prevent flooding during extreme precipitation events.

As clogging is the cause of most failures, runoff pretreatment is critical for successful operation of an infiltration system. Measures that can be taken to improve runoff quality include use of flotation (for oily water) and settlement (for grit and silt) chambers, filter cloth, detention ponds (for settlement), and sand filter chambers (to remove fine silts and clays).

A summary of features useful for clarifying and infiltrating stormwater is presented in Appendix B, and a discussion of how they might be applied in the study area follows.

Shallow Infiltration Systems

Shallow infiltration systems could be designed to infiltrate water into areas within well drained units, such as the Dashwood and Cassidy soils, and the exposed sand and gravel units. Cassidy soils cover about the northern quarter of the study area, and sand and gravel units are outlined in red on Fig. 2.

Examples of shallow infiltration enhancement systems include: swales, soak-a-way pits, seepage basins, shallow infiltration wells and seepage trenches (See Appendix B).

The hydraulic conductivity of the subsurface soils in the lowlands along the Campbell River is likely quite variable, due to the alluvial depositional regime under which these sediments were deposited. For this reason, logs of geotechnical boreholes or test pits should be reviewed to confirm the presence of suitably permeable sediments.
A series for infiltration tests in linear trenches should be conducted prior to the development of more detailed plans for stormwater infiltration. Wide dispersal of infiltration systems is

preferable, as this minimizes the potential for excessive water table mounding and slope instability. As a guide, conducting one test per soil type per 5 hectares could be used for preliminary planning. This could be modified if the results show a relatively high degree of consistency. An estimate of costs for constructing a test trench, running an infiltration test, analyzing the results, and preparing a report for ten pits typically is between $400 and $600 per trench.

Vertical Infiltration Wells

Clean stormwater that cannot infiltrate into shallow soils in the upland areas could be discharged into either the Quadra Sand unit, or a deeper sand and gravel unit, where present below the low permeability till-like or marine units. However, deep infiltration is not recommended for the study area, as recharge to deeper sediments would likely seep toward Discovery Passage and not have a beneficial effect on stream baseflows. The log for Well 43118 indicates the presence of a 3.0m thickness of potentially permeable silty sand and gravel at a depth of 20.4m below ground. Water infiltrated to granular material at this relatively shallow depth, if feasible, would provide recharge to local streams. Infiltration would require the construction of one or more infiltration wells (see Appendix B).

Two to three 25m deep test holes will be required to assess the feasibility of the deep hole infiltration method. A well typically costs about $10,000 and an infiltration test costs in the range $1,800 to $3,500, depending of the availability and cost of a water source, such as a fire hydrant or tanker truck. Engineering and interpretation costs would typically cost an additional $4,000 to $5,000 per well. Test holes should be located in areas where a site suitable for drilling exists, and where a stormwater main could be readily diverted into the well. Selected wells can also be used for long-term monitoring of groundwater levels and water quality. Water level monitoring is best performed using an electronic datalogger. These systems cost about $2,500 per well.

It is important to appreciate that the performance of any ground infiltration system will decline if suspended solids and bacteria are not adequately removed from the water prior to discharge. Further, an improperly functioning system has the potential to allow contaminants in surface water to enter an aquifer. Collection systems feeding infiltration wells should incorporate properly designed, constructed and maintained vegetated swales or other similar stormwater “best management practices.” The alternative to removing contaminants and infiltrating water is usually discharging raw storm water directly into a stream environment, potentially reducing habitat quality.

Detailed hydrogeological assessments should be conducted prior to construction and operation of deep infiltration wells. This type of investigation should consider both positive and negative impacts, such as stream base flow enhancement, potential for groundwater contamination, and slope instability. As noted in Appendix B, groundwater contamination resulting from ground infiltration of surface water runoff is very rare.

Hydrogeologic Assessment and Monitoring

If ground infiltration of surface water runoff is being seriously considered, a more detailed hydrogeologic assessment should be carried out. This typically involves digging test pits and installing standpipe piezometer tubes, and possibly drilling deeper test wells. Standpipe piezometers would be useful in the low-lying northern portions of the study area, while deeper wells would be useful in the uplands. In situ permeability tests could be run in the piezometers and inflow tests conducted on the wells. Long-term water level monitoring is typically carried out before and after the start of infiltration, and water samples are collected for geochemical analyses. Ideally, manual water level monitoring can be supplemented by automatic monitoring using a datalogger.

The hydrogeological assessment should be supplemented by dry season surface water monitoring at stations established at selected springs and streams. Such stations could take the form of small flumes in streams, or shallow standpipes at springs. Ideally water levels, flows (often calculated from levels), temperature and electrical conductivity should be monitored. As baseflows typically do not change rapidly during the dry season, monthly monitoring is considered a reasonable minimum. Supplemental monitoring using a datalogger is definitely desirable, as more frequent data allows for correlation between daily precipitation records and spring flow. It is suggested that two or three sites be selected near the headwaters of local streams. A fisheries consultant familiar with the construction of such systems should be retained to ensure that flume construction does not impact fish habitat. Depending on the type of flume and level of security (vandalism deterrence) sought, the cost for setting up a flume station could range from $8,000 to $15,000, while a standpipe could be installed in a few hours for about $400. To deter vandalism, standpipes should be completed with flush-mount roadboxes seated in concrete rather than stick-up type casings.

CONCLUSIONS

1. Previous studies have shown that development has probably impacted the natural baseflow regime in numerous Campbell River area streams. Continued development in the study area using conventional surface drainage networks may lead to alterations in peak flows and baseflows in local streams, particularly when the area of impervious surface exceeds 10 to 15% of the catchment area.

2. Infiltration of stormwater runoff has a number of benefits, including: 1) helping to reduce peak runoff flow; 2) helping to sustain low flows in streams; and 3) filtering out contaminants prior to discharge to streams.

3. Because much of the study area is currently undeveloped, there is an opportunity to apply stormwater best management practices to future developments.

4. Shallow infiltration may be feasible in the northern lowland, and in the central portion where sand and gravel are exposed.

5. The log of a drilled well suggests that there may be potential for deep infiltration using recharge wells.

RECOMMENDATIONS

In order to monitor the effects of continued development and/or stormwater infiltration systems, the City of Campbell River should consider establishing a hydrogeological monitoring network. As a minimum, this could include:

1. Documenting and establishing year-round monitoring stations at local streams and springs, and monitoring water levels, flow, temperature and electrical conductivity.

2. Constructing shallow monitoring wells in areas where the water table is within about 4m from ground surface, and where either new development is likely to take place in the near future, or development is likely to densify. This will provide baseline information that would be valuable when considering the construction of stormwater ground infiltration systems and assessing impacts of future development.

LIMITATIONS

This investigation has been conducted using a standard of care consistent with that expected of scientific and engineering professionals undertaking similar work under similar conditions in B.C. No warranty is expressed or implied.

This report is prepared for the sole use of Urban Systems Ltd. and their client, the City of Campbell River. Any use, interpretation, or reliance on this information by any third party is at the sole risk of that party, and Piteau accepts no liability for such unauthorized use.

CLOSURE

We trust that this report is sufficient for your current needs. If you have any questions or comments, please contact the undersigned.

Yours very truly,

PITEAU ASSOCIATES ENGINEERING LTD.

Arnd Burgert, P.Geo.

Reviewed by

Andrew Holmes, P.Eng
Principal, Senior Hydrogeologist

AB/ATH/dls

Att.

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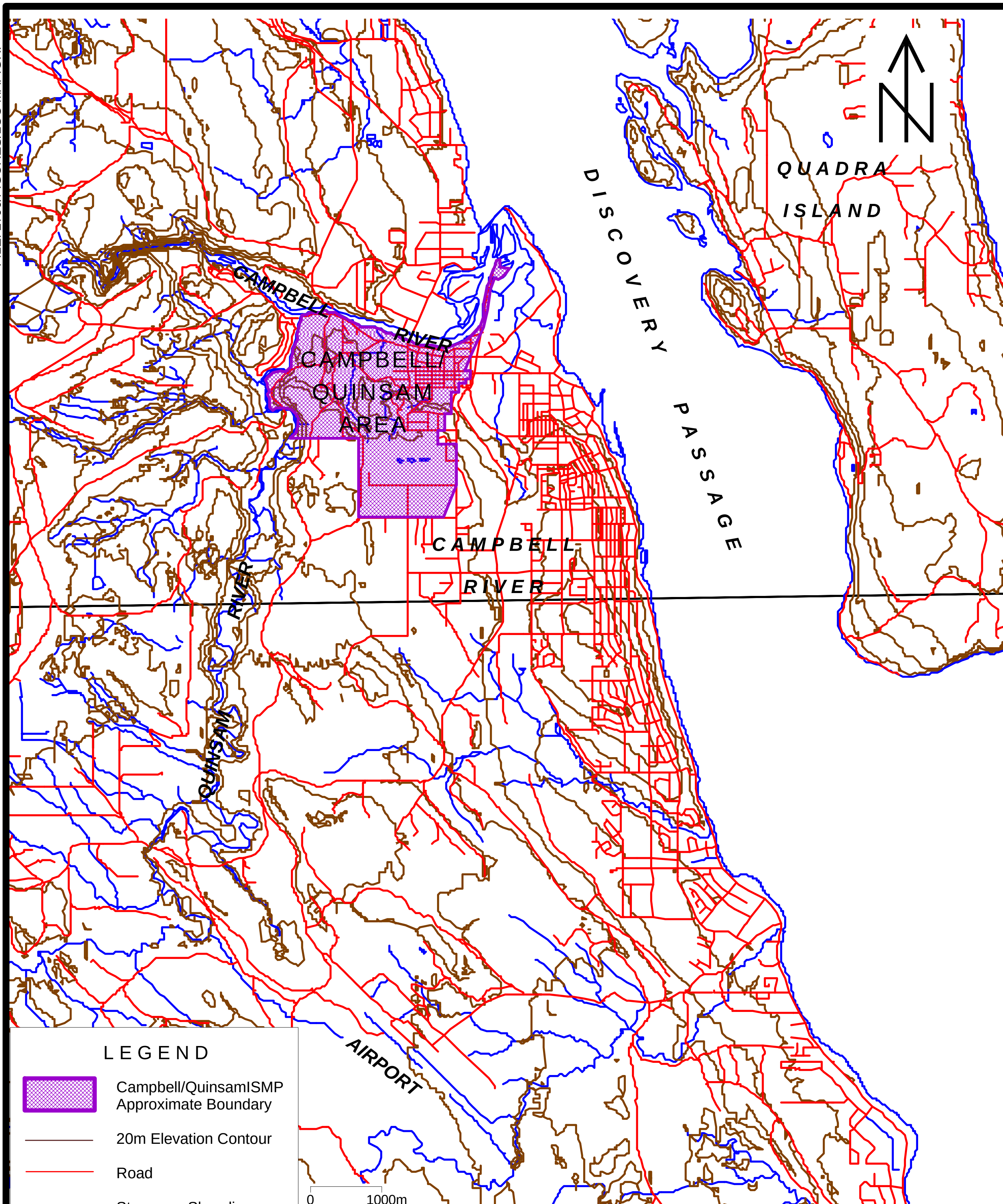
FIGURES



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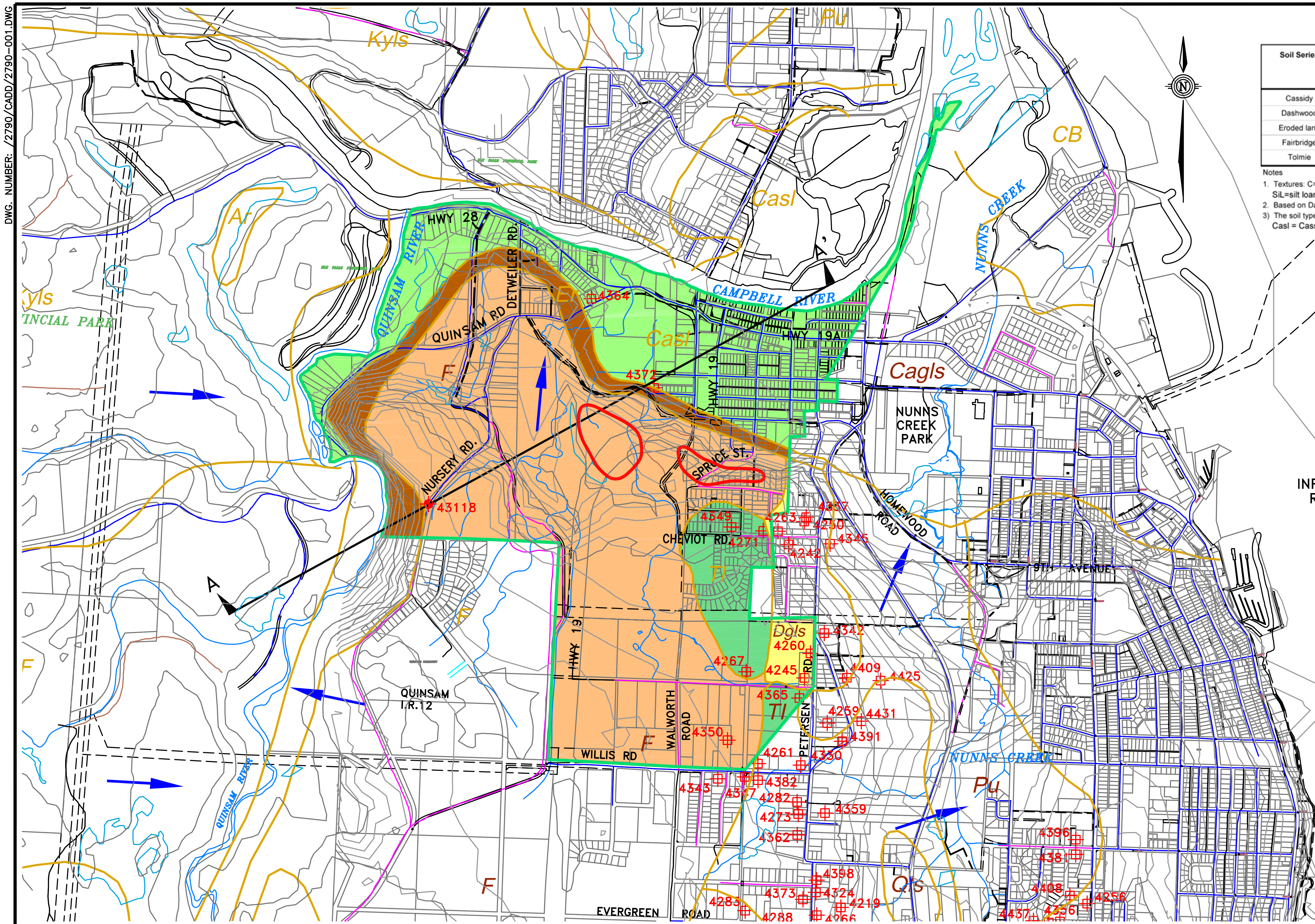
VANCOUVER LIMA

HYDROGEOLOGICAL ASSESSMENT, CAMPBELL/QUINSAM ISMP, CAMPBELL RIVER, B.C.	STUDY AREA	BY: AB	DATE: JUN 06
		APPROVED:	FIG: 1



SOIL TYPES IN CAMPBELL/QUINSAM AREA

Soil Series	Symbol	Soil			Soil Depth		Estimated Infiltration Potential (mm/hr)
		Classification	Drainage	Texture[1]	Min (m)	Max (m)	
Cassidy	Ca	Alluvial	variable	SL	0.43	0.56	6
Dashwood	Dgls	Brown Podzolic	well	GLS	0.00	0.00	250
Eroded land	Er		variable	variety			-
Fairbridge	F	Concretionary Brown	well	SiL to SiCL	0.00	0.00	3
Tolmie	Tl	Dark Grey Gleisolic	poor	L	0.0	0.0	<3

Notes
1. Textures: C=clay; G gravel, Si=silt; S=sand; LS=loamy sand; SL=sandy loam; SiCL=silty clay loam, SiL=silt loam
2. Based on Day, Farstad and Liard, 1959.
3) The soil type is sometimes included in the symbol. For example: Casl = Cassidy soil which is dominantly SL or sandy loam.

LEGEND

DUG WELL (WELL TAG NUMBER SHOWN)
DRILLED WELL (WELL TAG NUMBER SHOWN)

INFILTRATION RANKING	Symbol	Soil
1	Dgls	DASHWOOD
2	Casl	CASSIDY
3	F	FAIRBRIDGE
4	Tl	TOLMIE
5	Er	ERODED LAND

INTERPRETED DIRECTION OF SHALLOW GROUNDWATER FLOW
HIGHLY PERMEABLE SEDIMENTS EXPOSED NEAR SURFACE (APPROXIMATE BOUNDARY)
STUDY AREA BOUNDARY

NOTES:
1. SEE AREA LOCATION ON FIG. 1
2. BASE MAP FROM URBAN SYSTEMS LTD.
3. WATER WELL DATA BASED ON BC MINISTRY OF WATER, LANDS AND AIR PROTECTION WEB SITE. SEE LOG OF DRILLED WELL IN APPENDIX A.

0 200 400 600 800 1000m
SCALE 1:20,000

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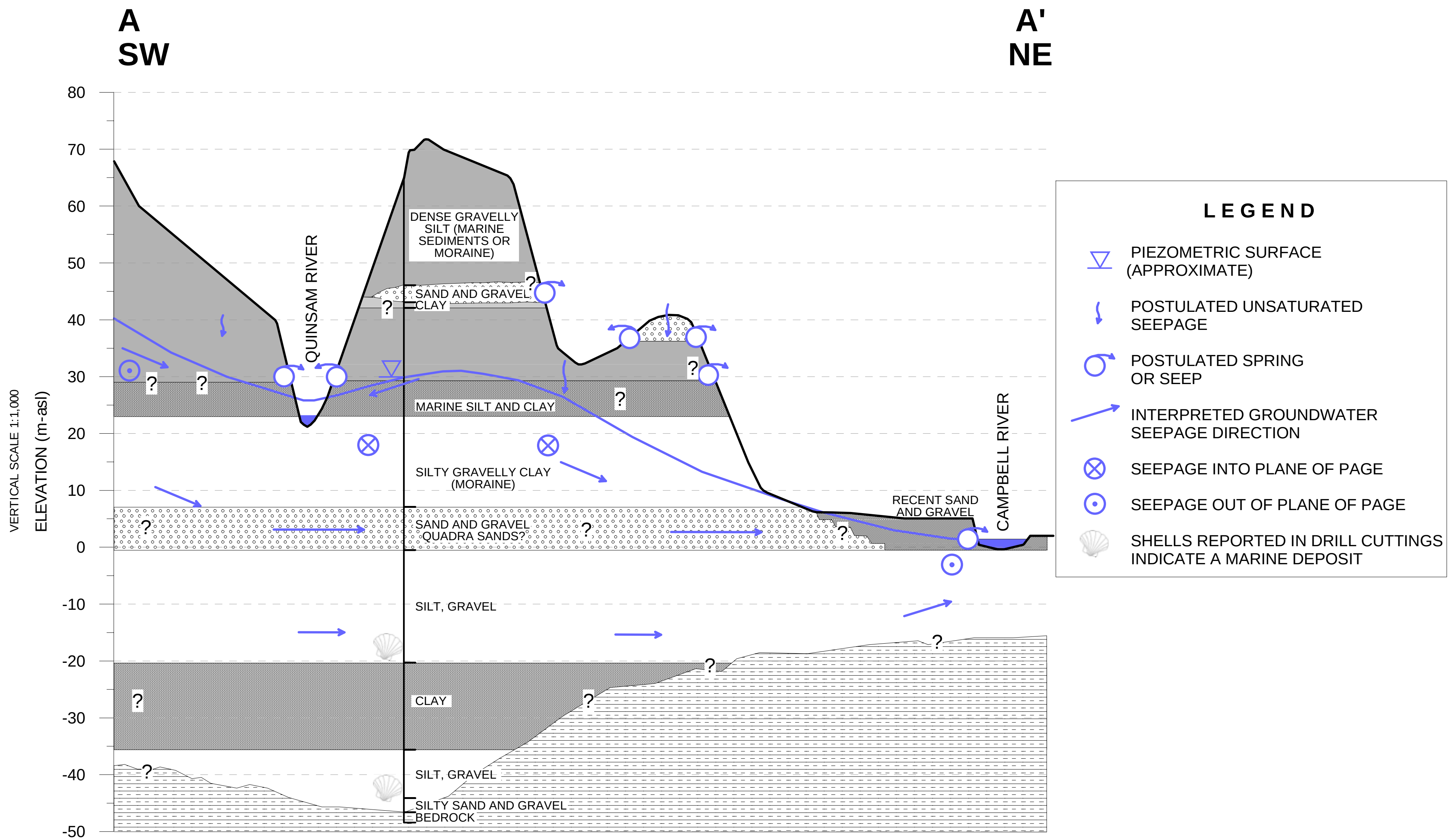
CAMPBELL RIVER, B.C.

SOILS OF THE CAMPBELL-QUINSAM AREA

BY: AB/ss
DATE: SEP. 06
APPROVED:
FIG: 2

FILE: H:/2790/SECTION/SECTION.GRF



HORIZONTAL SCALE

0 200 400 600 800 1000 m

1:20,000

NOTES:

1) See location of section on Fig. 2.
2) Vertical exaggeration 20x.

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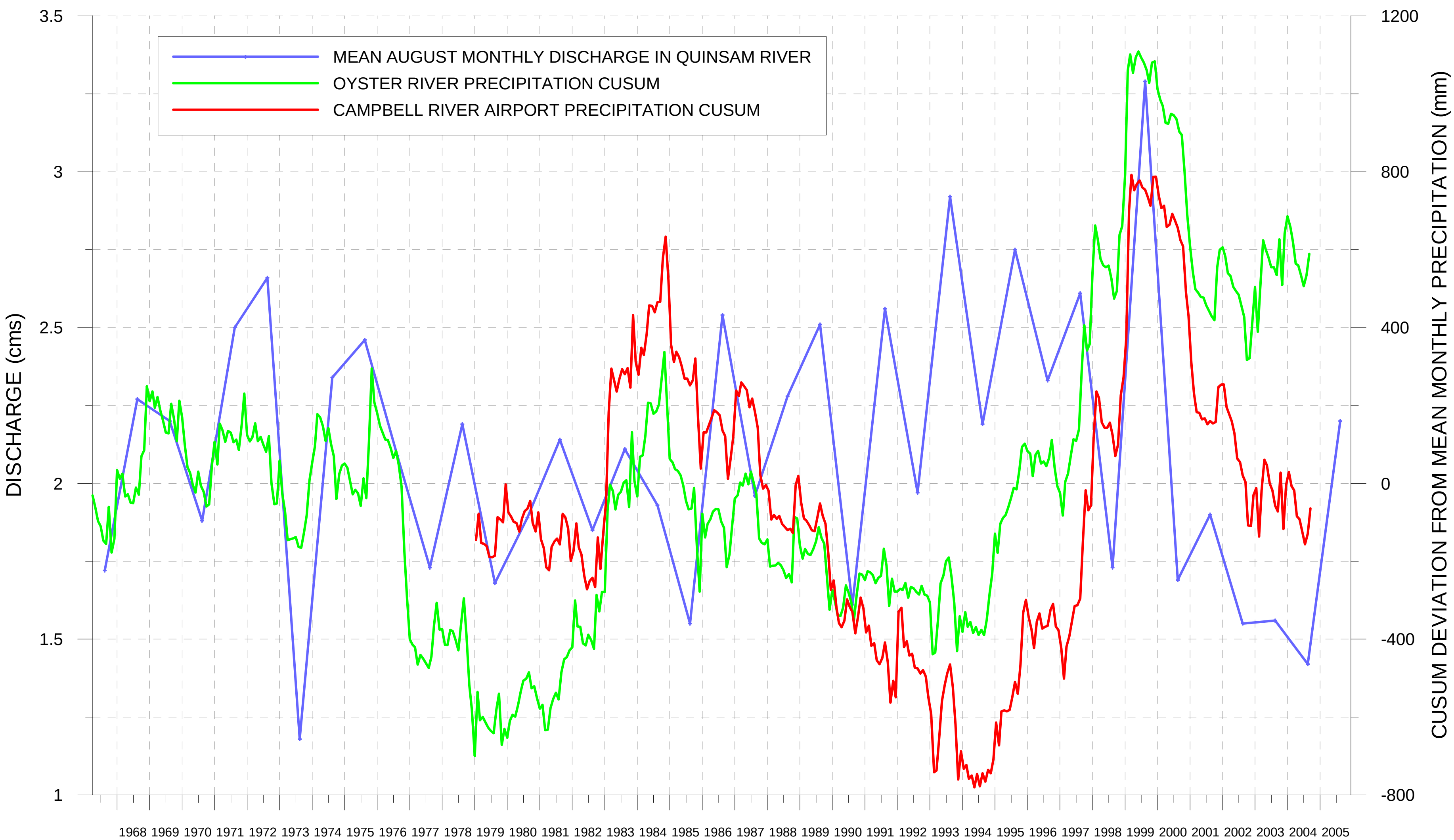
HYDROGEOLOGICAL SECTION A-A'

BY:	DATE:
AB	JUN 06
APPROVED:	FIG:
	3



NOTES:
1) Discharge data is from Water Survey of Canada Station No. BC08HD005, Quinsam River near Campbell River.
2) Precipitation data is from Environment Canada Oyster River UBC and Campbell River Airport stations.

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CAMPBELL/QUINSAM ISMP,
CAMPBELL RIVER, B.C.

QUINSAM RIVER
MEAN MONTHLY DISCHARGE
FOR AUGUST

BY: AB	DATE: JUN 06
APPROVED:	FIG: 4

APPENDIX A

LOG OF WELL 43118

BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 43118

Owner: FORESTRY

Address: QUINSAM SEED ORCHARD

Area: CAMPBELL RIVER

WELL LOCATION:
SAYWARD Land District
District Lot: 1476 Plan: Lot:
Township: Section: Range:
Indian Reserve: Meridian: Block:
Quarter:
Island
BCGS Number (NAD 27): 092K004213 Well: 1

Class of Well:
Subclass of Well:
Orientation of WEll:
Status of Well: New
Well Use: Irrigation
Observation Well Number:
Observation Well Status:
Construction Method: Drilled
Diameter: 6.0 inches
Well Depth: 380.0 feet
Elevation: 0
Bedrock Depth: 372 feet

Construction Date: 1979-08-09 00:00:00.0

Driller: Drillwell Enterprises
Well Identification Plate Number:
Plate Attached By:
Where Plate Attached:

PRODUCTION DATA AT TIME OF DRILLING:
Well Yield: GPM 12 (Driller's Estimate) G
Artesian Flow:
Static Level: 114 feet

Water Utility:
Water Supply System Name:
Water Supply System Well Name:

Surface Seal Flag:
Surface Seal Material:
Surface Seal Method:
Surface Seal Depth:
Surface Seal Thickness:

Lithology Info Flag:
Pump Test Info Flag:
File Info Flag:
Sieve Info Flag: Y
Screen Info Flag:
Water Chemistry Info Flag:
Field Chemistry Info Flag: Y
Site Info (SEAM):
Site Info Details:
Other Info Flag:
Other Info Details:

GENERAL REMARKS:

From 0 to 5 Ft. topsoil and silty brown clay
From 5 to 62 Ft. silty gray clay
From 62 to 67 Ft. silty sand and gravel, wet
From 0 to 0 Ft. blasting at 67'
From 67 to 72 Ft. silty sand and gravel, wet
From 72 to 75 Ft. silty gray clay
From 75 to 131 Ft. till, silty, dark grey, stoney, boulders
From 0 to 0 Ft. at 90'and 131'
From 0 to 0 Ft. blasting at 131 feet
From 131 to 190 Ft. silty stoney clay, till-like
From 190 to 215 Ft. sand and gravel, boulders 200'
From 215 to 250 Ft. silty till
From 250 to 280 Ft. silty till
From 280 to 330 Ft. silty clay
From 330 to 355 Ft. silty till, stoney
From 0 to 0 Ft. blasting at 335', rocks at 340'
From 358 to 366 Ft. silty sand and gravel
From 366 to 372 Ft. stoney till
From 372 to 380 Ft. bedrock
From 0 to 0 Ft. End of hole
From 0 to 0 Ft. null
From 0 to 0 Ft. Screen and casing pulled.
From 0 to 0 Ft. Hole abandoned.
From 0 to 0 Ft. Only 12 - 15 GPM. (looking for 40-100
From 0 to 0 Ft. GPM). Shells 270-280 and 340-370.

APPENDIX B

BACKGROUND INFORMATION ON SURFACE WATER INFILTRATION SYSTEMS IN CANADA

AND

OVERVIEW OF INFILTRATION ENHANCEMENT STRUCTURES

APPENDIX B

STORMWATER GROUND INFILTRATION SYSTEMS

B.1 General Comments

Infiltration systems include a wide range of devices that are designed to redirect surface water runoff into the ground. They can range from a simple splash pad with a pod of gravel handling roof runoff, to a complex system of buried sumps and perforated pipes handling runoff from a large area. Ideally, a watershed will have as many evenly distributed small systems as is possible, in order to try and emulate the pre-development conditions at the site.

The systems must be carefully designed to discharge water at a rate that the ground can accept, and have appropriate pre-treatment to maximize operating life and to protect groundwater quality. Contaminants that are commonly found in urban stormwater runoff include organic pathogens, suspended solids, hydrocarbons, and metals. Suitably designed infiltration infrastructure, filter these contaminants on media which are easily replaced, resulting in improved water quality recharging the ground. Studies (Deschesne, 2004; Datry, 2003; Dierkes and Geiger, 1999) have found that, even in infiltration systems that have been in operation for over ten years, contaminant concentrations fall off within a few centimetres of the infiltration surface.

Upland infiltration devices (such as infiltration trenches, porous pavements, percolation ponds, and grass roadside drainage swales) are located at urban source areas. Infiltration (percolation) ponds are usually located at stormwater outfalls, or adjacent to large paved areas. These ponds, along with perforated storm sewerage, can infiltrate flows and attenuate pollutants from upland runoff sources.

B.2 Experience in Ontario

The Ontario Ministry of the Environment (OME) encourages the use of infiltration systems in its Stormwater Management Planning and Design manual. However, they do raise a concern about contamination from salt applied to the municipal streets. Their recommendations include the following:

- If the infiltration system is to be a stand-alone system, then a design for reduced infiltration, relative to clean water infiltration (i.e., over-size the facilities) will be considered.
- Install enhanced pre-treatment (more than one pre-treatment device in series) in all infiltration facilities receiving runoff from roads.
- Pre-treatment can be provided by a combination of grass swales, filter strips or grit/oil separators. A pre-treatment volume of 15 mm/pervious hectare is recommended.

In Ontario, guidelines promote the use of infiltration drainage following a treatment train approach. If the ground is suitably permeable, roof drainage is disposed of to soak-a-ways. The next options to be considered are conveyance controls, such as swales, followed by end of pipe controls, such as infiltration trenches, basins and wetlands.

As part of the Great Lakes cleanup program, J.F. Sabourin and Associates (1999) conducted an assessment of roadside ditches and other storm management practices in Toronto, and concluded that grass swale infiltration systems with perforated pipes and infiltration trenches, were capable of retaining and infiltrating the runoff from a 25mm storm. The capital and maintenance cost of this type of system was estimated to be 28% less than a conventional curb and gutter system, and also had far less impact on the local water quality.

Some 20 infiltration basins were constructed in the 1970's in Guelph, Ontario. These are now believed to have sealed and become wetlands, indicating the need for some form of pre-treatment to remove fine material from the water entering the infiltration system. Recent experience with other types of infiltration systems has proved more successful.

In 1993, an experimental 2.1 km section of a perforated storm pipe infiltration system was installed in the City of Etobicoke. It was designed to minimize runoff and at the same time recharge the local aquifer (A.M. Candras Associates, 1997). This system has demonstrated that infiltrating stormwater into moderately low permeability sediments is feasible and beneficial.

B.3 Experience in British Columbia

Stormwater infiltration systems have been used in many areas of British Columbia, either as a designed system or as a consequence of water seeping from surface ditches and buried pipe networks. The Provincial Runoff Quality Control Guidelines (BC Environment, 1992) state that (Section 7.2.3), "Groundwater recharge, which has been lost due to increase in impervious area caused by development, is enhanced by BMPs which are designed to promote infiltration of collected runoff".

The Township of Langley has developed a system of perforated pipes connected to manholes that has performed satisfactorily since about 1987. This urban area, located over the Brookswood Aquifer, consists of very permeable sand and gravel and is capable of accepting a relatively high rate of stormwater infiltration. Field testing and back analysis of a portion of a section of one of these perforated pipes was carried out by Piteau in 2000. These hydraulic analyses have shown that the perforated infiltration pipe system could accept an average flow rate of 0.2 L/s per metre length of pipe, equivalent to the 1:5 year design storm event (Piteau, 2001). Higher short-term (less than one hour) rates were also possible. There was no evidence of any significant reduction of the infiltration capacity, due to a silt build up at the pipe – soil interface.

The District of Chilliwack has been relying on a network of over 200 soak-away well systems for stormwater infiltration into the Vedder Aquifer for at least 15 years. These systems are designed for a 28.3 L/s (1 cfs) discharge and consist of a 1.2m diameter concrete settling chamber, a 1.2m diameter concrete filter chamber and a 0.6m diameter steel infiltration well (see details on Fig. B1). According to one of the District of Chilliwack's representatives (pers. com. W. Moseanko, Oct. 2000), they clean out the chambers at least twice a year and have only had a problem with one well, which was located in a high water table area.

A settlement pond system with vertical wells has been successfully used in the Vedder area of Chilliwack (Piteau, 1989). Subsequent monitoring of their down-gradient production wells has not shown any evidence of contamination from this infiltration system (Carmichael, et. al., 1995).

B.4 Infiltration Infrastructure Conceptual Designs

Illustrated in the following are conceptual designs for the infiltration structures listed:

Figure	Structure
B1	Roof Downspout System

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Piteau Associates Engineering Ltd., 1989. Hydrogeologic Evaluation of Options for Ground Disposal of Stormwater Runoff, Watson-Glen, Phase II, Vedder Crossing, British Columbia. Report prepared for J. W. Wedler and Associates Ltd., July, 19 pp.

APPENDIX B

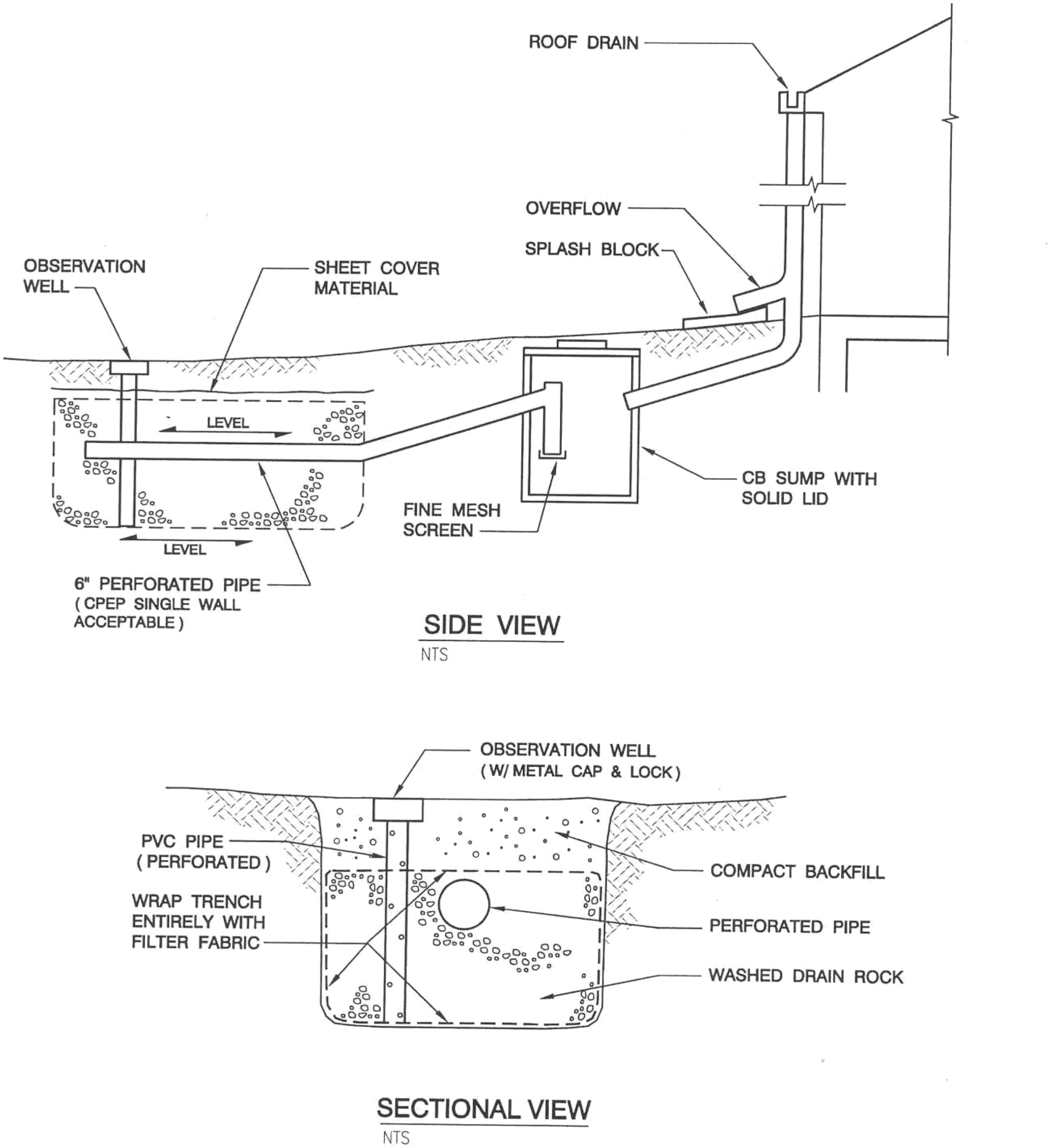


FIG. B1 TYPICAL ROOF DOWNSPOUT SYSTEM (FROM GVRD, 1999)

APPENDIX B

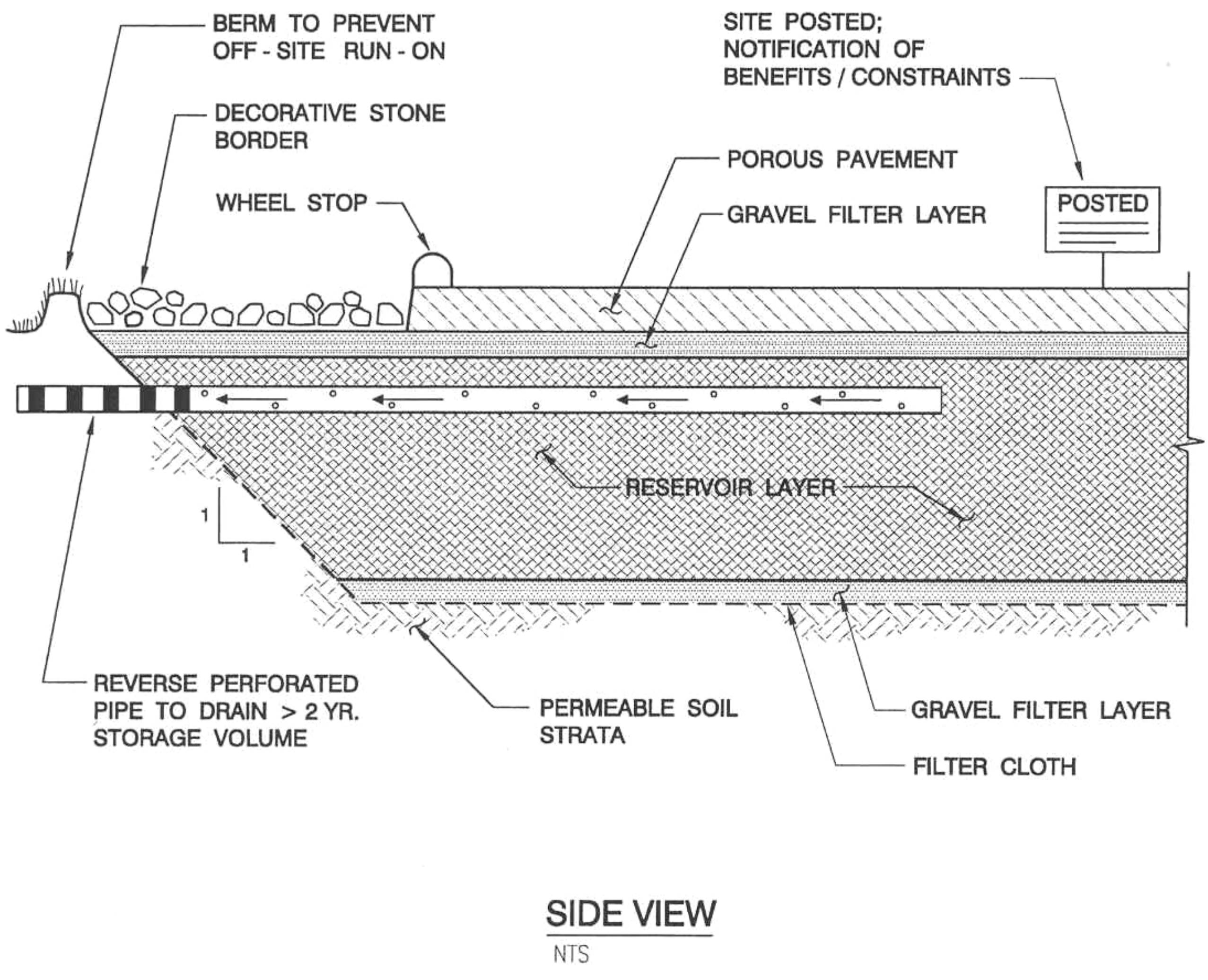


FIG. B2 SCHEMATIC OF POROUS PAVEMENT SYSTEM (FROM GVRD, 1999)

APPENDIX B

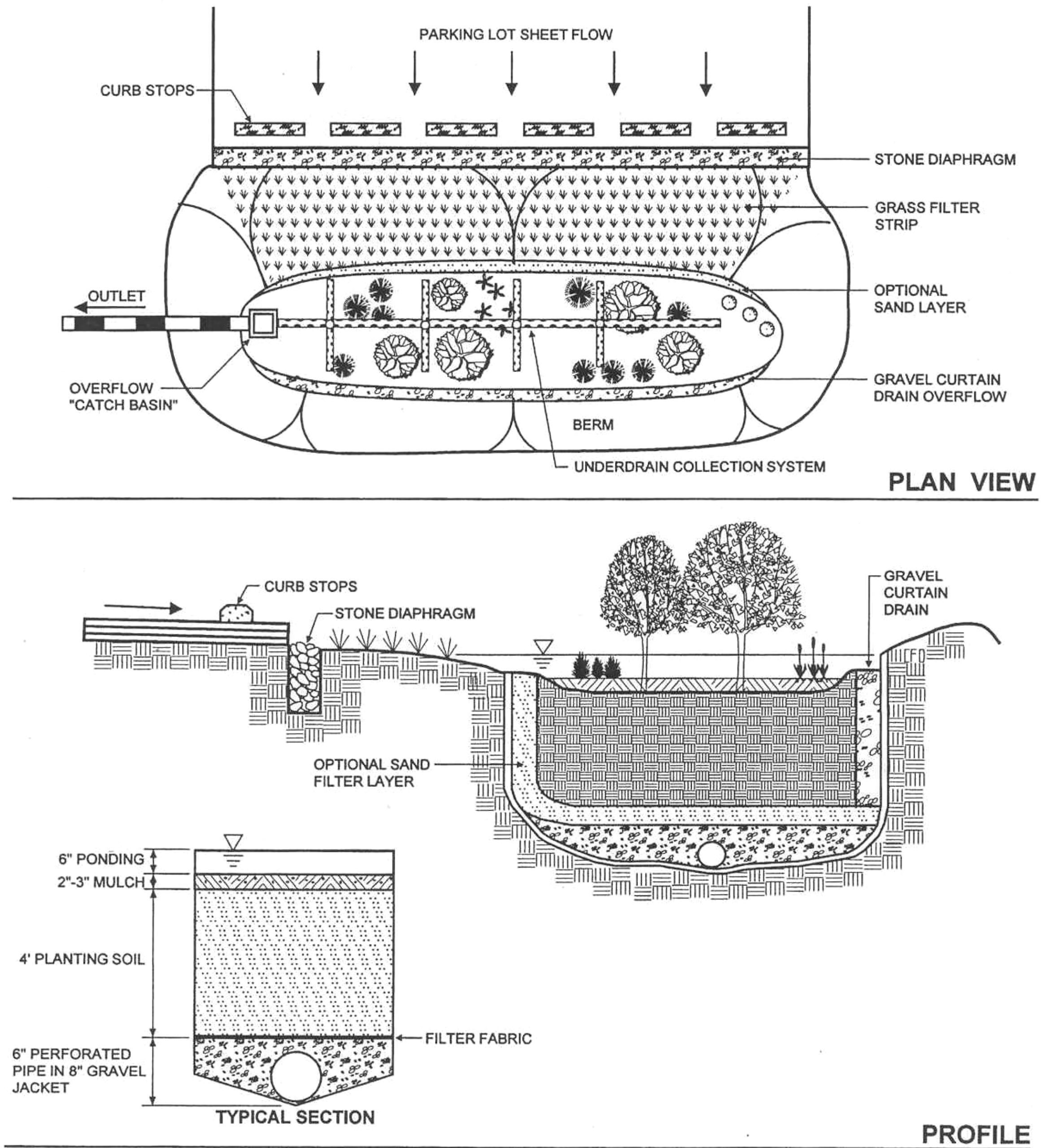


FIG. B3 BIORETENTION SWALE AND TRENCH (FROM GVRD, 1999)

APPENDIX B

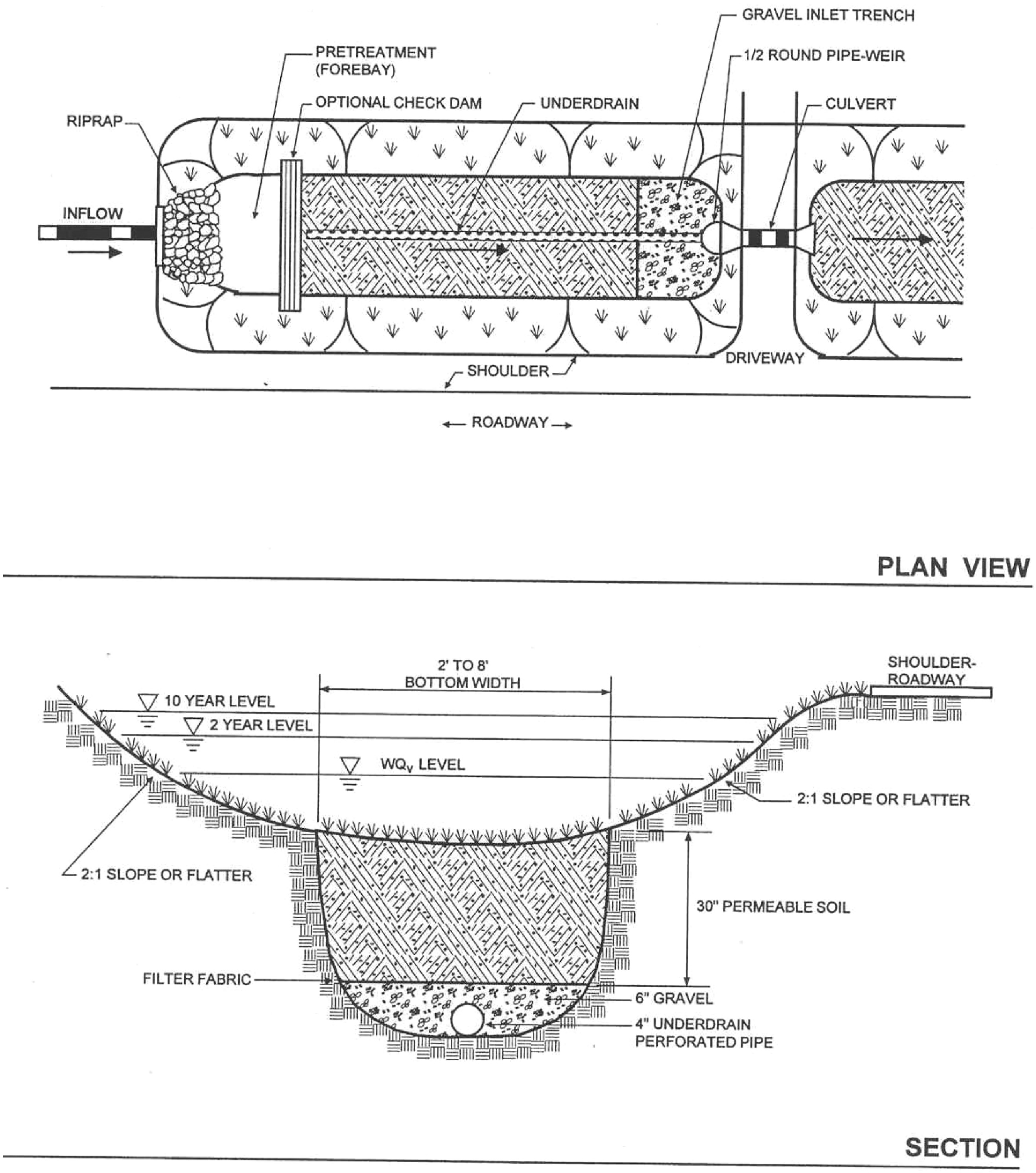


FIG. B4 EXAMPLE OF A DRY SWALE (FROM GVRD, 1999)

APPENDIX B

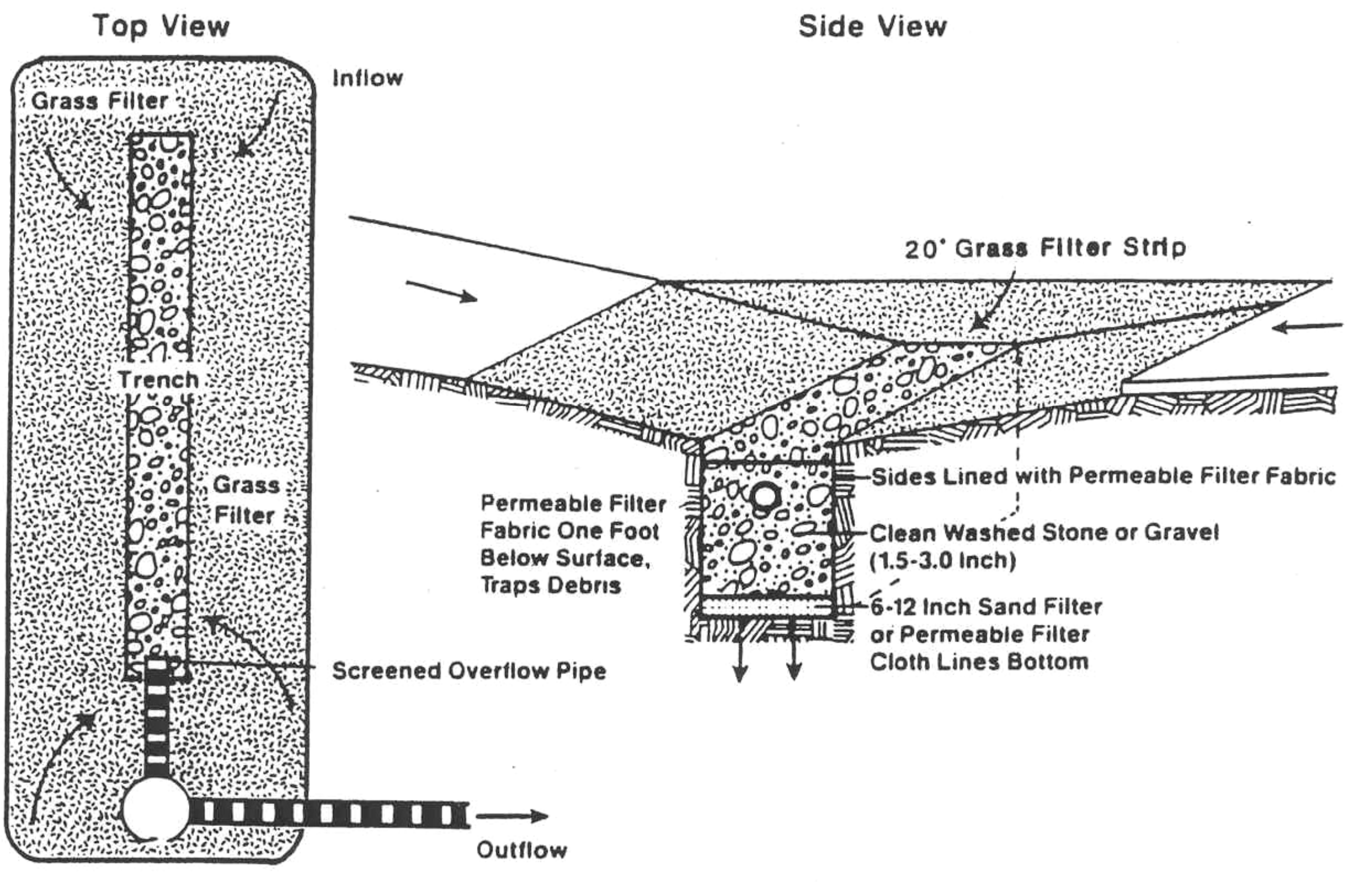


FIG. B5 INFILTRATION TRENCH

APPENDIX B

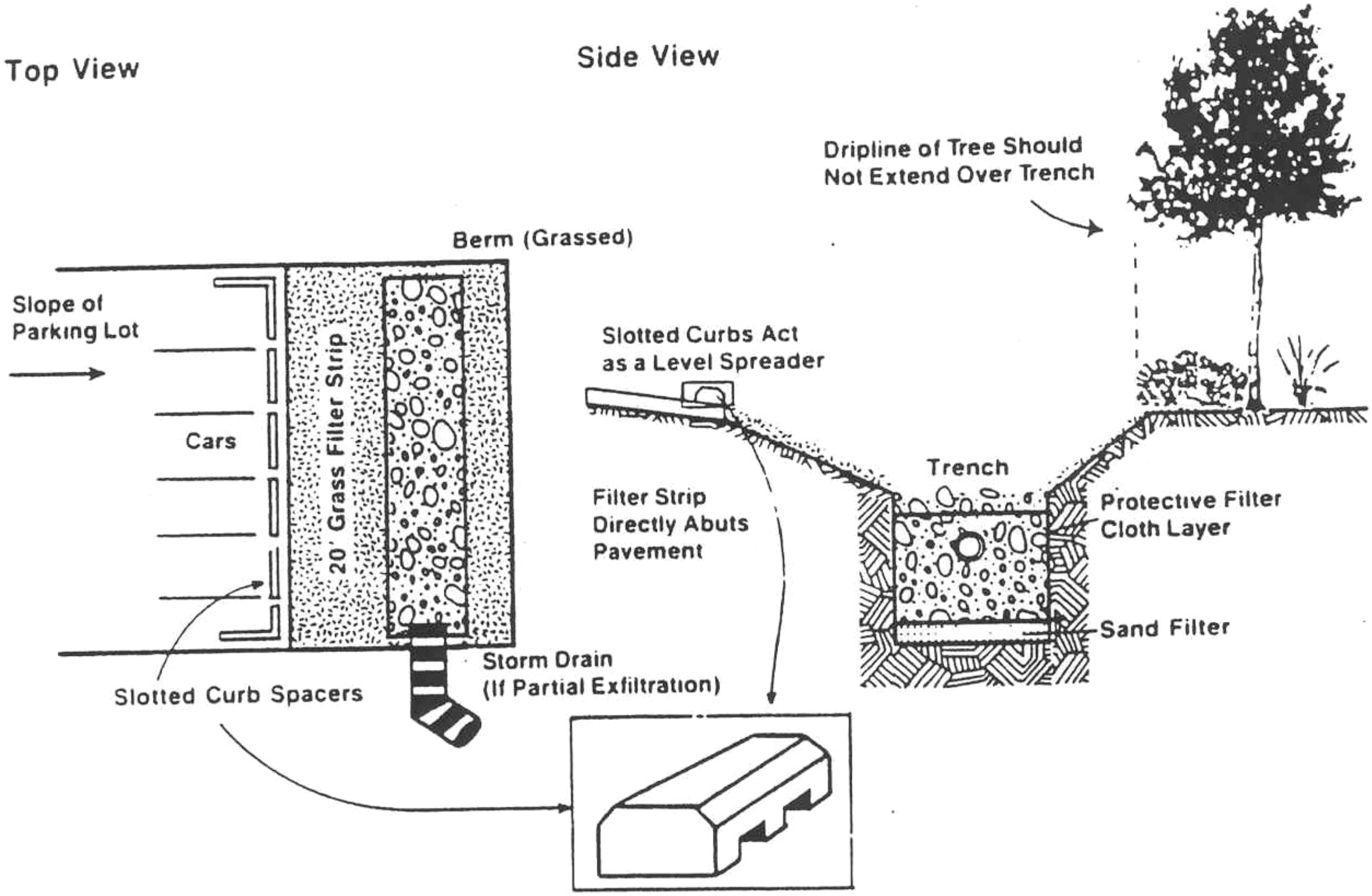


FIG. B6 PARKING LOT PERIMETER TRENCH

APPENDIX B

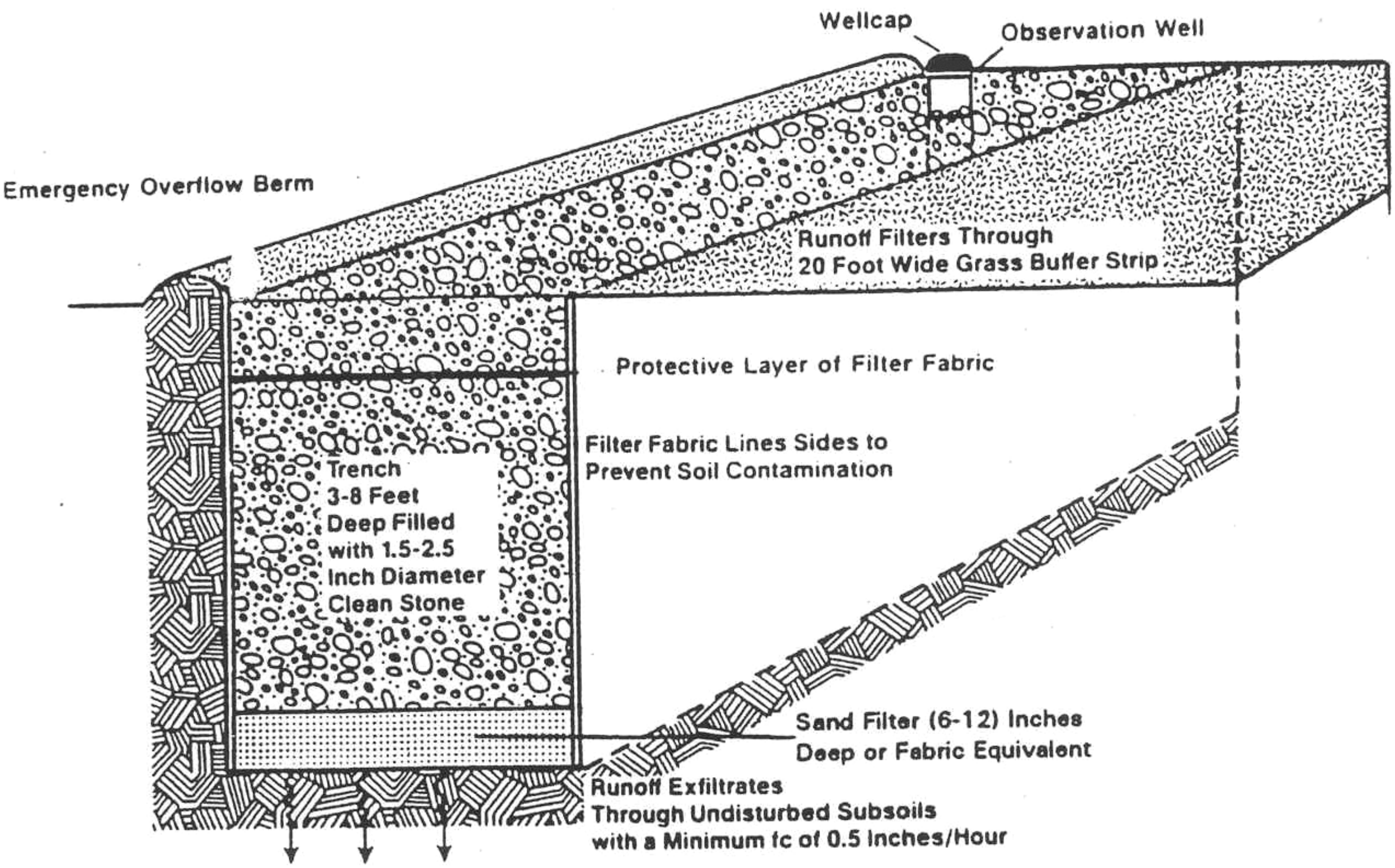
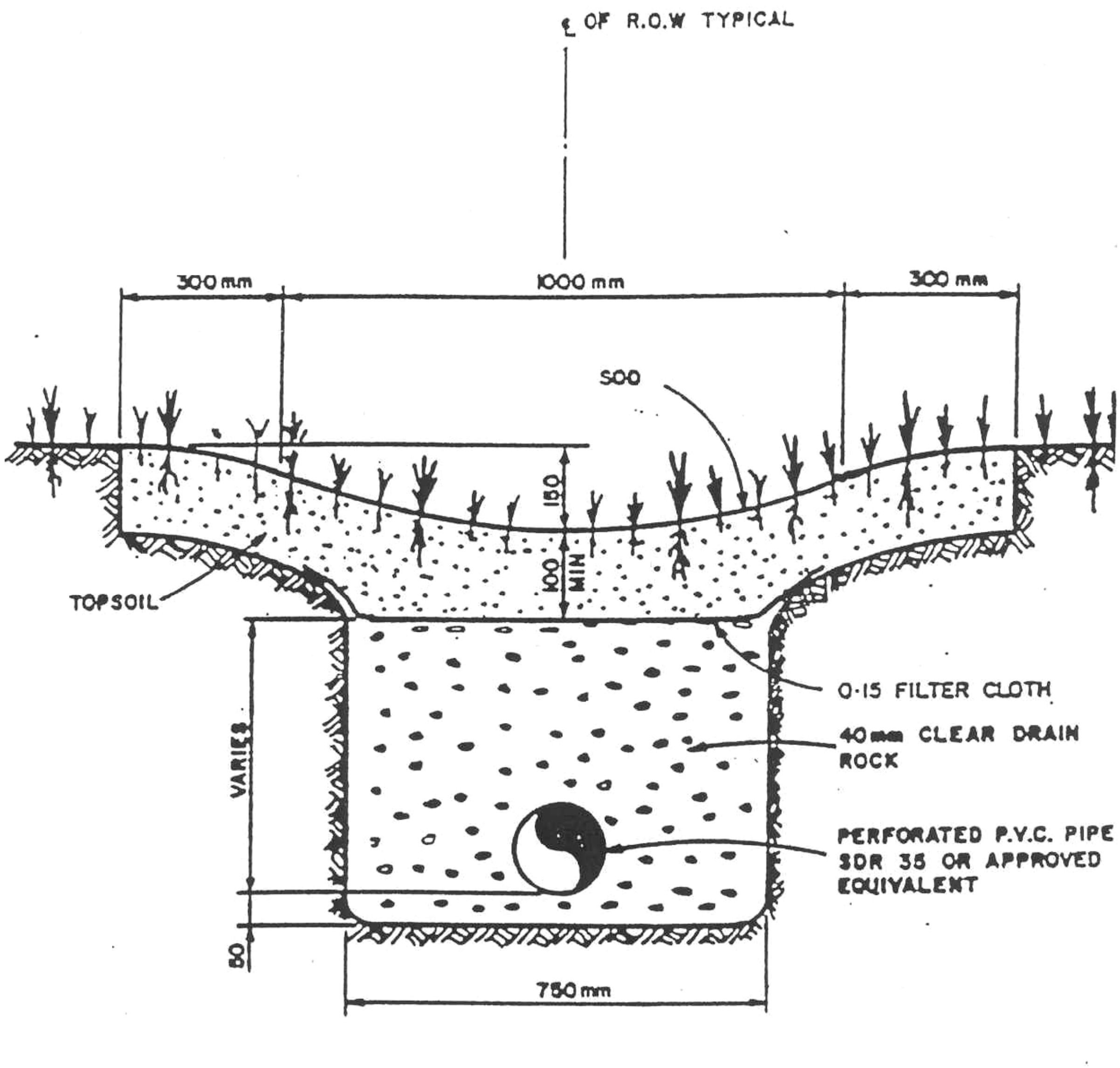


FIG. B7 INFILTRATION TRENCH

APPENDIX B



NOTES: 1. SWALE TO BE CENTRED ON 3·0m RIGHT OF WAY.
2. SOD TO BE PLACED ON MINIMUM 100mm TOPSOIL.

FIG. B8 FRENCH DRAIN (CITY OF CHILLIWACK FIGURE B-12)

APPENDIX B

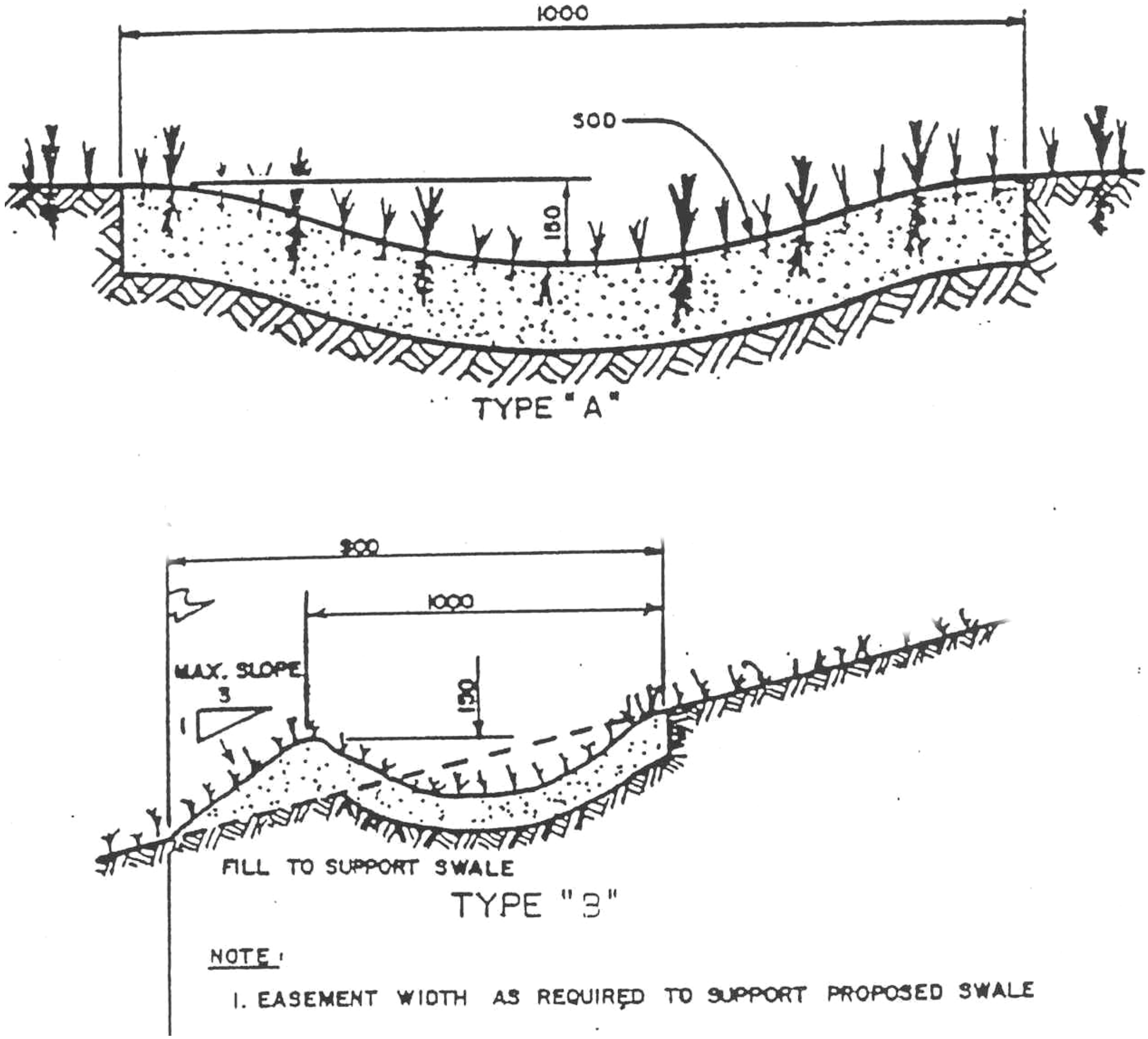
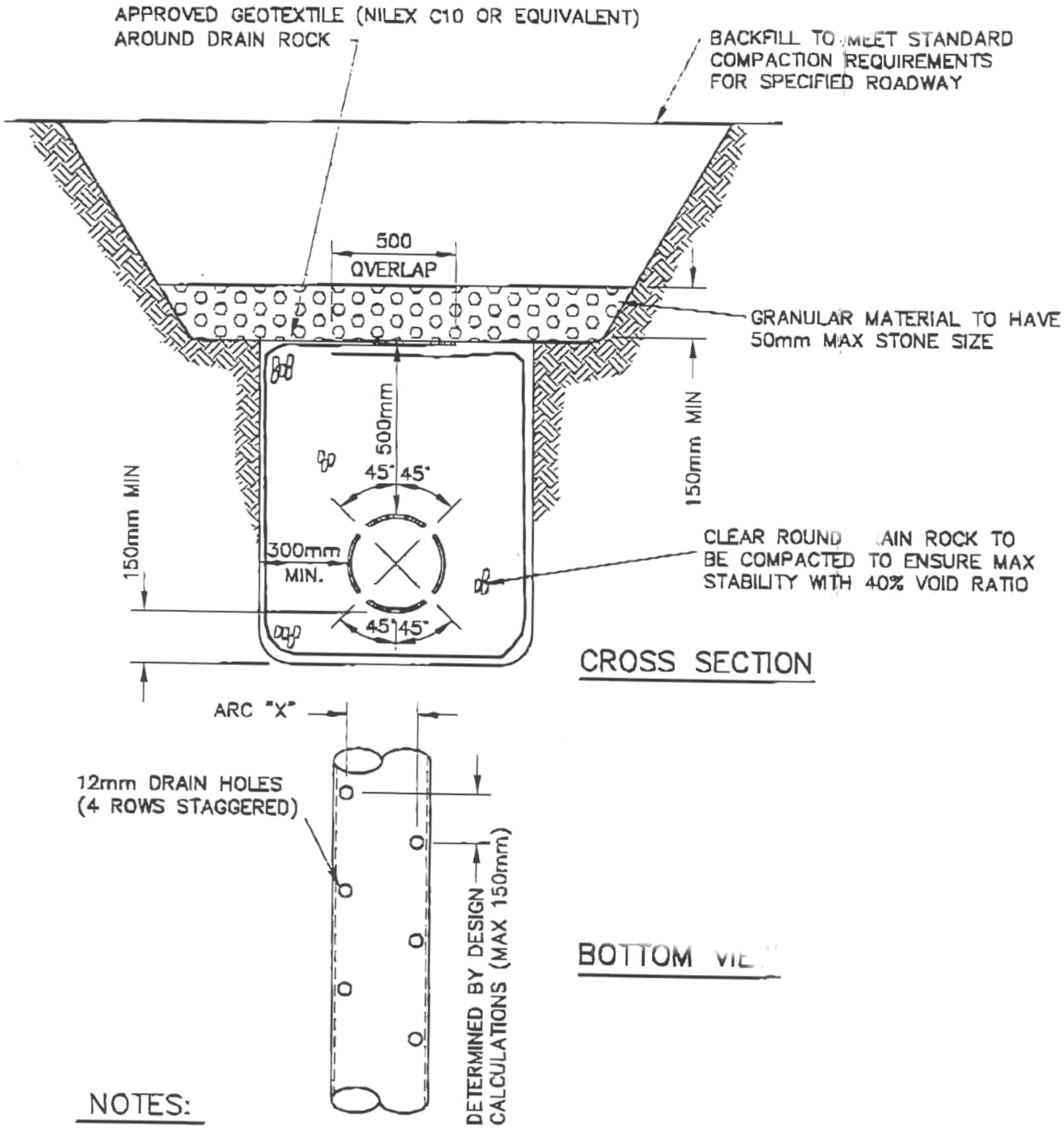


FIG. B9 INFILTRATION SWALE (CITY OF CHILLIWACK B-13)

APPENDIX B



NOTES:

1.) USE PERFORATED PVC PIPES.
2.) FIELD PERFORATION OF PIPE SHALL BE TO THIS STANDARD. FACTORY PERFORATED PIPE MUST BE APPROVED BY THE MUNICIPAL ENGINEER.
3.) PROVIDE 0.5m MIN OVERLAP FOR LONGITUDINAL OR TRANSVERSE JOINTS IN FABRIC.
4.) FILTER FABRIC TO BE APPROVED BY THE MUNICIPAL ENGINEER.
5.) CLEAR DRAIN ROCK TO BE SIZED 20mm
6.) ENSURE NO SILT OR CLAY LENS ADJACENT TO TRENCH WALL.

FIG. B10 EXFILTRATION TRENCH (TOWNSHIP OF LANGLEY SDD 7)

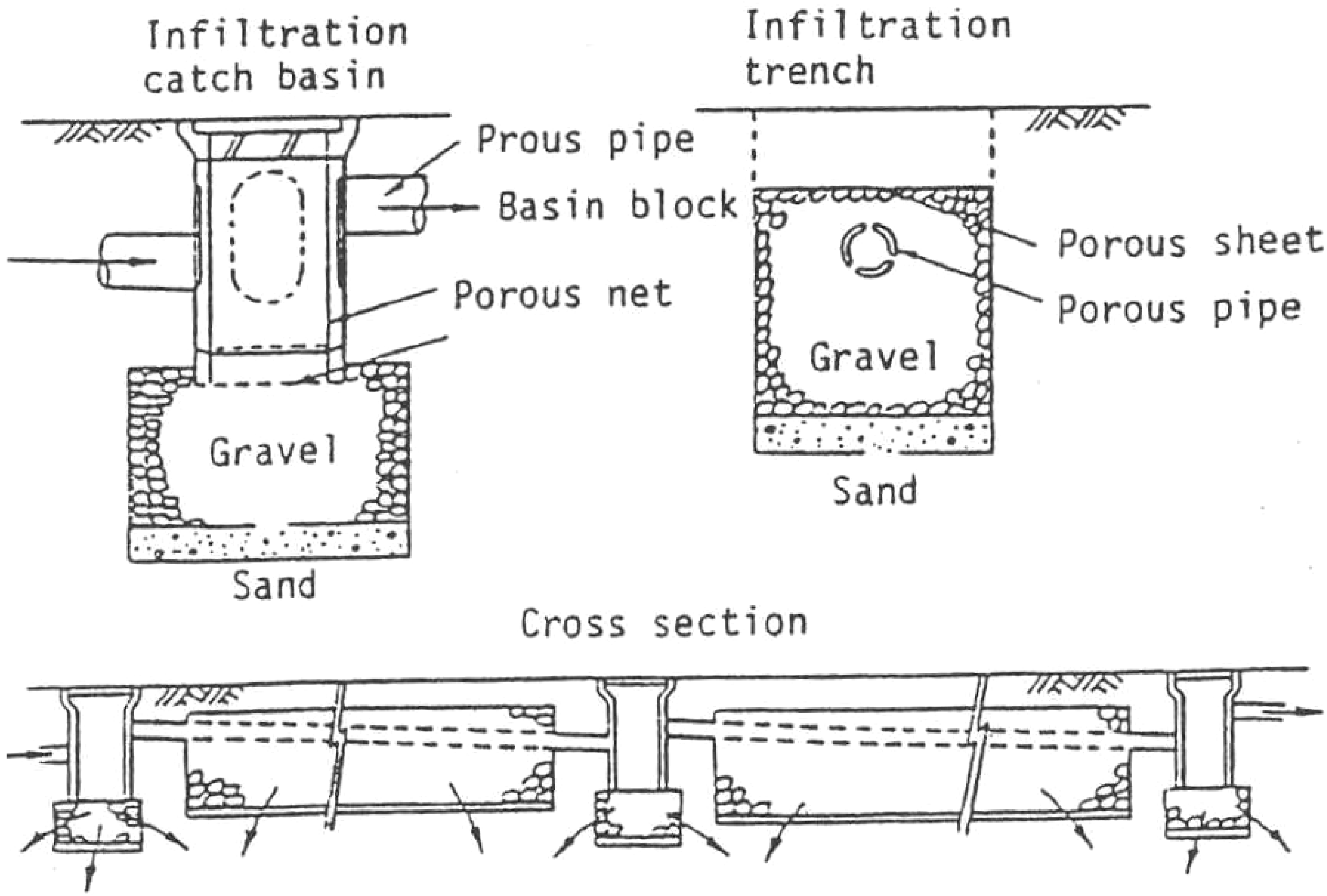
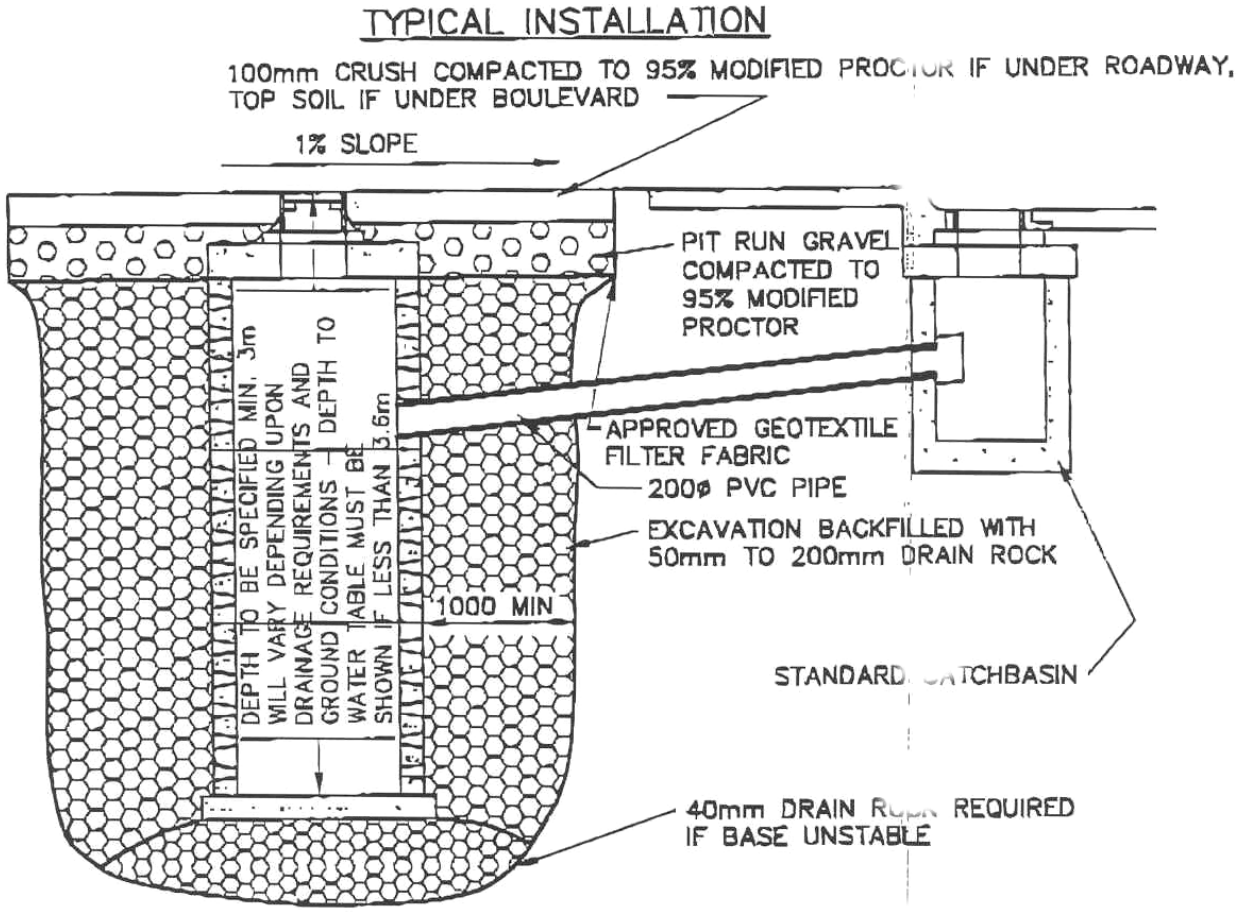


FIG. B11 INFILTRATION CATCH BASIN AND TRENCH STRUCTURES

APPENDIX B



NOTE:

1.) THE NUMBER AND SPACING OF DRAINAGE DRYWELLS MUST BE DETERMINED IN ACCORDANCE WITH DRAINAGE DESIGN CALCULATIONS, AND WILL DEPEND UPON THE AREA DRAINED AND EXISTING GROUND CONDITIONS.

2.) FILTER FABRIC TO BE PLACED OVER TOP OF BARREL PRIOR TO PLACING COVERSLAB. ACCESS TO DRYWELL NOT TO BE CUT THROUGH FILTER FABRIC UNTIL FINAL INSPECTION.

3.) THE DRYWELL SHALL BE INSTALLED ON THE UPHILL SIDE OF THE RIGHT OF WAY.

4.) SEE SDD9 FOR DRYWELL DETAILS

FIG. B12 DRY WELL (TOWNSHIP OF LANGLEY SDD 10)

APPENDIX B

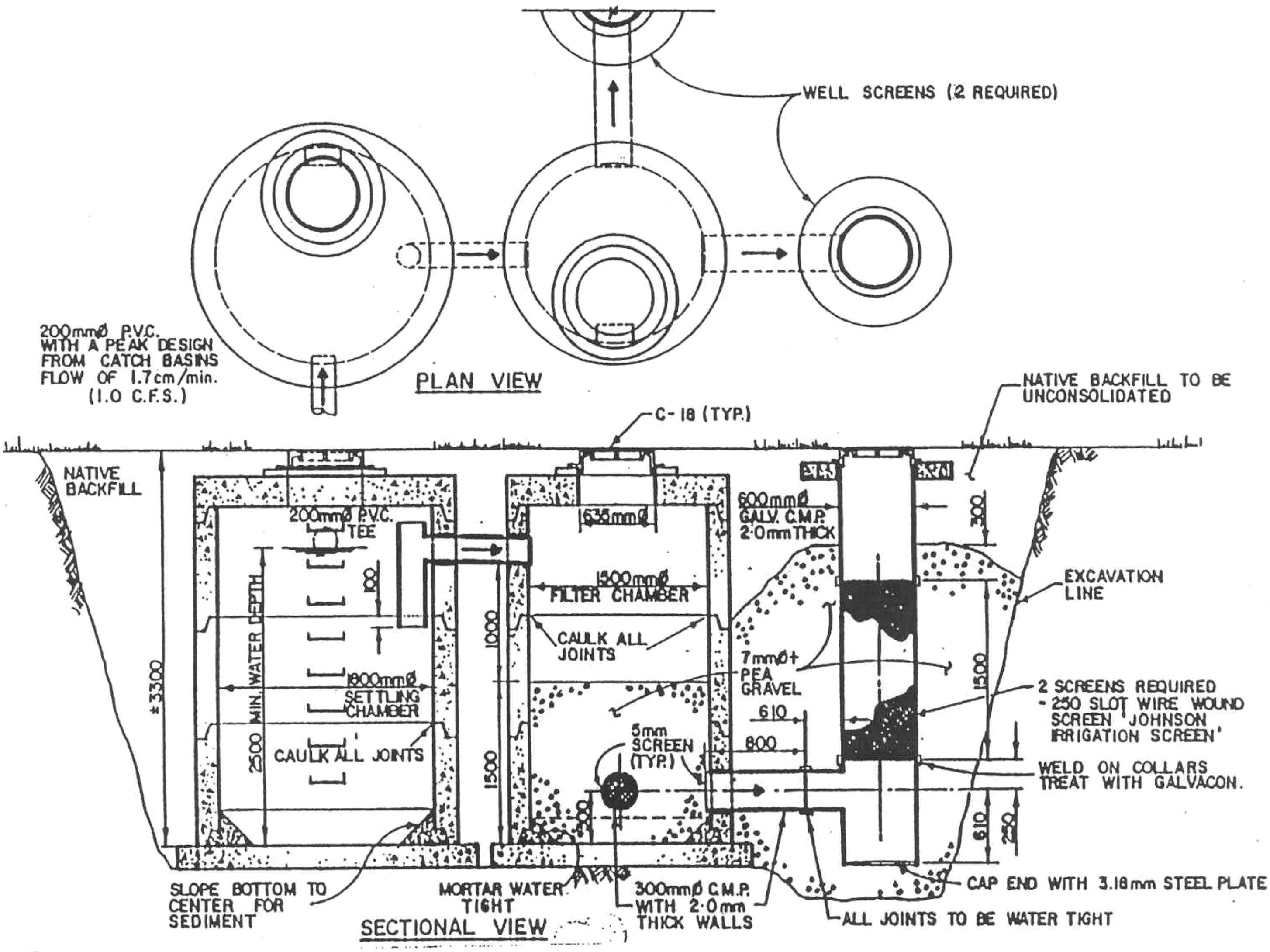


FIG. B13 SOAK-AWAY WELL (CITY OF CHILLIWACK B-16)

APPENDIX B

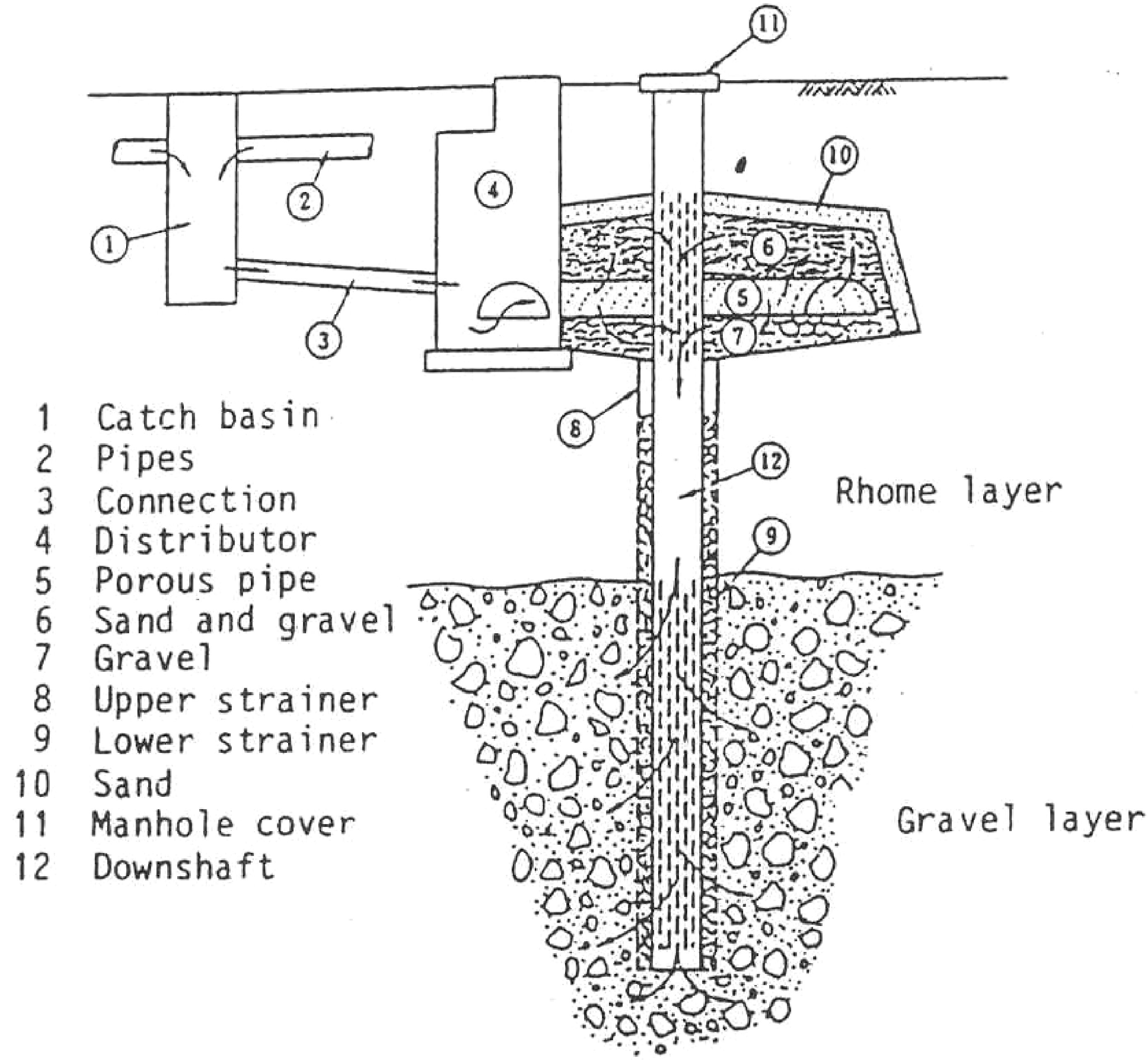


FIG. B14 STRUCTURE OF DRY INFILTRATION WELL

APPENDIX B

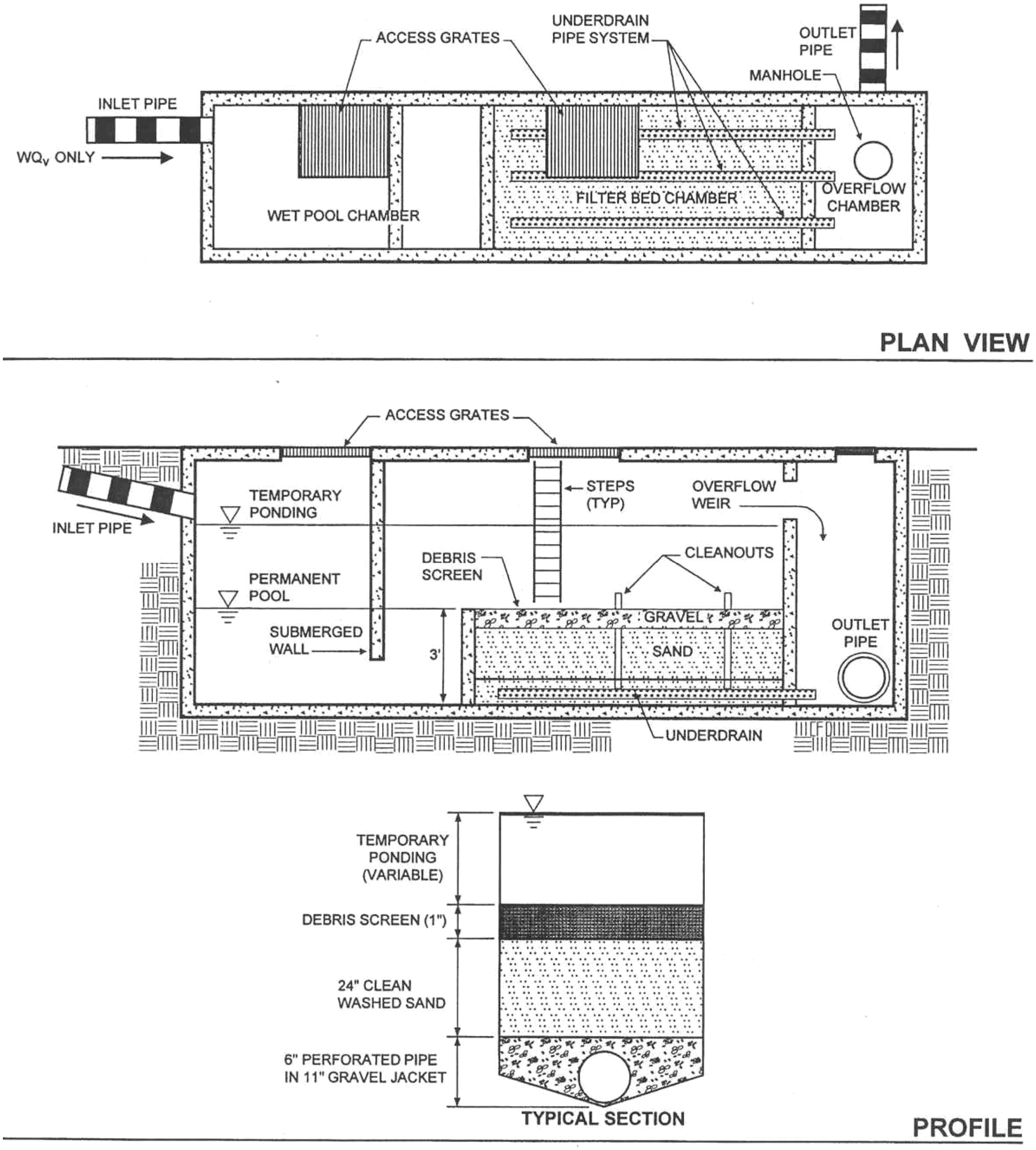


FIG. B15 UNDERGRUND SAND FILTER (GVRD, 1999)

APPENDIX B

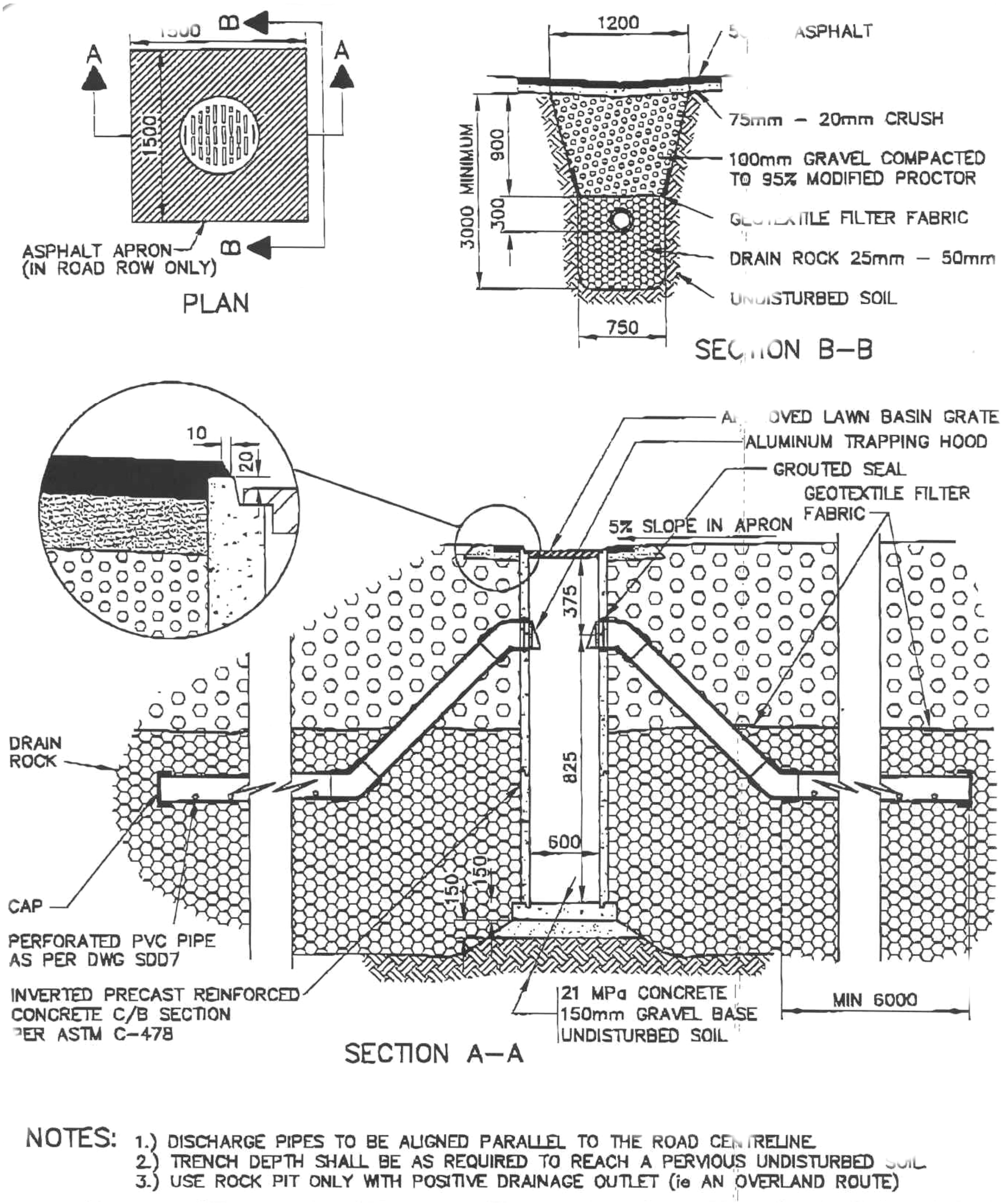


FIG. B16 ROCK PIT (TOWNSHIP OF LANGLEY SDD 8)

APPENDIX B

FIG. B17 PLASTIC INFILTRATOR PANELS BEING INSTALLED

PHOTOS

Photo 1: Subdued topography of the upland.

Photo 2: A small stream in the northern portion of the study area drains to the Campbell River.

Photo 3: New residential development west of Cheviot Road.

Photo 4: Fairbridge Soil exposed in a roadcut along Nursery Road consists of dense silt. Yellow notebook is 0.2m tall.

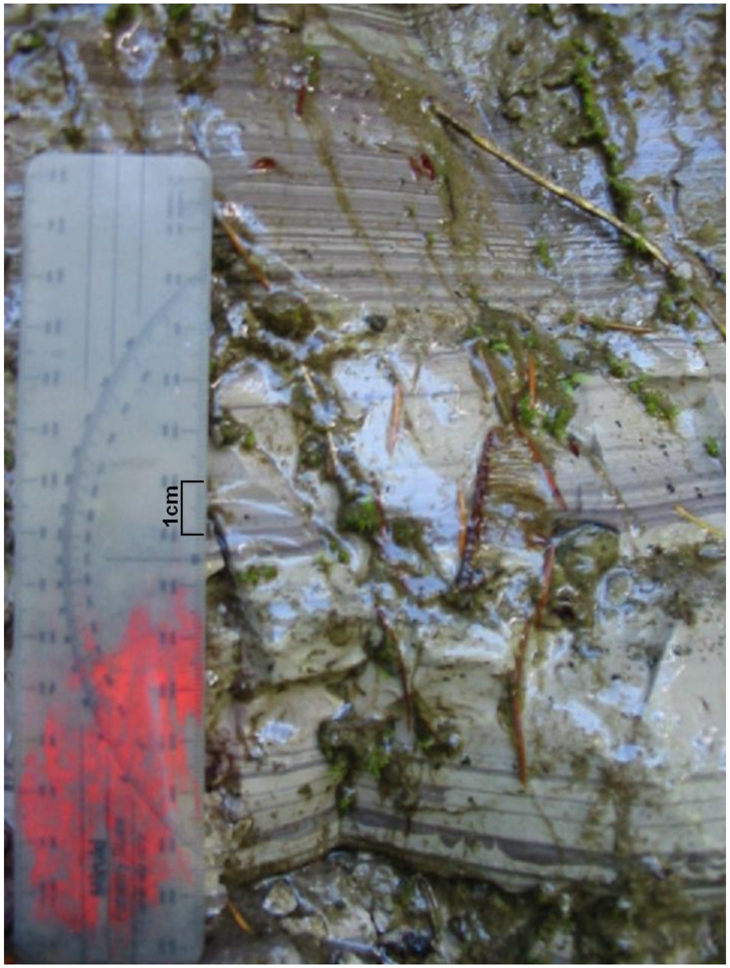


Photo 5: Laminated silt and clay exposed along Quinsam Road.


Photo 6: A thick section of silty sediments exposed at the west end of the study area.

Photo 7: Fairbridge soil consisting of dense silt and clay exposed at a new residential development west of Cheviot Road.

Photo 8: Fairbridge silt exposed at a development site east of Hwy. 19. The bench in the background consists of sand and gravel.

Photo 9: Sand and gravel exposed in a borrow pit
on a bench in the central portion of the study area.

Photo 10: Bedded sand and gravel exposed along Spruce Street is
interpreted as a post-glacial relict fluvial terrace.

Photo 11: Nanaimo Group sedimentary bedrock exposed in a valley below Spruce Street.

Photo 12: Quinsam River salmon fry.

APPENDIX D

HYDROLOGIC / HYDRAULIC MODELING
INPUT AND RESULTS

(Electronic Version on CD-ROM only)

NOTES on Modeling Results

The following items are included in this appendix:

- Model schematic showing links (pipes, culverts, ditches and streams) and nodes (generally, manholes and culvert ends, but also detention ponds)
- Output tables for four scenarios or conditions (existing; future unmanaged; future with ponds; and future with LID in selected areas) using the 2-year 24-hour storm event (on CD-ROM only)
- Output tables for four scenarios or conditions (existing; future unmanaged; future with ponds; and future with LID in selected areas) using the 5-year 24-hour storm event (on CD-ROM only)

Three output tables are provided for each of the three conditions and two storm events noted above:

- *Table E4 Conduit Connectivity* - Describes how conduits[*] (pipes, culverts, ditches and streams) and junctions[**] (manholes, culvert ends and other connection points between conduits, including ponds) are related
- *Table E9 Junction Summary Statistics* – Describes which nodes are experiencing flooding
- *Table E10 Conduit Summary Statistics* – Describes which pipes are surcharged

The output tables list the following critical data for assessing the adequacy of a pipe or system to convey the computed runoff:

- Conduit Name (as assigned by the City or, if not available, by USL during model development)
- Junction Name (as assigned by the City or, if not available, by USL during model development)
- Maximum junction area (m^2) (if greater than 1.22 m^2 it means flooding is occurring at some times)
- Design flow capacity (m^3/s) (i.e., existing pipe capacity)
- Maximum vertical depth (mm) (i.e., pipe diameter or vertical dimension if not circular)
- Maximum computed flow (m^3/s) (i.e., computed peak runoff)

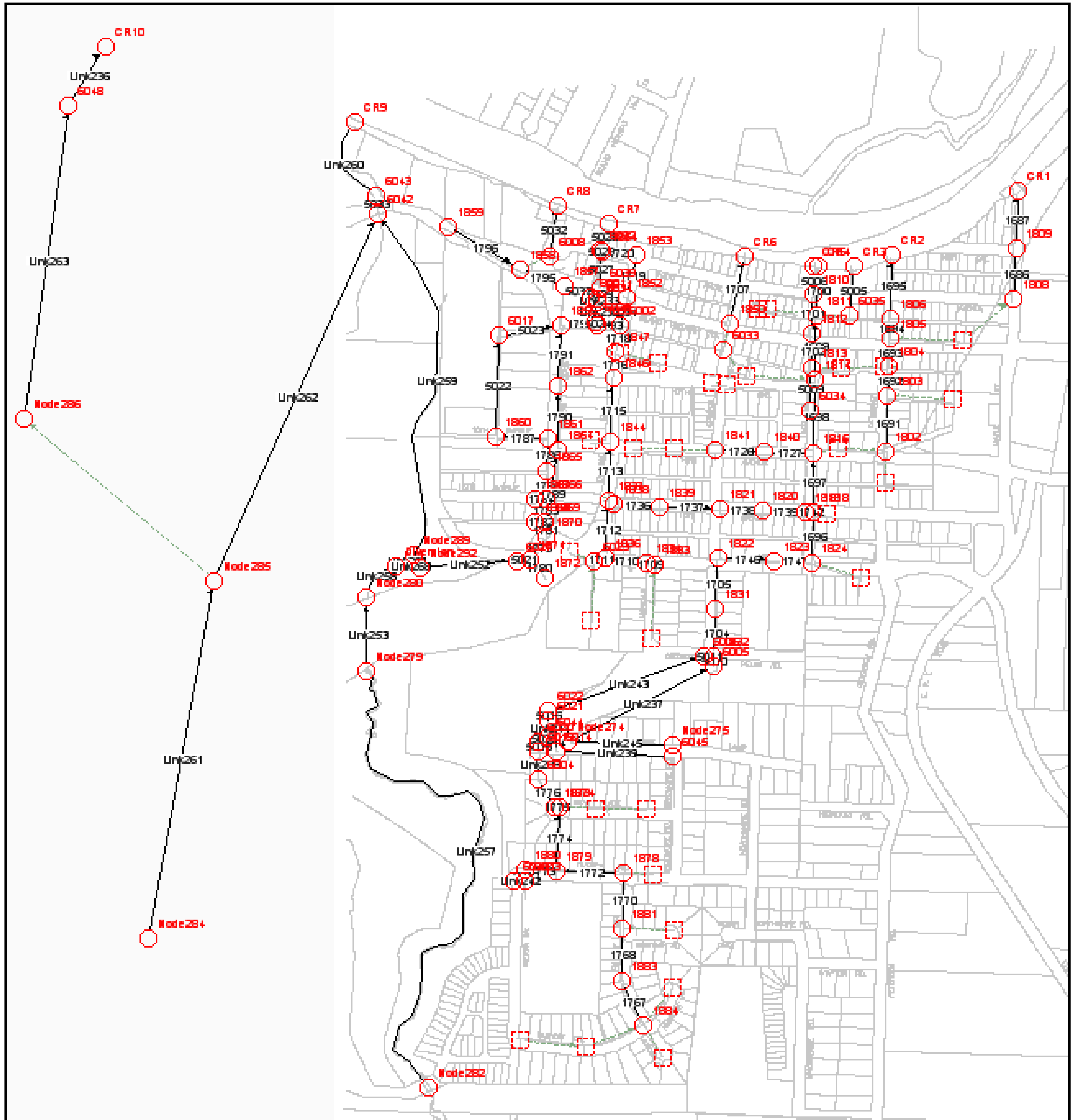
[*] Also called links
[**] Also called nodes

- Ratio of Maximum to Design Flows (if greater than 1 it means surcharging is occurring at some times)
- Maximum Depth at Pipe Ends Upstream / Downstream (m) (shows whether a pipe is surcharged for its entire length, or only the downstream section; if "maximum depth" greater than "maximum vertical depth" then pipe end is surcharged)

In some instances, the tables may indicate that a conduit is surcharged or a manhole is flooding. Engineering judgement was applied in some cases to eliminate such cases from the list of recommended infrastructure upgrades. Some conditions that would be considered include:

- The surcharge or flooding occurs only instantaneously in the model
- A pipe is flat or has an adverse slope
- Model instabilities due to the computational time step

Subsequent to development of the XP-SWMM model, an additional outfall (CR6.5) was found during the biophysical field reconnaissance; this outfall was not included in the City's storm sewer GIS database, though it does appear to be connected to the existing drainage system. The absence of this outfall in the model does not materially alter the modeling results. Future modeling efforts should verify this condition with adjustments made to the models.



XP-SWMM Model Schematic (Existing Conditions)

Link (pipe) numbers are in black; node (manhole) numbers in red

SUMMARY OF MODEL FILES FOR QUINSAM RIVER ISMP (CITY OF CAMPBELL RIVER)

Quinsam-ex.xp	Base model file, existing land use conditions and pipe sizes
Quinsam-future.xp	Quinsam-ex.xp model with land uses changed for future conditions as per City's OCP
Quinsam-futMAR.xp	Quinsam-future.xp model with LID applied to selected areas (see report text)
Quinsam-futPOND.xp	Quinsam-future.xp model with ponds for each future development catchment draining to Kingfisher and Detweiler Creeks

Campbell River / Quinsam River ISMP
XP-SWMM Modeling Results

XP-SWMM Output
Existing Conditions, 2 year 24 hour storm
Tables E4, E9 and E10

Table E4 - Conduit Connectivity

Input Number	Conduit Name	Upstream Node	Downstream Node	Upstream Elevation	Downstream Elevation	
1	1686	1808	1809	1.0500	0.8400	No Design
2	1687	1809	CR1	0.8400	0.5500	No Design
3	1691	1802	1803	1.0700	0.7700	No Design
4	1692	1803	1804	0.7100	0.5400	No Design
5	1693	1804	1805	0.5400	0.4800	No Design
6	1694	1805	1806	0.4800	0.4000	No Design
7	1695	1806	CR2	0.4000	0.1000	No Design
8	1696	1824	1818	1.9600	1.4200	No Design
9	1697	1818	1815	1.3500	0.6400	No Design
10	1698	1815	1814	0.5300	0.2000	No Design
11	1699	1814	1811	0.2000	0.0900	No Design
12	1700	1811	CR4	0.0900	-0.1100	No Design
13	1701	1812	1810	0.5000	0.2500	No Design
14	1702	1813	1812	0.8000	0.5000	No Design
15	1704	1832	1831	8.8000	7.3200	No Design
16	1705	1831	1822	7.3200	5.6000	No Design
17	1707	CR6	1850	0.1000	0.0000	No Design
18	1709	1833	1834	7.1600	7.0900	No Design
19	1710	1834	1836	7.0600	6.5300	No Design
20	1711	6023	1836	7.0000	6.9300	No Design
21	1712	1836	1837	6.5100	5.6300	No Design
22	1713	1837	1844	5.6300	4.4000	No Design
23	1715	1844	1846	4.4000	3.8600	No Design
24	1716	1846	1847	3.8600	3.6900	No Design
25	1718	1847	6002	3.6900	3.6900	No Design
26	1719	1852	1853	3.5800	3.5600	No Design
27	1720	1853	1854	3.5600	2.2300	No Design
28	1726	1841	1840	3.0300	2.4200	No Design
29	1727	1840	1815	2.4200	1.8200	No Design
30	1736	1838	1839	5.4500	5.0900	No Design
31	1737	1839	1821	5.0400	4.0500	No Design
32	1738	1821	1820	3.9200	3.6100	No Design

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33	1739	1820	1819	3.5500	3.2600	No Design
34	1742	1819	1818	3.1600	1.4200	No Design
35	1746	1822	1823	5.6000	3.4600	No Design
36	1747	1823	1824	3.4600	2.0600	No Design
37	1767	1884	1883	61.1500	60.7500	No Design
38	1768	1883	1881	60.7400	60.1900	No Design
39	1770	1881	1878	60.1700	56.9800	No Design
40	1772	1878	1879	56.8400	53.5700	No Design
41	1773	1880	1879	53.9200	53.6200	No Design
42	1774	1879	1874	53.5500	50.7900	No Design
43	1775	1874	1873	50.7100	50.4300	No Design
44	1776	1873	6004	50.4000	49.5000	No Design
45	1779	1871	1870	8.5900	7.6500	No Design
46	1780	1872	1871	9.5000	9.1400	No Design
47	1781	1870	1869	7.6500	7.6500	No Design
48	1782	1868	1869	7.9200	7.6500	No Design
49	1783	1869	1866	7.6500	7.0000	No Design
50	1784	1867	1866	7.4700	7.0000	No Design
51	1785	1866	1865	7.0000	6.5300	No Design
52	1786	1865	1861	6.5300	5.8800	No Design
53	1787	1861	1860	5.8800	5.6100	No Design
54	1789	1870	1864	7.6500	5.5300	No Design
55	1790	1864	1862	5.3800	4.6200	No Design
56	1791	1862	1856	4.6200	3.9000	No Design
57	1792	1856	6038	3.7900	3.7400	No Design
58	1793	6002	1855	3.6900	3.6500	No Design
59	1795	1857	1858	4.3400	3.8800	No Design
60	1796	1859	1858	5.9200	4.6000	No Design
61	5005	6035	CR3	0.5000	0.2000	No Design
62	5006	1810	CR5	0.2500	-0.1100	No Design
63	5009	6034	1813	1.1920	0.8000	No Design
64	5010	6005	1832	9.1300	8.8000	No Design
65	5011	6006	1832	9.1500	8.8000	No Design
66	5014	6014	6044	48.5000	46.0000	No Design
67	5015	6019	6020	47.0000	46.8000	No Design
68	5016	6021	6022	45.8000	45.4800	No Design
69	5018	6003	1880	54.0000	53.9200	No Design
70	5021	6027	1871	9.4500	8.6400	No Design
71	5022	1860	6017	5.6000	5.0000	No Design
72	5023	6017	1856	5.0000	3.9000	No Design
73	5024	1855	6038	3.6500	3.6500	No Design
74	5026	6031	6039	3.7500	3.6000	No Design
75	5027	6039	6032	3.6000	2.0000	No Design
76	5029	1854	6032	2.2300	2.2000	No Design
77	5030	1857	6001	4.3000	4.1400	No Design
78	5031	6001	6041	4.1100	3.7500	No Design
79	5032	6008	CR8	3.5000	3.0000	No Design
80	5033	6042	6043	3.8100	3.7000	No Design
81	5034	6002	1852	3.6900	3.6500	No Design

Campbell River / Quinsam River ISMP
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82	5035	6020	6044	46.7000	46.3000	No Design
83	Link232	6038	6031	3.7400	3.7100	No Design
84	Link233	6031	6041	3.7500	3.7500	No Design
85	5025	6041	6039	3.7500	3.6000	No Design
86	Link236	6048	CR10	2.0000	0.5000	No Design
87	Link237	Node274	6005	46.0000	10.0000	No Design
88	Link238	6004	6019	49.5000	47.0000	No Design
89	Link239	6045	6014	49.5000	48.5000	No Design
90	5028	6032	CR7	2.0000	1.8000	No Design
91	Link242	6046	6003	54.0440	54.0000	No Design
92	Link243	6022	6006	45.4800	10.0000	No Design
93	Link244	6044	6021	46.0000	45.8000	No Design
94	Link245	Node275	Node274	49.5000	46.0000	No Design
95	Link252	Node292	6027	29.0000	9.4500	No Design
96	Link253	Node279	Node280	42.0000	40.0000	No Design
97	Link257	Node282	Node279	64.0000	42.0000	No Design
98	Link258	Node280	Diversion	40.0000	29.0000	No Design
99	Link259	Node289	6042	29.0000	3.8100	No Design
100	Link260	6043	CR9	3.7000	0.5000	No Design
101	Link261	Node284	Node285	58.0000	35.0000	No Design
102	Link262	Node285	6042	35.0000	3.8100	No Design
103	Link263	Node286	6048	23.0000	2.0000	No Design

```
*=========================================*
|            Orifice Data                 |
*=========================================*
```

Orifice Name	From Junction	To Junction	Type	Area (m2)	Depth (m)	Discharge Coefficient	Height Above Junction (m)
Low Flow.1	Diversion	Node289	Rect Side	0.18	0.30	0.600	0.000

```
====> EQUIVALENT PIPE INFORMATION FOR ORIFICE            1
      CONDUIT NAME...........................       Low Flow.1
      Upstream node..........................        Diversion
      Downstream node........................          Node289
      PIPE DIAMETER.......................               0.30
      PIPE LENGTH.........................             300.00
      MANNINGS ROUGHNESS..................             0.0047
      INVERT ELEVATION AT UPSTREAM END.....           29.0000
      INVERT ELEVATION AT DOWNSTREAM END...           28.9970
```

Note: For a Bottom-outlet orifice the invert elevation of the downstream node will be adjusted to accomodate the equivalent conduit. Conduit grades are not affected.

```
*===========================================*
|                Weir Data                  |
```

Campbell River / Quinsam River ISMP
XP-SWMM Modeling Results

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Weir Name	From Junction	To Junction	Type	Crest Height(ft)	Weir Top (m)	Weir Length (m)	Discharge Coefficient	Weir Power
High Flow.1	Diversion	Node292	1	0.30	5.00	1.50	1.7000	1.5000

```
*=================================================*
|         FREE OUTFALL DATA (DATA GROUP I1)       |
|        BOUNDARY CONDITION ON DATA GROUP J1      |
*=================================================*
```

Outfall at Junction....CR7 has boundary condition number... 1
Outfall at Junction....CR1 has boundary condition number... 2
Outfall at Junction....CR2 has boundary condition number... 3
Outfall at Junction....CR3 has boundary condition number... 4
Outfall at Junction....CR4 has boundary condition number... 5
Outfall at Junction....CR5 has boundary condition number... 6
Outfall at Junction....CR6 has boundary condition number... 7
Outfall at Junction....CR8 has boundary condition number... 8
Outfall at Junction....CR9 has boundary condition number... 9
Outfall at Junction....CR10 has boundary condition number... 10

```
*=======================================================*
|        Table E9 - JUNCTION SUMMARY STATISTICS         |
| The Maximum area is only the area of the node, it     |
| does not include the area of the surrounding conduits|
*=======================================================*
```

Junction Name	Ground Elevation meters	Uppermost PipeCrown Elevation meters	Maximum Junction Elevation meters	Time of Occurence Hr.	Min.	Meters of Surcharge at Max Elevation	Freeboard of node meters	Maximum Junction Area m^2	Maximum Gutter Depth meters	Maximum Gutter Width meters	Maximum Gutter Velocity m/s
1802	2.8200	1.5200	1.4492	8	0	0.0000	1.3708	1.2200	0.0000	0.0000	0.0000
1803	2.4600	1.3200	1.4387	8	0	0.1187	1.0213	1.2200	0.0000	0.0000	0.0000
1804	2.2900	1.1500	1.4369	8	0	0.2869	0.8531	1.2200	0.0000	0.0000	0.0000
1805	2.2300	1.0900	1.4715	31	51	0.3815	0.7585	1.2200	0.0000	0.0000	0.0000
1806	2.1500	1.0100	1.4261	29	54	0.4161	0.7239	1.2200	0.0000	0.0000	0.0000
1808	2.8000	1.5750	1.4027	7	3	0.0000	1.3973	1.2200	0.0000	0.0000	0.0000
1809	2.5900	1.4500	1.4018	8	0	0.0000	1.1882	1.2200	0.0000	0.0000	0.0000
1810	1.7500	0.8500	1.4324	33	10	0.5824	0.3176	1.2200	0.0000	0.0000	0.0000
1811	1.8400	1.0050	1.5377	8	0	0.5327	0.3023	1.2200	0.0000	0.0000	0.0000
1812	1.7500	1.1000	1.4453	37	39	0.3453	0.3047	1.2200	0.0000	0.0000	0.0000
1813	1.7500	1.4000	1.4106	36	8	0.0106	0.3394	1.2200	0.0000	0.0000	0.0000
1814	1.9500	1.1150	1.6502	8	0	0.5352	0.2998	1.2200	0.0000	0.0000	0.0000

Campbell River / Quinsam River ISMP
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1815	2.9300	2.2000	1.9236	8	0	0.0000	1.0064	1.2200	0.0000	0.0000	0.0000
1818	3.1000	2.1100	2.1267	8	1	0.0167	0.9733	1.2200	0.0000	0.0000	0.0000
1819	4.9100	3.8700	3.2123	7	40	0.0000	1.6977	1.2200	0.0000	0.0000	0.0000
1820	5.3000	4.2200	3.6843	7	29	0.0000	1.6157	1.2200	0.0000	0.0000	0.0000
1821	5.6700	4.5300	4.0134	8	0	0.0000	1.6566	1.2200	0.0000	0.0000	0.0000
1822	8.3500	6.2100	5.8639	8	1	0.0000	2.4861	1.2200	0.0000	0.0000	0.0000
1823	5.2100	4.0700	3.7553	8	0	0.0000	1.4547	1.2200	0.0000	0.0000	0.0000
1824	3.7100	2.6700	2.4023	8	1	0.0000	1.3077	1.2200	0.0000	0.0000	0.0000
1831	9.0700	7.9300	7.6040	8	0	0.0000	1.4660	1.2200	0.0000	0.0000	0.0000
1832	10.5500	9.4100	9.0833	8	0	0.0000	1.4667	1.2200	0.0000	0.0000	0.0000
1833	8.9100	7.5400	7.3298	8	0	0.0000	1.5802	1.2200	0.0000	0.0000	0.0000
1834	8.8100	7.4700	7.1708	8	0	0.0000	1.6392	1.2200	0.0000	0.0000	0.0000
1836	8.2600	7.3050	6.6163	8	0	0.0000	1.6437	1.2200	0.0000	0.0000	0.0000
1837	7.3800	6.3050	5.7503	8	0	0.0000	1.6297	1.2200	0.0000	0.0000	0.0000
1838	7.2000	5.8300	5.4500	0	0	0.0000	1.7500	1.2200	0.0000	0.0000	0.0000
1839	6.7900	5.4700	5.1254	8	0	0.0000	1.6646	1.2200	0.0000	0.0000	0.0000
1840	4.1700	2.8000	2.5244	7	56	0.0000	1.6456	1.2200	0.0000	0.0000	0.0000
1841	4.7800	3.4100	3.1089	8	0	0.0000	1.6711	1.2200	0.0000	0.0000	0.0000
1844	6.1500	5.0750	4.5654	7	31	0.0000	1.5846	1.2200	0.0000	0.0000	0.0000
1846	5.6100	4.7600	4.1655	8	0	0.0000	1.4445	1.2200	0.0000	0.0000	0.0000
1847	5.4400	4.5900	4.1414	8	0	0.0000	1.2986	1.2200	0.0000	0.0000	0.0000
1850	1.7500	0.3000	1.4057	8	0	1.1057	0.3443	1.2200	0.0000	0.0000	0.0000
1852	5.3300	4.5500	4.0250	8	1	0.0000	1.3050	1.2200	0.0000	0.0000	0.0000
1853	5.3100	4.4600	3.7490	8	0	0.0000	1.5610	1.2200	0.0000	0.0000	0.0000
1854	3.9800	3.1300	2.6060	8	1	0.0000	1.3740	1.2200	0.0000	0.0000	0.0000
1855	5.4000	4.2600	4.1407	8	1	0.0000	1.2593	1.2200	0.0000	0.0000	0.0000
1856	5.5900	5.1000	4.2092	8	1	0.0000	1.3808	1.2200	0.0000	0.0000	0.0000
1857	6.0300	4.8650	4.5098	8	0	0.0000	1.5202	1.2200	0.0000	0.0000	0.0000
1858	5.4900	4.9750	4.5537	8	0	0.0000	0.9363	1.2200	0.0000	0.0000	0.0000
1859	6.9200	6.2950	6.0211	8	0	0.0000	0.8989	1.2200	0.0000	0.0000	0.0000
1860	7.3600	6.8000	5.7686	8	2	0.0000	1.5914	1.2200	0.0000	0.0000	0.0000
1861	7.6300	6.7800	6.0891	8	1	0.0000	1.5409	1.2200	0.0000	0.0000	0.0000
1862	6.3700	5.8200	4.8811	8	0	0.0000	1.4889	1.2200	0.0000	0.0000	0.0000
1864	7.1300	6.5800	5.6295	8	1	0.0000	1.5005	1.2200	0.0000	0.0000	0.0000
1865	8.2800	7.4300	6.6612	8	0	0.0000	1.6188	1.2200	0.0000	0.0000	0.0000
1866	8.7500	7.9000	7.1479	8	0	0.0000	1.6021	1.2200	0.0000	0.0000	0.0000
1867	9.2200	7.8450	7.5341	8	0	0.0000	1.6859	1.2200	0.0000	0.0000	0.0000
1868	9.6700	8.3200	7.9833	7	23	0.0000	1.6867	1.2200	0.0000	0.0000	0.0000
1869	9.4000	8.5500	7.7594	8	0	0.0000	1.6406	1.2200	0.0000	0.0000	0.0000
1870	9.4000	8.8500	7.8642	8	0	0.0000	1.5358	1.2200	0.0000	0.0000	0.0000
1871	10.3400	9.8400	8.8149	8	0	0.0000	1.5251	1.2200	0.0000	0.0000	0.0000
1872	10.8900	10.1750	9.5712	8	0	0.0000	1.3188	1.2200	0.0000	0.0000	0.0000
1873	52.1500	50.9550	50.6859	8	0	0.0000	1.4641	1.2200	0.0000	0.0000	0.0000
1874	52.4600	51.2400	50.9962	8	0	0.0000	1.4638	1.2200	0.0000	0.0000	0.0000
1878	58.5900	57.4300	56.9654	8	0	0.0000	1.6246	1.2200	0.0000	0.0000	0.0000
1879	55.3200	54.0700	53.7494	8	0	0.0000	1.5706	1.2200	0.0000	0.0000	0.0000
1880	55.6700	55.6700	54.1448	8	0	0.0000	1.5252	1.2200	0.0000	0.0000	0.0000
1881	61.9200	60.6200	60.2892	8	0	0.0000	1.6308	1.2200	0.0000	0.0000	0.0000
1883	62.4900	61.1250	60.9203	8	1	0.0000	1.5697	1.2200	0.0000	0.0000	0.0000

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1884	62.9000	61.5250	61.3409	8	0	0.0000	1.5591	1.2200	0.0000	0.0000	0.0000
6001	5.8500	4.7100	4.2482	8	0	0.0000	1.6018	1.2200	0.0000	0.0000	0.0000
6002	5.4000	4.5900	4.1224	8	1	0.0000	1.2776	1.2200	0.0000	0.0000	0.0000
6003	55.7500	55.7500	54.2198	8	0	0.0000	1.5302	1.2200	0.0000	0.0000	0.0000
6004	51.2500	51.2500	49.6396	8	1	0.0000	1.6104	1.2200	0.0000	0.0000	0.0000
6005	11.7500	11.5000	9.2514	7	56	0.0000	2.4986	1.2200	0.0000	0.0000	0.0000
6006	11.5000	11.5000	9.4556	8	3	0.0000	2.0444	1.2200	0.0000	0.0000	0.0000
6008	5.2500	3.8000	3.5679	8	0	0.0000	1.6821	1.2200	0.0000	0.0000	0.0000
6014	50.0000	50.0000	48.5592	8	0	0.0000	1.4408	1.2200	0.0000	0.0000	0.0000
6017	6.5500	6.2000	5.1332	8	0	0.0000	1.4168	1.2200	0.0000	0.0000	0.0000
6019	51.0000	48.7500	47.2872	8	2	0.0000	3.7128	1.2200	0.0000	0.0000	0.0000
6020	48.4500	47.5500	46.9453	8	1	0.0000	1.5047	1.2200	0.0000	0.0000	0.0000
6021	47.3000	47.3000	46.1456	8	1	0.0000	1.1544	1.2200	0.0000	0.0000	0.0000
6022	47.5000	46.9800	45.5831	8	3	0.0000	1.9169	1.2200	0.0000	0.0000	0.0000
6023	8.7500	7.3750	7.1152	8	0	0.0000	1.6348	1.2200	0.0000	0.0000	0.0000
6027	11.2000	10.6500	9.6535	8	6	0.0000	1.5465	1.2200	0.0000	0.0000	0.0000
6031	5.5000	4.9100	4.1245	8	2	0.0000	1.3755	1.2200	0.0000	0.0000	0.0000
6032	4.1000	4.1000	2.4032	8	2	0.0000	1.6968	1.2200	0.0000	0.0000	0.0000
6033	1.7500	0.0000	1.4000	0	0	1.4000	0.3500	1.2200	0.0000	0.0000	0.0000
6034	2.9500	1.7920	1.4108	36	9	0.0000	1.5392	1.2200	0.0000	0.0000	0.0000
6035	1.7500	0.8000	1.4612	37	2	0.6612	0.2888	1.2200	0.0000	0.0000	0.0000
6038	5.6500	4.9400	4.1523	8	2	0.0000	1.4977	1.2200	0.0000	0.0000	0.0000
6039	5.3500	5.2000	3.7028	8	2	0.0000	1.6472	1.2200	0.0000	0.0000	0.0000
CR7	3.9000	3.9000	2.0929	8	2	0.0000	1.8071	1.2200	0.0000	0.0000	0.0000
6041	6.0000	4.7500	4.0921	8	1	0.0000	1.9079	1.2200	0.0000	0.0000	0.0000
6042	7.0000	5.3100	4.0786	8	18	0.0000	2.9214	1.2200	0.0000	0.0000	0.0000
6043	7.0000	5.2000	3.8847	8	2	0.0000	3.1153	1.2200	0.0000	0.0000	0.0000
6044	48.0000	47.5000	46.1982	8	1	0.0000	1.8018	1.2200	0.0000	0.0000	0.0000
6045	51.0000	51.0000	49.5917	8	0	0.0000	1.4083	1.2200	0.0000	0.0000	0.0000
6046	55.8000	55.7940	54.2335	8	0	0.0000	1.5665	1.2200	0.0000	0.0000	0.0000
6048	3.7500	3.0000	2.1508	8	0	0.0000	1.5992	1.2200	0.0000	0.0000	0.0000
CR1	2.3000	1.1600	1.4000	0	0	0.2400	0.9000	1.2200	0.0000	0.0000	0.0000
CR2	1.8400	0.7100	1.4000	0	0	0.6900	0.4400	1.2200	0.0000	0.0000	0.0000
CR3	1.7500	0.5000	1.4000	0	0	0.9000	0.3500	1.2200	0.0000	0.0000	0.0000
CR4	1.7500	0.7400	1.4000	0	0	0.6600	0.3500	1.2200	0.0000	0.0000	0.0000
CR5	1.7500	0.4900	1.4000	0	0	0.9100	0.3500	1.2200	0.0000	0.0000	0.0000
CR6	1.8500	0.4000	1.4000	0	0	1.0000	0.4500	1.2200	0.0000	0.0000	0.0000
CR8	4.7500	3.3000	3.0620	8	0	0.0000	1.6880	1.2200	0.0000	0.0000	0.0000
CR9	1.7500	1.5000	1.4000	0	0	0.0000	0.3500	1.2200	0.0000	0.0000	0.0000
CR10	2.0000	1.2000	1.4000	0	0	0.2000	0.6000	1.2200	0.0000	0.0000	0.0000
Node274	47.5000	47.5000	46.0423	8	0	0.0000	1.4577	1.2200	0.0000	0.0000	0.0000
Node275	51.0000	51.0000	49.5934	8	0	0.0000	1.4066	1.2200	0.0000	0.0000	0.0000
Node279	47.0000	43.8000	42.3222	8	1	0.0000	4.6778	1.2200	0.0000	0.0000	0.0000
Node280	45.0000	41.8000	40.1242	8	1	0.0000	4.8758	1.2200	0.0000	0.0000	0.0000
Node282	66.0000	65.0000	64.1890	8	0	0.0000	1.8110	1.2200	0.0000	0.0000	0.0000
Node284	60.0000	59.0000	58.0813	8	0	0.0000	1.9187	1.2200	0.0000	0.0000	0.0000
Node285	37.0000	36.0000	35.1086	8	1	0.0000	1.8914	1.2200	0.0000	0.0000	0.0000
Node286	25.0000	24.0000	23.0324	8	0	0.0000	1.9676	1.2200	0.0000	0.0000	0.0000
Node289	34.0000	30.0000	29.1209	8	0	0.0000	4.8791	1.2200	0.0000	0.0000	0.0000

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Diversion	34.0000	30.0000	29.5117	8	2	0.0000	4.4883	1.2200	0.0000	0.0000	0.0000
Node292	34.0000	30.0000	29.0862	8	3	0.0000	4.9138	1.2200	0.0000	0.0000	0.0000

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*=====================================================*
|       Table E10 - CONDUIT SUMMARY STATISTICS        |
| Note: The peak flow may be less than the design flow |
| and the conduit may still surcharge because of the   |
| downstream boundary conditions.                      |
|                                                      |
| * denotes an open conduit that has been overtopped   |
|   this is a potential source of severe errors        |
*=====================================================*
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Conduit Name	Design Flow (cms)	Conduit Design Velocity (m/s)	Maximum Vertical Depth (mm)	Maximum Computed Flow (cms)	Time of Occurence Hr.	Time of Occurence Min.	Maximum Computed Velocity (m/s)	Time of Occurence Hr.	Time of Occurence Min.	Ratio of Max. to Design Flow	Maximum Water Elev at Pipe Ends Upstream (m)	Maximum Water Elev at Pipe Ends Dwnstrm (m)	Ratio d/D US	Ratio d/D DS	
1686	0.2464	1.1382	525.0000	0.0122	8	0	0.0756	8	1	0.0495	1.4027	1.4018	0.672	1.070	
1687	0.4054	1.3870	610.0000	0.0270	8	0	0.0955	8	0	0.0666	1.4018	1.4000	0.921	1.393	
1691	0.1486	0.9342	450.0000	0.0256	8	1	0.1772	8	1	0.1720	1.4492	1.4387	0.843	1.486	
1692	0.3450	1.1806	610.0000	0.0257	8	0	0.0850	8	0	0.0746	1.4387	1.4369	1.195	1.470	
1693	0.2095	0.7170	610.0000	0.0445	8	0	0.1518	8	0	0.2124	1.4369	1.4714	1.470	1.625	
1694	0.2795	0.9562	610.0000	0.0588	8	0	0.2003	8	0	0.2102	1.4715	1.4272	1.625	1.684	
1695	0.3123	1.0688	610.0000	0.0793	8	0	0.2701	8	0	0.2538	1.4261	1.4000	1.682	2.131	
1696	0.8164	2.2154	685.0000	0.3573	8	1	1.5520	9	19	0.4376	2.4023	2.1267	0.646	1.032	
1697	0.8937	1.9700	760.0000	0.3902	8	2	0.9512	11	8	0.4366	2.1267	1.9236	1.022	1.689	
1698	0.5402	1.1909	760.0000	0.4244	8	1	0.9305	8	2	0.7856	1.9236	1.6502	1.834	1.908	
1699	0.5536	0.8419	915.0000	0.4473	8	1	0.6777	8	1	0.8079	1.6502	1.5377	1.585	1.582	
1700	0.6932	1.2216	850.0000	0.4581	8	0	0.8037	8	0	0.6609	1.5377	1.4000	1.703	1.776	
1701	0.3380	1.1955	600.0000	0.0182	8	0	0.0642	8	0	0.0539	1.4451	1.4324	1.575	1.971	
1702	0.4103	1.4512	600.0000	0.0182	8	0	0.0643	8	0	0.0444	1.4107	1.4453	1.018	1.575	
1704	0.8005	2.7391	610.0000	0.2948	8	0	2.2178	8	1	0.3683	9.0833	7.6040	0.464	0.466	
1705	0.8300	2.8402	610.0000	0.3048	8	0	2.3088	8	1	0.3672	7.6040	5.8639	0.466	0.433	
1707	0.0670	0.2030	300.0000	-0.0159	8	0	-0.0481	8	0	-0.2370	1.4057	1.4000	4.352	4.667	*
1709	0.0654	0.5765	380.0000	0.0242	8	0	0.5161	8	0	0.3698	7.3298	7.2003	0.447	0.290	
1710	0.2135	1.6991	400.0000	0.0299	8	0	1.0689	8	1	0.1403	7.1708	6.6310	0.277	0.252	
1711	0.1169	1.0583	375.0000	0.0173	8	0	0.6170	8	0	0.1481	7.1152	7.0232	0.307	0.249	
1712	0.9275	2.5919	675.0000	0.0473	8	0	1.2810	8	1	0.0509	6.6163	5.7503	0.158	0.178	
1713	0.8521	2.3813	675.0000	0.0596	8	0	1.3029	8	0	0.0700	5.7503	4.5654	0.178	0.245	
1715	0.5474	1.5296	675.0000	0.0716	7	51	0.9416	7	20	0.1308	4.5654	4.1655	0.245	0.453	
1716	1.0277	1.6155	900.0000	0.0912	8	0	0.5462	5	15	0.0888	4.1655	4.1414	0.339	0.502	
1718	0.0532	0.0000	900.0000	0.1088	8	0	0.3578	7	20	2.0469	4.1414	4.1224	0.502	0.480	
1719	0.2736	0.4301	900.0000	0.2212	8	1	0.7576	8	1	0.8083	4.0250	3.7490	0.494	0.210	
1720	2.4503	3.8516	900.0000	0.2285	8	1	2.0280	8	1	0.0933	3.7490	2.6060	0.210	0.418	
1726	0.1802	1.5885	380.0000	0.0168	7	56	0.9448	8	0	0.0935	3.1089	2.5244	0.208	0.275	
1727	0.1796	1.5837	380.0000	0.0266	8	0	1.0678	8	0	0.1479	2.5244	1.9236	0.275	0.273	
1736	0.0654	0.5770	380.0000	0.0000	0	0	0.0000	0	0	0.0000	5.4500	5.1254	.0000	.0000	
1737	0.1627	1.4345	380.0000	0.0169	8	0	0.8914	8	0	0.1042	5.1254	4.1325	0.225	0.217	

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1738	0.3873	1.3252	610.0000	0.0169	8	0	0.6089	8	1	0.0438	4.0134	3.6901	0.153	0.131
1739	0.3666	1.2545	610.0000	0.0328	7	40	0.7022	8	0	0.0894	3.6843	3.3725	0.220	0.184
1742	2.1628	7.4004	610.0000	0.0328	7	40	7.4676	0	31	0.0152	3.2123	2.1267	0.086	1.158
1746	0.8722	2.9846	610.0000	0.3047	8	1	2.4766	8	1	0.3493	5.8639	3.7553	0.433	0.484
1747	0.8719	2.9833	610.0000	0.3428	8	0	2.3966	8	0	0.3932	3.7553	2.4023	0.484	0.561
1767	0.1406	1.2727	375.0000	0.0604	8	0	1.0833	8	1	0.4296	61.3409	60.9217	0.509	0.458
1768	0.1624	1.4700	375.0000	0.0603	8	1	1.1667	8	2	0.3712	60.9203	60.3481	0.481	0.422
1770	0.6130	3.8545	450.0000	0.0819	8	0	2.4513	8	0	0.1337	60.2892	57.0910	0.265	0.247
1772	0.5600	3.5211	450.0000	0.0949	8	0	2.4663	8	0	0.1695	56.9654	53.7494	0.279	0.399
1773	0.2491	1.5662	450.0000	0.0843	8	0	1.0892	8	1	0.3384	54.1448	53.8004	0.500	0.401
1774	0.5293	3.3281	450.0000	0.1877	8	0	2.7478	8	1	0.3546	53.7494	50.9962	0.443	0.458
1775	0.9108	4.2072	525.0000	0.2078	8	0	1.8079	0	29	0.2282	50.9962	50.6859	0.545	0.487
1776	0.6406	2.9593	525.0000	0.2078	8	1	1.8382	8	1	0.3244	50.6859	49.6396	0.545	0.266
1779	5.1185	4.5257	1200.000	0.2901	8	0	1.9868	8	1	0.0567	8.8149	7.8642	0.187	0.178
1780	0.4226	1.1808	675.0000	0.0079	8	0	0.6294	0	29	0.0186	9.5712	9.1934	0.106	0.079
1781	0.0532	0.0000	900.0000	0.0503	8	1	0.4629	8	2	0.9466	7.8642	7.7594	0.238	0.122
1782	0.2437	1.9394	400.0000	0.0124	8	0	1.0891	0	29	0.0508	7.9833	7.7594	0.158	0.273
1783	2.1702	3.4113	900.0000	0.0626	8	0	1.3448	8	0	0.0288	7.7594	7.1479	0.122	0.164
1784	0.2561	2.3184	375.0000	0.0163	8	0	2.4835	0	29	0.0637	7.5341	7.1479	0.171	0.394
1785	1.6548	2.6012	900.0000	0.0788	8	0	1.1721	8	1	0.0476	7.1479	6.6612	0.164	0.146
1786	1.7708	2.7835	900.0000	0.0788	8	1	1.2481	8	1	0.0445	6.6612	6.0891	0.146	0.232
1787	0.9183	1.4434	900.0000	0.0868	8	1	0.7958	8	2	0.0945	6.0891	5.7761	0.232	0.185
1789	2.9635	3.4224	1050.000	0.2396	8	1	1.9047	8	1	0.0808	7.8642	5.7312	0.204	0.192
1790	2.9712	2.6271	1200.000	0.2491	8	1	1.4523	8	1	0.0838	5.6295	4.8811	0.208	0.218
1791	2.9846	2.6390	1200.000	0.2733	8	1	1.4634	8	1	0.0916	4.8811	4.2092	0.218	0.258
1792	2.2539	1.0435	1200.000	0.4013	8	1	0.5327	8	1	0.1781	4.2092	4.1523	0.349	0.344
1793	0.1885	0.6452	610.0000	-0.0962	8	11	-0.3977	8	14	-0.5100	4.1224	4.1407	0.709	0.804
1795	0.3023	1.3962	525.0000	-0.0499	8	0	-0.2480	8	0	-0.1651	4.5537	4.5098	0.407	1.200
1796	0.1540	1.3945	375.0000	0.0233	8	0	0.9714	8	0	0.1510	6.0211	4.6982	0.270	0.262
5005	0.0533	0.7547	300.0000	0.0094	43	31	0.1317	43	31	0.1766	1.4611	1.4000	3.204	4.000
5006	0.4732	1.6735	600.0000	0.0283	8	0	0.0993	8	0	0.0597	1.4324	1.4000	1.971	2.517
5009	0.4033	1.4264	600.0000	-0.0064	36	8	0.0338	28	58	-0.0159	1.4108	1.4106	0.365	1.018
5010	0.3744	2.3541	450.0000	0.0450	8	0	1.0831	7	38	0.1203	9.2514	9.0833	0.270	0.630
5011	0.8108	2.8676	600.0000	0.2439	8	3	1.7011	8	4	0.3009	9.4556	9.0833	0.509	0.472
5014	0.7426	5.9092	400.0000	0.0353	8	0	4.8371	0	29	0.0475	48.5592	46.1982	0.148	0.495
5015	1.3973	3.1628	750.0000	0.2075	8	2	1.3901	8	2	0.1485	47.2872	46.9949	0.383	0.260
5016	1.8870	4.2712	750.0000	0.2424	8	2	1.3303	8	6	0.1285	46.1456	45.5831	0.461	0.138
5018	9.2425	1.3204	1750.000	0.0802	8	0	0.3871	8	0	0.0087	54.2198	54.1448	0.126	0.128
5021	5.6825	5.0245	1200.000	0.2472	8	5	1.9944	8	0	0.0435	9.6535	8.8149	0.170	0.146
5022	1.2277	1.0231	1200.000	0.0914	8	1	0.5539	8	1	0.0745	5.7686	5.1332	0.140	0.111
5023	2.0806	1.7338	1200.000	0.1224	8	0	0.8117	8	0	0.0588	5.1332	4.2092	0.111	0.258
5024	0.0188	0.0000	610.0000	-0.0920	8	11	-0.3673	8	14	-4.8844	4.1407	4.1523	0.804	0.823
5026	0.7246	1.1390	900.0000	0.1897	8	2	0.8266	8	2	0.2618	4.1245	3.7028	0.416	0.114
5027	16.1398	5.6041	1600.000	0.3755	8	2	1.5703	8	2	0.0233	3.7028	2.4032	0.064	0.252
5029	1.2065	1.8965	900.0000	0.2334	8	1	0.9625	8	1	0.1935	2.6060	2.4679	0.418	0.298
5030	0.2291	1.0581	525.0000	0.0600	8	0	0.7656	8	0	0.2618	4.5098	4.3005	0.400	0.306
5031	0.5690	2.0124	600.0000	0.0600	8	0	1.4236	0	33	0.1054	4.2482	4.0921	0.230	0.570
5032	0.0669	0.9468	300.0000	0.0069	8	0	0.5815	8	0	0.1032	3.5679	3.0620	0.226	0.207
5033	5.8344	2.1609	1500.000	0.4691	8	19	1.0017	8	19	0.0804	4.0786	3.8847	0.179	0.123

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5034	0.4674	0.7347	900.0000	0.2092	8	1	0.7043	8	2	0.4476	4.1224	4.0250	0.480	0.417
5035	1.9190	4.3438	750.0000	0.2076	8	2	1.7264	8	3	0.1082	46.9453	46.4660	0.327	0.221
Link232	2.1224	0.9826	1200.000	0.3104	8	2	0.4181	8	3	0.1463	4.1523	4.1245	0.344	0.345
Link233	0.0704	0.0000	1000.000	0.1213	8	4	0.4597	8	7	1.7223	4.1245	4.0921	0.374	0.342
5025	0.9887	1.2589	1000.000	0.1803	8	2	0.8264	8	2	0.1824	4.0921	3.7028	0.342	0.103
Link236	1.0533	2.7370	700.0000	0.1072	8	0	1.1475	8	0	0.1018	2.1508	1.4000	0.215	1.286
Link237	42.5308	6.3009	1500.000	0.0450	8	0	0.7605	0	28	0.0011	46.0423	10.0268	0.028	0.018
Link238	37.0144	4.7002	1750.000	0.2077	8	1	1.3061	0	29	0.0056	49.6396	47.2872	0.080	0.164
Link239	4.6551	1.2414	1500.000	0.0237	8	0	0.2592	0	28	0.0051	49.5917	48.5592	0.061	0.039
5028	14.4354	4.1677	2100.000	0.6168	8	2	1.3745	8	2	0.0427	2.4032	2.0929	0.192	0.139
Link242	9.1913	1.3130	1750.000	0.0365	8	0	0.2302	6	26	0.0040	54.2335	54.2198	0.108	0.126
Link243	42.2225	6.2552	1500.000	0.2439	8	3	2.0733	0	28	0.0058	45.5831	10.0982	0.069	0.065
Link244	18.6199	2.7585	1500.000	0.2424	8	1	1.0820	0	29	0.0130	46.1982	46.1456	0.132	0.230
Link245	8.7089	2.3224	1500.000	0.0413	8	0	0.9072	0	28	0.0047	49.5934	46.0423	0.062	0.028
Link252	18.7252	5.3500	1000.000	0.2482	8	3	1.1717	8	2	0.0133	29.0862	9.6535	0.086	0.203
Link253	11.0937	4.3596	1800.000	0.4873	8	1	1.6988	8	1	0.0439	42.3222	40.1242	0.179	0.069
Link257	8.3039	2.3725	1000.000	0.4148	8	0	0.9753	0	29	0.0499	64.1890	42.3222	0.189	0.322
Link258	19.8639	5.6754	1000.000	0.4873	8	1	5.3021	0	36	0.0245	40.1242	29.5117	0.124	0.512
Link259	10.8958	3.1131	1000.000	0.2554	8	0	1.5118	0	35	0.0234	29.1209	4.0786	0.121	0.269
Link260	9.7933	2.1763	1000.000	0.5120	8	2	0.5469	8	2	0.0523	3.8847	1.4000	0.185	0.900
Link261	14.1354	3.1412	1000.000	0.1865	8	0	0.9033	0	28	0.0132	58.0813	35.1086	0.081	0.109
Link262	10.9475	2.4328	1000.000	0.2346	8	1	0.5876	8	0	0.0214	35.1086	4.0786	0.109	0.269
Link263	10.3736	2.9639	1000.000	0.0267	8	0	2.1126	0	29	0.0026	23.0324	2.1508	0.032	0.151
Low Flow.1	0.2620	0.1467	300.0000	0.2387	8	3	1.4043	8	3	0.9113	29.5117	29.1209	1.706	0.413
High Flow.1	Undefnd	Undefnd	Undefn	0.2483	8	2								
FREE # 1	Undefnd	Undefnd	Undefn	0.6168	8	2								
FREE # 2	Undefnd	Undefnd	Undefn	0.0270	8	0								
FREE # 3	Undefnd	Undefnd	Undefn	0.0793	8	0								
FREE # 4	Undefnd	Undefnd	Undefn	0.0095	43	31								
FREE # 5	Undefnd	Undefnd	Undefn	0.4581	8	0								
FREE # 6	Undefnd	Undefnd	Undefn	0.0283	8	0								
FREE # 7	Undefnd	Undefnd	Undefn	0.0159	8	0								
FREE # 8	Undefnd	Undefnd	Undefn	0.0069	8	0								
FREE # 9	Undefnd	Undefnd	Undefn	0.5120	8	2								
FREE #10	Undefnd	Undefnd	Undefn	0.1072	8	0								

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XP-SWMM Output
Existing Conditions, 5 year 24 hour storm
Tables E4, E9 and E10

Table E4 - Conduit Connectivity

Input Number	Conduit Name	Upstream Node	Downstream Node	Upstream Elevation	Downstream Elevation	
1	1686	1808	1809	1.0500	0.8400	No Design
2	1687	1809	CR1	0.8400	0.5500	No Design
3	1691	1802	1803	1.0700	0.7700	No Design
4	1692	1803	1804	0.7100	0.5400	No Design
5	1693	1804	1805	0.5400	0.4800	No Design
6	1694	1805	1806	0.4800	0.4000	No Design
7	1695	1806	CR2	0.4000	0.1000	No Design
8	1696	1824	1818	1.9600	1.4200	No Design
9	1697	1818	1815	1.3500	0.6400	No Design
10	1698	1815	1814	0.5300	0.2000	No Design
11	1699	1814	1811	0.2000	0.0900	No Design
12	1700	1811	CR4	0.0900	-0.1100	No Design
13	1701	1812	1810	0.5000	0.2500	No Design
14	1702	1813	1812	0.8000	0.5000	No Design
15	1704	1832	1831	8.8000	7.3200	No Design
16	1705	1831	1822	7.3200	5.6000	No Design
17	1707	1850	CR6	0.1000	0.0000	No Design
18	1709	1833	1834	7.1600	7.0900	No Design
19	1710	1834	1836	7.0600	6.5300	No Design
20	1711	6023	1836	7.0000	6.9300	No Design
21	1712	1836	1837	6.5100	5.6300	No Design
22	1713	1837	1844	5.6300	4.4000	No Design
23	1715	1844	1846	4.4000	3.8600	No Design
24	1716	1846	1847	3.8600	3.6900	No Design
25	1718	1847	6002	3.6900	3.6900	No Design
26	1719	1852	1853	3.5800	3.5600	No Design
27	1720	1853	1854	3.5600	2.2300	No Design
28	1726	1841	1840	3.0300	2.4200	No Design
29	1727	1840	1815	2.4200	1.8200	No Design
30	1736	1838	1839	5.4500	5.0900	No Design
31	1737	1839	1821	5.0400	4.0500	No Design
32	1738	1821	1820	3.9200	3.6100	No Design

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33	1739	1820	1819	3.5500	3.2600	No Design
34	1742	1819	1818	3.1600	1.4200	No Design
35	1746	1822	1823	5.6000	3.4600	No Design
36	1747	1823	1824	3.4600	2.0600	No Design
37	1767	1884	1883	61.1500	60.7500	No Design
38	1768	1883	1881	60.7400	60.1900	No Design
39	1770	1881	1878	60.1700	56.9800	No Design
40	1772	1878	1879	56.8400	53.5700	No Design
41	1773	1880	1879	53.9200	53.6200	No Design
42	1774	1879	1874	53.5500	50.7900	No Design
43	1775	1874	1873	50.7100	50.4300	No Design
44	1776	1873	6004	50.4000	49.5000	No Design
45	1779	1871	1870	8.5900	7.6500	No Design
46	1780	1872	1871	9.5000	9.1400	No Design
47	1781	1870	1869	7.6500	7.6500	No Design
48	1782	1868	1869	7.9200	7.6500	No Design
49	1783	1869	1866	7.6500	7.0000	No Design
50	1784	1867	1866	7.4700	7.0000	No Design
51	1785	1866	1865	7.0000	6.5300	No Design
52	1786	1865	1861	6.5300	5.8800	No Design
53	1787	1861	1860	5.8800	5.6100	No Design
54	1789	1870	1864	7.6500	5.5300	No Design
55	1790	1864	1862	5.3800	4.6200	No Design
56	1791	1862	1856	4.6200	3.9000	No Design
57	1792	1856	6038	3.7900	3.7400	No Design
58	1793	6002	1855	3.6900	3.6500	No Design
59	1795	1857	1858	4.3400	3.8800	No Design
60	1796	1859	1858	5.9200	4.6000	No Design
61	5005	6035	CR3	0.5000	0.2000	No Design
62	5006	1810	CR5	0.2500	-0.1100	No Design
63	5009	6034	1813	1.1920	0.8000	No Design
64	5010	6005	1832	9.1300	8.8000	No Design
65	5011	6006	1832	9.1500	8.8000	No Design
66	5014	6014	6044	48.5000	46.0000	No Design
67	5015	6019	6020	47.0000	46.8000	No Design
68	5016	6021	6022	45.8000	45.4800	No Design
69	5018	6003	1880	54.0000	53.9200	No Design
70	5021	6027	1871	9.4500	8.6400	No Design
71	5022	1860	6017	5.6000	5.0000	No Design
72	5023	6017	1856	5.0000	3.9000	No Design
73	5024	1855	6038	3.6500	3.6500	No Design
74	5026	6031	6039	3.7500	3.6000	No Design
75	5027	6039	6032	3.6000	2.0000	No Design
76	5029	1854	6032	2.2300	2.2000	No Design
77	5030	1857	6001	4.3000	4.1400	No Design
78	5031	6001	6041	4.1100	3.7500	No Design
79	5032	6008	CR8	3.5000	3.0000	No Design
80	5033	6042	6043	3.8100	3.7000	No Design
81	5034	6002	1852	3.6900	3.6500	No Design

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82	5035	6020	6044	46.7000	46.3000	No Design
83	Link232	6038	6031	3.7400	3.7100	No Design
84	Link233	6031	6041	3.7500	3.7500	No Design
85	5025	6041	6039	3.7500	3.6000	No Design
86	Link236	6048	CR10	2.0000	0.5000	No Design
87	Link237	Node274	6005	46.0000	10.0000	No Design
88	Link238	6004	6019	49.5000	47.0000	No Design
89	Link239	6045	6014	49.5000	48.5000	No Design
90	5028	6032	CR7	2.0000	1.8000	No Design
91	Link242	6046	6003	54.0440	54.0000	No Design
92	Link243	6022	6006	45.4800	10.0000	No Design
93	Link244	6044	6021	46.0000	45.8000	No Design
94	Link245	Node275	Node274	49.5000	46.0000	No Design
95	Link252	Node292	6027	29.0000	9.4500	No Design
96	Link253	Node279	Node280	42.0000	40.0000	No Design
97	Link257	Node282	Node279	64.0000	42.0000	No Design
98	Link258	Node280	Diversion	40.0000	29.0000	No Design
99	Link259	Node289	6042	29.0000	3.8100	No Design
100	Link260	6043	CR9	3.7000	0.5000	No Design
101	Link261	Node284	Node285	58.0000	35.0000	No Design
102	Link262	Node285	6042	35.0000	3.8100	No Design
103	Link263	Node286	6048	23.0000	2.0000	No Design

```
*=========================================*
|            Orifice Data                 |
*=========================================*
```

Orifice Name	From Junction	To Junction	Type	Area (m2)	Depth (m)	Discharge Coefficient	Height Above Junction (m)
Low Flow.1	Diversion	Node289	Rect Side	0.18	0.30	0.600	0.000

```
====> EQUIVALENT PIPE INFORMATION FOR ORIFICE            1
      CONDUIT NAME..........................       Low Flow.1
      Upstream node..........................       Diversion
      Downstream node........................         Node289
      PIPE DIAMETER.......................              0.30
      PIPE LENGTH.........................            300.00
      MANNINGS ROUGHNESS..................            0.0047
      INVERT ELEVATION AT UPSTREAM END.....          29.0000
      INVERT ELEVATION AT DOWNSTREAM END...          28.9970
```

Note: For a Bottom-outlet orifice the invert elevation of the downstream node will be adjusted to accomodate the equivalent conduit. Conduit grades are not affected.

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*==========================================*
|                Weir Data                 |
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Weir Name	From Junction	To Junction	Type	Crest Height(ft)	Weir Top (m)	Weir Length (m)	Discharge Coefficient	Weir Power
High Flow.1	Diversion	Node292	1	0.30	5.00	1.50	1.7000	1.5000

FREE OUTFALL DATA (DATA GROUP I1)
BOUNDARY CONDITION ON DATA GROUP J1

Outfall at Junction....CR7 has boundary condition number... 1
Outfall at Junction....CR1 has boundary condition number... 2
Outfall at Junction....CR2 has boundary condition number... 3
Outfall at Junction....CR3 has boundary condition number... 4
Outfall at Junction....CR4 has boundary condition number... 5
Outfall at Junction....CR5 has boundary condition number... 6
Outfall at Junction....CR6 has boundary condition number... 7
Outfall at Junction....CR8 has boundary condition number... 8
Outfall at Junction....CR9 has boundary condition number... 9
Outfall at Junction....CR10 has boundary condition number... 10

Table E9 - JUNCTION SUMMARY STATISTICS
The Maximum area is only the area of the node, it does not include the area of the surrounding conduits

Junction Name	Ground Elevation meters	Uppermost PipeCrown Elevation meters	Maximum Junction Elevation meters	Time of Occurence Hr.	Min.	Meters of Surcharge at Max Elevation	Freeboard of node meters	Maximum Junction Area m^2	Maximum Gutter Depth meters	Maximum Gutter Width meters	Maximum Gutter Velocity m/s
1802	2.8200	1.5200	1.4678	8	0	0.0000	1.3522	1.2200	0.0000	0.0000	0.0000
1803	2.4600	1.3200	1.4535	8	0	0.1335	1.0065	1.2200	0.0000	0.0000	0.0000
1804	2.2900	1.1500	1.4511	8	0	0.3011	0.8389	1.2200	0.0000	0.0000	0.0000
1805	2.2300	1.0900	1.5139	39	24	0.4239	0.7161	1.2200	0.0000	0.0000	0.0000
1806	2.1500	1.0100	1.4396	39	24	0.4296	0.7104	1.2200	0.0000	0.0000	0.0000
1808	2.8000	1.5750	1.4036	8	0	0.0000	1.3964	1.2200	0.0000	0.0000	0.0000
1809	2.5900	1.4500	1.4025	8	0	0.0000	1.1875	1.2200	0.0000	0.0000	0.0000
1810	1.7500	0.8500	1.4388	33	16	0.5888	0.3112	1.2200	0.0000	0.0000	0.0000
1811	1.8400	1.0050	1.6014	8	0	0.5964	0.2386	1.2200	0.0000	0.0000	0.0000
1812	1.7500	1.1000	1.4346	33	45	0.3346	0.3154	1.2200	0.0000	0.0000	0.0000
1813	1.7500	1.4000	1.4120	46	11	0.0120	0.3380	1.2200	0.0000	0.0000	0.0000

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1814	1.9500	1.1150	1.7658	8	0	0.6508	0.1842	1.2200	0.0000	0.0000	0.0000
1815	2.9300	2.2000	2.1659	8	0	0.0000	0.7641	1.2200	0.0000	0.0000	0.0000
1818	3.1000	2.1100	2.4501	8	0	0.3401	0.6499	1.2200	0.0000	0.0000	0.0000
1819	4.9100	3.8700	3.2163	8	0	0.0000	1.6937	1.2200	0.0000	0.0000	0.0000
1820	5.3000	4.2200	3.6963	8	0	0.0000	1.6037	1.2200	0.0000	0.0000	0.0000
1821	5.6700	4.5300	4.0212	8	0	0.0000	1.6488	1.2200	0.0000	0.0000	0.0000
1822	8.3500	6.2100	5.8980	8	1	0.0000	2.4520	1.2200	0.0000	0.0000	0.0000
1823	5.2100	4.0700	3.8088	8	0	0.0000	1.4012	1.2200	0.0000	0.0000	0.0000
1824	3.7100	2.6700	2.7481	8	0	0.0781	0.9619	1.2200	0.0000	0.0000	0.0000
1831	9.0700	7.9300	7.6424	8	0	0.0000	1.4276	1.2200	0.0000	0.0000	0.0000
1832	10.5500	9.4100	9.1227	8	0	0.0000	1.4273	1.2200	0.0000	0.0000	0.0000
1833	8.9100	7.5400	7.3450	8	0	0.0000	1.5650	1.2200	0.0000	0.0000	0.0000
1834	8.8100	7.4700	7.1812	8	0	0.0000	1.6288	1.2200	0.0000	0.0000	0.0000
1836	8.2600	7.3050	6.6255	8	0	0.0000	1.6345	1.2200	0.0000	0.0000	0.0000
1837	7.3800	6.3050	5.7607	8	0	0.0000	1.6193	1.2200	0.0000	0.0000	0.0000
1838	7.2000	5.8300	5.4500	0	0	0.0000	1.7500	1.2200	0.0000	0.0000	0.0000
1839	6.7900	5.4700	5.1329	8	0	0.0000	1.6571	1.2200	0.0000	0.0000	0.0000
1840	4.1700	2.8000	2.5312	7	12	0.0000	1.6388	1.2200	0.0000	0.0000	0.0000
1841	4.7800	3.4100	3.1163	8	0	0.0000	1.6637	1.2200	0.0000	0.0000	0.0000
1844	6.1500	5.0750	4.5812	7	35	0.0000	1.5688	1.2200	0.0000	0.0000	0.0000
1846	5.6100	4.7600	4.2108	8	0	0.0000	1.3992	1.2200	0.0000	0.0000	0.0000
1847	5.4400	4.5900	4.1877	8	0	0.0000	1.2523	1.2200	0.0000	0.0000	0.0000
1850	1.7500	0.4000	1.4078	8	0	1.0078	0.3422	1.2200	0.0000	0.0000	0.0000
1852	5.3300	4.5500	4.0656	8	0	0.0000	1.2644	1.2200	0.0000	0.0000	0.0000
1853	5.3100	4.4600	3.7691	8	0	0.0000	1.5409	1.2200	0.0000	0.0000	0.0000
1854	3.9800	3.1300	2.6440	8	0	0.0000	1.3360	1.2200	0.0000	0.0000	0.0000
1855	5.4000	4.2600	4.1899	8	1	0.0000	1.2101	1.2200	0.0000	0.0000	0.0000
1856	5.5900	5.1000	4.2694	8	1	0.0000	1.3206	1.2200	0.0000	0.0000	0.0000
1857	6.0300	4.8650	4.5298	8	0	0.0000	1.5002	1.2200	0.0000	0.0000	0.0000
1858	5.4900	4.9750	4.5837	8	0	0.0000	0.9063	1.2200	0.0000	0.0000	0.0000
1859	6.9200	6.2950	6.0301	8	0	0.0000	0.8899	1.2200	0.0000	0.0000	0.0000
1860	7.3600	6.8000	5.7974	8	2	0.0000	1.5626	1.2200	0.0000	0.0000	0.0000
1861	7.6300	6.7800	6.1165	8	1	0.0000	1.5135	1.2200	0.0000	0.0000	0.0000
1862	6.3700	5.8200	4.9149	8	0	0.0000	1.4551	1.2200	0.0000	0.0000	0.0000
1864	7.1300	6.5800	5.6633	8	0	0.0000	1.4667	1.2200	0.0000	0.0000	0.0000
1865	8.2800	7.4300	6.6795	8	0	0.0000	1.6005	1.2200	0.0000	0.0000	0.0000
1866	8.7500	7.9000	7.1676	8	0	0.0000	1.5824	1.2200	0.0000	0.0000	0.0000
1867	9.2200	7.8450	7.5393	8	0	0.0000	1.6807	1.2200	0.0000	0.0000	0.0000
1868	9.6700	8.3200	7.9889	7	24	0.0000	1.6811	1.2200	0.0000	0.0000	0.0000
1869	9.4000	8.5500	7.7755	8	0	0.0000	1.6245	1.2200	0.0000	0.0000	0.0000
1870	9.4000	8.8500	7.8929	8	0	0.0000	1.5071	1.2200	0.0000	0.0000	0.0000
1871	10.3400	9.8400	8.8499	8	0	0.0000	1.4901	1.2200	0.0000	0.0000	0.0000
1872	10.8900	10.1750	9.5774	8	0	0.0000	1.3126	1.2200	0.0000	0.0000	0.0000
1873	52.1500	50.9550	50.7325	8	0	0.0000	1.4175	1.2200	0.0000	0.0000	0.0000
1874	52.4600	51.2400	51.0475	8	0	0.0000	1.4125	1.2200	0.0000	0.0000	0.0000
1878	58.5900	57.4300	56.9827	8	0	0.0000	1.6073	1.2200	0.0000	0.0000	0.0000
1879	55.3200	54.0700	53.7763	8	0	0.0000	1.5437	1.2200	0.0000	0.0000	0.0000
1880	55.6700	55.6700	54.1781	8	0	0.0000	1.4919	1.2200	0.0000	0.0000	0.0000
1881	61.9200	60.6200	60.3064	8	0	0.0000	1.6136	1.2200	0.0000	0.0000	0.0000

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1883	62.4900	61.1250	60.9521	8	1	0.0000	1.5379	1.2200	0.0000	0.0000	0.0000
1884	62.9000	61.5250	61.3738	8	0	0.0000	1.5262	1.2200	0.0000	0.0000	0.0000
6001	5.8500	4.7100	4.2648	8	0	0.0000	1.5852	1.2200	0.0000	0.0000	0.0000
6002	5.4000	4.5900	4.1679	8	1	0.0000	1.2321	1.2200	0.0000	0.0000	0.0000
6003	55.7500	55.7500	54.2472	8	0	0.0000	1.5028	1.2200	0.0000	0.0000	0.0000
6004	51.2500	51.2500	49.6577	8	1	0.0000	1.5923	1.2200	0.0000	0.0000	0.0000
6005	11.7500	11.5000	9.2644	8	0	0.0000	2.4856	1.2200	0.0000	0.0000	0.0000
6006	11.5000	11.5000	9.5072	8	2	0.0000	1.9928	1.2200	0.0000	0.0000	0.0000
6008	5.2500	3.8000	3.5738	8	0	0.0000	1.6762	1.2200	0.0000	0.0000	0.0000
6014	50.0000	50.0000	48.5642	8	0	0.0000	1.4358	1.2200	0.0000	0.0000	0.0000
6017	6.5500	6.2000	5.1534	8	0	0.0000	1.3966	1.2200	0.0000	0.0000	0.0000
6019	51.0000	48.7500	47.3362	8	1	0.0000	3.6638	1.2200	0.0000	0.0000	0.0000
6020	48.4500	47.5500	46.9824	8	1	0.0000	1.4676	1.2200	0.0000	0.0000	0.0000
6021	47.3000	47.3000	46.1975	8	1	0.0000	1.1025	1.2200	0.0000	0.0000	0.0000
6022	47.5000	46.9800	45.5953	8	2	0.0000	1.9047	1.2200	0.0000	0.0000	0.0000
6023	8.7500	7.3750	7.1261	8	0	0.0000	1.6239	1.2200	0.0000	0.0000	0.0000
6027	11.2000	10.6500	9.6821	8	6	0.0000	1.5179	1.2200	0.0000	0.0000	0.0000
6031	5.5000	4.9100	4.1706	8	1	0.0000	1.3294	1.2200	0.0000	0.0000	0.0000
6032	4.1000	4.1000	2.4541	8	1	0.0000	1.6459	1.2200	0.0000	0.0000	0.0000
6033	1.7500	0.0000	1.4000	0	0	1.4000	0.3500	1.2200	0.0000	0.0000	0.0000
6034	2.9500	1.7920	1.4106	33	51	0.0000	1.5394	1.2200	0.0000	0.0000	0.0000
6035	1.7500	0.8000	1.4643	39	54	0.6643	0.2857	1.2200	0.0000	0.0000	0.0000
6038	5.6500	4.9400	4.2041	8	1	0.0000	1.4459	1.2200	0.0000	0.0000	0.0000
6039	5.3500	5.2000	3.7182	8	1	0.0000	1.6318	1.2200	0.0000	0.0000	0.0000
CR7	3.9000	3.9000	2.1253	8	1	0.0000	1.7747	1.2200	0.0000	0.0000	0.0000
6041	6.0000	4.7500	4.1337	8	1	0.0000	1.8663	1.2200	0.0000	0.0000	0.0000
6042	7.0000	5.3100	4.1007	8	17	0.0000	2.8993	1.2200	0.0000	0.0000	0.0000
6043	7.0000	5.2000	3.8983	8	1	0.0000	3.1017	1.2200	0.0000	0.0000	0.0000
6044	48.0000	47.5000	46.2372	8	1	0.0000	1.7628	1.2200	0.0000	0.0000	0.0000
6045	51.0000	51.0000	49.6013	8	0	0.0000	1.3987	1.2200	0.0000	0.0000	0.0000
6046	55.8000	55.7940	54.2587	8	0	0.0000	1.5413	1.2200	0.0000	0.0000	0.0000
6048	3.7500	3.0000	2.1635	8	0	0.0000	1.5865	1.2200	0.0000	0.0000	0.0000
CR1	2.3000	1.1600	1.4000	0	0	0.2400	0.9000	1.2200	0.0000	0.0000	0.0000
CR2	1.8400	0.7100	1.4000	0	0	0.6900	0.4400	1.2200	0.0000	0.0000	0.0000
CR3	1.7500	0.5000	1.4000	0	0	0.9000	0.3500	1.2200	0.0000	0.0000	0.0000
CR4	1.7500	0.7400	1.4000	0	0	0.6600	0.3500	1.2200	0.0000	0.0000	0.0000
CR5	1.7500	0.4900	1.4000	0	0	0.9100	0.3500	1.2200	0.0000	0.0000	0.0000
CR6	1.8500	0.3000	1.4000	0	0	1.1000	0.4500	1.2200	0.0000	0.0000	0.0000
CR8	4.7500	3.3000	3.0673	8	0	0.0000	1.6827	1.2200	0.0000	0.0000	0.0000
CR9	1.7500	1.5000	1.4000	0	0	0.0000	0.3500	1.2200	0.0000	0.0000	0.0000
CR10	2.0000	1.2000	1.4000	0	0	0.2000	0.6000	1.2200	0.0000	0.0000	0.0000
Node274	47.5000	47.5000	46.0457	8	0	0.0000	1.4543	1.2200	0.0000	0.0000	0.0000
Node275	51.0000	51.0000	49.6030	8	0	0.0000	1.3970	1.2200	0.0000	0.0000	0.0000
Node279	47.0000	43.8000	42.3511	8	0	0.0000	4.6489	1.2200	0.0000	0.0000	0.0000
Node280	45.0000	41.8000	40.1368	8	1	0.0000	4.8632	1.2200	0.0000	0.0000	0.0000
Node282	66.0000	65.0000	64.2079	8	0	0.0000	1.7921	1.2200	0.0000	0.0000	0.0000
Node284	60.0000	59.0000	58.0896	8	0	0.0000	1.9104	1.2200	0.0000	0.0000	0.0000
Node285	37.0000	36.0000	35.1199	8	1	0.0000	1.8801	1.2200	0.0000	0.0000	0.0000
Node286	25.0000	24.0000	23.0357	8	0	0.0000	1.9643	1.2200	0.0000	0.0000	0.0000

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Node289	34.0000	30.0000	29.1254	8	0	0.0000	4.8746	1.2200	0.0000	0.0000	0.0000
Diversion	34.0000	30.0000	29.5514	8	2	0.0000	4.4486	1.2200	0.0000	0.0000	0.0000
Node292	34.0000	30.0000	29.1005	8	3	0.0000	4.8995	1.2200	0.0000	0.0000	0.0000

```
*=====================================================*
|        Table E10 - CONDUIT SUMMARY STATISTICS       |
| Note: The peak flow may be less than the design flow |
| and the conduit may still surcharge because of the   |
| downstream boundary conditions.                      |
|                                                      |
| * denotes an open conduit that has been overtopped   |
|   this is a potential source of severe errors        |
*=====================================================*
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Conduit Name	Design Flow (cms)	Conduit Design Velocity (m/s)	Maximum Vertical Depth (mm)	Maximum Computed Flow (cms)	Time of Occurence Hr.	Time of Occurence Min.	Maximum Computed Velocity (m/s)	Time of Occurence Hr.	Time of Occurence Min.	Ratio of Max. to Design Flow	Maximum Water Elev at Pipe Ends Upstream (m)	Maximum Water Elev at Pipe Ends Dwnstrm (m)	Ratio d/D US	Ratio d/D DS	
1686	0.2464	1.1382	525.0000	0.0143	8	0	0.0886	8	1	0.0582	1.4036	1.4025	0.674	1.071	
1687	0.4054	1.3870	610.0000	0.0317	8	0	0.1122	8	0	0.0783	1.4025	1.4000	0.922	1.393	
1691	0.1486	0.9342	450.0000	0.0301	8	1	0.2013	8	1	0.2024	1.4678	1.4535	0.884	1.519	
1692	0.3450	1.1806	610.0000	0.0302	8	0	0.1009	8	0	0.0876	1.4535	1.4511	1.219	1.494	
1693	0.2095	0.7170	610.0000	0.0523	8	0	0.1785	8	0	0.2498	1.4511	1.5137	1.494	1.695	
1694	0.2795	0.9562	610.0000	0.0691	8	0	0.2356	8	0	0.2473	1.5139	1.4380	1.695	1.702	
1695	0.3123	1.0688	610.0000	0.0933	8	0	0.3176	8	0	0.2986	1.4396	1.4000	1.704	2.131	
1696	0.8164	2.2154	685.0000	0.4352	8	1	1.5524	10	34	0.5330	2.7481	2.4501	1.151	1.504	
1697	0.8937	1.9700	760.0000	0.4736	8	1	1.0406	8	1	0.5299	2.4501	2.1659	1.448	2.008	
1698	0.5402	1.1909	760.0000	0.5142	8	1	1.1254	8	1	0.9519	2.1659	1.7658	2.152	2.060	
1699	0.5536	0.8419	915.0000	0.5413	8	0	0.8196	8	0	0.9778	1.7658	1.6014	1.711	1.652	
1700	0.6932	1.2216	850.0000	0.5542	8	0	0.9719	8	0	0.7995	1.6014	1.4000	1.778	1.776	
1701	0.3380	1.1955	600.0000	0.0214	8	0	0.0756	8	0	0.0634	1.4346	1.4388	1.558	1.981	
1702	0.4103	1.4512	600.0000	0.0214	8	0	0.0755	8	0	0.0523	1.4120	1.4334	1.020	1.556	
1704	0.8005	2.7391	610.0000	0.3613	8	0	2.3025	8	0	0.4513	9.1227	7.6424	0.529	0.529	
1705	0.8300	2.8402	610.0000	0.3731	8	0	2.4038	8	1	0.4495	7.6424	5.8980	0.529	0.488	
1707	0.0670	0.2030	300.0000	0.0187	8	0	0.0566	8	0	0.2786	1.4078	1.4000	4.359	4.667	*
1709	0.0654	0.5765	380.0000	0.0284	8	0	0.5424	8	0	0.4347	7.3450	7.2100	0.487	0.316	
1710	0.2135	1.6991	400.0000	0.0352	8	0	1.1093	8	1	0.1649	7.1812	6.6398	0.303	0.274	
1711	0.1169	1.0583	375.0000	0.0203	8	0	0.6404	8	0	0.1740	7.1261	7.0313	0.336	0.270	
1712	0.9275	2.5919	675.0000	0.0555	8	0	1.3356	8	1	0.0599	6.6255	5.7607	0.171	0.194	
1713	0.8521	2.3813	675.0000	0.0701	8	0	1.3601	8	0	0.0823	5.7607	4.5812	0.194	0.268	
1715	0.5474	1.5296	675.0000	0.0841	8	0	0.9648	7	18	0.1537	4.5812	4.2108	0.268	0.520	
1716	1.0277	1.6155	900.0000	0.1073	8	0	0.5478	4	16	0.1044	4.2108	4.1877	0.390	0.553	
1718	0.0532	0.0000	900.0000	0.1280	8	0	0.3707	7	19	2.4082	4.1877	4.1679	0.553	0.531	
1719	0.2736	0.4301	900.0000	0.2630	8	1	0.8060	8	1	0.9612	4.0656	3.7691	0.540	0.232	
1720	2.4503	3.8516	900.0000	0.2717	8	0	2.0966	8	1	0.1109	3.7691	2.6440	0.232	0.460	
1726	0.1802	1.5885	380.0000	0.0198	8	0	0.9888	8	0	0.1100	3.1163	2.5312	0.227	0.293	
1727	0.1796	1.5837	380.0000	0.0309	8	0	1.1027	7	13	0.1719	2.5312	2.1659	0.293	0.910	
1736	0.0654	0.5770	380.0000	0.0000	0	0	0.0000	0	0	0.0000	5.4500	5.1329	.0000	.0000	

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1737	0.1627	1.4345	380.0000	0.0199	8	0	0.9326	8	0	0.1225	5.1329	4.1397	0.244	0.236
1738	0.3873	1.3252	610.0000	0.0199	8	0	0.6374	8	1	0.0514	4.0212	3.6970	0.166	0.143
1739	0.3666	1.2545	610.0000	0.0385	8	0	0.7316	8	0	0.1051	3.6963	3.3828	0.240	0.201
1742	2.1628	7.4004	610.0000	0.0385	8	0	3.7114	0	27	0.0178	3.2163	2.4501	0.092	1.689
1746	0.8722	2.9846	610.0000	0.3730	8	1	2.5742	8	1	0.4276	5.8980	3.8088	0.488	0.572
1747	0.8719	2.9833	610.0000	0.4176	8	0	2.4061	7	17	0.4790	3.8088	2.7481	0.572	1.128
1767	0.1406	1.2727	375.0000	0.0775	8	0	1.1441	8	1	0.5515	61.3738	60.9521	0.597	0.539
1768	0.1624	1.4700	375.0000	0.0773	8	1	1.2214	8	2	0.4760	60.9521	60.3722	0.566	0.486
1770	0.6130	3.8545	450.0000	0.1047	8	0	2.5981	8	0	0.1708	60.3064	57.1058	0.303	0.280
1772	0.5600	3.5211	450.0000	0.1208	8	0	2.6194	8	0	0.2156	56.9827	53.7763	0.317	0.458
1773	0.2491	1.5662	450.0000	0.1034	8	0	1.1267	8	1	0.4152	54.1781	53.8221	0.574	0.449
1774	0.5293	3.3281	450.0000	0.2346	8	0	2.8790	8	1	0.4431	53.7763	51.0475	0.503	0.572
1775	0.9108	4.2072	525.0000	0.2583	8	0	1.7779	8	0	0.2836	51.0475	50.7325	0.643	0.576
1776	0.6406	2.9593	525.0000	0.2583	8	0	1.9058	8	1	0.4031	50.7325	49.6577	0.633	0.300
1779	5.1185	4.5257	1200.000	0.3710	8	0	2.0733	8	1	0.0725	8.8499	7.8929	0.217	0.202
1780	0.4226	1.1808	675.0000	0.0093	8	0	0.4577	0	24	0.0219	9.5774	9.1974	0.115	0.085
1781	0.0532	0.0000	900.0000	0.0668	8	1	0.5138	8	2	1.2565	7.8929	7.7755	0.270	0.139
1782	0.2437	1.9394	400.0000	0.0146	8	0	0.9093	7	15	0.0597	7.9889	7.7755	0.172	0.314
1783	2.1702	3.4113	900.0000	0.0812	8	0	1.4263	8	0	0.0374	7.7755	7.1676	0.139	0.186
1784	0.2561	2.3184	375.0000	0.0192	8	0	1.1263	7	16	0.0748	7.5393	7.1676	0.185	0.447
1785	1.6548	2.6012	900.0000	0.1003	8	0	1.2438	8	1	0.0606	7.1676	6.6795	0.186	0.166
1786	1.7708	2.7835	900.0000	0.1003	8	1	1.3211	8	1	0.0566	6.6795	6.1165	0.166	0.263
1787	0.9183	1.4434	900.0000	0.1097	8	1	0.8454	8	2	0.1195	6.1165	5.7977	0.263	0.209
1789	2.9635	3.4224	1050.000	0.3039	8	1	2.0215	8	1	0.1026	7.8929	5.7563	0.231	0.215
1790	2.9712	2.6271	1200.000	0.3152	8	1	1.5361	8	1	0.1061	5.6633	4.9149	0.236	0.246
1791	2.9846	2.6390	1200.000	0.3437	8	0	1.5350	8	1	0.1152	4.9149	4.2694	0.246	0.308
1792	2.2539	1.0435	1200.000	0.5021	8	1	0.5838	8	1	0.2228	4.2694	4.2041	0.399	0.387
1793	0.1885	0.6452	610.0000	-0.1159	8	10	-0.4390	8	14	-0.6148	4.1679	4.1899	0.783	0.885
1795	0.3023	1.3962	525.0000	-0.0587	8	0	-0.2902	8	0	-0.1943	4.5837	4.5298	0.464	1.238
1796	0.1540	1.3945	375.0000	0.0274	8	0	1.0154	8	0	0.1777	6.0301	4.7069	0.294	0.285
5005	0.0533	0.7547	300.0000	0.0099	30	4	0.1378	30	4	0.1847	1.4643	1.4000	3.214	4.000
5006	0.4732	1.6735	600.0000	0.0332	8	0	0.1168	8	0	0.0702	1.4388	1.4000	1.981	2.517
5009	0.4033	1.4264	600.0000	-0.0090	33	48	0.0479	46	14	-0.0223	1.4106	1.4120	0.364	1.020
5010	0.3744	2.3541	450.0000	0.0530	8	0	1.1070	7	31	0.1414	9.2644	9.1227	0.299	0.717
5011	0.8108	2.8676	600.0000	0.3011	8	2	1.7367	8	4	0.3713	9.5072	9.1227	0.595	0.538
5014	0.7426	5.9092	400.0000	0.0415	8	0	4.0448	0	25	0.0559	48.5642	46.2372	0.160	0.593
5015	1.3973	3.1628	750.0000	0.2580	8	1	1.4079	7	15	0.1846	47.3362	47.0180	0.448	0.291
5016	1.8870	4.2712	750.0000	0.2990	8	1	1.3720	8	6	0.1585	46.1975	45.5953	0.530	0.154
5018	9.2425	1.3204	1750.000	0.0984	8	0	0.3977	8	0	0.0106	54.2472	54.1781	0.141	0.147
5021	5.6825	5.0245	1200.000	0.3201	8	5	2.1257	8	0	0.0563	9.6821	8.8499	0.193	0.175
5022	1.2277	1.0231	1200.000	0.1152	8	1	0.5969	8	1	0.0938	5.7974	5.1534	0.165	0.128
5023	2.0806	1.7338	1200.000	0.1517	8	0	0.8667	8	0	0.0729	5.1534	4.2694	0.128	0.308
5024	0.0188	0.0000	610.0000	-0.1111	8	11	-0.4074	8	13	-5.8986	4.1899	4.2041	0.885	0.908
5026	0.7246	1.1390	900.0000	0.2368	8	2	0.8857	8	2	0.3268	4.1706	3.7182	0.467	0.131
5027	16.1398	5.6041	1600.000	0.4692	8	1	1.7170	8	1	0.0291	3.7182	2.4541	0.074	0.284
5029	1.2065	1.8965	900.0000	0.2775	8	0	1.0087	8	0	0.2300	2.6440	2.4934	0.460	0.326
5030	0.2291	1.0581	525.0000	0.0705	8	0	0.7992	8	0	0.3080	4.5298	4.3146	0.438	0.333
5031	0.5690	2.0124	600.0000	0.0705	8	0	1.0101	7	19	0.1240	4.2648	4.1337	0.258	0.639
5032	0.0669	0.9468	300.0000	0.0081	8	0	0.6087	8	0	0.1213	3.5738	3.0673	0.246	0.224

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5033	5.8344	2.1609	1500.000	0.5252	8	17	1.0370	8	17	0.0900	4.1007	3.8983	0.194	0.132
5034	0.4674	0.7347	900.0000	0.2489	8	1	0.7374	8	2	0.5325	4.1679	4.0656	0.531	0.462
5035	1.9190	4.3438	750.0000	0.2580	8	2	1.7752	8	3	0.1345	46.9824	46.4854	0.376	0.247
Link232	2.1224	0.9826	1200.000	0.3926	8	2	0.4703	8	2	0.1850	4.2041	4.1706	0.387	0.384
Link233	0.0704	0.0000	1000.000	0.1563	8	4	0.5073	8	7	2.2200	4.1706	4.1337	0.421	0.384
5025	0.9887	1.2589	1000.000	0.2259	8	1	0.8856	8	2	0.2285	4.1337	3.7182	0.384	0.118
Link236	1.0533	2.7370	700.0000	0.1262	8	0	1.2599	8	0	0.1198	2.1635	1.4000	0.234	1.286
Link237	42.5308	6.3009	1500.000	0.0530	8	0	2.6588	0	23	0.0012	46.0457	10.0315	0.030	0.021
Link238	37.0144	4.7002	1750.000	0.2582	8	1	1.3838	0	24	0.0070	49.6577	47.3362	0.090	0.192
Link239	4.6551	1.2414	1500.000	0.0279	8	0	0.2598	8	0	0.0060	49.6013	48.5642	0.068	0.043
5028	14.4354	4.1677	2100.000	0.7561	8	1	1.4232	8	2	0.0524	2.4541	2.1253	0.216	0.155
Link242	9.1913	1.3130	1750.000	0.0429	8	0	0.2310	6	18	0.0047	54.2587	54.2472	0.123	0.141
Link243	42.2225	6.2552	1500.000	0.3011	8	2	2.3757	0	24	0.0071	45.5953	10.1134	0.077	0.076
Link244	18.6199	2.7585	1500.000	0.2990	8	1	1.6317	0	25	0.0161	46.2372	46.1975	0.158	0.265
Link245	8.7089	2.3224	1500.000	0.0486	8	0	0.8575	0	24	0.0056	49.6030	46.0457	0.069	0.030
Link252	18.7252	5.3500	1000.000	0.3214	8	3	1.2916	8	2	0.0172	29.1005	9.6821	0.100	0.232
Link253	11.0937	4.3596	1800.000	0.5736	8	1	1.7718	8	1	0.0517	42.3511	40.1368	0.195	0.076
Link257	8.3039	2.3725	1000.000	0.4878	8	0	0.9360	8	0	0.0587	64.2079	42.3511	0.208	0.351
Link258	19.8639	5.6754	1000.000	0.5736	8	1	4.4003	0	25	0.0289	40.1368	29.5514	0.137	0.551
Link259	10.8958	3.1131	1000.000	0.2716	8	0	0.8823	5	10	0.0249	29.1254	4.1007	0.125	0.291
Link260	9.7933	2.1763	1000.000	0.5774	8	1	0.5891	8	1	0.0590	3.8983	1.4000	0.198	0.900
Link261	14.1354	3.1412	1000.000	0.2192	8	0	2.2483	0	23	0.0155	58.0896	35.1199	0.090	0.120
Link262	10.9475	2.4328	1000.000	0.2769	8	1	0.6543	0	23	0.0253	35.1199	4.1007	0.120	0.291
Link263	10.3736	2.9639	1000.000	0.0314	8	0	2.4827	0	23	0.0030	23.0357	2.1635	0.036	0.164
Low Flow.1	0.2620	0.1467	300.0000	0.2519	8	2	1.4784	8	2	0.9615	29.5514	29.1254	1.838	0.428
High Flow.1	Undefnd	Undefnd	Undefn	0.3215	8	2								
FREE # 1	Undefnd	Undefnd	Undefn	0.7561	8	1								
FREE # 2	Undefnd	Undefnd	Undefn	0.0317	8	0								
FREE # 3	Undefnd	Undefnd	Undefn	0.0933	8	0								
FREE # 4	Undefnd	Undefnd	Undefn	0.0102	45	34								
FREE # 5	Undefnd	Undefnd	Undefn	0.5542	8	0								
FREE # 6	Undefnd	Undefnd	Undefn	0.0332	8	0								
FREE # 7	Undefnd	Undefnd	Undefn	0.0187	8	0								
FREE # 8	Undefnd	Undefnd	Undefn	0.0081	8	0								
FREE # 9	Undefnd	Undefnd	Undefn	0.5774	8	1								
FREE #10	Undefnd	Undefnd	Undefn	0.1262	8	0								

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XP-SWMM Output
Future Conditions (LID applied in selected areas), 2 year 24 hour storm
Tables E4, E9 and E10

Table E4 - Conduit Connectivity

Input Number	Conduit Name	Upstream Node	Downstream Node	Upstream Elevation	Downstream Elevation	
1	1686	1808	1809	1.0500	0.8400	No Design
2	1687	1809	CR1	0.8400	0.5500	No Design
3	1691	1802	1803	1.0700	0.7700	No Design
4	1692	1803	1804	0.7100	0.5400	No Design
5	1693	1804	1805	0.5400	0.4800	No Design
6	1694	1805	1806	0.4800	0.4000	No Design
7	1695	1806	CR2	0.4000	0.1000	No Design
8	1696	1824	1818	1.9600	1.4200	No Design
9	1697	1818	1815	1.3500	0.6400	No Design
10	1698	1815	1814	0.5300	0.2000	No Design
11	1699	1814	1811	0.2000	0.0900	No Design
12	1700	1811	CR4	0.0900	-0.1100	No Design
13	1701	1812	1810	0.5000	0.2500	No Design
14	1702	1813	1812	0.8000	0.5000	No Design
15	1704	1832	1831	8.8000	7.3200	No Design
16	1705	1831	1822	7.3200	5.6000	No Design
17	1707	1850	CR6	0.1000	0.0000	No Design
18	1709	1833	1834	7.1600	7.0900	No Design
19	1710	1834	1836	7.0600	6.5300	No Design
20	1711	6023	1836	7.0000	6.9300	No Design
21	1712	1836	1837	6.5100	5.6300	No Design
22	1713	1837	1844	5.6300	4.4000	No Design
23	1715	1844	1846	4.4000	3.8600	No Design
24	1716	1846	1847	3.8600	3.6900	No Design
25	1718	1847	6002	3.6900	3.6900	No Design
26	1719	1852	1853	3.5800	3.5600	No Design
27	1720	1853	1854	3.5600	2.2300	No Design
28	1726	1841	1840	3.0300	2.4200	No Design
29	1727	1840	1815	2.4200	1.8200	No Design
30	1736	1838	1839	5.4500	5.0900	No Design
31	1737	1839	1821	5.0400	4.0500	No Design
32	1738	1821	1820	3.9200	3.6100	No Design

Campbell River / Quinsam River ISMP
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33	1739	1820	1819	3.5500	3.2600	No Design
34	1742	1819	1818	3.1600	1.4200	No Design
35	1746	1822	1823	5.6000	3.4600	No Design
36	1747	1823	1824	3.4600	2.0600	No Design
37	1767	1884	1883	61.1500	60.7500	No Design
38	1768	1883	1881	60.7400	60.1900	No Design
39	1770	1881	1878	60.1700	56.9800	No Design
40	1772	1878	1879	56.8400	53.5700	No Design
41	1773	1880	1879	53.9200	53.6200	No Design
42	1774	1879	1874	53.5500	50.7900	No Design
43	1775	1874	1873	50.7100	50.4300	No Design
44	1776	1873	6004	50.4000	49.5000	No Design
45	1779	1871	1870	8.5900	7.6500	No Design
46	1780	1872	1871	9.5000	9.1400	No Design
47	1781	1870	1869	7.6500	7.6500	No Design
48	1782	1868	1869	7.9200	7.6500	No Design
49	1783	1869	1866	7.6500	7.0000	No Design
50	1784	1867	1866	7.4700	7.0000	No Design
51	1785	1866	1865	7.0000	6.5300	No Design
52	1786	1865	1861	6.5300	5.8800	No Design
53	1787	1861	1860	5.8800	5.6100	No Design
54	1789	1870	1864	7.6500	5.5300	No Design
55	1790	1864	1862	5.3800	4.6200	No Design
56	1791	1862	1856	4.6200	3.9000	No Design
57	1792	1856	6038	3.7900	3.7400	No Design
58	1793	6002	1855	3.6900	3.6500	No Design
59	1795	1857	1858	4.3400	3.8800	No Design
60	1796	1859	1858	5.9200	4.6000	No Design
61	5005	6035	CR3	0.5000	0.2000	No Design
62	5006	1810	CR5	0.2500	-0.1100	No Design
63	5009	6034	1813	1.1920	0.8000	No Design
64	5010	6005	1832	9.1300	8.8000	No Design
65	5011	6006	1832	9.1500	8.8000	No Design
66	5014	6014	6044	48.5000	46.0000	No Design
67	5015	6019	6020	47.0000	46.8000	No Design
68	5016	6021	6022	45.8000	45.4800	No Design
69	5018	6003	1880	54.0000	53.9200	No Design
70	5021	6027	1871	9.4500	8.6400	No Design
71	5022	1860	6017	5.6000	5.0000	No Design
72	5023	6017	1856	5.0000	3.9000	No Design
73	5024	1855	6038	3.6500	3.6500	No Design
74	5026	6031	6039	3.7500	3.6000	No Design
75	5027	6039	6032	3.6000	2.0000	No Design
76	5029	1854	6032	2.2300	2.2000	No Design
77	5030	1857	6001	4.3000	4.1400	No Design
78	5031	6001	6041	4.1100	3.7500	No Design
79	5032	6008	CR8	3.5000	3.0000	No Design
80	5033	6042	6043	3.8100	3.7000	No Design
81	5034	6002	1852	3.6900	3.6500	No Design

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82	5035	6020	6044	46.7000	46.3000	No Design
83	Link232	6038	6031	3.7400	3.7100	No Design
84	Link233	6031	6041	3.7500	3.7500	No Design
85	5025	6041	6039	3.7500	3.6000	No Design
86	Link236	6048	CR10	2.0000	0.5000	No Design
87	Link237	Node274	6005	46.0000	10.0000	No Design
88	Link238	6004	6019	49.5000	47.0000	No Design
89	Link239	6045	6014	49.5000	48.5000	No Design
90	5028	6032	CR7	2.0000	1.8000	No Design
91	Link242	6046	6003	54.0440	54.0000	No Design
92	Link243	6022	6006	45.4800	10.0000	No Design
93	Link244	6044	6021	46.0000	45.8000	No Design
94	Link245	Node275	Node274	49.5000	46.0000	No Design
95	Link252	Node292	6027	29.0000	9.4500	No Design
96	Link253	Node279	Node280	42.0000	40.0000	No Design
97	Link257	Node282	Node279	64.0000	42.0000	No Design
98	Link258	Node280	Diversion	40.0000	29.0000	No Design
99	Link259	Node289	6042	29.0000	3.8100	No Design
100	Link260	6043	CR9	3.7000	0.5000	No Design
101	Link261	Node284	Node285	58.0000	35.0000	No Design
102	Link262	Node285	6042	35.0000	3.8100	No Design
103	Link263	Node286	6048	23.0000	2.0000	No Design

```
*===========================================*
|             Orifice Data                  |
*===========================================*
```

Orifice Name	From Junction	To Junction	Type	Area (m2)	Depth (m)	Discharge Coefficient	Height Above Junction (m)
Low Flow.1	Diversion	Node289	Rect Side	0.18	0.30	0.600	0.000

```
====> EQUIVALENT PIPE INFORMATION FOR ORIFICE            1
      CONDUIT NAME..........................      Low Flow.1
      Upstream node..........................      Diversion
      Downstream node........................        Node289
      PIPE DIAMETER.......................              0.30
      PIPE LENGTH.........................            300.00
      MANNINGS ROUGHNESS..................            0.0047
      INVERT ELEVATION AT UPSTREAM END.....          29.0000
      INVERT ELEVATION AT DOWNSTREAM END...          28.9970
```

Note: For a Bottom-outlet orifice the invert elevation of the downstream node will be adjusted to accomodate the equivalent conduit. Conduit grades are not affected.

```
*============================================*
|                Weir Data                   |
```

Campbell River / Quinsam River ISMP
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Weir Name	From Junction	To Junction	Type	Crest Height(ft)	Weir Top (m)	Weir Length (m)	Discharge Coefficient	Weir Power
High Flow.1	Diversion	Node292	1	0.30	5.00	1.50	1.7000	1.5000

FREE OUTFALL DATA (DATA GROUP I1)
BOUNDARY CONDITION ON DATA GROUP J1

Outfall at Junction....CR7 has boundary condition number... 1
Outfall at Junction....CR1 has boundary condition number... 2
Outfall at Junction....CR2 has boundary condition number... 3
Outfall at Junction....CR3 has boundary condition number... 4
Outfall at Junction....CR4 has boundary condition number... 5
Outfall at Junction....CR5 has boundary condition number... 6
Outfall at Junction....CR6 has boundary condition number... 7
Outfall at Junction....CR8 has boundary condition number... 8
Outfall at Junction....CR9 has boundary condition number... 9
Outfall at Junction....CR10 has boundary condition number... 10

Weir Outfall Data
Boundary Condition on data group J1

INTERNAL CONNECTIVITY INFORMATION

CONDUIT	JUNCTION	JUNCTION
Low Flow.1	Diversion	Node289
High Flow.1	Diversion	Node292
FREE # 1	CR7	BOUNDARY
FREE # 2	CR1	BOUNDARY
FREE # 3	CR2	BOUNDARY
FREE # 4	CR3	BOUNDARY
FREE # 5	CR4	BOUNDARY
FREE # 6	CR5	BOUNDARY
FREE # 7	CR6	BOUNDARY
FREE # 8	CR8	BOUNDARY
FREE # 9	CR9	BOUNDARY

Campbell River / Quinsam River ISMP
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FREE #10 CR10 BOUNDARY

```
*==================================================*
|       Boundary Condition Information             |
|                Data Groups J1-J4                 |
*==================================================*
```

```
BC NUMBER..         1 Control water surface elevation is..     1.400 meters.
BC NUMBER..         2 Control water surface elevation is..     1.400 meters.
BC NUMBER..         3 Control water surface elevation is..     1.400 meters.
BC NUMBER..         4 Control water surface elevation is..     1.400 meters.
BC NUMBER..         5 Control water surface elevation is..     1.400 meters.
BC NUMBER..         6 Control water surface elevation is..     1.400 meters.
BC NUMBER..         7 Control water surface elevation is..     1.400 meters.
BC NUMBER..         8 Control water surface elevation is..     1.400 meters.
BC NUMBER..         9 Control water surface elevation is..     1.400 meters.
BC NUMBER..        10 Control water surface elevation is..     1.400 meters.
```

```
*=====================================================*
|       Table E9 - JUNCTION SUMMARY STATISTICS        |
| The Maximum area is only the area of the node, it   |
| does not include the area of the surrounding conduits|
*=====================================================*
```

Junction Name	Ground Elevation meters	Uppermost PipeCrown Elevation meters	Maximum Junction Elevation meters	Time of Occurence Hr.	Min.	Meters of Surcharge at Max Elevation	Freeboard of node meters	Maximum Junction Area m^2	Maximum Gutter Depth meters	Maximum Gutter Width meters	Maximum Gutter Velocity m/s
1802	2.8200	1.5200	1.4817	8	0	0.0000	1.3383	1.2200	0.0000	0.0000	0.0000
1803	2.4600	1.3200	1.4572	8	0	0.1372	1.0028	1.2200	0.0000	0.0000	0.0000
1804	2.2900	1.1500	1.4671	44	8	0.3171	0.8229	1.2200	0.0000	0.0000	0.0000
1805	2.2300	1.0900	1.4713	44	7	0.3813	0.7587	1.2200	0.0000	0.0000	0.0000
1806	2.1500	1.0100	1.4643	44	7	0.4543	0.6857	1.2200	0.0000	0.0000	0.0000
1808	2.8000	1.5750	1.4027	7	3	0.0000	1.3973	1.2200	0.0000	0.0000	0.0000
1809	2.5900	1.4500	1.4018	8	0	0.0000	1.1882	1.2200	0.0000	0.0000	0.0000
1810	1.7500	0.8500	1.4313	40	11	0.5813	0.3187	1.2200	0.0000	0.0000	0.0000
1811	1.8400	1.0050	1.5637	8	0	0.5587	0.2763	1.2200	0.0000	0.0000	0.0000
1812	1.7500	1.1000	1.4316	37	18	0.3316	0.3184	1.2200	0.0000	0.0000	0.0000
1813	1.7500	1.4000	1.4093	30	44	0.0093	0.3407	1.2200	0.0000	0.0000	0.0000
1814	1.9500	1.1150	1.6977	8	0	0.5827	0.2523	1.2200	0.0000	0.0000	0.0000
1815	2.9300	2.2000	2.0209	8	1	0.0000	0.9091	1.2200	0.0000	0.0000	0.0000
1818	3.1000	2.1100	2.2327	8	1	0.1227	0.8673	1.2200	0.0000	0.0000	0.0000
1819	4.9100	3.8700	3.2242	8	0	0.0000	1.6858	1.2200	0.0000	0.0000	0.0000
1820	5.3000	4.2200	3.7201	8	0	0.0000	1.5799	1.2200	0.0000	0.0000	0.0000
1821	5.6700	4.5300	4.0321	7	31	0.0000	1.6379	1.2200	0.0000	0.0000	0.0000
1822	8.3500	6.2100	5.8644	8	1	0.0000	2.4856	1.2200	0.0000	0.0000	0.0000

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1823	5.2100	4.0700	3.7519	8	0	0.0000	1.4581	1.2200	0.0000	0.0000	0.0000
1824	3.7100	2.6700	2.4597	8	1	0.0000	1.2503	1.2200	0.0000	0.0000	0.0000
1831	9.0700	7.9300	7.6038	8	0	0.0000	1.4662	1.2200	0.0000	0.0000	0.0000
1832	10.5500	9.4100	9.0833	8	0	0.0000	1.4667	1.2200	0.0000	0.0000	0.0000
1833	8.9100	7.5400	7.3298	8	0	0.0000	1.5802	1.2200	0.0000	0.0000	0.0000
1834	8.8100	7.4700	7.1708	8	0	0.0000	1.6392	1.2200	0.0000	0.0000	0.0000
1836	8.2600	7.3050	6.6163	8	0	0.0000	1.6437	1.2200	0.0000	0.0000	0.0000
1837	7.3800	6.3050	5.7507	8	0	0.0000	1.6293	1.2200	0.0000	0.0000	0.0000
1838	7.2000	5.8300	5.4500	0	0	0.0000	1.7500	1.2200	0.0000	0.0000	0.0000
1839	6.7900	5.4700	5.1473	8	0	0.0000	1.6427	1.2200	0.0000	0.0000	0.0000
1840	4.1700	2.8000	2.5518	7	28	0.0000	1.6182	1.2200	0.0000	0.0000	0.0000
1841	4.7800	3.4100	3.1295	8	0	0.0000	1.6505	1.2200	0.0000	0.0000	0.0000
1844	6.1500	5.0750	4.5664	7	33	0.0000	1.5836	1.2200	0.0000	0.0000	0.0000
1846	5.6100	4.7600	4.1334	8	0	0.0000	1.4766	1.2200	0.0000	0.0000	0.0000
1847	5.4400	4.5900	4.0943	8	0	0.0000	1.3457	1.2200	0.0000	0.0000	0.0000
1850	1.7500	0.4000	1.4057	8	0	1.0057	0.3443	1.2200	0.0000	0.0000	0.0000
1852	5.3300	4.5500	3.9806	11	3	0.0000	1.3494	1.2200	0.0000	0.0000	0.0000
1853	5.3100	4.4600	3.7266	11	3	0.0000	1.5834	1.2200	0.0000	0.0000	0.0000
1854	3.9800	3.1300	2.5619	11	3	0.0000	1.4181	1.2200	0.0000	0.0000	0.0000
1855	5.4000	4.2600	4.1054	11	4	0.0000	1.2946	1.2200	0.0000	0.0000	0.0000
1856	5.5900	5.1000	4.1818	11	4	0.0000	1.4082	1.2200	0.0000	0.0000	0.0000
1857	6.0300	4.8650	4.5105	8	0	0.0000	1.5195	1.2200	0.0000	0.0000	0.0000
1858	5.4900	4.9750	4.5543	8	0	0.0000	0.9357	1.2200	0.0000	0.0000	0.0000
1859	6.9200	6.2950	6.0211	8	0	0.0000	0.8989	1.2200	0.0000	0.0000	0.0000
1860	7.3600	6.8000	5.7563	11	4	0.0000	1.6037	1.2200	0.0000	0.0000	0.0000
1861	7.6300	6.7800	6.0771	11	3	0.0000	1.5529	1.2200	0.0000	0.0000	0.0000
1862	6.3700	5.8200	4.8867	11	2	0.0000	1.4833	1.2200	0.0000	0.0000	0.0000
1864	7.1300	6.5800	5.6388	11	2	0.0000	1.4912	1.2200	0.0000	0.0000	0.0000
1865	8.2800	7.4300	6.6562	11	1	0.0000	1.6238	1.2200	0.0000	0.0000	0.0000
1866	8.7500	7.9000	7.1422	11	1	0.0000	1.6078	1.2200	0.0000	0.0000	0.0000
1867	9.2200	7.8450	7.5346	7	25	0.0000	1.6854	1.2200	0.0000	0.0000	0.0000
1868	9.6700	8.3200	7.9879	7	17	0.0000	1.6821	1.2200	0.0000	0.0000	0.0000
1869	9.4000	8.5500	7.7614	11	1	0.0000	1.6386	1.2200	0.0000	0.0000	0.0000
1870	9.4000	8.8500	7.8737	11	2	0.0000	1.5263	1.2200	0.0000	0.0000	0.0000
1871	10.3400	9.8400	8.8278	11	0	0.0000	1.5122	1.2200	0.0000	0.0000	0.0000
1872	10.8900	10.1750	9.6344	11	0	0.0000	1.2556	1.2200	0.0000	0.0000	0.0000
1873	52.1500	50.9550	50.6859	8	0	0.0000	1.4641	1.2200	0.0000	0.0000	0.0000
1874	52.4600	51.2400	50.9962	8	0	0.0000	1.4638	1.2200	0.0000	0.0000	0.0000
1878	58.5900	57.4300	56.9654	8	0	0.0000	1.6246	1.2200	0.0000	0.0000	0.0000
1879	55.3200	54.0700	53.7494	8	0	0.0000	1.5706	1.2200	0.0000	0.0000	0.0000
1880	55.6700	55.6700	54.1448	8	0	0.0000	1.5252	1.2200	0.0000	0.0000	0.0000
1881	61.9200	60.6200	60.2892	8	0	0.0000	1.6308	1.2200	0.0000	0.0000	0.0000
1883	62.4900	61.1250	60.9203	8	1	0.0000	1.5697	1.2200	0.0000	0.0000	0.0000
1884	62.9000	61.5250	61.3409	8	0	0.0000	1.5591	1.2200	0.0000	0.0000	0.0000
6001	5.8500	4.7100	4.2486	8	0	0.0000	1.6014	1.2200	0.0000	0.0000	0.0000
6002	5.4000	4.5900	4.0762	11	3	0.0000	1.3238	1.2200	0.0000	0.0000	0.0000
6003	55.7500	55.7500	54.2198	8	0	0.0000	1.5302	1.2200	0.0000	0.0000	0.0000
6004	51.2500	51.2500	49.6396	8	1	0.0000	1.6104	1.2200	0.0000	0.0000	0.0000
6005	11.7500	11.5000	9.2514	7	56	0.0000	2.4986	1.2200	0.0000	0.0000	0.0000

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6006	11.5000	11.5000	9.4556	8	3	0.0000	2.0444	1.2200	0.0000	0.0000	0.0000
6008	5.2500	3.8000	3.5679	8	0	0.0000	1.6821	1.2200	0.0000	0.0000	0.0000
6014	50.0000	50.0000	48.5592	8	0	0.0000	1.4408	1.2200	0.0000	0.0000	0.0000
6017	6.5500	6.2000	5.1163	11	1	0.0000	1.4337	1.2200	0.0000	0.0000	0.0000
6019	51.0000	48.7500	47.2872	8	2	0.0000	3.7128	1.2200	0.0000	0.0000	0.0000
6020	48.4500	47.5500	46.9453	8	1	0.0000	1.5047	1.2200	0.0000	0.0000	0.0000
6021	47.3000	47.3000	46.1456	8	1	0.0000	1.1544	1.2200	0.0000	0.0000	0.0000
6022	47.5000	46.9800	45.5831	8	3	0.0000	1.9169	1.2200	0.0000	0.0000	0.0000
6023	8.7500	7.3750	7.1152	8	0	0.0000	1.6348	1.2200	0.0000	0.0000	0.0000
6027	11.2000	10.6500	9.6631	11	10	0.0000	1.5369	1.2200	0.0000	0.0000	0.0000
6031	5.5000	4.9100	4.0956	11	4	0.0000	1.4044	1.2200	0.0000	0.0000	0.0000
6032	4.1000	4.1000	2.3594	11	4	0.0000	1.7406	1.2200	0.0000	0.0000	0.0000
6034	2.9500	1.7920	1.4102	37	25	0.0000	1.5398	1.2200	0.0000	0.0000	0.0000
6035	1.7500	0.8000	1.4950	40	30	0.6950	0.2550	1.2200	0.0000	0.0000	0.0000
6038	5.6500	4.9400	4.1222	11	4	0.0000	1.5278	1.2200	0.0000	0.0000	0.0000
6039	5.3500	5.2000	3.6923	11	4	0.0000	1.6577	1.2200	0.0000	0.0000	0.0000
CR7	3.9000	3.9000	2.0671	11	4	0.0000	1.8329	1.2200	0.0000	0.0000	0.0000
6041	6.0000	4.7500	4.0617	11	4	0.0000	1.9383	1.2200	0.0000	0.0000	0.0000
6042	7.0000	5.3100	4.1232	11	21	0.0000	2.8768	1.2200	0.0000	0.0000	0.0000
6043	7.0000	5.2000	3.9052	11	21	0.0000	3.0948	1.2200	0.0000	0.0000	0.0000
6044	48.0000	47.5000	46.1982	8	1	0.0000	1.8018	1.2200	0.0000	0.0000	0.0000
6045	51.0000	51.0000	49.5917	8	0	0.0000	1.4083	1.2200	0.0000	0.0000	0.0000
6046	55.8000	55.7940	54.2336	8	0	0.0000	1.5664	1.2200	0.0000	0.0000	0.0000
6048	3.7500	3.0000	2.2253	11	2	0.0000	1.5247	1.2200	0.0000	0.0000	0.0000
CR1	2.3000	1.1600	1.4000	0	0	0.2400	0.9000	1.2200	0.0000	0.0000	0.0000
CR2	1.8400	0.7100	1.4000	0	0	0.6900	0.4400	1.2200	0.0000	0.0000	0.0000
CR3	1.7500	0.5000	1.4000	0	0	0.9000	0.3500	1.2200	0.0000	0.0000	0.0000
CR4	1.7500	0.7400	1.4000	0	0	0.6600	0.3500	1.2200	0.0000	0.0000	0.0000
CR5	1.7500	0.4900	1.4000	0	0	0.9100	0.3500	1.2200	0.0000	0.0000	0.0000
CR6	1.8500	0.3000	1.4000	0	0	1.1000	0.4500	1.2200	0.0000	0.0000	0.0000
CR8	4.7500	3.3000	3.0620	8	0	0.0000	1.6880	1.2200	0.0000	0.0000	0.0000
CR9	1.7500	1.5000	1.4000	0	0	0.0000	0.3500	1.2200	0.0000	0.0000	0.0000
CR10	2.0000	1.2000	1.4000	0	0	0.2000	0.6000	1.2200	0.0000	0.0000	0.0000
Node274	47.5000	47.5000	46.0423	8	0	0.0000	1.4577	1.2200	0.0000	0.0000	0.0000
Node275	51.0000	51.0000	49.5934	8	0	0.0000	1.4066	1.2200	0.0000	0.0000	0.0000
Node279	47.0000	43.8000	42.3336	11	4	0.0000	4.6664	1.2200	0.0000	0.0000	0.0000
Node280	45.0000	41.8000	40.1292	11	5	0.0000	4.8708	1.2200	0.0000	0.0000	0.0000
Node282	66.0000	65.0000	64.2012	11	1	0.0000	1.7988	1.2200	0.0000	0.0000	0.0000
Node284	60.0000	59.0000	58.0813	8	0	0.0000	1.9187	1.2200	0.0000	0.0000	0.0000
Node285	37.0000	36.0000	35.1246	11	2	0.0000	1.8754	1.2200	0.0000	0.0000	0.0000
Node286	25.0000	24.0000	23.0798	11	0	0.0000	1.9202	1.2200	0.0000	0.0000	0.0000
Node289	34.0000	30.0000	29.1350	11	1	0.0000	4.8650	1.2200	0.0000	0.0000	0.0000
Diversion	34.0000	30.0000	29.5261	11	6	0.0000	4.4739	1.2200	0.0000	0.0000	0.0000
Node292	34.0000	30.0000	29.0914	11	7	0.0000	4.9086	1.2200	0.0000	0.0000	0.0000

```
*=====================================================*
|        Table E10 - CONDUIT SUMMARY STATISTICS       |
| Note: The peak flow may be less than the design flow |
| and the conduit may still surcharge because of the   |
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| downstream boundary conditions.                        |
|                                                        |
| * denotes an open conduit that has been overtopped     |
|   this is a potential source of severe errors          |
*========================================================*
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Conduit Name	Design Flow (cms)	Conduit Design Velocity (m/s)	Maximum Vertical Depth (mm)	Maximum Computed Flow (cms)	Time of Occurence Hr.	Time of Occurence Min.	Maximum Computed Velocity (m/s)	Time of Occurence Hr.	Time of Occurence Min.	Ratio of Max. to Design Flow	Maximum Water Elev at Pipe Ends Upstream (m)	Maximum Water Elev at Pipe Ends Dwnstrm (m)	Ratio d/D US	Ratio d/D DS	
1686	0.2464	1.1382	525.0000	0.0122	8	0	0.0756	8	1	0.0495	1.4027	1.4018	0.672	1.070	
1687	0.4054	1.3870	610.0000	0.0270	8	0	0.0955	8	0	0.0666	1.4018	1.4000	0.921	1.393	
1691	0.1486	0.9342	450.0000	0.0393	8	1	0.2571	8	1	0.2645	1.4817	1.4572	0.915	1.527	
1692	0.3450	1.1806	610.0000	0.0394	8	0	0.1321	8	0	0.1143	1.4572	1.4671	1.225	1.520	
1693	0.2095	0.7170	610.0000	0.0582	8	0	0.1987	8	0	0.2780	1.4681	1.4713	1.522	1.625	
1694	0.2795	0.9562	610.0000	0.0725	8	0	0.2472	8	0	0.2595	1.4647	1.4643	1.614	1.745	
1695	0.3123	1.0688	610.0000	0.0930	8	0	0.3169	8	0	0.2979	1.4601	1.4000	1.738	2.131	
1696	0.8164	2.2154	685.0000	0.3571	8	2	1.5265	9	34	0.4374	2.4597	2.2327	0.730	1.186	
1697	0.8937	1.9700	760.0000	0.4079	8	2	0.9360	11	15	0.4565	2.2327	2.0209	1.161	1.817	
1698	0.5402	1.1909	760.0000	0.4609	8	1	1.0097	8	1	0.8531	2.0209	1.6977	1.962	1.971	
1699	0.5536	0.8419	915.0000	0.4887	8	1	0.7402	8	1	0.8828	1.6977	1.5637	1.637	1.611	
1700	0.6932	1.2216	850.0000	0.4996	8	0	0.8763	8	0	0.7207	1.5637	1.4000	1.734	1.776	
1701	0.3380	1.1955	600.0000	0.0182	8	0	0.0642	8	0	0.0539	1.4313	1.4313	1.552	1.969	
1702	0.4103	1.4512	600.0000	0.0182	8	0	0.0643	8	0	0.0444	1.4093	1.4316	1.015	1.553	
1704	0.8005	2.7391	610.0000	0.2948	8	0	2.2178	8	1	0.3683	9.0833	7.6038	0.465	0.465	
1705	0.8300	2.8402	610.0000	0.3048	8	0	2.3102	8	1	0.3672	7.6038	5.8644	0.465	0.433	
1707	0.0670	0.2030	300.0000	0.0159	8	0	0.0481	8	0	0.2370	1.4057	1.4000	4.352	4.667	*
1709	0.0654	0.5765	380.0000	0.0242	8	0	0.5161	8	0	0.3698	7.3298	7.2003	0.447	0.290	
1710	0.2135	1.6991	400.0000	0.0300	8	0	1.0689	8	1	0.1403	7.1708	6.6310	0.277	0.252	
1711	0.1169	1.0583	375.0000	0.0173	8	0	0.6170	8	0	0.1481	7.1152	7.0232	0.307	0.249	
1712	0.9275	2.5919	675.0000	0.0473	8	0	1.2810	8	1	0.0509	6.6163	5.7507	0.157	0.179	
1713	0.8521	2.3813	675.0000	0.0596	8	0	1.2949	8	0	0.0700	5.7507	4.5664	0.179	0.247	
1715	0.5474	1.5296	675.0000	0.0716	7	54	0.9554	7	23	0.1308	4.5664	4.1334	0.247	0.405	
1716	1.0277	1.6155	900.0000	0.0980	8	0	0.5988	6	16	0.0954	4.1334	4.0943	0.304	0.449	
1718	0.0532	0.0000	900.0000	0.1157	8	0	0.4345	7	20	2.1757	4.0943	4.0762	0.449	0.429	
1719	0.2736	0.4301	900.0000	0.1791	11	3	0.7038	11	3	0.6545	3.9806	3.7266	0.445	0.185	
1720	2.4503	3.8516	900.0000	0.1832	11	3	1.9385	11	3	0.0748	3.7266	2.5619	0.185	0.369	
1726	0.1802	1.5885	380.0000	0.0260	8	0	1.0589	8	0	0.1444	3.1295	2.5518	0.262	0.347	
1727	0.1796	1.5837	380.0000	0.0410	7	29	1.1862	7	29	0.2280	2.5518	2.0209	0.347	0.529	
1736	0.0654	0.5770	380.0000	0.0000	0	0	0.0000	0	0	0.0000	5.4500	5.1473	.0000	.0000	
1737	0.1627	1.4345	380.0000	0.0262	8	0	1.0022	8	0	0.1610	5.1473	4.1529	0.282	0.271	
1738	0.3873	1.3252	610.0000	0.0262	8	0	0.7110	8	0	0.0676	4.0321	3.7201	0.184	0.180	
1739	0.3666	1.2545	610.0000	0.0507	8	0	0.7796	7	29	0.1382	3.7201	3.4009	0.279	0.231	
1742	2.1628	7.4004	610.0000	0.0507	8	0	1.7255	1	11	0.0234	3.2242	2.2327	0.105	1.332	
1746	0.8722	2.9846	610.0000	0.3047	8	1	2.4761	8	1	0.3493	5.8644	3.7519	0.433	0.478	
1747	0.8719	2.9833	610.0000	0.3428	8	0	2.3736	8	8	0.3932	3.7519	2.4597	0.478	0.655	
1767	0.1406	1.2727	375.0000	0.0604	8	0	1.0833	8	1	0.4296	61.3409	60.9217	0.509	0.458	
1768	0.1624	1.4700	375.0000	0.0603	8	1	1.1668	8	2	0.3712	60.9203	60.3481	0.481	0.422	

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1770	0.6130	3.8545	450.0000	0.0819	8	0	2.4513	8	1	0.1337	60.2892	57.0910	0.265	0.247
1772	0.5600	3.5211	450.0000	0.0949	8	0	2.4663	8	0	0.1695	56.9654	53.7494	0.279	0.399
1773	0.2491	1.5662	450.0000	0.0843	8	0	1.0892	8	1	0.3384	54.1448	53.8004	0.500	0.401
1774	0.5293	3.3281	450.0000	0.1877	8	0	2.7478	8	1	0.3546	53.7494	50.9962	0.443	0.458
1775	0.9108	4.2072	525.0000	0.2078	8	0	1.8079	0	29	0.2282	50.9962	50.6859	0.545	0.487
1776	0.6406	2.9593	525.0000	0.2078	8	1	1.8382	8	1	0.3244	50.6859	49.6396	0.545	0.266
1779	5.1185	4.5257	1200.000	0.3183	11	1	2.1592	0	29	0.0622	8.8278	7.8737	0.198	0.186
1780	0.4226	1.1808	675.0000	0.0292	11	0	0.5946	11	0	0.0690	9.6344	9.2431	0.199	0.153
1781	0.0532	0.0000	900.0000	0.0573	11	9	0.4964	11	10	1.0788	7.8737	7.7614	0.249	0.124
1782	0.2437	1.9394	400.0000	0.0124	8	0	1.0891	0	29	0.0508	7.9879	7.7614	0.170	0.279
1783	2.1702	3.4113	900.0000	0.0640	11	1	1.3519	11	1	0.0295	7.7614	7.1422	0.124	0.158
1784	0.2561	2.3184	375.0000	0.0163	8	0	2.4835	0	29	0.0637	7.5346	7.1422	0.172	0.379
1785	1.6548	2.6012	900.0000	0.0731	11	1	1.1491	11	1	0.0442	7.1422	6.6562	0.158	0.140
1786	1.7708	2.7835	900.0000	0.0730	11	1	1.2282	11	2	0.0412	6.6562	6.0771	0.140	0.219
1787	0.9183	1.4434	900.0000	0.0774	11	3	0.7714	11	3	0.0843	6.0771	5.7666	0.219	0.174
1789	2.9635	3.4224	1050.000	0.2609	11	2	1.9477	11	2	0.0880	7.8737	5.7406	0.213	0.201
1790	2.9712	2.6271	1200.000	0.2662	11	2	1.4755	11	3	0.0896	5.6388	4.8867	0.216	0.222
1791	2.9846	2.6390	1200.000	0.2795	11	3	1.4792	11	3	0.0937	4.8867	4.1818	0.222	0.235
1792	2.2539	1.0435	1200.000	0.3819	11	4	0.5430	11	5	0.1694	4.1818	4.1222	0.326	0.318
1793	0.1885	0.6452	610.0000	-0.1058	11	13	-0.4651	11	17	-0.5612	4.0762	4.1054	0.633	0.747
1795	0.3023	1.3962	525.0000	-0.0499	8	0	-0.2479	8	0	-0.1651	4.5543	4.5105	0.408	1.201
1796	0.1540	1.3945	375.0000	0.0233	8	0	0.9715	8	0	0.1510	6.0211	4.6982	0.270	0.262
5005	0.0533	0.7547	300.0000	-0.0127	40	29	-0.1761	40	29	-0.2372	1.4950	1.4000	3.317	4.000
5006	0.4732	1.6735	600.0000	0.0283	8	0	0.0993	8	0	0.0597	1.4313	1.4000	1.969	2.517
5009	0.4033	1.4264	600.0000	-0.0071	39	26	0.0358	43	30	-0.0176	1.4102	1.4093	0.364	1.016
5010	0.3744	2.3541	450.0000	0.0450	8	0	1.0831	7	38	0.1203	9.2514	9.0833	0.270	0.630
5011	0.8108	2.8676	600.0000	0.2439	8	3	1.7011	8	4	0.3009	9.4556	9.0833	0.509	0.472
5014	0.7426	5.9092	400.0000	0.0353	8	0	4.8371	0	29	0.0475	48.5592	46.1982	0.148	0.495
5015	1.3973	3.1628	750.0000	0.2075	8	2	1.3901	8	2	0.1485	47.2872	46.9949	0.383	0.260
5016	1.8870	4.2712	750.0000	0.2424	8	2	1.3304	8	6	0.1285	46.1456	45.5831	0.461	0.138
5018	9.2425	1.3204	1750.000	0.0802	8	0	0.3871	8	0	0.0087	54.2198	54.1448	0.126	0.128
5021	5.6825	5.0245	1200.000	0.2735	11	9	2.0442	11	1	0.0481	9.6631	8.8278	0.178	0.157
5022	1.2277	1.0231	1200.000	0.0799	11	4	0.5249	11	4	0.0651	5.7563	5.1163	0.130	0.097
5023	2.0806	1.7338	1200.000	0.0994	11	1	0.7627	8	0	0.0478	5.1163	4.1818	0.097	0.235
5024	0.0188	0.0000	610.0000	-0.1034	11	14	-0.4314	11	17	-5.4899	4.1054	4.1222	0.747	0.774
5026	0.7246	1.1390	900.0000	0.1623	11	4	0.7875	11	4	0.2239	4.0956	3.6923	0.384	0.103
5027	16.1398	5.6041	1600.000	0.3159	11	4	1.4746	11	4	0.0196	3.6923	2.3594	0.058	0.225
5029	1.2065	1.8965	900.0000	0.1859	11	3	0.9053	11	3	0.1541	2.5619	2.4383	0.369	0.265
5030	0.2291	1.0581	525.0000	0.0600	8	0	0.7625	8	1	0.2618	4.5105	4.3005	0.401	0.306
5031	0.5690	2.0124	600.0000	0.0600	8	0	1.0482	7	30	0.1054	4.2486	4.0617	0.231	0.519
5032	0.0669	0.9468	300.0000	0.0069	8	0	0.5815	8	0	0.1032	3.5679	3.0620	0.226	0.207
5033	5.8344	2.1609	1500.000	0.5858	11	21	1.0763	11	21	0.1004	4.1232	3.9052	0.209	0.137
5034	0.4674	0.7347	900.0000	0.1724	11	3	0.6736	11	3	0.3690	4.0762	3.9806	0.429	0.367
5035	1.9190	4.3438	750.0000	0.2076	8	2	1.7264	8	3	0.1082	46.9453	46.4660	0.327	0.221
Link232	2.1224	0.9826	1200.000	0.2794	11	5	0.4059	11	5	0.1316	4.1222	4.0956	0.318	0.321
Link233	0.0704	0.0000	1000.000	0.1174	11	7	0.4961	11	13	1.6672	4.0956	4.0617	0.346	0.312
5025	0.9887	1.2589	1000.000	0.1505	11	4	0.7848	11	5	0.1523	4.0617	3.6923	0.312	0.092
Link236	1.0533	2.7370	700.0000	0.2085	11	2	1.5455	11	2	0.1979	2.2253	1.4000	0.322	1.286
Link237	42.5308	6.3009	1500.000	0.0450	8	0	0.7605	0	28	0.0011	46.0423	10.0268	0.028	0.018

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Link238	37.0144	4.7002	1750.000	0.2077	8	1	1.3061	0	29	0.0056	49.6396	47.2872	0.080	0.164
Link239	4.6551	1.2414	1500.000	0.0237	8	0	0.2592	0	28	0.0051	49.5917	48.5592	0.061	0.039
5028	14.4354	4.1677	2100.000	0.5061	11	4	1.3260	11	5	0.0351	2.3594	2.0671	0.171	0.127
Link242	9.1913	1.3130	1750.000	0.0365	8	0	0.2302	6	26	0.0040	54.2336	54.2198	0.108	0.126
Link243	42.2225	6.2552	1500.000	0.2439	8	3	2.0733	0	28	0.0058	45.5831	10.0982	0.069	0.065
Link244	18.6199	2.7585	1500.000	0.2424	8	1	1.0820	0	29	0.0130	46.1982	46.1456	0.132	0.230
Link245	8.7089	2.3224	1500.000	0.0413	8	0	0.9072	0	28	0.0047	49.5934	46.0423	0.062	0.028
Link252	18.7252	5.3500	1000.000	0.2741	11	7	1.2175	11	6	0.0146	29.0914	9.6631	0.091	0.213
Link253	11.0937	4.3596	1800.000	0.5209	11	4	1.7282	11	4	0.0470	42.3336	40.1292	0.185	0.072
Link257	8.3039	2.3725	1000.000	0.4616	11	1	0.9753	0	29	0.0556	64.2012	42.3336	0.201	0.334
Link258	19.8639	5.6754	1000.000	0.5209	11	5	5.3043	0	36	0.0262	40.1292	29.5261	0.129	0.526
Link259	10.8958	3.1131	1000.000	0.3074	11	1	1.5126	0	37	0.0282	29.1350	4.1232	0.135	0.313
Link260	9.7933	2.1763	1000.000	0.6117	11	21	0.6102	11	21	0.0625	3.9052	1.4000	0.205	0.900
Link261	14.1354	3.1412	1000.000	0.1865	8	0	0.9032	0	28	0.0132	58.0813	35.1246	0.081	0.125
Link262	10.9475	2.4328	1000.000	0.2954	11	2	0.6355	11	1	0.0270	35.1246	4.1232	0.125	0.313
Link263	10.3736	2.9639	1000.000	0.1210	11	0	2.1221	0	29	0.0117	23.0798	2.2253	0.080	0.225
Low Flow.1	0.2620	0.1467	300.0000	0.2464	11	6	1.4422	11	7	0.9407	29.5261	29.1350	1.754	0.460
High Flow.1	Undefnd	Undefnd	Undefn	0.2742	11	6								
FREE # 1	Undefnd	Undefnd	Undefn	0.5061	11	4								
FREE # 2	Undefnd	Undefnd	Undefn	0.0270	8	0								
FREE # 3	Undefnd	Undefnd	Undefn	0.0930	8	0								
FREE # 4	Undefnd	Undefnd	Undefn	-0.0127	40	29								
FREE # 5	Undefnd	Undefnd	Undefn	0.4996	8	0								
FREE # 6	Undefnd	Undefnd	Undefn	0.0283	8	0								
FREE # 7	Undefnd	Undefnd	Undefn	0.0159	8	0								
FREE # 8	Undefnd	Undefnd	Undefn	0.0069	8	0								
FREE # 9	Undefnd	Undefnd	Undefn	0.6117	11	21								
FREE #10	Undefnd	Undefnd	Undefn	0.2085	11	2								

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XP-SWMM Output
Future Conditions (with LID in selected areas), 5 year 24 hour storm
Tables E4, E9 and E10

```
*==================================================*
|          Table E4 - Conduit Connectivity         |
*==================================================*
```

Input Number	Conduit Name	Upstream Node	Downstream Node	Upstream Elevation	Downstream Elevation	
1	1686	1808	1809	1.0500	0.8400	No Design
2	1687	1809	CR1	0.8400	0.5500	No Design
3	1691	1802	1803	1.0700	0.7700	No Design
4	1692	1803	1804	0.7100	0.5400	No Design
5	1693	1804	1805	0.5400	0.4800	No Design
6	1694	1805	1806	0.4800	0.4000	No Design
7	1695	1806	CR2	0.4000	0.1000	No Design
8	1696	1824	1818	1.9600	1.4200	No Design
9	1697	1818	1815	1.3500	0.6400	No Design
10	1698	1815	1814	0.5300	0.2000	No Design
11	1699	1814	1811	0.2000	0.0900	No Design
12	1700	1811	CR4	0.0900	-0.1100	No Design
13	1701	1812	1810	0.5000	0.2500	No Design
14	1702	1813	1812	0.8000	0.5000	No Design
15	1704	1832	1831	8.8000	7.3200	No Design
16	1705	1831	1822	7.3200	5.6000	No Design
17	1707	1850	CR6	0.1000	0.0000	No Design
18	1709	1833	1834	7.1600	7.0900	No Design
19	1710	1834	1836	7.0600	6.5300	No Design
20	1711	6023	1836	7.0000	6.9300	No Design
21	1712	1836	1837	6.5100	5.6300	No Design
22	1713	1837	1844	5.6300	4.4000	No Design
23	1715	1844	1846	4.4000	3.8600	No Design
24	1716	1846	1847	3.8600	3.6900	No Design
25	1718	1847	6002	3.6900	3.6900	No Design
26	1719	1852	1853	3.5800	3.5600	No Design
27	1720	1853	1854	3.5600	2.2300	No Design
28	1726	1841	1840	3.0300	2.4200	No Design
29	1727	1840	1815	2.4200	1.8200	No Design
30	1736	1838	1839	5.4500	5.0900	No Design
31	1737	1839	1821	5.0400	4.0500	No Design
32	1738	1821	1820	3.9200	3.6100	No Design

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33	1739	1820	1819	3.5500	3.2600	No Design
34	1742	1819	1818	3.1600	1.4200	No Design
35	1746	1822	1823	5.6000	3.4600	No Design
36	1747	1823	1824	3.4600	2.0600	No Design
37	1767	1884	1883	61.1500	60.7500	No Design
38	1768	1883	1881	60.7400	60.1900	No Design
39	1770	1881	1878	60.1700	56.9800	No Design
40	1772	1878	1879	56.8400	53.5700	No Design
41	1773	1880	1879	53.9200	53.6200	No Design
42	1774	1879	1874	53.5500	50.7900	No Design
43	1775	1874	1873	50.7100	50.4300	No Design
44	1776	1873	6004	50.4000	49.5000	No Design
45	1779	1871	1870	8.5900	7.6500	No Design
46	1780	1872	1871	9.5000	9.1400	No Design
47	1781	1870	1869	7.6500	7.6500	No Design
48	1782	1868	1869	7.9200	7.6500	No Design
49	1783	1869	1866	7.6500	7.0000	No Design
50	1784	1867	1866	7.4700	7.0000	No Design
51	1785	1866	1865	7.0000	6.5300	No Design
52	1786	1865	1861	6.5300	5.8800	No Design
53	1787	1861	1860	5.8800	5.6100	No Design
54	1789	1870	1864	7.6500	5.5300	No Design
55	1790	1864	1862	5.3800	4.6200	No Design
56	1791	1862	1856	4.6200	3.9000	No Design
57	1792	1856	6038	3.7900	3.7400	No Design
58	1793	6002	1855	3.6900	3.6500	No Design
59	1795	1857	1858	4.3400	3.8800	No Design
60	1796	1859	1858	5.9200	4.6000	No Design
61	5005	6035	CR3	0.5000	0.2000	No Design
62	5006	1810	CR5	0.2500	-0.1100	No Design
63	5009	6034	1813	1.1920	0.8000	No Design
64	5010	6005	1832	9.1300	8.8000	No Design
65	5011	6006	1832	9.1500	8.8000	No Design
66	5014	6014	6044	48.5000	46.0000	No Design
67	5015	6019	6020	47.0000	46.8000	No Design
68	5016	6021	6022	45.8000	45.4800	No Design
69	5018	6003	1880	54.0000	53.9200	No Design
70	5021	6027	1871	9.4500	8.6400	No Design
71	5022	1860	6017	5.6000	5.0000	No Design
72	5023	6017	1856	5.0000	3.9000	No Design
73	5024	1855	6038	3.6500	3.6500	No Design
74	5026	6031	6039	3.7500	3.6000	No Design
75	5027	6039	6032	3.6000	2.0000	No Design
76	5029	1854	6032	2.2300	2.2000	No Design
77	5030	1857	6001	4.3000	4.1400	No Design
78	5031	6001	6041	4.1100	3.7500	No Design
79	5032	6008	CR8	3.5000	3.0000	No Design
80	5033	6042	6043	3.8100	3.7000	No Design
81	5034	6002	1852	3.6900	3.6500	No Design

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XP-SWMM Modeling Results

82	5035	6020	6044	46.7000	46.3000	No Design
83	Link232	6038	6031	3.7400	3.7100	No Design
84	Link233	6031	6041	3.7500	3.7500	No Design
85	5025	6041	6039	3.7500	3.6000	No Design
86	Link236	6048	CR10	2.0000	0.5000	No Design
87	Link237	Node274	6005	46.0000	10.0000	No Design
88	Link238	6004	6019	49.5000	47.0000	No Design
89	Link239	6045	6014	49.5000	48.5000	No Design
90	5028	6032	CR7	2.0000	1.8000	No Design
91	Link242	6046	6003	54.0440	54.0000	No Design
92	Link243	6022	6006	45.4800	10.0000	No Design
93	Link244	6044	6021	46.0000	45.8000	No Design
94	Link245	Node275	Node274	49.5000	46.0000	No Design
95	Link252	Node292	6027	29.0000	9.4500	No Design
96	Link253	Node279	Node280	42.0000	40.0000	No Design
97	Link257	Node282	Node279	64.0000	42.0000	No Design
98	Link258	Node280	Diversion	40.0000	29.0000	No Design
99	Link259	Node289	6042	29.0000	3.8100	No Design
100	Link260	6043	CR9	3.7000	0.5000	No Design
101	Link261	Node284	Node285	58.0000	35.0000	No Design
102	Link262	Node285	6042	35.0000	3.8100	No Design
103	Link263	Node286	6048	23.0000	2.0000	No Design

```
*=========================================*
|             Orifice Data                |
*=========================================*
```

Orifice Name	From Junction	To Junction	Type	Area (m2)	Depth (m)	Discharge Coefficient	Height Above Junction (m)
Low Flow.1	Diversion	Node289	Rect Side	0.18	0.30	0.600	0.000

```
====> EQUIVALENT PIPE INFORMATION FOR ORIFICE            1
      CONDUIT NAME...........................       Low Flow.1
      Upstream node..........................        Diversion
      Downstream node........................          Node289
      PIPE DIAMETER.......................                0.30
      PIPE LENGTH.........................              300.00
      MANNINGS ROUGHNESS..................              0.0047
      INVERT ELEVATION AT UPSTREAM END.....            29.0000
      INVERT ELEVATION AT DOWNSTREAM END...            28.9970
```

Note: For a Bottom-outlet orifice the invert elevation of the downstream node will be adjusted to accomodate the equivalent conduit. Conduit grades are not affected.

```
*==========================================*
|                 Weir Data                |
```

Campbell River / Quinsam River ISMP
XP-SWMM Modeling Results

```
*===========================================*

            Weir            From              To          Crest      Weir      Weir   Discharge        Weir
            Name        Junction        Junction  Type  Height(ft)   Top (m)  Length (m) Coefficient       Power
---------------- --------------- ---------------  ----  ----------   -------  ---------- ----------- -----------
     High Flow.1       Diversion         Node292     1        0.30      5.00        1.50      1.7000      1.5000


*================================================*
|          FREE OUTFALL DATA (DATA GROUP I1)     |
|         BOUNDARY CONDITION ON DATA GROUP J1    |
*================================================*

Outfall at Junction....CR7              has boundary condition number...        1
Outfall at Junction....CR1              has boundary condition number...        2
Outfall at Junction....CR2              has boundary condition number...        3
Outfall at Junction....CR3              has boundary condition number...        4
Outfall at Junction....CR4              has boundary condition number...        5
Outfall at Junction....CR5              has boundary condition number...        6
Outfall at Junction....CR6              has boundary condition number...        7
Outfall at Junction....CR8              has boundary condition number...        8
Outfall at Junction....CR9              has boundary condition number...        9
Outfall at Junction....CR10             has boundary condition number...       10


*=============================================*
|               Weir Outfall Data             |
|      Boundary Condition on data group J1    |
*=============================================*



*================================================*
|        INTERNAL CONNECTIVITY INFORMATION       |
*================================================*

         CONDUIT         JUNCTION         JUNCTION
---------------- ---------------- ----------------
      Low Flow.1        Diversion          Node289
     High Flow.1        Diversion          Node292
        FREE # 1              CR7         BOUNDARY
        FREE # 2              CR1         BOUNDARY
        FREE # 3              CR2         BOUNDARY
        FREE # 4              CR3         BOUNDARY
        FREE # 5              CR4         BOUNDARY
        FREE # 6              CR5         BOUNDARY
        FREE # 7              CR6         BOUNDARY
        FREE # 8              CR8         BOUNDARY
        FREE # 9              CR9         BOUNDARY
```

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```
       FREE #10            CR10         BOUNDARY

 *=====================================================*
 |        Boundary Condition Information               |
 |                 Data Groups J1-J4                   |
 *=====================================================*


BC NUMBER..         1 Control water surface elevation is..     1.400 meters.
BC NUMBER..         2 Control water surface elevation is..     1.400 meters.
BC NUMBER..         3 Control water surface elevation is..     1.400 meters.
BC NUMBER..         4 Control water surface elevation is..     1.400 meters.
BC NUMBER..         5 Control water surface elevation is..     1.400 meters.
BC NUMBER..         6 Control water surface elevation is..     1.400 meters.
BC NUMBER..         7 Control water surface elevation is..     1.400 meters.
BC NUMBER..         8 Control water surface elevation is..     1.400 meters.
BC NUMBER..         9 Control water surface elevation is..     1.400 meters.
BC NUMBER..        10 Control water surface elevation is..     1.400 meters.


 *======================================================*
 |        Table E9 - JUNCTION SUMMARY STATISTICS        |
 | The Maximum area is only the area of the node, it    |
 | does not include the area of the surrounding conduits|
 *======================================================*
```

Junction Name	Ground Elevation meters	Uppermost PipeCrown Elevation meters	Maximum Junction Elevation meters	Time of Occurence Hr.	Min.	Meters of Surcharge at Max Elevation	Freeboard of node meters	Maximum Junction Area m^2	Maximum Gutter Depth meters	Maximum Gutter Width meters	Maximum Gutter Velocity m/s
1802	2.8200	1.5200	1.5147	8	0	0.0000	1.3053	1.2200	0.0000	0.0000	0.0000
1803	2.4600	1.3200	1.4807	37	28	0.1607	0.9793	1.2200	0.0000	0.0000	0.0000
1804	2.2900	1.1500	1.4964	37	28	0.3464	0.7936	1.2200	0.0000	0.0000	0.0000
1805	2.2300	1.0900	1.5478	37	28	0.4578	0.6822	1.2200	0.0000	0.0000	0.0000
1806	2.1500	1.0100	1.4933	37	28	0.4833	0.6567	1.2200	0.0000	0.0000	0.0000
1808	2.8000	1.5750	1.4036	8	0	0.0000	1.3964	1.2200	0.0000	0.0000	0.0000
1809	2.5900	1.4500	1.4025	8	0	0.0000	1.1875	1.2200	0.0000	0.0000	0.0000
1810	1.7500	0.8500	1.4346	33	35	0.5846	0.3154	1.2200	0.0000	0.0000	0.0000
1811	1.8400	1.0050	1.6388	8	0	0.6338	0.2012	1.2200	0.0000	0.0000	0.0000
1812	1.7500	1.1000	1.4516	32	49	0.3516	0.2984	1.2200	0.0000	0.0000	0.0000
1813	1.7500	1.4000	1.4153	35	37	0.0153	0.3347	1.2200	0.0000	0.0000	0.0000
1814	1.9500	1.1150	1.8342	8	0	0.7192	0.1158	1.2200	0.0000	0.0000	0.0000
1815	2.9300	2.2000	2.3048	8	0	0.1048	0.6252	1.2200	0.0000	0.0000	0.0000
1818	3.1000	2.1100	2.6358	7	56	0.5258	0.4642	1.2200	0.0000	0.0000	0.0000
1819	4.9100	3.8700	3.2297	7	51	0.0000	1.6803	1.2200	0.0000	0.0000	0.0000
1820	5.3000	4.2200	3.7385	8	0	0.0000	1.5615	1.2200	0.0000	0.0000	0.0000
1821	5.6700	4.5300	4.0409	7	43	0.0000	1.6291	1.2200	0.0000	0.0000	0.0000
1822	8.3500	6.2100	5.8961	8	1	0.0000	2.4539	1.2200	0.0000	0.0000	0.0000

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1823	5.2100	4.0700	3.8341	8	0	0.0000	1.3759	1.2200	0.0000	0.0000	0.0000
1824	3.7100	2.6700	2.9107	8	0	0.2407	0.7993	1.2200	0.0000	0.0000	0.0000
1831	9.0700	7.9300	7.6432	8	0	0.0000	1.4268	1.2200	0.0000	0.0000	0.0000
1832	10.5500	9.4100	9.1226	8	0	0.0000	1.4274	1.2200	0.0000	0.0000	0.0000
1833	8.9100	7.5400	7.3450	8	0	0.0000	1.5650	1.2200	0.0000	0.0000	0.0000
1834	8.8100	7.4700	7.1812	8	0	0.0000	1.6288	1.2200	0.0000	0.0000	0.0000
1836	8.2600	7.3050	6.6255	8	0	0.0000	1.6345	1.2200	0.0000	0.0000	0.0000
1837	7.3800	6.3050	5.7606	8	0	0.0000	1.6194	1.2200	0.0000	0.0000	0.0000
1838	7.2000	5.8300	5.4500	0	0	0.0000	1.7500	1.2200	0.0000	0.0000	0.0000
1839	6.7900	5.4700	5.1570	8	0	0.0000	1.6330	1.2200	0.0000	0.0000	0.0000
1840	4.1700	2.8000	2.5644	8	0	0.0000	1.6056	1.2200	0.0000	0.0000	0.0000
1841	4.7800	3.4100	3.1382	7	47	0.0000	1.6418	1.2200	0.0000	0.0000	0.0000
1844	6.1500	5.0750	4.5819	7	34	0.0000	1.5681	1.2200	0.0000	0.0000	0.0000
1846	5.6100	4.7600	4.1849	9	5	0.0000	1.4251	1.2200	0.0000	0.0000	0.0000
1847	5.4400	4.5900	4.1687	9	7	0.0000	1.2713	1.2200	0.0000	0.0000	0.0000
1850	1.7500	0.4000	1.4078	8	0	1.0078	0.3422	1.2200	0.0000	0.0000	0.0000
1852	5.3300	4.5500	4.0517	9	9	0.0000	1.2783	1.2200	0.0000	0.0000	0.0000
1853	5.3100	4.4600	3.7613	9	9	0.0000	1.5487	1.2200	0.0000	0.0000	0.0000
1854	3.9800	3.1300	2.6282	9	9	0.0000	1.3518	1.2200	0.0000	0.0000	0.0000
1855	5.4000	4.2600	4.1925	9	16	0.0000	1.2075	1.2200	0.0000	0.0000	0.0000
1856	5.5900	5.1000	4.2910	9	17	0.0000	1.2990	1.2200	0.0000	0.0000	0.0000
1857	6.0300	4.8650	4.5306	8	0	0.0000	1.4994	1.2200	0.0000	0.0000	0.0000
1858	5.4900	4.9750	4.5844	8	0	0.0000	0.9056	1.2200	0.0000	0.0000	0.0000
1859	6.9200	6.2950	6.0301	8	0	0.0000	0.8899	1.2200	0.0000	0.0000	0.0000
1860	7.3600	6.8000	5.8091	9	18	0.0000	1.5509	1.2200	0.0000	0.0000	0.0000
1861	7.6300	6.7800	6.1273	9	15	0.0000	1.5027	1.2200	0.0000	0.0000	0.0000
1862	6.3700	5.8200	4.9497	9	16	0.0000	1.4203	1.2200	0.0000	0.0000	0.0000
1864	7.1300	6.5800	5.7026	9	15	0.0000	1.4274	1.2200	0.0000	0.0000	0.0000
1865	8.2800	7.4300	6.6901	9	15	0.0000	1.5899	1.2200	0.0000	0.0000	0.0000
1866	8.7500	7.9000	7.1789	9	14	0.0000	1.5711	1.2200	0.0000	0.0000	0.0000
1867	9.2200	7.8450	7.5401	7	23	0.0000	1.6799	1.2200	0.0000	0.0000	0.0000
1868	9.6700	8.3200	7.9917	7	18	0.0000	1.6783	1.2200	0.0000	0.0000	0.0000
1869	9.4000	8.5500	7.7928	9	15	0.0000	1.6072	1.2200	0.0000	0.0000	0.0000
1870	9.4000	8.8500	7.9278	9	15	0.0000	1.4722	1.2200	0.0000	0.0000	0.0000
1871	10.3400	9.8400	8.8942	9	13	0.0000	1.4458	1.2200	0.0000	0.0000	0.0000
1872	10.8900	10.1750	9.6605	9	0	0.0000	1.2295	1.2200	0.0000	0.0000	0.0000
1873	52.1500	50.9550	50.7325	8	0	0.0000	1.4175	1.2200	0.0000	0.0000	0.0000
1874	52.4600	51.2400	51.0475	8	0	0.0000	1.4125	1.2200	0.0000	0.0000	0.0000
1878	58.5900	57.4300	56.9827	8	0	0.0000	1.6073	1.2200	0.0000	0.0000	0.0000
1879	55.3200	54.0700	53.7763	8	0	0.0000	1.5437	1.2200	0.0000	0.0000	0.0000
1880	55.6700	55.6700	54.1781	8	0	0.0000	1.4919	1.2200	0.0000	0.0000	0.0000
1881	61.9200	60.6200	60.3064	8	0	0.0000	1.6136	1.2200	0.0000	0.0000	0.0000
1883	62.4900	61.1250	60.9521	8	1	0.0000	1.5379	1.2200	0.0000	0.0000	0.0000
1884	62.9000	61.5250	61.3738	8	0	0.0000	1.5262	1.2200	0.0000	0.0000	0.0000
6001	5.8500	4.7100	4.2630	8	0	0.0000	1.5870	1.2200	0.0000	0.0000	0.0000
6002	5.4000	4.5900	4.1551	9	9	0.0000	1.2449	1.2200	0.0000	0.0000	0.0000
6003	55.7500	55.7500	54.2472	8	0	0.0000	1.5028	1.2200	0.0000	0.0000	0.0000
6004	51.2500	51.2500	49.6577	8	1	0.0000	1.5923	1.2200	0.0000	0.0000	0.0000
6005	11.7500	11.5000	9.2644	8	0	0.0000	2.4856	1.2200	0.0000	0.0000	0.0000

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6006	11.5000	11.5000	9.5072	8	2	0.0000	1.9928	1.2200	0.0000	0.0000	0.0000
6008	5.2500	3.8000	3.5738	8	0	0.0000	1.6762	1.2200	0.0000	0.0000	0.0000
6014	50.0000	50.0000	48.5642	8	0	0.0000	1.4358	1.2200	0.0000	0.0000	0.0000
6017	6.5500	6.2000	5.1522	9	18	0.0000	1.3978	1.2200	0.0000	0.0000	0.0000
6019	51.0000	48.7500	47.3362	8	1	0.0000	3.6638	1.2200	0.0000	0.0000	0.0000
6020	48.4500	47.5500	46.9824	8	1	0.0000	1.4676	1.2200	0.0000	0.0000	0.0000
6021	47.3000	47.3000	46.1975	8	1	0.0000	1.1025	1.2200	0.0000	0.0000	0.0000
6022	47.5000	46.9800	45.5953	8	2	0.0000	1.9047	1.2200	0.0000	0.0000	0.0000
6023	8.7500	7.3750	7.1261	8	0	0.0000	1.6239	1.2200	0.0000	0.0000	0.0000
6027	11.2000	10.6500	9.7158	9	14	0.0000	1.4842	1.2200	0.0000	0.0000	0.0000
6031	5.5000	4.9100	4.1789	9	17	0.0000	1.3211	1.2200	0.0000	0.0000	0.0000
6032	4.1000	4.1000	2.4497	9	16	0.0000	1.6503	1.2200	0.0000	0.0000	0.0000
6034	2.9500	1.7920	1.4133	35	38	0.0000	1.5367	1.2200	0.0000	0.0000	0.0000
6035	1.7500	0.8000	1.4728	37	14	0.6728	0.2772	1.2200	0.0000	0.0000	0.0000
6038	5.6500	4.9400	4.2161	9	17	0.0000	1.4339	1.2200	0.0000	0.0000	0.0000
6039	5.3500	5.2000	3.7198	9	17	0.0000	1.6302	1.2200	0.0000	0.0000	0.0000
CR7	3.9000	3.9000	2.1222	9	16	0.0000	1.7778	1.2200	0.0000	0.0000	0.0000
6041	6.0000	4.7500	4.1364	9	16	0.0000	1.8636	1.2200	0.0000	0.0000	0.0000
6042	7.0000	5.3100	4.1772	10	20	0.0000	2.8228	1.2200	0.0000	0.0000	0.0000
6043	7.0000	5.2000	3.9357	10	21	0.0000	3.0643	1.2200	0.0000	0.0000	0.0000
6044	48.0000	47.5000	46.2372	8	1	0.0000	1.7628	1.2200	0.0000	0.0000	0.0000
6045	51.0000	51.0000	49.6013	8	0	0.0000	1.3987	1.2200	0.0000	0.0000	0.0000
6046	55.8000	55.7940	54.2587	8	0	0.0000	1.5413	1.2200	0.0000	0.0000	0.0000
6048	3.7500	3.0000	2.2702	10	2	0.0000	1.4798	1.2200	0.0000	0.0000	0.0000
CR1	2.3000	1.1600	1.4000	0	0	0.2400	0.9000	1.2200	0.0000	0.0000	0.0000
CR2	1.8400	0.7100	1.4000	0	0	0.6900	0.4400	1.2200	0.0000	0.0000	0.0000
CR3	1.7500	0.5000	1.4000	0	0	0.9000	0.3500	1.2200	0.0000	0.0000	0.0000
CR4	1.7500	0.7400	1.4000	0	0	0.6600	0.3500	1.2200	0.0000	0.0000	0.0000
CR5	1.7500	0.4900	1.4000	0	0	0.9100	0.3500	1.2200	0.0000	0.0000	0.0000
CR6	1.8500	0.3000	1.4000	0	0	1.1000	0.4500	1.2200	0.0000	0.0000	0.0000
CR8	4.7500	3.3000	3.0673	8	0	0.0000	1.6827	1.2200	0.0000	0.0000	0.0000
CR9	1.7500	1.5000	1.4000	0	0	0.0000	0.3500	1.2200	0.0000	0.0000	0.0000
CR10	2.0000	1.2000	1.4000	0	0	0.2000	0.6000	1.2200	0.0000	0.0000	0.0000
Node274	47.5000	47.5000	46.0457	8	0	0.0000	1.4543	1.2200	0.0000	0.0000	0.0000
Node275	51.0000	51.0000	49.6030	8	0	0.0000	1.3970	1.2200	0.0000	0.0000	0.0000
Node279	47.0000	43.8000	42.3869	9	9	0.0000	4.6131	1.2200	0.0000	0.0000	0.0000
Node280	45.0000	41.8000	40.1530	9	9	0.0000	4.8470	1.2200	0.0000	0.0000	0.0000
Node282	66.0000	65.0000	64.2385	9	2	0.0000	1.7615	1.2200	0.0000	0.0000	0.0000
Node284	60.0000	59.0000	58.0896	8	0	0.0000	1.9104	1.2200	0.0000	0.0000	0.0000
Node285	37.0000	36.0000	35.1500	9	9	0.0000	1.8500	1.2200	0.0000	0.0000	0.0000
Node286	25.0000	24.0000	23.0961	9	1	0.0000	1.9039	1.2200	0.0000	0.0000	0.0000
Node289	34.0000	30.0000	29.1465	10	1	0.0000	4.8535	1.2200	0.0000	0.0000	0.0000
Diversion	34.0000	30.0000	29.6002	9	11	0.0000	4.3998	1.2200	0.0000	0.0000	0.0000
Node292	34.0000	30.0000	29.1177	9	12	0.0000	4.8823	1.2200	0.0000	0.0000	0.0000

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*=====================================================*
|       Table E10 - CONDUIT SUMMARY STATISTICS        |
| Note: The peak flow may be less than the design flow |
| and the conduit may still surcharge because of the   |
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| downstream boundary conditions.                      |
|                                                      |
| * denotes an open conduit that has been overtopped   |
|   this is a potential source of severe errors        |
*======================================================*
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Conduit Name	Design Flow (cms)	Conduit Design Velocity (m/s)	Maximum Vertical Depth (mm)	Maximum Computed Flow (cms)	Time of Occurence Hr.	Time of Occurence Min.	Maximum Computed Velocity (m/s)	Time of Occurence Hr.	Time of Occurence Min.	Ratio of Max. to Design Flow	Maximum Water Elev at Pipe Ends Upstream (m)	Maximum Water Elev at Pipe Ends Dwnstrm (m)	Ratio d/D US	Ratio d/D DS	
1686	0.2464	1.1382	525.0000	0.0143	8	0	0.0886	8	1	0.0582	1.4036	1.4025	0.674	1.071	
1687	0.4054	1.3870	610.0000	0.0317	8	0	0.1122	8	0	0.0783	1.4025	1.4000	0.922	1.393	
1691	0.1486	0.9342	450.0000	0.0462	8	0	0.2921	8	1	0.3112	1.5147	1.4807	0.988	1.579	
1692	0.3450	1.1806	610.0000	0.0463	8	0	0.1582	8	0	0.1343	1.4808	1.4964	1.264	1.568	
1693	0.2095	0.7170	610.0000	0.0685	8	0	0.2336	8	0	0.3270	1.4966	1.5483	1.568	1.751	
1694	0.2795	0.9562	610.0000	0.0853	8	0	0.2908	8	0	0.3054	1.5478	1.4935	1.751	1.793	
1695	0.3123	1.0688	610.0000	0.1095	8	0	0.3728	8	0	0.3505	1.4933	1.4000	1.792	2.131	
1696	0.8164	2.2154	685.0000	0.4417	7	56	1.5287	11	12	0.5410	2.9107	2.6359	1.388	1.775	
1697	0.8937	1.9700	760.0000	0.4979	7	56	1.0926	7	56	0.5571	2.6358	2.3048	1.692	2.191	
1698	0.5402	1.1909	760.0000	0.5576	8	1	1.2190	8	1	1.0322	2.3048	1.8342	2.335	2.150	
1699	0.5536	0.8419	915.0000	0.5907	8	0	0.8939	8	0	1.0670	1.8342	1.6388	1.786	1.693	
1700	0.6932	1.2216	850.0000	0.6035	8	0	1.0581	8	0	0.8707	1.6388	1.4000	1.822	1.776	
1701	0.3380	1.1955	600.0000	0.0214	8	0	0.0756	8	0	0.0634	1.4516	1.4322	1.586	1.970	
1702	0.4103	1.4512	600.0000	0.0214	8	0	0.0755	8	0	0.0523	1.4153	1.4510	1.025	1.585	
1704	0.8005	2.7391	610.0000	0.3613	8	0	2.3031	8	1	0.4513	9.1226	7.6432	0.529	0.530	
1705	0.8300	2.8402	610.0000	0.3731	8	0	2.3989	8	1	0.4495	7.6432	5.8961	0.530	0.485	
1707	0.0670	0.2030	300.0000	0.0187	8	0	0.0566	8	0	0.2786	1.4078	1.4000	4.359	4.667	*
1709	0.0654	0.5765	380.0000	0.0284	8	0	0.5424	8	0	0.4347	7.3450	7.2100	0.487	0.316	
1710	0.2135	1.6991	400.0000	0.0352	8	0	1.1093	8	1	0.1649	7.1812	6.6398	0.303	0.274	
1711	0.1169	1.0583	375.0000	0.0203	8	0	0.6404	8	0	0.1740	7.1261	7.0313	0.336	0.270	
1712	0.9275	2.5919	675.0000	0.0555	8	0	1.3356	8	1	0.0599	6.6255	5.7606	0.171	0.193	
1713	0.8521	2.3813	675.0000	0.0701	8	0	1.3601	8	0	0.0823	5.7606	4.5819	0.193	0.269	
1715	0.5474	1.5296	675.0000	0.0841	7	53	0.9836	7	21	0.1537	4.5819	4.1849	0.269	0.481	
1716	1.0277	1.6155	900.0000	0.1153	8	0	0.6095	6	14	0.1121	4.1849	4.1687	0.361	0.532	
1718	0.0532	0.0000	900.0000	0.1360	8	0	0.4513	7	21	2.5593	4.1687	4.1551	0.532	0.517	
1719	0.2736	0.4301	900.0000	0.2486	9	9	0.7905	9	9	0.9087	4.0517	3.7613	0.524	0.224	
1720	2.4503	3.8516	900.0000	0.2546	9	9	2.0713	9	9	0.1039	3.7613	2.6282	0.224	0.442	
1726	0.1802	1.5885	380.0000	0.0306	8	0	1.0997	7	36	0.1699	3.1382	2.5644	0.285	0.380	
1727	0.1796	1.5837	380.0000	0.0477	7	50	1.1953	7	5	0.2657	2.5644	2.3048	0.380	1.276	
1736	0.0654	0.5770	380.0000	0.0000	0	0	0.0000	0	0	0.0000	5.4500	5.1570	.0000	.0000	
1737	0.1627	1.4345	380.0000	0.0308	8	0	1.0445	8	0	0.1893	5.1570	4.1618	0.308	0.294	
1738	0.3873	1.3252	610.0000	0.0308	7	43	0.7448	7	43	0.0795	4.0409	3.7385	0.198	0.211	
1739	0.3666	1.2545	610.0000	0.0601	7	57	0.8055	7	43	0.1638	3.7385	3.4138	0.309	0.252	
1742	2.1628	7.4004	610.0000	0.0726	7	44	3.7071	0	27	0.0336	3.2297	2.6359	0.114	1.993	
1746	0.8722	2.9846	610.0000	0.3730	8	1	2.5661	8	2	0.4276	5.8961	3.8341	0.485	0.613	
1747	0.8719	2.9833	610.0000	0.4176	8	1	2.3792	9	0	0.4790	3.8341	2.9107	0.613	1.395	
1767	0.1406	1.2727	375.0000	0.0775	8	0	1.1441	8	1	0.5515	61.3738	60.9521	0.597	0.539	
1768	0.1624	1.4700	375.0000	0.0773	8	1	1.2214	8	2	0.4760	60.9521	60.3722	0.566	0.486	

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1770	0.6130	3.8545	450.0000	0.1047	8	0	2.5981	8	0	0.1708	60.3064	57.1058	0.303	0.280
1772	0.5600	3.5211	450.0000	0.1208	8	0	2.6194	8	0	0.2156	56.9827	53.7763	0.317	0.458
1773	0.2491	1.5662	450.0000	0.1034	8	0	1.1267	8	1	0.4152	54.1781	53.8221	0.574	0.449
1774	0.5293	3.3281	450.0000	0.2346	8	0	2.8790	8	1	0.4431	53.7763	51.0475	0.503	0.572
1775	0.9108	4.2072	525.0000	0.2583	8	0	1.7779	8	0	0.2836	51.0475	50.7325	0.643	0.576
1776	0.6406	2.9593	525.0000	0.2583	8	0	1.9058	8	1	0.4031	50.7325	49.6577	0.633	0.300
1779	5.1185	4.5257	1200.000	0.4829	9	14	2.1661	9	15	0.0943	8.8942	7.9278	0.253	0.232
1780	0.4226	1.1808	675.0000	0.0413	9	0	0.6535	9	0	0.0977	9.6605	9.2630	0.238	0.182
1781	0.0532	0.0000	900.0000	0.0921	9	15	0.5871	9	15	1.7329	7.9278	7.7928	0.309	0.159
1782	0.2437	1.9394	400.0000	0.0146	8	0	0.9469	7	20	0.0597	7.9917	7.7928	0.179	0.357
1783	2.1702	3.4113	900.0000	0.1012	9	15	1.5005	9	15	0.0467	7.7928	7.1789	0.159	0.199
1784	0.2561	2.3184	375.0000	0.0192	8	0	1.2085	7	22	0.0748	7.5401	7.1789	0.187	0.477
1785	1.6548	2.6012	900.0000	0.1134	9	14	1.2812	9	15	0.0685	7.1789	6.6901	0.199	0.178
1786	1.7708	2.7835	900.0000	0.1134	9	15	1.3604	9	16	0.0640	6.6901	6.1273	0.178	0.275
1787	0.9183	1.4434	900.0000	0.1197	9	16	0.8655	9	17	0.1304	6.1273	5.8091	0.275	0.221
1789	2.9635	3.4224	1050.000	0.3907	9	15	2.1507	9	16	0.1318	7.9278	5.7872	0.265	0.245
1790	2.9712	2.6271	1200.000	0.3980	9	15	1.6190	9	16	0.1339	5.7026	4.9497	0.269	0.275
1791	2.9846	2.6390	1200.000	0.4163	9	16	1.6054	9	17	0.1395	4.9497	4.2910	0.275	0.326
1792	2.2539	1.0435	1200.000	0.5707	9	18	0.6361	9	19	0.2532	4.2910	4.2161	0.417	0.397
1793	0.1885	0.6452	610.0000	-0.1462	9	20	-0.5453	10	18	-0.7756	4.1551	4.1925	0.762	0.889
1795	0.3023	1.3962	525.0000	-0.0587	8	0	-0.2902	8	0	-0.1943	4.5844	4.5306	0.466	1.239
1796	0.1540	1.3945	375.0000	0.0274	8	0	1.0154	8	0	0.1777	6.0301	4.7069	0.294	0.285
5005	0.0533	0.7547	300.0000	0.0117	37	14	0.1635	37	14	0.2197	1.4728	1.4000	3.243	4.000
5006	0.4732	1.6735	600.0000	0.0332	8	0	0.1168	8	0	0.0702	1.4322	1.4000	1.970	2.517
5009	0.4033	1.4264	600.0000	-0.0067	32	53	0.0572	32	54	-0.0166	1.4133	1.4153	0.369	1.025
5010	0.3744	2.3541	450.0000	0.0530	8	0	1.1071	7	31	0.1414	9.2644	9.1226	0.299	0.717
5011	0.8108	2.8676	600.0000	0.3011	8	3	1.7367	8	4	0.3713	9.5072	9.1226	0.595	0.538
5014	0.7426	5.9092	400.0000	0.0415	8	0	4.0448	0	25	0.0559	48.5642	46.2372	0.160	0.593
5015	1.3973	3.1628	750.0000	0.2580	8	1	1.4079	7	15	0.1846	47.3362	47.0180	0.448	0.291
5016	1.8870	4.2712	750.0000	0.2990	8	1	1.3720	8	6	0.1585	46.1975	45.5953	0.530	0.154
5018	9.2425	1.3204	1750.000	0.0984	8	0	0.3977	8	0	0.0106	54.2472	54.1781	0.141	0.147
5021	5.6825	5.0245	1200.000	0.4188	9	14	2.2584	9	14	0.0737	9.7158	8.8942	0.222	0.212
5022	1.2277	1.0231	1200.000	0.1232	9	18	0.6055	9	19	0.1003	5.8091	5.1522	0.174	0.127
5023	2.0806	1.7338	1200.000	0.1498	9	18	0.8508	9	19	0.0720	5.1522	4.2910	0.127	0.326
5024	0.0188	0.0000	610.0000	-0.1428	9	20	-0.5107	10	17	-7.5802	4.1925	4.2161	0.889	0.928
5026	0.7246	1.1390	900.0000	0.2453	9	17	0.8943	9	17	0.3385	4.1789	3.7198	0.477	0.133
5027	16.1398	5.6041	1600.000	0.4794	9	17	1.7426	9	17	0.0297	3.7198	2.4497	0.075	0.281
5029	1.2065	1.8965	900.0000	0.2584	9	9	0.9885	9	9	0.2142	2.6282	2.4827	0.442	0.314
5030	0.2291	1.0581	525.0000	0.0705	8	0	0.7955	8	0	0.3079	4.5306	4.3146	0.439	0.333
5031	0.5690	2.0124	600.0000	0.0705	8	0	1.0718	7	25	0.1240	4.2630	4.1364	0.255	0.644
5032	0.0669	0.9468	300.0000	0.0081	8	0	0.6087	8	0	0.1213	3.5738	3.0673	0.246	0.224
5033	5.8344	2.1609	1500.000	0.7367	10	21	1.1558	10	21	0.1263	4.1772	3.9357	0.245	0.157
5034	0.4674	0.7347	900.0000	0.2389	9	8	0.7329	9	8	0.5112	4.1551	4.0517	0.517	0.446
5035	1.9190	4.3438	750.0000	0.2580	8	2	1.7752	8	3	0.1345	46.9824	46.4854	0.376	0.247
Link232	2.1224	0.9826	1200.000	0.4281	9	18	0.5004	9	18	0.2017	4.2161	4.1789	0.397	0.391
Link233	0.0704	0.0000	1000.000	0.1830	9	19	0.5780	10	16	2.5997	4.1789	4.1364	0.429	0.386
5025	0.9887	1.2589	1000.000	0.2297	9	16	0.8920	9	16	0.2323	4.1364	3.7198	0.386	0.120
Link236	1.0533	2.7370	700.0000	0.2747	10	3	1.6962	10	3	0.2608	2.2702	1.4000	0.386	1.286
Link237	42.5308	6.3009	1500.000	0.0530	8	0	2.6588	0	23	0.0012	46.0457	10.0315	0.030	0.021

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Link238	37.0144	4.7002	1750.000	0.2582	8	1	1.3838	0	24	0.0070	49.6577	47.3362	0.090	0.192
Link239	4.6551	1.2414	1500.000	0.0279	8	0	0.2598	8	0	0.0060	49.6013	48.5642	0.068	0.043
5028	14.4354	4.1677	2100.000	0.7429	9	16	1.4179	9	16	0.0515	2.4497	2.1222	0.214	0.153
Link242	9.1913	1.3130	1750.000	0.0429	8	0	0.2310	6	18	0.0047	54.2587	54.2472	0.123	0.141
Link243	42.2225	6.2552	1500.000	0.3011	8	2	2.3757	0	24	0.0071	45.5953	10.1134	0.077	0.076
Link244	18.6199	2.7585	1500.000	0.2990	8	1	1.6317	0	25	0.0161	46.2372	46.1975	0.158	0.265
Link245	8.7089	2.3224	1500.000	0.0486	8	0	0.8575	0	24	0.0056	49.6030	46.0457	0.069	0.030
Link252	18.7252	5.3500	1000.000	0.4194	9	12	1.4255	9	11	0.0224	29.1177	9.7158	0.118	0.266
Link253	11.0937	4.3596	1800.000	0.6925	9	9	1.8591	9	9	0.0624	42.3869	40.1530	0.215	0.085
Link257	8.3039	2.3725	1000.000	0.6175	9	2	1.0209	9	1	0.0744	64.2385	42.3869	0.238	0.387
Link258	19.8639	5.6754	1000.000	0.6925	9	9	4.4007	0	25	0.0349	40.1530	29.6002	0.153	0.600
Link259	10.8958	3.1131	1000.000	0.3530	10	1	0.9373	9	1	0.0324	29.1465	4.1772	0.146	0.367
Link260	9.7933	2.1763	1000.000	0.7731	10	21	0.7010	10	21	0.0789	3.9357	1.4000	0.236	0.900
Link261	14.1354	3.1412	1000.000	0.2192	8	0	2.2481	0	23	0.0155	58.0896	35.1500	0.090	0.150
Link262	10.9475	2.4328	1000.000	0.4032	9	9	0.7288	9	4	0.0368	35.1500	4.1772	0.150	0.367
Link263	10.3736	2.9639	1000.000	0.1650	9	1	2.4852	0	23	0.0159	23.0961	2.2702	0.096	0.270
Low Flow.1	0.2620	0.1467	300.0000	0.2726	9	12	1.5872	9	12	1.0406	29.6002	29.1465	2.001	0.498
High Flow.1	Undefnd	Undefnd	Undefn	0.4195	9	11								
FREE # 1	Undefnd	Undefnd	Undefn	0.7429	9	16								
FREE # 2	Undefnd	Undefnd	Undefn	0.0317	8	0								
FREE # 3	Undefnd	Undefnd	Undefn	0.1095	8	0								
FREE # 4	Undefnd	Undefnd	Undefn	0.0117	37	14								
FREE # 5	Undefnd	Undefnd	Undefn	0.6035	8	0								
FREE # 6	Undefnd	Undefnd	Undefn	0.0332	8	0								
FREE # 7	Undefnd	Undefnd	Undefn	0.0187	8	0								
FREE # 8	Undefnd	Undefnd	Undefn	0.0081	8	0								
FREE # 9	Undefnd	Undefnd	Undefn	0.7731	10	21								
FREE #10	Undefnd	Undefnd	Undefn	0.2747	10	3								

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XP-SWMM Output
Future Conditions (no controls), 2 year 24 hour storm
Tables E4, E9 and E10

```
 *==================================================*
 |          Table E4 - Conduit Connectivity         |
 *==================================================*
```

Input Number	Conduit Name	Upstream Node	Downstream Node	Upstream Elevation	Downstream Elevation	
1	1686	1808	1809	1.0500	0.8400	No Design
2	1687	1809	CR1	0.8400	0.5500	No Design
3	1691	1802	1803	1.0700	0.7700	No Design
4	1692	1803	1804	0.7100	0.5400	No Design
5	1693	1804	1805	0.5400	0.4800	No Design
6	1694	1805	1806	0.4800	0.4000	No Design
7	1695	1806	CR2	0.4000	0.1000	No Design
8	1696	1824	1818	1.9600	1.4200	No Design
9	1697	1818	1815	1.3500	0.6400	No Design
10	1698	1815	1814	0.5300	0.2000	No Design
11	1699	1814	1811	0.2000	0.0900	No Design
12	1700	1811	CR4	0.0900	-0.1100	No Design
13	1701	1812	1810	0.5000	0.2500	No Design
14	1702	1813	1812	0.8000	0.5000	No Design
15	1704	1832	1831	8.8000	7.3200	No Design
16	1705	1831	1822	7.3200	5.6000	No Design
17	1707	1850	CR6	0.1000	0.0000	No Design
18	1709	1833	1834	7.1600	7.0900	No Design
19	1710	1834	1836	7.0600	6.5300	No Design
20	1711	6023	1836	7.0000	6.9300	No Design
21	1712	1836	1837	6.5100	5.6300	No Design
22	1713	1837	1844	5.6300	4.4000	No Design
23	1715	1844	1846	4.4000	3.8600	No Design
24	1716	1846	1847	3.8600	3.6900	No Design
25	1718	1847	6002	3.6900	3.6900	No Design
26	1719	1852	1853	3.5800	3.5600	No Design
27	1720	1853	1854	3.5600	2.2300	No Design
28	1726	1841	1840	3.0300	2.4200	No Design
29	1727	1840	1815	2.4200	1.8200	No Design
30	1736	1838	1839	5.4500	5.0900	No Design
31	1737	1839	1821	5.0400	4.0500	No Design
32	1738	1821	1820	3.9200	3.6100	No Design

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33	1739	1820	1819	3.5500	3.2600	No Design
34	1742	1819	1818	3.1600	1.4200	No Design
35	1746	1822	1823	5.6000	3.4600	No Design
36	1747	1823	1824	3.4600	2.0600	No Design
37	1767	1884	1883	61.1500	60.7500	No Design
38	1768	1883	1881	60.7400	60.1900	No Design
39	1770	1881	1878	60.1700	56.9800	No Design
40	1772	1878	1879	56.8400	53.5700	No Design
41	1773	1880	1879	53.9200	53.6200	No Design
42	1774	1879	1874	53.5500	50.7900	No Design
43	1775	1874	1873	50.7100	50.4300	No Design
44	1776	1873	6004	50.4000	49.5000	No Design
45	1779	1871	1870	8.5900	7.6500	No Design
46	1780	1872	1871	9.5000	9.1400	No Design
47	1781	1870	1869	7.6500	7.6500	No Design
48	1782	1868	1869	7.9200	7.6500	No Design
49	1783	1869	1866	7.6500	7.0000	No Design
50	1784	1867	1866	7.4700	7.0000	No Design
51	1785	1866	1865	7.0000	6.5300	No Design
52	1786	1865	1861	6.5300	5.8800	No Design
53	1787	1861	1860	5.8800	5.6100	No Design
54	1789	1870	1864	7.6500	5.5300	No Design
55	1790	1864	1862	5.3800	4.6200	No Design
56	1791	1862	1856	4.6200	3.9000	No Design
57	1792	1856	6038	3.7900	3.7400	No Design
58	1793	6002	1855	3.6900	3.6500	No Design
59	1795	1857	1858	4.3400	3.8800	No Design
60	1796	1859	1858	5.9200	4.6000	No Design
61	5005	6035	CR3	0.5000	0.2000	No Design
62	5006	1810	CR5	0.2500	-0.1100	No Design
63	5009	6034	1813	1.1920	0.8000	No Design
64	5010	6005	1832	9.1300	8.8000	No Design
65	5011	6006	1832	9.1500	8.8000	No Design
66	5014	6014	6044	48.5000	46.0000	No Design
67	5015	6019	6020	47.0000	46.8000	No Design
68	5016	6021	6022	45.8000	45.4800	No Design
69	5018	6003	1880	54.0000	53.9200	No Design
70	5021	6027	1871	9.4500	8.6400	No Design
71	5022	1860	6017	5.6000	5.0000	No Design
72	5023	6017	1856	5.0000	3.9000	No Design
73	5024	1855	6038	3.6500	3.6500	No Design
74	5026	6031	6039	3.7500	3.6000	No Design
75	5027	6039	6032	3.6000	2.0000	No Design
76	5029	1854	6032	2.2300	2.2000	No Design
77	5030	1857	6001	4.3000	4.1400	No Design
78	5031	6001	6041	4.1100	3.7500	No Design
79	5032	6008	CR8	3.5000	3.0000	No Design
80	5033	6042	6043	3.8100	3.7000	No Design
81	5034	6002	1852	3.6900	3.6500	No Design

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82	5035	6020	6044	46.7000	46.3000	No Design
83	Link232	6038	6031	3.7400	3.7100	No Design
84	Link233	6031	6041	3.7500	3.7500	No Design
85	5025	6041	6039	3.7500	3.6000	No Design
86	Link236	6048	CR10	2.0000	0.5000	No Design
87	Link237	Node274	6005	46.0000	10.0000	No Design
88	Link238	6004	6019	49.5000	47.0000	No Design
89	Link239	6045	6014	49.5000	48.5000	No Design
90	5028	6032	CR7	2.0000	1.8000	No Design
91	Link242	6046	6003	54.0440	54.0000	No Design
92	Link243	6022	6006	45.4800	10.0000	No Design
93	Link244	6044	6021	46.0000	45.8000	No Design
94	Link245	Node275	Node274	49.5000	46.0000	No Design
95	Link252	Node292	6027	29.0000	9.4500	No Design
96	Link253	Node279	Node280	42.0000	40.0000	No Design
97	Link257	Node282	Node279	64.0000	42.0000	No Design
98	Link258	Node280	Diversion	40.0000	29.0000	No Design
99	Link259	Node289	6042	29.0000	3.8100	No Design
100	Link260	6043	CR9	3.7000	0.5000	No Design
101	Link261	Node284	Node285	58.0000	35.0000	No Design
102	Link262	Node285	6042	35.0000	3.8100	No Design
103	Link263	Node286	6048	23.0000	2.0000	No Design

```
*==========================================*
|             Orifice Data                 |
*==========================================*
```

Orifice Name	From Junction	To Junction	Type	Area (m2)	Depth (m)	Discharge Coefficient	Height Above Junction (m)
Low Flow.1	Diversion	Node289	Rect Side	0.18	0.30	0.600	0.000

```
====> EQUIVALENT PIPE INFORMATION FOR ORIFICE            1
      CONDUIT NAME...........................      Low Flow.1
      Upstream node..........................       Diversion
      Downstream node........................         Node289
      PIPE DIAMETER.......................               0.30
      PIPE LENGTH.........................             300.00
      MANNINGS ROUGHNESS..................             0.0047
      INVERT ELEVATION AT UPSTREAM END.....           29.0000
      INVERT ELEVATION AT DOWNSTREAM END...           28.9970
```

Note: For a Bottom-outlet orifice the invert elevation of the downstream node will be adjusted to accomodate the equivalent conduit. Conduit grades are not affected.

```
*===========================================*
|                Weir Data                  |
```

Campbell River / Quinsam River ISMP
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===

Weir Name	From Junction	To Junction	Type	Crest Height(ft)	Weir Top (m)	Weir Length (m)	Discharge Coefficient	Weir Power
High Flow.1	Diversion	Node292	1	0.30	5.00	1.50	1.7000	1.5000

```
*================================================*
|          FREE OUTFALL DATA (DATA GROUP I1)     |
|         BOUNDARY CONDITION ON DATA GROUP J1    |
*================================================*
```

```
Outfall at Junction....CR7             has boundary condition number...        1
Outfall at Junction....CR1             has boundary condition number...        2
Outfall at Junction....CR2             has boundary condition number...        3
Outfall at Junction....CR3             has boundary condition number...        4
Outfall at Junction....CR4             has boundary condition number...        5
Outfall at Junction....CR5             has boundary condition number...        6
Outfall at Junction....CR6             has boundary condition number...        7
Outfall at Junction....CR8             has boundary condition number...        8
Outfall at Junction....CR9             has boundary condition number...        9
Outfall at Junction....CR10            has boundary condition number...       10
```

```
*======================================================*
|        Table E9 - JUNCTION SUMMARY STATISTICS        |
| The Maximum area is only the area of the node, it    |
| does not include the area of the surrounding conduits|
*======================================================*
```

Junction Name	Ground Elevation meters	Uppermost PipeCrown Elevation meters	Maximum Junction Elevation meters	Time of Occurence Hr.	Min.	Meters of Surcharge at Max Elevation	Freeboard of node meters	Maximum Junction Area m^2	Maximum Gutter Depth meters	Maximum Gutter Width meters	Maximum Gutter Velocity m/s
1802	2.8200	1.5200	1.4817	8	0	0.0000	1.3383	1.2200	0.0000	0.0000	0.0000
1803	2.4600	1.3200	1.4851	42	39	0.1651	0.9749	1.2200	0.0000	0.0000	0.0000
1804	2.2900	1.1500	1.5601	42	39	0.4101	0.7299	1.2200	0.0000	0.0000	0.0000
1805	2.2300	1.0900	1.5578	42	39	0.4678	0.6722	1.2200	0.0000	0.0000	0.0000
1806	2.1500	1.0100	1.4375	42	39	0.4275	0.7125	1.2200	0.0000	0.0000	0.0000
1808	2.8000	1.5750	1.4027	7	3	0.0000	1.3973	1.2200	0.0000	0.0000	0.0000
1809	2.5900	1.4500	1.4018	8	0	0.0000	1.1882	1.2200	0.0000	0.0000	0.0000
1810	1.7500	0.8500	1.4262	30	15	0.5762	0.3238	1.2200	0.0000	0.0000	0.0000
1811	1.8400	1.0050	1.5637	8	0	0.5587	0.2763	1.2200	0.0000	0.0000	0.0000
1812	1.7500	1.1000	1.4468	34	11	0.3468	0.3032	1.2200	0.0000	0.0000	0.0000
1813	1.7500	1.4000	1.4082	47	11	0.0082	0.3418	1.2200	0.0000	0.0000	0.0000

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1814	1.9500	1.1150	1.6976	8	0	0.5826	0.2524	1.2200	0.0000	0.0000	0.0000
1815	2.9300	2.2000	2.0208	8	1	0.0000	0.9092	1.2200	0.0000	0.0000	0.0000
1818	3.1000	2.1100	2.2326	8	1	0.1226	0.8674	1.2200	0.0000	0.0000	0.0000
1819	4.9100	3.8700	3.2242	8	0	0.0000	1.6858	1.2200	0.0000	0.0000	0.0000
1820	5.3000	4.2200	3.7201	8	0	0.0000	1.5799	1.2200	0.0000	0.0000	0.0000
1821	5.6700	4.5300	4.0321	7	31	0.0000	1.6379	1.2200	0.0000	0.0000	0.0000
1822	8.3500	6.2100	5.8644	8	1	0.0000	2.4856	1.2200	0.0000	0.0000	0.0000
1823	5.2100	4.0700	3.7519	8	0	0.0000	1.4581	1.2200	0.0000	0.0000	0.0000
1824	3.7100	2.6700	2.4597	8	1	0.0000	1.2503	1.2200	0.0000	0.0000	0.0000
1831	9.0700	7.9300	7.6038	8	0	0.0000	1.4662	1.2200	0.0000	0.0000	0.0000
1832	10.5500	9.4100	9.0833	8	0	0.0000	1.4667	1.2200	0.0000	0.0000	0.0000
1833	8.9100	7.5400	7.3298	8	0	0.0000	1.5802	1.2200	0.0000	0.0000	0.0000
1834	8.8100	7.4700	7.1708	8	0	0.0000	1.6392	1.2200	0.0000	0.0000	0.0000
1836	8.2600	7.3050	6.6163	8	0	0.0000	1.6437	1.2200	0.0000	0.0000	0.0000
1837	7.3800	6.3050	5.7507	8	0	0.0000	1.6293	1.2200	0.0000	0.0000	0.0000
1838	7.2000	5.8300	5.4500	0	0	0.0000	1.7500	1.2200	0.0000	0.0000	0.0000
1839	6.7900	5.4700	5.1473	8	0	0.0000	1.6427	1.2200	0.0000	0.0000	0.0000
1840	4.1700	2.8000	2.5518	7	28	0.0000	1.6182	1.2200	0.0000	0.0000	0.0000
1841	4.7800	3.4100	3.1295	8	0	0.0000	1.6505	1.2200	0.0000	0.0000	0.0000
1844	6.1500	5.0750	4.5640	7	34	0.0000	1.5860	1.2200	0.0000	0.0000	0.0000
1846	5.6100	4.7600	4.2173	8	0	0.0000	1.3927	1.2200	0.0000	0.0000	0.0000
1847	5.4400	4.5900	4.1989	8	0	0.0000	1.2411	1.2200	0.0000	0.0000	0.0000
1850	1.7500	0.4000	1.4057	8	0	1.0057	0.3443	1.2200	0.0000	0.0000	0.0000
1852	5.3300	4.5500	4.0769	8	1	0.0000	1.2531	1.2200	0.0000	0.0000	0.0000
1853	5.3100	4.4600	3.7742	8	0	0.0000	1.5358	1.2200	0.0000	0.0000	0.0000
1854	3.9800	3.1300	2.6524	8	1	0.0000	1.3276	1.2200	0.0000	0.0000	0.0000
1855	5.4000	4.2600	4.2156	8	1	0.0000	1.1844	1.2200	0.0000	0.0000	0.0000
1856	5.5900	5.1000	4.3117	8	1	0.0000	1.2783	1.2200	0.0000	0.0000	0.0000
1857	6.0300	4.8650	4.5091	8	0	0.0000	1.5209	1.2200	0.0000	0.0000	0.0000
1858	5.4900	4.9750	4.5531	8	0	0.0000	0.9369	1.2200	0.0000	0.0000	0.0000
1859	6.9200	6.2950	6.0211	8	0	0.0000	0.8989	1.2200	0.0000	0.0000	0.0000
1860	7.3600	6.8000	5.8179	8	2	0.0000	1.5421	1.2200	0.0000	0.0000	0.0000
1861	7.6300	6.7800	6.1353	8	0	0.0000	1.4947	1.2200	0.0000	0.0000	0.0000
1862	6.3700	5.8200	4.9523	8	0	0.0000	1.4177	1.2200	0.0000	0.0000	0.0000
1864	7.1300	6.5800	5.7032	8	0	0.0000	1.4268	1.2200	0.0000	0.0000	0.0000
1865	8.2800	7.4300	6.6947	8	0	0.0000	1.5853	1.2200	0.0000	0.0000	0.0000
1866	8.7500	7.9000	7.1839	8	0	0.0000	1.5661	1.2200	0.0000	0.0000	0.0000
1867	9.2200	7.8450	7.5341	8	0	0.0000	1.6859	1.2200	0.0000	0.0000	0.0000
1868	9.6700	8.3200	7.9818	7	24	0.0000	1.6882	1.2200	0.0000	0.0000	0.0000
1869	9.4000	8.5500	7.7941	8	0	0.0000	1.6059	1.2200	0.0000	0.0000	0.0000
1870	9.4000	8.8500	7.9276	8	0	0.0000	1.4724	1.2200	0.0000	0.0000	0.0000
1871	10.3400	9.8400	8.8936	8	0	0.0000	1.4464	1.2200	0.0000	0.0000	0.0000
1872	10.8900	10.1750	9.6345	8	0	0.0000	1.2555	1.2200	0.0000	0.0000	0.0000
1873	52.1500	50.9550	50.6859	8	0	0.0000	1.4641	1.2200	0.0000	0.0000	0.0000
1874	52.4600	51.2400	50.9962	8	0	0.0000	1.4638	1.2200	0.0000	0.0000	0.0000
1878	58.5900	57.4300	56.9654	8	0	0.0000	1.6246	1.2200	0.0000	0.0000	0.0000
1879	55.3200	54.0700	53.7494	8	0	0.0000	1.5706	1.2200	0.0000	0.0000	0.0000
1880	55.6700	55.6700	54.1448	8	0	0.0000	1.5252	1.2200	0.0000	0.0000	0.0000
1881	61.9200	60.6200	60.2892	8	0	0.0000	1.6308	1.2200	0.0000	0.0000	0.0000

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1883	62.4900	61.1250	60.9203	8	1	0.0000	1.5697	1.2200	0.0000	0.0000	0.0000
1884	62.9000	61.5250	61.3409	8	0	0.0000	1.5591	1.2200	0.0000	0.0000	0.0000
6001	5.8500	4.7100	4.2512	8	0	0.0000	1.5988	1.2200	0.0000	0.0000	0.0000
6002	5.4000	4.5900	4.1825	8	1	0.0000	1.2175	1.2200	0.0000	0.0000	0.0000
6003	55.7500	55.7500	54.2198	8	0	0.0000	1.5302	1.2200	0.0000	0.0000	0.0000
6004	51.2500	51.2500	49.6396	8	1	0.0000	1.6104	1.2200	0.0000	0.0000	0.0000
6005	11.7500	11.5000	9.2514	7	56	0.0000	2.4986	1.2200	0.0000	0.0000	0.0000
6006	11.5000	11.5000	9.4556	8	3	0.0000	2.0444	1.2200	0.0000	0.0000	0.0000
6008	5.2500	3.8000	3.5679	8	0	0.0000	1.6821	1.2200	0.0000	0.0000	0.0000
6014	50.0000	50.0000	48.5592	8	0	0.0000	1.4408	1.2200	0.0000	0.0000	0.0000
6017	6.5500	6.2000	5.1637	8	0	0.0000	1.3863	1.2200	0.0000	0.0000	0.0000
6019	51.0000	48.7500	47.2872	8	2	0.0000	3.7128	1.2200	0.0000	0.0000	0.0000
6020	48.4500	47.5500	46.9453	8	1	0.0000	1.5047	1.2200	0.0000	0.0000	0.0000
6021	47.3000	47.3000	46.1456	8	1	0.0000	1.1544	1.2200	0.0000	0.0000	0.0000
6022	47.5000	46.9800	45.5831	8	3	0.0000	1.9169	1.2200	0.0000	0.0000	0.0000
6023	8.7500	7.3750	7.1152	8	0	0.0000	1.6348	1.2200	0.0000	0.0000	0.0000
6027	11.2000	10.6500	9.7162	8	5	0.0000	1.4838	1.2200	0.0000	0.0000	0.0000
6031	5.5000	4.9100	4.1979	8	2	0.0000	1.3021	1.2200	0.0000	0.0000	0.0000
6032	4.1000	4.1000	2.4765	8	1	0.0000	1.6235	1.2200	0.0000	0.0000	0.0000
6034	2.9500	1.7920	1.4079	47	12	0.0000	1.5421	1.2200	0.0000	0.0000	0.0000
6035	1.7500	0.8000	1.4605	36	39	0.6605	0.2895	1.2200	0.0000	0.0000	0.0000
6038	5.6500	4.9400	4.2368	8	2	0.0000	1.4132	1.2200	0.0000	0.0000	0.0000
6039	5.3500	5.2000	3.7268	8	2	0.0000	1.6232	1.2200	0.0000	0.0000	0.0000
CR7	3.9000	3.9000	2.1392	8	1	0.0000	1.7608	1.2200	0.0000	0.0000	0.0000
6041	6.0000	4.7500	4.1550	8	1	0.0000	1.8450	1.2200	0.0000	0.0000	0.0000
6042	7.0000	5.3100	4.1703	8	12	0.0000	2.8297	1.2200	0.0000	0.0000	0.0000
6043	7.0000	5.2000	3.9334	8	10	0.0000	3.0666	1.2200	0.0000	0.0000	0.0000
6044	48.0000	47.5000	46.1982	8	1	0.0000	1.8018	1.2200	0.0000	0.0000	0.0000
6045	51.0000	51.0000	49.5917	8	0	0.0000	1.4083	1.2200	0.0000	0.0000	0.0000
6046	55.8000	55.7940	54.2335	8	0	0.0000	1.5665	1.2200	0.0000	0.0000	0.0000
6048	3.7500	3.0000	2.2490	8	0	0.0000	1.5010	1.2200	0.0000	0.0000	0.0000
CR1	2.3000	1.1600	1.4000	0	0	0.2400	0.9000	1.2200	0.0000	0.0000	0.0000
CR2	1.8400	0.7100	1.4000	0	0	0.6900	0.4400	1.2200	0.0000	0.0000	0.0000
CR3	1.7500	0.5000	1.4000	0	0	0.9000	0.3500	1.2200	0.0000	0.0000	0.0000
CR4	1.7500	0.7400	1.4000	0	0	0.6600	0.3500	1.2200	0.0000	0.0000	0.0000
CR5	1.7500	0.4900	1.4000	0	0	0.9100	0.3500	1.2200	0.0000	0.0000	0.0000
CR6	1.8500	0.3000	1.4000	0	0	1.1000	0.4500	1.2200	0.0000	0.0000	0.0000
CR8	4.7500	3.3000	3.0620	8	0	0.0000	1.6880	1.2200	0.0000	0.0000	0.0000
CR9	1.7500	1.5000	1.4000	0	0	0.0000	0.3500	1.2200	0.0000	0.0000	0.0000
CR10	2.0000	1.2000	1.4000	0	0	0.2000	0.6000	1.2200	0.0000	0.0000	0.0000
Node274	47.5000	47.5000	46.0423	8	0	0.0000	1.4577	1.2200	0.0000	0.0000	0.0000
Node275	51.0000	51.0000	49.5934	8	0	0.0000	1.4066	1.2200	0.0000	0.0000	0.0000
Node279	47.0000	43.8000	42.3862	8	0	0.0000	4.6138	1.2200	0.0000	0.0000	0.0000
Node280	45.0000	41.8000	40.1526	8	1	0.0000	4.8474	1.2200	0.0000	0.0000	0.0000
Node282	66.0000	65.0000	64.2336	8	0	0.0000	1.7664	1.2200	0.0000	0.0000	0.0000
Node284	60.0000	59.0000	58.0813	8	0	0.0000	1.9187	1.2200	0.0000	0.0000	0.0000
Node285	37.0000	36.0000	35.1512	8	0	0.0000	1.8488	1.2200	0.0000	0.0000	0.0000
Node286	25.0000	24.0000	23.0833	8	0	0.0000	1.9167	1.2200	0.0000	0.0000	0.0000
Node289	34.0000	30.0000	29.1432	8	0	0.0000	4.8568	1.2200	0.0000	0.0000	0.0000

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Diversion	34.0000	30.0000	29.5996	8	2	0.0000	4.4004	1.2200	0.0000	0.0000	0.0000
Node292	34.0000	30.0000	29.1175	8	2	0.0000	4.8825	1.2200	0.0000	0.0000	0.0000

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*=====================================================*
|       Table E10 - CONDUIT SUMMARY STATISTICS        |
| Note: The peak flow may be less than the design flow |
| and the conduit may still surcharge because of the  |
| downstream boundary conditions.                     |
|                                                     |
| * denotes an open conduit that has been overtopped  |
|   this is a potential source of severe errors       |
*=====================================================*
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Conduit Name	Design Flow (cms)	Conduit Design Velocity (m/s)	Maximum Vertical Depth (mm)	Maximum Computed Flow (cms)	Time of Occurence Hr.	Time of Occurence Min.	Maximum Computed Velocity (m/s)	Time of Occurence Hr.	Time of Occurence Min.	Ratio of Max. to Design Flow	Maximum Water Elev at Pipe Ends Upstream (m)	Maximum Water Elev at Pipe Ends Dwnstrm (m)	Ratio d/D US	Ratio d/D DS	
1686	0.2464	1.1382	525.0000	0.0122	8	0	0.0756	8	1	0.0495	1.4027	1.4018	0.672	1.070	
1687	0.4054	1.3870	610.0000	0.0270	8	0	0.0955	8	0	0.0666	1.4018	1.4000	0.921	1.393	
1691	0.1486	0.9342	450.0000	0.0393	8	1	0.2571	8	1	0.2644	1.4817	1.4850	0.915	1.589	
1692	0.3450	1.1806	610.0000	-0.0561	42	39	-0.1912	42	39	-0.1625	1.4851	1.5598	1.271	1.672	
1693	0.2095	0.7170	610.0000	-0.0670	42	39	-0.2283	42	39	-0.3200	1.5601	1.5578	1.672	1.767	
1694	0.2795	0.9562	610.0000	0.0725	8	0	0.2472	8	0	0.2595	1.5578	1.4375	1.767	1.701	
1695	0.3123	1.0688	610.0000	0.0930	8	0	0.3169	8	0	0.2979	1.4346	1.4000	1.696	2.131	
1696	0.8164	2.2154	685.0000	0.3571	8	2	1.5270	9	35	0.4374	2.4597	2.2326	0.729	1.186	
1697	0.8937	1.9700	760.0000	0.4079	8	2	0.9360	11	15	0.4564	2.2326	2.0208	1.161	1.817	
1698	0.5402	1.1909	760.0000	0.4608	8	1	1.0097	8	1	0.8531	2.0208	1.6976	1.962	1.971	
1699	0.5536	0.8419	915.0000	0.4887	8	1	0.7402	8	1	0.8827	1.6976	1.5637	1.637	1.611	
1700	0.6932	1.2216	850.0000	0.4996	8	0	0.8763	8	0	0.7207	1.5637	1.4000	1.734	1.776	
1701	0.3380	1.1955	600.0000	0.0182	8	0	0.0642	8	0	0.0539	1.4465	1.4259	1.577	1.960	
1702	0.4103	1.4512	600.0000	0.0182	8	0	0.0643	8	0	0.0444	1.4082	1.4468	1.014	1.578	
1704	0.8005	2.7391	610.0000	0.2948	8	0	2.2178	8	1	0.3683	9.0833	7.6038	0.464	0.465	
1705	0.8300	2.8402	610.0000	0.3048	8	0	2.3102	8	1	0.3672	7.6038	5.8644	0.465	0.433	
1707	0.0670	0.2030	300.0000	0.0159	8	0	0.0481	8	0	0.2370	1.4057	1.4000	4.352	4.667	*
1709	0.0654	0.5765	380.0000	0.0242	8	0	0.5161	8	0	0.3698	7.3298	7.2003	0.447	0.290	
1710	0.2135	1.6991	400.0000	0.0299	8	0	1.0689	8	1	0.1403	7.1708	6.6310	0.277	0.252	
1711	0.1169	1.0583	375.0000	0.0173	8	0	0.6170	8	0	0.1481	7.1152	7.0232	0.307	0.249	
1712	0.9275	2.5919	675.0000	0.0473	8	0	1.2810	8	1	0.0509	6.6163	5.7507	0.157	0.179	
1713	0.8521	2.3813	675.0000	0.0596	8	0	1.2988	8	0	0.0700	5.7507	4.5640	0.179	0.243	
1715	0.5474	1.5296	675.0000	0.0716	8	0	0.9146	7	18	0.1308	4.5640	4.2173	0.243	0.529	
1716	1.0277	1.6155	900.0000	0.0979	8	0	0.5167	3	17	0.0953	4.2173	4.1989	0.397	0.565	
1718	0.0532	0.0000	900.0000	0.1156	8	0	0.3244	7	19	2.1738	4.1989	4.1825	0.565	0.547	
1719	0.2736	0.4301	900.0000	0.2752	8	1	0.8195	8	1	1.0058	4.0769	3.7742	0.552	0.238	
1720	2.4503	3.8516	900.0000	0.2826	8	1	2.1130	8	1	0.1153	3.7742	2.6524	0.238	0.469	
1726	0.1802	1.5885	380.0000	0.0260	8	0	1.0589	8	0	0.1444	3.1295	2.5518	0.262	0.347	
1727	0.1796	1.5837	380.0000	0.0410	7	29	1.1862	7	29	0.2280	2.5518	2.0208	0.347	0.529	
1736	0.0654	0.5770	380.0000	0.0000	0	0	0.0000	0	0	0.0000	5.4500	5.1473	.0000	.0000	
1737	0.1627	1.4345	380.0000	0.0262	8	0	1.0022	8	0	0.1610	5.1473	4.1529	0.282	0.271	

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1738	0.3873	1.3252	610.0000	0.0262	8	0	0.7110	8	0	0.0676	4.0321	3.7201	0.184	0.180
1739	0.3666	1.2545	610.0000	0.0507	8	0	0.7796	7	29	0.1382	3.7201	3.4009	0.279	0.231
1742	2.1628	7.4004	610.0000	0.0507	8	0	1.7394	29	23	0.0234	3.2242	2.2326	0.105	1.332
1746	0.8722	2.9846	610.0000	0.3047	8	1	2.4761	8	1	0.3493	5.8644	3.7519	0.433	0.478
1747	0.8719	2.9833	610.0000	0.3428	8	0	2.3736	8	8	0.3932	3.7519	2.4597	0.478	0.655
1767	0.1406	1.2727	375.0000	0.0604	8	0	1.0833	8	1	0.4296	61.3409	60.9217	0.509	0.458
1768	0.1624	1.4700	375.0000	0.0603	8	1	1.1667	8	2	0.3712	60.9203	60.3481	0.481	0.422
1770	0.6130	3.8545	450.0000	0.0819	8	0	2.4513	8	0	0.1337	60.2892	57.0910	0.265	0.247
1772	0.5600	3.5211	450.0000	0.0949	8	0	2.4663	8	0	0.1695	56.9654	53.7494	0.279	0.399
1773	0.2491	1.5662	450.0000	0.0843	8	0	1.0892	8	1	0.3384	54.1448	53.8004	0.500	0.401
1774	0.5293	3.3281	450.0000	0.1877	8	0	2.7478	8	1	0.3546	53.7494	50.9962	0.443	0.458
1775	0.9108	4.2072	525.0000	0.2078	8	0	1.8079	0	29	0.2282	50.9962	50.6859	0.545	0.487
1776	0.6406	2.9593	525.0000	0.2078	8	1	1.8382	8	1	0.3244	50.6859	49.6396	0.545	0.266
1779	5.1185	4.5257	1200.000	0.4814	8	0	2.1655	8	1	0.0940	8.8936	7.9276	0.253	0.231
1780	0.4226	1.1808	675.0000	0.0289	8	0	0.6286	0	29	0.0683	9.6345	9.2425	0.199	0.152
1781	0.0532	0.0000	900.0000	0.0910	8	1	0.5803	8	2	1.7111	7.9276	7.7941	0.308	0.160
1782	0.2437	1.9394	400.0000	0.0124	8	0	1.0891	0	29	0.0508	7.9818	7.7941	0.154	0.360
1783	2.1702	3.4113	900.0000	0.1032	8	0	1.5058	8	0	0.0476	7.7941	7.1839	0.160	0.204
1784	0.2561	2.3184	375.0000	0.0163	8	0	2.4835	0	29	0.0637	7.5341	7.1839	0.171	0.490
1785	1.6548	2.6012	900.0000	0.1195	8	0	1.2980	8	1	0.0722	7.1839	6.6947	0.204	0.183
1786	1.7708	2.7835	900.0000	0.1195	8	1	1.3755	8	1	0.0675	6.6947	6.1353	0.183	0.284
1787	0.9183	1.4434	900.0000	0.1275	8	1	0.8809	8	2	0.1389	6.1353	5.8179	0.284	0.231
1789	2.9635	3.4224	1050.000	0.3902	8	1	2.1503	8	1	0.1317	7.9276	5.7870	0.264	0.245
1790	2.9712	2.6271	1200.000	0.3998	8	1	1.6205	8	1	0.1346	5.7032	4.9523	0.269	0.277
1791	2.9846	2.6390	1200.000	0.4241	8	0	1.6056	8	1	0.1421	4.9523	4.3117	0.277	0.343
1792	2.2539	1.0435	1200.000	0.5970	8	1	0.6388	8	1	0.2649	4.3117	4.2368	0.435	0.414
1793	0.1885	0.6452	610.0000	-0.1429	8	7	-0.5180	8	12	-0.7579	4.1825	4.2156	0.807	0.927
1795	0.3023	1.3962	525.0000	-0.0499	8	0	-0.2480	8	0	-0.1651	4.5531	4.5091	0.406	1.198
1796	0.1540	1.3945	375.0000	0.0233	8	0	0.9714	8	0	0.1510	6.0211	4.6982	0.270	0.262
5005	0.0533	0.7547	300.0000	0.0081	36	37	0.1127	36	37	0.1513	1.4605	1.4000	3.202	4.000
5006	0.4732	1.6735	600.0000	0.0283	8	0	0.0993	8	0	0.0597	1.4259	1.4000	1.960	2.517
5009	0.4033	1.4264	600.0000	-0.0048	44	14	0.0314	39	25	-0.0119	1.4079	1.4083	0.360	1.014
5010	0.3744	2.3541	450.0000	0.0450	8	0	1.0831	7	38	0.1203	9.2514	9.0833	0.270	0.630
5011	0.8108	2.8676	600.0000	0.2439	8	3	1.7011	8	4	0.3009	9.4556	9.0833	0.509	0.472
5014	0.7426	5.9092	400.0000	0.0353	8	0	4.8371	0	29	0.0475	48.5592	46.1982	0.148	0.495
5015	1.3973	3.1628	750.0000	0.2075	8	2	1.3901	8	2	0.1485	47.2872	46.9949	0.383	0.260
5016	1.8870	4.2712	750.0000	0.2424	8	2	1.3303	8	6	0.1285	46.1456	45.5831	0.461	0.138
5018	9.2425	1.3204	1750.000	0.0802	8	0	0.3871	8	0	0.0087	54.2198	54.1448	0.126	0.128
5021	5.6825	5.0245	1200.000	0.4171	8	0	2.2568	8	0	0.0734	9.7162	8.8936	0.222	0.211
5022	1.2277	1.0231	1200.000	0.1321	8	1	0.6217	8	1	0.1076	5.8179	5.1637	0.182	0.136
5023	2.0806	1.7338	1200.000	0.1673	8	0	0.8873	8	0	0.0804	5.1637	4.3117	0.136	0.343
5024	0.0188	0.0000	610.0000	-0.1387	8	7	-0.4863	8	12	-7.3621	4.2156	4.2368	0.927	0.962
5026	0.7246	1.1390	900.0000	0.2664	8	2	0.9182	8	2	0.3676	4.1979	3.7268	0.498	0.141
5027	16.1398	5.6041	1600.000	0.5241	8	2	1.8002	8	2	0.0325	3.7268	2.4765	0.079	0.298
5029	1.2065	1.8965	900.0000	0.2875	8	1	1.0182	8	1	0.2383	2.6524	2.4987	0.469	0.332
5030	0.2291	1.0581	525.0000	0.0600	8	0	0.7690	8	0	0.2618	4.5091	4.3005	0.398	0.306
5031	0.5690	2.0124	600.0000	0.0600	8	0	0.9337	7	18	0.1054	4.2512	4.1550	0.235	0.675
5032	0.0669	0.9468	300.0000	0.0069	8	0	0.5815	8	0	0.1032	3.5679	3.0620	0.226	0.207
5033	5.8344	2.1609	1500.000	0.7161	8	13	1.1446	8	13	0.1227	4.1703	3.9334	0.240	0.156

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5034	0.4674	0.7347	900.0000	0.2632	8	1	0.7512	8	2	0.5631	4.1825	4.0769	0.547	0.474
5035	1.9190	4.3438	750.0000	0.2076	8	2	1.7264	8	3	0.1082	46.9453	46.4660	0.327	0.221
Link232	2.1224	0.9826	1200.000	0.4590	8	2	0.5142	8	2	0.2162	4.2368	4.1979	0.414	0.407
Link233	0.0704	0.0000	1000.000	0.1929	8	3	0.5752	8	6	2.7400	4.1979	4.1550	0.448	0.405
5025	0.9887	1.2589	1000.000	0.2522	8	1	0.9195	8	1	0.2551	4.1550	3.7268	0.405	0.127
Link236	1.0533	2.7370	700.0000	0.2426	8	0	1.6278	8	0	0.2303	2.2490	1.4000	0.356	1.286
Link237	42.5308	6.3009	1500.000	0.0450	8	0	0.7605	0	28	0.0011	46.0423	10.0268	0.028	0.018
Link238	37.0144	4.7002	1750.000	0.2077	8	1	1.3061	0	29	0.0056	49.6396	47.2872	0.080	0.164
Link239	4.6551	1.2414	1500.000	0.0237	8	0	0.2592	0	28	0.0051	49.5917	48.5592	0.061	0.039
5028	14.4354	4.1677	2100.000	0.8196	8	1	1.4420	8	2	0.0568	2.4765	2.1392	0.227	0.162
Link242	9.1913	1.3130	1750.000	0.0365	8	0	0.2303	6	24	0.0040	54.2335	54.2198	0.108	0.126
Link243	42.2225	6.2552	1500.000	0.2439	8	3	2.0733	0	28	0.0058	45.5831	10.0982	0.069	0.065
Link244	18.6199	2.7585	1500.000	0.2424	8	1	1.0820	0	29	0.0130	46.1982	46.1456	0.132	0.230
Link245	8.7089	2.3224	1500.000	0.0413	8	0	0.9072	0	28	0.0047	49.5934	46.0423	0.062	0.028
Link252	18.7252	5.3500	1000.000	0.4181	8	2	1.4231	8	1	0.0223	29.1175	9.7162	0.118	0.266
Link253	11.0937	4.3596	1800.000	0.6900	8	0	1.8573	8	1	0.0622	42.3862	40.1526	0.215	0.085
Link257	8.3039	2.3725	1000.000	0.5961	8	0	1.0037	8	0	0.0718	64.2336	42.3862	0.234	0.386
Link258	19.8639	5.6754	1000.000	0.6900	8	1	5.3267	0	35	0.0347	40.1526	29.5996	0.153	0.600
Link259	10.8958	3.1131	1000.000	0.3399	8	0	1.1030	0	48	0.0312	29.1432	4.1703	0.143	0.360
Link260	9.7933	2.1763	1000.000	0.7603	8	10	0.6943	8	10	0.0776	3.9334	1.4000	0.233	0.900
Link261	14.1354	3.1412	1000.000	0.1865	8	0	0.9147	0	28	0.0132	58.0813	35.1512	0.081	0.151
Link262	10.9475	2.4328	1000.000	0.4086	8	0	0.7229	8	0	0.0373	35.1512	4.1703	0.151	0.360
Link263	10.3736	2.9639	1000.000	0.1300	8	0	1.3747	0	29	0.0125	23.0833	2.2490	0.083	0.249
Low Flow.1	0.2620	0.1467	300.0000	0.2715	8	1	1.5824	8	2	1.0364	29.5996	29.1432	1.999	0.488
High Flow.1	Undefnd	Undefnd	Undefn	0.4182	8	2								
FREE # 1	Undefnd	Undefnd	Undefn	0.8196	8	1								
FREE # 2	Undefnd	Undefnd	Undefn	0.0270	8	0								
FREE # 3	Undefnd	Undefnd	Undefn	0.0930	8	0								
FREE # 4	Undefnd	Undefnd	Undefn	-0.0104	40	6								
FREE # 5	Undefnd	Undefnd	Undefn	0.4996	8	0								
FREE # 6	Undefnd	Undefnd	Undefn	0.0283	8	0								
FREE # 7	Undefnd	Undefnd	Undefn	0.0159	8	0								
FREE # 8	Undefnd	Undefnd	Undefn	0.0069	8	0								
FREE # 9	Undefnd	Undefnd	Undefn	0.7603	8	10								
FREE #10	Undefnd	Undefnd	Undefn	0.2426	8	0								

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XP-SWMM Output
Future Conditions (no controls), 5 year 24 hour storm
Tables E4, E9 and E10

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*==================================================*
|          Table E4 - Conduit Connectivity         |
*==================================================*
```

Input Number	Conduit Name	Upstream Node	Downstream Node	Upstream Elevation	Downstream Elevation	
1	1686	1808	1809	1.0500	0.8400	No Design
2	1687	1809	CR1	0.8400	0.5500	No Design
3	1691	1802	1803	1.0700	0.7700	No Design
4	1692	1803	1804	0.7100	0.5400	No Design
5	1693	1804	1805	0.5400	0.4800	No Design
6	1694	1805	1806	0.4800	0.4000	No Design
7	1695	1806	CR2	0.4000	0.1000	No Design
8	1696	1824	1818	1.9600	1.4200	No Design
9	1697	1818	1815	1.3500	0.6400	No Design
10	1698	1815	1814	0.5300	0.2000	No Design
11	1699	1814	1811	0.2000	0.0900	No Design
12	1700	1811	CR4	0.0900	-0.1100	No Design
13	1701	1812	1810	0.5000	0.2500	No Design
14	1702	1813	1812	0.8000	0.5000	No Design
15	1704	1832	1831	8.8000	7.3200	No Design
16	1705	1831	1822	7.3200	5.6000	No Design
17	1707	1850	CR6	0.1000	0.0000	No Design
18	1709	1833	1834	7.1600	7.0900	No Design
19	1710	1834	1836	7.0600	6.5300	No Design
20	1711	6023	1836	7.0000	6.9300	No Design
21	1712	1836	1837	6.5100	5.6300	No Design
22	1713	1837	1844	5.6300	4.4000	No Design
23	1715	1844	1846	4.4000	3.8600	No Design
24	1716	1846	1847	3.8600	3.6900	No Design
25	1718	1847	6002	3.6900	3.6900	No Design
26	1719	1852	1853	3.5800	3.5600	No Design
27	1720	1853	1854	3.5600	2.2300	No Design
28	1726	1841	1840	3.0300	2.4200	No Design
29	1727	1840	1815	2.4200	1.8200	No Design
30	1736	1838	1839	5.4500	5.0900	No Design
31	1737	1839	1821	5.0400	4.0500	No Design
32	1738	1821	1820	3.9200	3.6100	No Design

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33	1739	1820	1819	3.5500	3.2600	No Design
34	1742	1819	1818	3.1600	1.4200	No Design
35	1746	1822	1823	5.6000	3.4600	No Design
36	1747	1823	1824	3.4600	2.0600	No Design
37	1767	1884	1883	61.1500	60.7500	No Design
38	1768	1883	1881	60.7400	60.1900	No Design
39	1770	1881	1878	60.1700	56.9800	No Design
40	1772	1878	1879	56.8400	53.5700	No Design
41	1773	1880	1879	53.9200	53.6200	No Design
42	1774	1879	1874	53.5500	50.7900	No Design
43	1775	1874	1873	50.7100	50.4300	No Design
44	1776	1873	6004	50.4000	49.5000	No Design
45	1779	1871	1870	8.5900	7.6500	No Design
46	1780	1872	1871	9.5000	9.1400	No Design
47	1781	1870	1869	7.6500	7.6500	No Design
48	1782	1868	1869	7.9200	7.6500	No Design
49	1783	1869	1866	7.6500	7.0000	No Design
50	1784	1867	1866	7.4700	7.0000	No Design
51	1785	1866	1865	7.0000	6.5300	No Design
52	1786	1865	1861	6.5300	5.8800	No Design
53	1787	1861	1860	5.8800	5.6100	No Design
54	1789	1870	1864	7.6500	5.5300	No Design
55	1790	1864	1862	5.3800	4.6200	No Design
56	1791	1862	1856	4.6200	3.9000	No Design
57	1792	1856	6038	3.7900	3.7400	No Design
58	1793	6002	1855	3.6900	3.6500	No Design
59	1795	1857	1858	4.3400	3.8800	No Design
60	1796	1859	1858	5.9200	4.6000	No Design
61	5005	6035	CR3	0.5000	0.2000	No Design
62	5006	1810	CR5	0.2500	-0.1100	No Design
63	5009	6034	1813	1.1920	0.8000	No Design
64	5010	6005	1832	9.1300	8.8000	No Design
65	5011	6006	1832	9.1500	8.8000	No Design
66	5014	6014	6044	48.5000	46.0000	No Design
67	5015	6019	6020	47.0000	46.8000	No Design
68	5016	6021	6022	45.8000	45.4800	No Design
69	5018	6003	1880	54.0000	53.9200	No Design
70	5021	6027	1871	9.4500	8.6400	No Design
71	5022	1860	6017	5.6000	5.0000	No Design
72	5023	6017	1856	5.0000	3.9000	No Design
73	5024	1855	6038	3.6500	3.6500	No Design
74	5026	6031	6039	3.7500	3.6000	No Design
75	5027	6039	6032	3.6000	2.0000	No Design
76	5029	1854	6032	2.2300	2.2000	No Design
77	5030	1857	6001	4.3000	4.1400	No Design
78	5031	6001	6041	4.1100	3.7500	No Design
79	5032	6008	CR8	3.5000	3.0000	No Design
80	5033	6042	6043	3.8100	3.7000	No Design
81	5034	6002	1852	3.6900	3.6500	No Design

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82	5035	6020	6044	46.7000	46.3000	No Design
83	Link232	6038	6031	3.7400	3.7100	No Design
84	Link233	6031	6041	3.7500	3.7500	No Design
85	5025	6041	6039	3.7500	3.6000	No Design
86	Link236	6048	CR10	2.0000	0.5000	No Design
87	Link237	Node274	6005	46.0000	10.0000	No Design
88	Link238	6004	6019	49.5000	47.0000	No Design
89	Link239	6045	6014	49.5000	48.5000	No Design
90	5028	6032	CR7	2.0000	1.8000	No Design
91	Link242	6046	6003	54.0440	54.0000	No Design
92	Link243	6022	6006	45.4800	10.0000	No Design
93	Link244	6044	6021	46.0000	45.8000	No Design
94	Link245	Node275	Node274	49.5000	46.0000	No Design
95	Link252	Node292	6027	29.0000	9.4500	No Design
96	Link253	Node279	Node280	42.0000	40.0000	No Design
97	Link257	Node282	Node279	64.0000	42.0000	No Design
98	Link258	Node280	Diversion	40.0000	29.0000	No Design
99	Link259	Node289	6042	29.0000	3.8100	No Design
100	Link260	6043	CR9	3.7000	0.5000	No Design
101	Link261	Node284	Node285	58.0000	35.0000	No Design
102	Link262	Node285	6042	35.0000	3.8100	No Design
103	Link263	Node286	6048	23.0000	2.0000	No Design

```
*==========================================*
|            Orifice Data                  |
*==========================================*
```

Orifice Name	From Junction	To Junction	Type	Area (m2)	Depth (m)	Discharge Coefficient	Height Above Junction (m)
Low Flow.1	Diversion	Node289	Rect Side	0.18	0.30	0.600	0.000

```
====> EQUIVALENT PIPE INFORMATION FOR ORIFICE            1
      CONDUIT NAME..........................       Low Flow.1
      Upstream node..........................       Diversion
      Downstream node........................         Node289
      PIPE DIAMETER.......................               0.30
      PIPE LENGTH.........................             300.00
      MANNINGS ROUGHNESS..................             0.0047
      INVERT ELEVATION AT UPSTREAM END.....           29.0000
      INVERT ELEVATION AT DOWNSTREAM END...           28.9970
```

Note: For a Bottom-outlet orifice the invert elevation of the downstream node will be adjusted to accomodate the equivalent conduit. Conduit grades are not affected.

```
*============================================*
|                Weir Data                   |
```

Campbell River / Quinsam River ISMP
XP-SWMM Modeling Results

==

Weir Name	From Junction	To Junction	Type	Crest Height(ft)	Weir Top (m)	Weir Length (m)	Discharge Coefficient	Weir Power
High Flow.1	Diversion	Node292	1	0.30	5.00	1.50	1.7000	1.5000

==
| FREE OUTFALL DATA (DATA GROUP I1) |
| BOUNDARY CONDITION ON DATA GROUP J1 |
==

Outfall at Junction....CR7 has boundary condition number... 1
Outfall at Junction....CR1 has boundary condition number... 2
Outfall at Junction....CR2 has boundary condition number... 3
Outfall at Junction....CR3 has boundary condition number... 4
Outfall at Junction....CR4 has boundary condition number... 5
Outfall at Junction....CR5 has boundary condition number... 6
Outfall at Junction....CR6 has boundary condition number... 7
Outfall at Junction....CR8 has boundary condition number... 8
Outfall at Junction....CR9 has boundary condition number... 9
Outfall at Junction....CR10 has boundary condition number... 10

==
| Table E9 - JUNCTION SUMMARY STATISTICS |
| The Maximum area is only the area of the node, it |
| does not include the area of the surrounding conduits|
==

Junction Name	Ground Elevation meters	Uppermost PipeCrown Elevation meters	Maximum Junction Elevation meters	Time of Occurence Hr.	Min.	Meters of Surcharge at Max Elevation	Freeboard of node meters	Maximum Junction Area m^2	Maximum Gutter Depth meters	Maximum Gutter Width meters	Maximum Gutter Velocity m/s
1802	2.8200	1.5200	1.5147	8	0	0.0000	1.3053	1.2200	0.0000	0.0000	0.0000
1803	2.4600	1.3200	1.4792	8	0	0.1592	0.9808	1.2200	0.0000	0.0000	0.0000
1804	2.2900	1.1500	1.4735	8	0	0.3235	0.8165	1.2200	0.0000	0.0000	0.0000
1805	2.2300	1.0900	1.4624	8	0	0.3724	0.7676	1.2200	0.0000	0.0000	0.0000
1806	2.1500	1.0100	1.4480	8	0	0.4380	0.7020	1.2200	0.0000	0.0000	0.0000
1808	2.8000	1.5750	1.4036	8	0	0.0000	1.3964	1.2200	0.0000	0.0000	0.0000
1809	2.5900	1.4500	1.4025	8	0	0.0000	1.1875	1.2200	0.0000	0.0000	0.0000
1810	1.7500	0.8500	1.4219	31	3	0.5719	0.3281	1.2200	0.0000	0.0000	0.0000
1811	1.8400	1.0050	1.6388	8	0	0.6338	0.2012	1.2200	0.0000	0.0000	0.0000
1812	1.7500	1.1000	1.4354	31	7	0.3354	0.3146	1.2200	0.0000	0.0000	0.0000
1813	1.7500	1.4000	1.4072	31	10	0.0072	0.3428	1.2200	0.0000	0.0000	0.0000
1814	1.9500	1.1150	1.8342	8	0	0.7192	0.1158	1.2200	0.0000	0.0000	0.0000

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1815	2.9300	2.2000	2.3050	8	0	0.1050	0.6250	1.2200	0.0000	0.0000	0.0000
1818	3.1000	2.1100	2.6329	7	56	0.5229	0.4671	1.2200	0.0000	0.0000	0.0000
1819	4.9100	3.8700	3.2297	7	48	0.0000	1.6803	1.2200	0.0000	0.0000	0.0000
1820	5.3000	4.2200	3.7385	8	0	0.0000	1.5615	1.2200	0.0000	0.0000	0.0000
1821	5.6700	4.5300	4.0409	7	43	0.0000	1.6291	1.2200	0.0000	0.0000	0.0000
1822	8.3500	6.2100	5.8961	8	1	0.0000	2.4539	1.2200	0.0000	0.0000	0.0000
1823	5.2100	4.0700	3.8341	8	0	0.0000	1.3759	1.2200	0.0000	0.0000	0.0000
1824	3.7100	2.6700	2.9108	8	0	0.2408	0.7992	1.2200	0.0000	0.0000	0.0000
1831	9.0700	7.9300	7.6432	8	0	0.0000	1.4268	1.2200	0.0000	0.0000	0.0000
1832	10.5500	9.4100	9.1226	8	0	0.0000	1.4274	1.2200	0.0000	0.0000	0.0000
1833	8.9100	7.5400	7.3450	8	0	0.0000	1.5650	1.2200	0.0000	0.0000	0.0000
1834	8.8100	7.4700	7.1812	8	0	0.0000	1.6288	1.2200	0.0000	0.0000	0.0000
1836	8.2600	7.3050	6.6254	8	0	0.0000	1.6346	1.2200	0.0000	0.0000	0.0000
1837	7.3800	6.3050	5.7608	8	0	0.0000	1.6192	1.2200	0.0000	0.0000	0.0000
1838	7.2000	5.8300	5.4500	0	0	0.0000	1.7500	1.2200	0.0000	0.0000	0.0000
1839	6.7900	5.4700	5.1570	8	0	0.0000	1.6330	1.2200	0.0000	0.0000	0.0000
1840	4.1700	2.8000	2.5644	8	0	0.0000	1.6056	1.2200	0.0000	0.0000	0.0000
1841	4.7800	3.4100	3.1382	7	49	0.0000	1.6418	1.2200	0.0000	0.0000	0.0000
1844	6.1500	5.0750	4.5813	8	0	0.0000	1.5687	1.2200	0.0000	0.0000	0.0000
1846	5.6100	4.7600	4.2658	8	0	0.0000	1.3442	1.2200	0.0000	0.0000	0.0000
1847	5.4400	4.5900	4.2474	8	0	0.0000	1.1926	1.2200	0.0000	0.0000	0.0000
1850	1.7500	0.4000	1.4078	8	0	1.0078	0.3422	1.2200	0.0000	0.0000	0.0000
1852	5.3300	4.5500	4.1181	8	0	0.0000	1.2119	1.2200	0.0000	0.0000	0.0000
1853	5.3100	4.4600	3.7951	8	0	0.0000	1.5149	1.2200	0.0000	0.0000	0.0000
1854	3.9800	3.1300	2.6937	8	0	0.0000	1.2863	1.2200	0.0000	0.0000	0.0000
1855	5.4000	4.2600	4.2732	8	1	0.0132	1.1268	1.2200	0.0000	0.0000	0.0000
1856	5.5900	5.1000	4.3836	8	1	0.0000	1.2064	1.2200	0.0000	0.0000	0.0000
1857	6.0300	4.8650	4.5287	8	0	0.0000	1.5013	1.2200	0.0000	0.0000	0.0000
1858	5.4900	4.9750	4.5829	8	0	0.0000	0.9071	1.2200	0.0000	0.0000	0.0000
1859	6.9200	6.2950	6.0301	8	0	0.0000	0.8899	1.2200	0.0000	0.0000	0.0000
1860	7.3600	6.8000	5.8545	8	1	0.0000	1.5055	1.2200	0.0000	0.0000	0.0000
1861	7.6300	6.7800	6.1670	8	0	0.0000	1.4630	1.2200	0.0000	0.0000	0.0000
1862	6.3700	5.8200	4.9935	8	0	0.0000	1.3765	1.2200	0.0000	0.0000	0.0000
1864	7.1300	6.5800	5.7434	8	0	0.0000	1.3866	1.2200	0.0000	0.0000	0.0000
1865	8.2800	7.4300	6.7177	8	0	0.0000	1.5623	1.2200	0.0000	0.0000	0.0000
1866	8.7500	7.9000	7.2080	8	0	0.0000	1.5420	1.2200	0.0000	0.0000	0.0000
1867	9.2200	7.8450	7.5393	8	0	0.0000	1.6807	1.2200	0.0000	0.0000	0.0000
1868	9.6700	8.3200	7.9879	8	0	0.0000	1.6821	1.2200	0.0000	0.0000	0.0000
1869	9.4000	8.5500	7.8146	8	0	0.0000	1.5854	1.2200	0.0000	0.0000	0.0000
1870	9.4000	8.8500	7.9617	8	0	0.0000	1.4383	1.2200	0.0000	0.0000	0.0000
1871	10.3400	9.8400	8.9364	8	0	0.0000	1.4036	1.2200	0.0000	0.0000	0.0000
1872	10.8900	10.1750	9.6460	8	0	0.0000	1.2440	1.2200	0.0000	0.0000	0.0000
1873	52.1500	50.9550	50.7325	8	0	0.0000	1.4175	1.2200	0.0000	0.0000	0.0000
1874	52.4600	51.2400	51.0475	8	0	0.0000	1.4125	1.2200	0.0000	0.0000	0.0000
1878	58.5900	57.4300	56.9827	8	0	0.0000	1.6073	1.2200	0.0000	0.0000	0.0000
1879	55.3200	54.0700	53.7762	8	0	0.0000	1.5438	1.2200	0.0000	0.0000	0.0000
1880	55.6700	55.6700	54.1781	8	0	0.0000	1.4919	1.2200	0.0000	0.0000	0.0000
1881	61.9200	60.6200	60.3064	8	0	0.0000	1.6136	1.2200	0.0000	0.0000	0.0000
1883	62.4900	61.1250	60.9521	8	1	0.0000	1.5379	1.2200	0.0000	0.0000	0.0000

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1884	62.9000	61.5250	61.3738	8	0	0.0000	1.5262	1.2200	0.0000	0.0000	0.0000
6001	5.8500	4.7100	4.2727	8	0	0.0000	1.5773	1.2200	0.0000	0.0000	0.0000
6002	5.4000	4.5900	4.2294	8	0	0.0000	1.1706	1.2200	0.0000	0.0000	0.0000
6003	55.7500	55.7500	54.2472	8	0	0.0000	1.5028	1.2200	0.0000	0.0000	0.0000
6004	51.2500	51.2500	49.6577	8	1	0.0000	1.5923	1.2200	0.0000	0.0000	0.0000
6005	11.7500	11.5000	9.2644	8	0	0.0000	2.4856	1.2200	0.0000	0.0000	0.0000
6006	11.5000	11.5000	9.5072	8	2	0.0000	1.9928	1.2200	0.0000	0.0000	0.0000
6008	5.2500	3.8000	3.5738	8	0	0.0000	1.6762	1.2200	0.0000	0.0000	0.0000
6014	50.0000	50.0000	48.5642	8	0	0.0000	1.4358	1.2200	0.0000	0.0000	0.0000
6017	6.5500	6.2000	5.1888	8	0	0.0000	1.3612	1.2200	0.0000	0.0000	0.0000
6019	51.0000	48.7500	47.3362	8	1	0.0000	3.6638	1.2200	0.0000	0.0000	0.0000
6020	48.4500	47.5500	46.9824	8	1	0.0000	1.4676	1.2200	0.0000	0.0000	0.0000
6021	47.3000	47.3000	46.1975	8	1	0.0000	1.1025	1.2200	0.0000	0.0000	0.0000
6022	47.5000	46.9800	45.5953	8	2	0.0000	1.9047	1.2200	0.0000	0.0000	0.0000
6023	8.7500	7.3750	7.1261	8	0	0.0000	1.6239	1.2200	0.0000	0.0000	0.0000
6027	11.2000	10.6500	9.7515	8	5	0.0000	1.4485	1.2200	0.0000	0.0000	0.0000
6031	5.5000	4.9100	4.2535	8	1	0.0000	1.2465	1.2200	0.0000	0.0000	0.0000
6032	4.1000	4.1000	2.5342	8	1	0.0000	1.5658	1.2200	0.0000	0.0000	0.0000
6034	2.9500	1.7920	1.4086	31	9	0.0000	1.5414	1.2200	0.0000	0.0000	0.0000
6035	1.7500	0.8000	1.4593	47	18	0.6593	0.2907	1.2200	0.0000	0.0000	0.0000
6038	5.6500	4.9400	4.2998	8	1	0.0000	1.3502	1.2200	0.0000	0.0000	0.0000
6039	5.3500	5.2000	3.7455	8	1	0.0000	1.6045	1.2200	0.0000	0.0000	0.0000
CR7	3.9000	3.9000	2.1714	8	1	0.0000	1.7286	1.2200	0.0000	0.0000	0.0000
6041	6.0000	4.7500	4.2050	8	1	0.0000	1.7950	1.2200	0.0000	0.0000	0.0000
6042	7.0000	5.3100	4.2039	8	11	0.0000	2.7961	1.2200	0.0000	0.0000	0.0000
6043	7.0000	5.2000	3.9521	8	8	0.0000	3.0479	1.2200	0.0000	0.0000	0.0000
6044	48.0000	47.5000	46.2372	8	1	0.0000	1.7628	1.2200	0.0000	0.0000	0.0000
6045	51.0000	51.0000	49.6013	8	0	0.0000	1.3987	1.2200	0.0000	0.0000	0.0000
6046	55.8000	55.7940	54.2587	8	0	0.0000	1.5413	1.2200	0.0000	0.0000	0.0000
6048	3.7500	3.0000	2.2770	8	0	0.0000	1.4730	1.2200	0.0000	0.0000	0.0000
CR1	2.3000	1.1600	1.4000	0	0	0.2400	0.9000	1.2200	0.0000	0.0000	0.0000
CR2	1.8400	0.7100	1.4000	0	0	0.6900	0.4400	1.2200	0.0000	0.0000	0.0000
CR3	1.7500	0.5000	1.4000	0	0	0.9000	0.3500	1.2200	0.0000	0.0000	0.0000
CR4	1.7500	0.7400	1.4000	0	0	0.6600	0.3500	1.2200	0.0000	0.0000	0.0000
CR5	1.7500	0.4900	1.4000	0	0	0.9100	0.3500	1.2200	0.0000	0.0000	0.0000
CR6	1.8500	0.3000	1.4000	0	0	1.1000	0.4500	1.2200	0.0000	0.0000	0.0000
CR8	4.7500	3.3000	3.0673	8	0	0.0000	1.6827	1.2200	0.0000	0.0000	0.0000
CR9	1.7500	1.5000	1.4000	0	0	0.0000	0.3500	1.2200	0.0000	0.0000	0.0000
CR10	2.0000	1.2000	1.4000	0	0	0.2000	0.6000	1.2200	0.0000	0.0000	0.0000
Node274	47.5000	47.5000	46.0457	8	0	0.0000	1.4543	1.2200	0.0000	0.0000	0.0000
Node275	51.0000	51.0000	49.6030	8	0	0.0000	1.3970	1.2200	0.0000	0.0000	0.0000
Node279	47.0000	43.8000	42.4203	8	0	0.0000	4.5797	1.2200	0.0000	0.0000	0.0000
Node280	45.0000	41.8000	40.1680	8	1	0.0000	4.8320	1.2200	0.0000	0.0000	0.0000
Node282	66.0000	65.0000	64.2567	8	0	0.0000	1.7433	1.2200	0.0000	0.0000	0.0000
Node284	60.0000	59.0000	58.0896	8	0	0.0000	1.9104	1.2200	0.0000	0.0000	0.0000
Node285	37.0000	36.0000	35.1667	8	0	0.0000	1.8333	1.2200	0.0000	0.0000	0.0000
Node286	25.0000	24.0000	23.0918	8	0	0.0000	1.9082	1.2200	0.0000	0.0000	0.0000
Node289	34.0000	30.0000	29.1503	8	0	0.0000	4.8497	1.2200	0.0000	0.0000	0.0000
Diversion	34.0000	30.0000	29.6479	8	1	0.0000	4.3521	1.2200	0.0000	0.0000	0.0000

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Node292	34.0000	30.0000	29.1342	8	2	0.0000	4.8658	1.2200	0.0000	0.0000	0.0000

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*=====================================================*
|        Table E10 - CONDUIT SUMMARY STATISTICS       |
| Note: The peak flow may be less than the design flow |
| and the conduit may still surcharge because of the   |
| downstream boundary conditions.                      |
|                                                      |
| * denotes an open conduit that has been overtopped   |
|   this is a potential source of severe errors        |
*=====================================================*
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Conduit Name	Design Flow (cms)	Conduit Design Velocity (m/s)	Maximum Vertical Depth (mm)	Maximum Computed Flow (cms)	Time of Occurence Hr.	Min.	Maximum Computed Velocity (m/s)	Time of Occurence Hr.	Min.	Ratio of Max. to Design Flow	Maximum Water Elev at Pipe Ends Upstream (m)	Dwnstrm (m)	Ratio d/D US	DS	
1686	0.2464	1.1382	525.0000	0.0143	8	0	0.0886	8	1	0.0582	1.4036	1.4025	0.674	1.071	
1687	0.4054	1.3870	610.0000	0.0317	8	0	0.1122	8	0	0.0783	1.4025	1.4000	0.922	1.393	
1691	0.1486	0.9342	450.0000	0.0462	8	1	0.2921	8	1	0.3112	1.5147	1.4792	0.988	1.576	
1692	0.3450	1.1806	610.0000	0.0463	8	0	0.1582	8	0	0.1342	1.4792	1.4735	1.261	1.530	
1693	0.2095	0.7170	610.0000	0.0685	8	0	0.2336	8	0	0.3269	1.4735	1.4624	1.530	1.610	
1694	0.2795	0.9562	610.0000	0.0853	8	0	0.2908	8	0	0.3054	1.4624	1.4479	1.610	1.718	
1695	0.3123	1.0688	610.0000	0.1095	8	0	0.3728	8	0	0.3505	1.4480	1.4000	1.718	2.131	
1696	0.8164	2.2154	685.0000	0.4410	7	56	1.5287	11	12	0.5402	2.9108	2.6329	1.388	1.771	
1697	0.8937	1.9700	760.0000	0.4973	7	56	1.0913	7	56	0.5565	2.6329	2.3050	1.688	2.191	
1698	0.5402	1.1909	760.0000	0.5577	8	1	1.2190	8	1	1.0323	2.3050	1.8342	2.335	2.150	
1699	0.5536	0.8419	915.0000	0.5907	8	0	0.8939	8	0	1.0670	1.8342	1.6388	1.786	1.693	
1700	0.6932	1.2216	850.0000	0.6036	8	0	1.0582	8	0	0.8708	1.6388	1.4000	1.822	1.776	
1701	0.3380	1.1955	600.0000	0.0214	8	0	0.0756	8	0	0.0634	1.4334	1.4215	1.556	1.952	
1702	0.4103	1.4512	600.0000	0.0214	8	0	0.0755	8	0	0.0523	1.4072	1.4354	1.012	1.559	
1704	0.8005	2.7391	610.0000	0.3613	8	0	2.3031	8	1	0.4513	9.1226	7.6432	0.529	0.530	
1705	0.8300	2.8402	610.0000	0.3731	8	0	2.3989	8	1	0.4495	7.6432	5.8961	0.530	0.485	
1707	0.0670	0.2030	300.0000	0.0187	8	0	0.0566	8	0	0.2786	1.4078	1.4000	4.359	4.667	*
1709	0.0654	0.5765	380.0000	0.0284	8	0	0.5424	8	0	0.4347	7.3450	7.2100	0.487	0.316	
1710	0.2135	1.6991	400.0000	0.0352	8	0	1.1093	8	1	0.1649	7.1812	6.6398	0.303	0.274	
1711	0.1169	1.0583	375.0000	0.0203	8	0	0.6404	8	0	0.1740	7.1261	7.0313	0.336	0.270	
1712	0.9275	2.5919	675.0000	0.0555	8	0	1.3356	8	1	0.0599	6.6254	5.7608	0.171	0.194	
1713	0.8521	2.3813	675.0000	0.0701	8	0	1.3581	7	22	0.0823	5.7608	4.5813	0.194	0.269	
1715	0.5474	1.5296	675.0000	0.0841	8	0	0.9313	7	17	0.1537	4.5813	4.2658	0.269	0.601	
1716	1.0277	1.6155	900.0000	0.1152	8	0	0.5195	2	22	0.1121	4.2658	4.2474	0.451	0.619	
1718	0.0532	0.0000	900.0000	0.1360	8	0	0.3390	7	18	2.5579	4.2474	4.2294	0.619	0.599	
1719	0.2736	0.4301	900.0000	0.3213	8	0	0.8676	8	1	1.1744	4.1181	3.7951	0.598	0.261	
1720	2.4503	3.8516	900.0000	0.3301	8	0	2.1682	8	1	0.1347	3.7951	2.6937	0.261	0.515	
1726	0.1802	1.5885	380.0000	0.0306	8	0	1.0997	7	36	0.1699	3.1382	2.5644	0.285	0.380	
1727	0.1796	1.5837	380.0000	0.0477	7	54	1.1953	7	5	0.2658	2.5644	2.3050	0.380	1.276	
1736	0.0654	0.5770	380.0000	0.0000	0	0	0.0000	0	0	0.0000	5.4500	5.1570	.0000	.0000	
1737	0.1627	1.4345	380.0000	0.0308	8	0	1.0445	8	0	0.1893	5.1570	4.1618	0.308	0.294	
1738	0.3873	1.3252	610.0000	0.0308	7	44	0.7448	7	43	0.0795	4.0409	3.7385	0.198	0.211	

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1739	0.3666	1.2545	610.0000	0.0601	7	52	0.8055	7	43	0.1639	3.7385	3.4138	0.309	0.252
1742	2.1628	7.4004	610.0000	0.0752	7	44	3.7071	0	27	0.0348	3.2297	2.6329	0.114	1.988
1746	0.8722	2.9846	610.0000	0.3730	8	1	2.5661	8	2	0.4276	5.8961	3.8341	0.485	0.613
1747	0.8719	2.9833	610.0000	0.4176	8	1	2.3792	9	0	0.4790	3.8341	2.9108	0.613	1.395
1767	0.1406	1.2727	375.0000	0.0775	8	0	1.1440	8	1	0.5515	61.3738	60.9521	0.597	0.539
1768	0.1624	1.4700	375.0000	0.0773	8	1	1.2214	8	2	0.4760	60.9521	60.3722	0.566	0.486
1770	0.6130	3.8545	450.0000	0.1047	8	0	2.5981	8	0	0.1708	60.3064	57.1058	0.303	0.280
1772	0.5600	3.5211	450.0000	0.1208	8	0	2.6194	8	0	0.2156	56.9827	53.7762	0.317	0.458
1773	0.2491	1.5662	450.0000	0.1034	8	0	1.1267	8	1	0.4152	54.1781	53.8221	0.574	0.449
1774	0.5293	3.3281	450.0000	0.2346	8	0	2.8790	8	1	0.4431	53.7762	51.0475	0.503	0.572
1775	0.9108	4.2072	525.0000	0.2583	8	0	1.7779	8	0	0.2836	51.0475	50.7325	0.643	0.576
1776	0.6406	2.9593	525.0000	0.2583	8	0	1.9058	8	1	0.4031	50.7325	49.6577	0.633	0.300
1779	5.1185	4.5257	1200.000	0.5979	8	0	2.2405	8	1	0.1168	8.9364	7.9617	0.289	0.260
1780	0.4226	1.1808	675.0000	0.0339	8	0	0.6155	7	20	0.0803	9.6460	9.2516	0.216	0.165
1781	0.0532	0.0000	900.0000	0.1169	8	1	0.6356	8	1	2.2000	7.9617	7.8146	0.346	0.183
1782	0.2437	1.9394	400.0000	0.0146	8	0	0.8557	7	12	0.0597	7.9879	7.8146	0.170	0.412
1783	2.1702	3.4113	900.0000	0.1314	8	0	1.5817	8	0	0.0606	7.8146	7.2080	0.183	0.231
1784	0.2561	2.3184	375.0000	0.0192	8	0	1.0535	6	6	0.0748	7.5393	7.2080	0.185	0.555
1785	1.6548	2.6012	900.0000	0.1505	8	0	1.3701	8	1	0.0910	7.2080	6.7177	0.231	0.209
1786	1.7708	2.7835	900.0000	0.1505	8	0	1.4463	8	1	0.0850	6.7177	6.1670	0.209	0.319
1787	0.9183	1.4434	900.0000	0.1600	8	1	0.9350	8	2	0.1743	6.1670	5.8545	0.319	0.272
1789	2.9635	3.4224	1050.000	0.4807	8	0	2.2575	8	1	0.1622	7.9617	5.8156	0.297	0.272
1790	2.9712	2.6271	1200.000	0.4920	8	0	1.6942	8	2	0.1656	5.7434	4.9935	0.303	0.311
1791	2.9846	2.6390	1200.000	0.5206	8	0	1.6627	8	1	0.1744	4.9935	4.3836	0.311	0.403
1792	2.2539	1.0435	1200.000	0.7343	8	1	0.6912	8	1	0.3258	4.3836	4.2998	0.495	0.466
1793	0.1885	0.6452	610.0000	-0.1653	8	5	-0.5714	8	12	-0.8769	4.2294	4.2732	0.884	1.022
1795	0.3023	1.3962	525.0000	-0.0587	8	0	-0.2903	8	0	-0.1943	4.5829	4.5287	0.463	1.236
1796	0.1540	1.3945	375.0000	0.0274	8	0	1.0154	8	0	0.1777	6.0301	4.7069	0.294	0.285
5005	0.0533	0.7547	300.0000	0.0090	30	4	0.1258	30	4	0.1687	1.4593	1.4000	3.198	4.000
5006	0.4732	1.6735	600.0000	0.0332	8	0	0.1168	8	0	0.0702	1.4215	1.4000	1.952	2.517
5009	0.4033	1.4264	600.0000	-0.0119	31	8	-0.0449	31	8	-0.0295	1.4086	1.4071	0.361	1.012
5010	0.3744	2.3541	450.0000	0.0530	8	0	1.1071	7	31	0.1414	9.2644	9.1226	0.299	0.717
5011	0.8108	2.8676	600.0000	0.3011	8	2	1.7367	8	4	0.3713	9.5072	9.1226	0.595	0.538
5014	0.7426	5.9092	400.0000	0.0415	8	0	4.0448	0	25	0.0559	48.5642	46.2372	0.160	0.593
5015	1.3973	3.1628	750.0000	0.2580	8	1	1.4080	7	15	0.1846	47.3362	47.0180	0.448	0.291
5016	1.8870	4.2712	750.0000	0.2990	8	1	1.3719	8	6	0.1585	46.1975	45.5953	0.530	0.154
5018	9.2425	1.3204	1750.000	0.0984	8	0	0.3977	8	0	0.0106	54.2472	54.1781	0.141	0.147
5021	5.6825	5.0245	1200.000	0.5223	8	0	2.3591	8	0	0.0919	9.7515	8.9364	0.251	0.247
5022	1.2277	1.0231	1200.000	0.1655	8	1	0.6675	8	1	0.1348	5.8545	5.1888	0.212	0.157
5023	2.0806	1.7338	1200.000	0.2069	8	0	0.9479	8	0	0.0994	5.1888	4.3836	0.157	0.403
5024	0.0188	0.0000	610.0000	-0.1606	8	8	-0.5403	8	13	-8.5220	4.2732	4.2998	1.022	1.065
5026	0.7246	1.1390	900.0000	0.3301	8	1	0.9818	8	1	0.4556	4.2535	3.7455	0.559	0.162
5027	16.1398	5.6041	1600.000	0.6514	8	1	1.9630	8	1	0.0404	3.7455	2.5342	0.091	0.334
5029	1.2065	1.8965	900.0000	0.3359	8	0	1.0532	8	0	0.2784	2.6937	2.5342	0.515	0.371
5030	0.2291	1.0581	525.0000	0.0705	8	0	0.8037	8	0	0.3080	4.5287	4.3146	0.436	0.333
5031	0.5690	2.0124	600.0000	0.0705	8	0	0.9425	6	19	0.1240	4.2727	4.2050	0.271	0.758
5032	0.0669	0.9468	300.0000	0.0081	8	0	0.6087	8	0	0.1213	3.5738	3.0673	0.246	0.224
5033	5.8344	2.1609	1500.000	0.8144	8	11	1.1915	8	12	0.1396	4.2039	3.9521	0.263	0.168
5034	0.4674	0.7347	900.0000	0.3071	8	1	0.7844	8	1	0.6572	4.2294	4.1181	0.599	0.520

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5035	1.9190	4.3438	750.0000	0.2580	8	2	1.7752	8	3	0.1345	46.9824	46.4854	0.376	0.247
Link232	2.1224	0.9826	1200.000	0.5746	8	1	0.5719	8	2	0.2707	4.2998	4.2535	0.466	0.453
Link233	0.0704	0.0000	1000.000	0.2448	8	3	0.6276	8	6	3.4778	4.2535	4.2050	0.503	0.455
5025	0.9887	1.2589	1000.000	0.3148	8	1	0.9836	8	1	0.3184	4.2050	3.7455	0.455	0.145
Link236	1.0533	2.7370	700.0000	0.2854	8	0	1.7177	8	0	0.2709	2.2770	1.4000	0.396	1.286
Link237	42.5308	6.3009	1500.000	0.0530	8	0	2.6588	0	23	0.0012	46.0457	10.0315	0.030	0.021
Link238	37.0144	4.7002	1750.000	0.2582	8	1	1.3838	0	24	0.0070	49.6577	47.3362	0.090	0.192
Link239	4.6551	1.2414	1500.000	0.0279	8	0	0.2598	8	0	0.0060	49.6013	48.5642	0.068	0.043
5028	14.4354	4.1677	2100.000	0.9967	8	1	1.4950	8	1	0.0690	2.5342	2.1714	0.254	0.177
Link242	9.1913	1.3130	1750.000	0.0429	8	0	0.2310	6	18	0.0047	54.2587	54.2472	0.123	0.141
Link243	42.2225	6.2552	1500.000	0.3011	8	2	2.3757	0	24	0.0071	45.5953	10.1134	0.077	0.076
Link244	18.6199	2.7585	1500.000	0.2990	8	1	1.6317	0	25	0.0161	46.2372	46.1975	0.158	0.265
Link245	8.7089	2.3224	1500.000	0.0486	8	0	0.8575	0	24	0.0056	49.6030	46.0457	0.069	0.030
Link252	18.7252	5.3500	1000.000	0.5232	8	2	1.5407	8	1	0.0279	29.1342	9.7515	0.134	0.301
Link253	11.0937	4.3596	1800.000	0.8118	8	0	1.9379	8	1	0.0732	42.4203	40.1680	0.233	0.093
Link257	8.3039	2.3725	1000.000	0.7009	8	0	1.2931	0	24	0.0844	64.2567	42.4203	0.257	0.420
Link258	19.8639	5.6754	1000.000	0.8118	8	1	5.9960	0	25	0.0409	40.1680	29.6479	0.168	0.648
Link259	10.8958	3.1131	1000.000	0.3688	8	0	0.9251	7	30	0.0339	29.1503	4.2039	0.150	0.394
Link260	9.7933	2.1763	1000.000	0.8668	8	8	0.7485	8	8	0.0885	3.9521	1.4000	0.252	0.900
Link261	14.1354	3.1412	1000.000	0.2192	8	0	2.2703	0	23	0.0155	58.0896	35.1667	0.090	0.167
Link262	10.9475	2.4328	1000.000	0.4817	8	0	0.7674	8	0	0.0440	35.1667	4.2039	0.167	0.394
Link263	10.3736	2.9639	1000.000	0.1529	8	0	2.4248	0	23	0.0147	23.0918	2.2770	0.092	0.277
Low Flow.1	0.2620	0.1467	300.0000	0.2883	8	1	1.6747	8	1	1.1004	29.6479	29.1503	2.160	0.511
High Flow.1	Undefnd	Undefnd	Undefn	0.5233	8	1								
FREE # 1	Undefnd	Undefnd	Undefn	0.9967	8	1								
FREE # 2	Undefnd	Undefnd	Undefn	0.0317	8	0								
FREE # 3	Undefnd	Undefnd	Undefn	0.1095	8	0								
FREE # 4	Undefnd	Undefnd	Undefn	-0.0107	29	53								
FREE # 5	Undefnd	Undefnd	Undefn	0.6036	8	0								
FREE # 6	Undefnd	Undefnd	Undefn	0.0332	8	0								
FREE # 7	Undefnd	Undefnd	Undefn	0.0187	8	0								
FREE # 8	Undefnd	Undefnd	Undefn	0.0081	8	0								
FREE # 9	Undefnd	Undefnd	Undefn	0.8668	8	8								
FREE #10	Undefnd	Undefnd	Undefn	0.2854	8	0								

Campbell River / Quinsam River ISMP
XP-SWMM Modeling Results

XP-SWMM Output
Future Conditions (with ponds), 2 year 24 hour storm
Tables E4, E9 and E10

Table E4 - Conduit Connectivity

Input Number	Conduit Name	Upstream Node	Downstream Node	Upstream Elevation	Downstream Elevation	
1	1686	1808	1809	1.0500	0.8400	No Design
2	1687	1809	CR1	0.8400	0.5500	No Design
3	1691	1802	1803	1.0700	0.7700	No Design
4	1692	1803	1804	0.7100	0.5400	No Design
5	1693	1804	1805	0.5400	0.4800	No Design
6	1694	1805	1806	0.4800	0.4000	No Design
7	1695	1806	CR2	0.4000	0.1000	No Design
8	1696	1824	1818	1.9600	1.4200	No Design
9	1697	1818	1815	1.3500	0.6400	No Design
10	1698	1815	1814	0.5300	0.2000	No Design
11	1699	1814	1811	0.2000	0.0900	No Design
12	1700	1811	CR4	0.0900	-0.1100	No Design
13	1701	1812	1810	0.5000	0.2500	No Design
14	1702	1813	1812	0.8000	0.5000	No Design
15	1704	1832	1831	8.8000	7.3200	No Design
16	1705	1831	1822	7.3200	5.6000	No Design
17	1707	1850	CR6	0.1000	0.0000	No Design
18	1709	1833	1834	7.1600	7.0900	No Design
19	1710	1834	1836	7.0600	6.5300	No Design
20	1711	6023	1836	7.0000	6.9300	No Design
21	1712	1836	1837	6.5100	5.6300	No Design
22	1713	1837	1844	5.6300	4.4000	No Design
23	1715	1844	1846	4.4000	3.8600	No Design
24	1716	1846	1847	3.8600	3.6900	No Design
25	1718	1847	6002	3.6900	3.6900	No Design
26	1719	1852	1853	3.5800	3.5600	No Design
27	1720	1853	1854	3.5600	2.2300	No Design
28	1726	1841	1840	3.0300	2.4200	No Design
29	1727	1840	1815	2.4200	1.8200	No Design
30	1736	1838	1839	5.4500	5.0900	No Design
31	1737	1839	1821	5.0400	4.0500	No Design
32	1738	1821	1820	3.9200	3.6100	No Design

Campbell River / Quinsam River ISMP
XP-SWMM Modeling Results

33	1739	1820	1819	3.5500	3.2600	No Design
34	1742	1819	1818	3.1600	1.4200	No Design
35	1746	1822	1823	5.6000	3.4600	No Design
36	1747	1823	1824	3.4600	2.0600	No Design
37	1767	1884	1883	61.1500	60.7500	No Design
38	1768	1883	1881	60.7400	60.1900	No Design
39	1770	1881	1878	60.1700	56.9800	No Design
40	1772	1878	1879	56.8400	53.5700	No Design
41	1773	1880	1879	53.9200	53.6200	No Design
42	1774	1879	1874	53.5500	50.7900	No Design
43	1775	1874	1873	50.7100	50.4300	No Design
44	1776	1873	6004	50.4000	49.5000	No Design
45	1779	1871	1870	8.5900	7.6500	No Design
46	1780	1872	1871	9.5000	9.1400	No Design
47	1781	1870	1869	7.6500	7.6500	No Design
48	1782	1868	1869	7.9200	7.6500	No Design
49	1783	1869	1866	7.6500	7.0000	No Design
50	1784	1867	1866	7.4700	7.0000	No Design
51	1785	1866	1865	7.0000	6.5300	No Design
52	1786	1865	1861	6.5300	5.8800	No Design
53	1787	1861	1860	5.8800	5.6100	No Design
54	1789	1870	1864	7.6500	5.5300	No Design
55	1790	1864	1862	5.3800	4.6200	No Design
56	1791	1862	1856	4.6200	3.9000	No Design
57	1792	1856	6038	3.7900	3.7400	No Design
58	1793	6002	1855	3.6900	3.6500	No Design
59	1795	1857	1858	4.3400	3.8800	No Design
60	1796	1859	1858	5.9200	4.6000	No Design
61	5005	6035	CR3	0.5000	0.2000	No Design
62	5006	1810	CR5	0.2500	-0.1100	No Design
63	5009	6034	1813	1.1920	0.8000	No Design
64	5010	6005	1832	9.1300	8.8000	No Design
65	5011	6006	1832	9.1500	8.8000	No Design
66	5014	6014	6044	48.5000	46.0000	No Design
67	5015	6019	6020	47.0000	46.8000	No Design
68	5016	6021	6022	45.8000	45.4800	No Design
69	5018	6003	1880	54.0000	53.9200	No Design
70	5021	6027	1871	9.4500	8.6400	No Design
71	5022	1860	6017	5.6000	5.0000	No Design
72	5023	6017	1856	5.0000	3.9000	No Design
73	5024	1855	6038	3.6500	3.6500	No Design
74	5026	6031	6039	3.7500	3.6000	No Design
75	5027	6039	6032	3.6000	2.0000	No Design
76	5029	1854	6032	2.2300	2.2000	No Design
77	5030	1857	6001	4.3000	4.1400	No Design
78	5031	6001	6041	4.1100	3.7500	No Design
79	5032	6008	CR8	3.5000	3.0000	No Design
80	5033	6042	6043	3.8100	3.7000	No Design
81	5034	6002	1852	3.6900	3.6500	No Design

Campbell River / Quinsam River ISMP
XP-SWMM Modeling Results

82	5035	6020	6044	46.7000	46.3000	No Design
83	Link232	6038	6031	3.7400	3.7100	No Design
84	Link233	6031	6041	3.7500	3.7500	No Design
85	5025	6041	6039	3.7500	3.6000	No Design
86	Link236	6048	CR10	2.0000	0.5000	No Design
87	Link237	Node274	6005	46.0000	10.0000	No Design
88	Link238	6004	6019	49.5000	47.0000	No Design
89	Link239	6045	6014	49.5000	48.5000	No Design
90	5028	6032	CR7	2.0000	1.8000	No Design
91	Link242	6046	6003	54.0440	54.0000	No Design
92	Link243	6022	6006	45.4800	10.0000	No Design
93	Link244	6044	6021	46.0000	45.8000	No Design
94	Link245	Node275	Node274	49.5000	46.0000	No Design
95	Link252	Node292	6027	29.0000	9.4500	No Design
96	Link253	Node279	Node280	42.0000	40.0000	No Design
97	Link257	Node295	Node279	64.0000	42.0000	No Design
98	Link258	Node280	Diversion	40.0000	29.0000	No Design
99	Link259	Node289	6042	29.0000	3.8100	No Design
100	Link260	6043	CR9	3.7000	0.5000	No Design
101	Link261	Node284	Node285	58.0000	35.0000	No Design
102	Link262	Node285	6042	35.0000	3.8100	No Design
103	Link263	Node297	6048	23.0000	2.0000	No Design
104	Area 1 Out	Node282	Node295	64.0000	64.0000	No Design
105	Area 7 Out	Node286	Node297	23.0000	23.0000	No Design
106	Area 2 Out	Node298	Node279	42.0000	42.0000	No Design
107	Area 8 Out	Node300	6048	2.0000	2.0000	No Design
108	Area 3 Out	Node302	Node289	29.0000	29.0000	No Design
109	Area 4 Out	Node304	Node285	35.0000	35.0000	No Design
110	Area 5 Out	Node306	Node285	35.0000	35.0000	No Design

```
*==========================================*
|          Storage Junction Data           |
*==========================================*
```

STORAGE JUNCTION NUMBER OR NAME	JUNCTION TYPE	MAXIMUM OR CONSTANT SURFACE AREA (M2)	PEAK OR CONSTANT VOLUME (CUBIC MET.)	CROWN ELEVATION (M)	DEPTH STARTS FROM
Node282	Constant	4800.0000	9600.0000	66.0000	Node Invert
Node286	Constant	2800.0000	5600.0000	25.0000	Node Invert
Node298	Constant	600.0000	3000.0000	47.0000	Node Invert
Node300	Constant	1100.0000	1925.0000	3.7500	Node Invert
Node302	Constant	1500.0000	7500.0000	34.0000	Node Invert
Node304	Constant	600.0000	1200.0000	37.0000	Node Invert
Node306	Constant	4500.0000	9000.0000	37.0000	Node Invert

```
*==========================================*
```

Campbell River / Quinsam River ISMP
XP-SWMM Modeling Results

```
|             Orifice Data                |
*=========================================*

         Orifice            From            To                  Area      Depth      Discharge  Height Above
            Name        Junction      Junction       Type       (m2)       (m)     Coefficient  Junction  (m)
---------------- --------------- ---------------      ----      -----      -----    -----------  -------------
      Low Flow.1       Diversion         Node289 Rect Side      0.18       0.30          0.600          0.000

====> EQUIVALENT PIPE INFORMATION FOR ORIFICE          1
      CONDUIT NAME..........................       Low Flow.1
      Upstream node..........................       Diversion
      Downstream node........................         Node289
      PIPE DIAMETER.......................             0.30
      PIPE LENGTH.........................           300.00
      MANNINGS ROUGHNESS..................           0.0047
      INVERT ELEVATION AT UPSTREAM END.....         29.0000
      INVERT ELEVATION AT DOWNSTREAM END...         28.9970

Note: For a Bottom-outlet orifice the invert elevation of the downstream node will be
      adjusted to accomodate the equivalent conduit.  Conduit grades are not affected.


*============================================*
|               Weir Data                    |
*============================================*

            Weir            From              To           Crest       Weir      Weir    Discharge         Weir
            Name        Junction        Junction  Type  Height(ft)   Top (m)  Length (m) Coefficient        Power
---------------- --------------- ---------------  ----  ----------   -------  ---------- ----------- -----------
     High Flow.1       Diversion         Node292     1        0.30      5.00        1.50      1.7000       1.5000


*=================================================*
|          FREE OUTFALL DATA (DATA GROUP I1)      |
|         BOUNDARY CONDITION ON DATA GROUP J1     |
*=================================================*

Outfall at Junction....CR7             has boundary condition number...        1
Outfall at Junction....CR1             has boundary condition number...        2
Outfall at Junction....CR2             has boundary condition number...        3
Outfall at Junction....CR3             has boundary condition number...        4
Outfall at Junction....CR4             has boundary condition number...        5
Outfall at Junction....CR5             has boundary condition number...        6
Outfall at Junction....CR6             has boundary condition number...        7
Outfall at Junction....CR8             has boundary condition number...        8
Outfall at Junction....CR9             has boundary condition number...        9
Outfall at Junction....CR10            has boundary condition number...       10
```

Campbell River / Quinsam River ISMP
XP-SWMM Modeling Results

```
*=============================================*
|             Weir Outfall Data               |
|      Boundary Condition on data group J1    |
*=============================================*



*================================================*
|        INTERNAL CONNECTIVITY INFORMATION       |
*================================================*

         CONDUIT         JUNCTION         JUNCTION
---------------- ---------------- ----------------
      Low Flow.1        Diversion          Node289
     High Flow.1        Diversion          Node292
        FREE # 1              CR7         BOUNDARY
        FREE # 2              CR1         BOUNDARY
        FREE # 3              CR2         BOUNDARY
        FREE # 4              CR3         BOUNDARY
        FREE # 5              CR4         BOUNDARY
        FREE # 6              CR5         BOUNDARY
        FREE # 7              CR6         BOUNDARY
        FREE # 8              CR8         BOUNDARY
        FREE # 9              CR9         BOUNDARY
        FREE #10             CR10         BOUNDARY

*===================================================*
|        Boundary Condition Information             |
|                 Data Groups J1-J4                 |
*===================================================*


BC NUMBER..         1 Control water surface elevation is..     1.400 meters.
BC NUMBER..         2 Control water surface elevation is..     1.400 meters.
BC NUMBER..         3 Control water surface elevation is..     1.400 meters.
BC NUMBER..         4 Control water surface elevation is..     1.400 meters.
BC NUMBER..         5 Control water surface elevation is..     1.400 meters.
BC NUMBER..         6 Control water surface elevation is..     1.400 meters.
BC NUMBER..         7 Control water surface elevation is..     1.400 meters.
BC NUMBER..         8 Control water surface elevation is..     1.400 meters.
BC NUMBER..         9 Control water surface elevation is..     1.400 meters.
BC NUMBER..        10 Control water surface elevation is..     1.400 meters.


*======================================================*
|        Table E9 - JUNCTION SUMMARY STATISTICS        |
| The Maximum area is only the area of the node, it    |
| does not include the area of the surrounding conduits|
```

Campbell River / Quinsam River ISMP
XP-SWMM Modeling Results

==

Junction Name	Ground Elevation meters	Uppermost PipeCrown Elevation meters	Maximum Junction Elevation meters	Time of Occurence Hr.	Min.	Meters of Surcharge at Max Elevation	Freeboard of node meters	Maximum Junction Area m^2	Maximum Gutter Depth meters	Maximum Gutter Width meters	Maximum Gutter Velocity m/s
1802	2.8200	1.5200	1.4817	8	0	0.0000	1.3383	1.2200	0.0000	0.0000	0.0000
1803	2.4600	1.3200	1.4739	88	3	0.1539	0.9861	1.2200	0.0000	0.0000	0.0000
1804	2.2900	1.1500	1.4779	88	2	0.3279	0.8121	1.2200	0.0000	0.0000	0.0000
1805	2.2300	1.0900	1.5005	88	2	0.4105	0.7295	1.2200	0.0000	0.0000	0.0000
1806	2.1500	1.0100	1.4861	88	2	0.4761	0.6639	1.2200	0.0000	0.0000	0.0000
1808	2.8000	1.5750	1.4027	7	3	0.0000	1.3973	1.2200	0.0000	0.0000	0.0000
1809	2.5900	1.4500	1.4019	29	49	0.0000	1.1881	1.2200	0.0000	0.0000	0.0000
1810	1.7500	0.8500	1.4350	57	13	0.5850	0.3150	1.2200	0.0000	0.0000	0.0000
1811	1.8400	1.0050	1.5637	8	0	0.5587	0.2763	1.2200	0.0000	0.0000	0.0000
1812	1.7500	1.1000	1.4357	86	30	0.3357	0.3143	1.2200	0.0000	0.0000	0.0000
1813	1.7500	1.4000	1.4172	86	30	0.0172	0.3328	1.2200	0.0000	0.0000	0.0000
1814	1.9500	1.1150	1.6976	8	0	0.5826	0.2524	1.2200	0.0000	0.0000	0.0000
1815	2.9300	2.2000	2.0209	8	1	0.0000	0.9091	1.2200	0.0000	0.0000	0.0000
1818	3.1000	2.1100	2.2326	8	1	0.1226	0.8674	1.2200	0.0000	0.0000	0.0000
1819	4.9100	3.8700	3.2242	8	0	0.0000	1.6858	1.2200	0.0000	0.0000	0.0000
1820	5.3000	4.2200	3.7201	8	0	0.0000	1.5799	1.2200	0.0000	0.0000	0.0000
1821	5.6700	4.5300	4.0321	7	31	0.0000	1.6379	1.2200	0.0000	0.0000	0.0000
1822	8.3500	6.2100	5.8644	8	1	0.0000	2.4856	1.2200	0.0000	0.0000	0.0000
1823	5.2100	4.0700	3.7519	8	0	0.0000	1.4581	1.2200	0.0000	0.0000	0.0000
1824	3.7100	2.6700	2.4597	8	1	0.0000	1.2503	1.2200	0.0000	0.0000	0.0000
1831	9.0700	7.9300	7.6038	8	0	0.0000	1.4662	1.2200	0.0000	0.0000	0.0000
1832	10.5500	9.4100	9.0833	8	0	0.0000	1.4667	1.2200	0.0000	0.0000	0.0000
1833	8.9100	7.5400	7.3298	8	0	0.0000	1.5802	1.2200	0.0000	0.0000	0.0000
1834	8.8100	7.4700	7.1708	8	0	0.0000	1.6392	1.2200	0.0000	0.0000	0.0000
1836	8.2600	7.3050	6.6163	7	43	0.0000	1.6437	1.2200	0.0000	0.0000	0.0000
1837	7.3800	6.3050	5.7507	8	0	0.0000	1.6293	1.2200	0.0000	0.0000	0.0000
1838	7.2000	5.8300	5.4500	0	0	0.0000	1.7500	1.2200	0.0000	0.0000	0.0000
1839	6.7900	5.4700	5.1473	8	0	0.0000	1.6427	1.2200	0.0000	0.0000	0.0000
1840	4.1700	2.8000	2.5518	7	28	0.0000	1.6182	1.2200	0.0000	0.0000	0.0000
1841	4.7800	3.4100	3.1295	8	0	0.0000	1.6505	1.2200	0.0000	0.0000	0.0000
1844	6.1500	5.0750	4.5662	7	33	0.0000	1.5838	1.2200	0.0000	0.0000	0.0000
1846	5.6100	4.7600	4.1403	8	0	0.0000	1.4697	1.2200	0.0000	0.0000	0.0000
1847	5.4400	4.5900	4.1046	8	1	0.0000	1.3354	1.2200	0.0000	0.0000	0.0000
1850	1.7500	0.4000	1.4057	8	0	1.0057	0.3443	1.2200	0.0000	0.0000	0.0000
1852	5.3300	4.5500	3.9836	8	2	0.0000	1.3464	1.2200	0.0000	0.0000	0.0000
1853	5.3100	4.4600	3.7294	8	1	0.0000	1.5806	1.2200	0.0000	0.0000	0.0000
1854	3.9800	3.1300	2.5690	8	1	0.0000	1.4110	1.2200	0.0000	0.0000	0.0000
1855	5.4000	4.2600	4.0826	8	2	0.0000	1.3174	1.2200	0.0000	0.0000	0.0000
1856	5.5900	5.1000	4.1262	8	2	0.0000	1.4638	1.2200	0.0000	0.0000	0.0000
1857	6.0300	4.8650	4.5104	8	0	0.0000	1.5196	1.2200	0.0000	0.0000	0.0000
1858	5.4900	4.9750	4.5542	8	0	0.0000	0.9358	1.2200	0.0000	0.0000	0.0000
1859	6.9200	6.2950	6.0211	8	0	0.0000	0.8989	1.2200	0.0000	0.0000	0.0000

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1860	7.3600	6.8000	5.7260	8	3	0.0000	1.6340	1.2200	0.0000	0.0000	0.0000
1861	7.6300	6.7800	6.0490	8	2	0.0000	1.5810	1.2200	0.0000	0.0000	0.0000
1862	6.3700	5.8200	4.8210	11	0	0.0000	1.5490	1.2200	0.0000	0.0000	0.0000
1864	7.1300	6.5800	5.5651	11	0	0.0000	1.5649	1.2200	0.0000	0.0000	0.0000
1865	8.2800	7.4300	6.6328	8	1	0.0000	1.6472	1.2200	0.0000	0.0000	0.0000
1866	8.7500	7.9000	7.1168	8	0	0.0000	1.6332	1.2200	0.0000	0.0000	0.0000
1867	9.2200	7.8450	7.5340	7	27	0.0000	1.6860	1.2200	0.0000	0.0000	0.0000
1868	9.6700	8.3200	7.9854	7	23	0.0000	1.6846	1.2200	0.0000	0.0000	0.0000
1869	9.4000	8.5500	7.7290	9	0	0.0000	1.6710	1.2200	0.0000	0.0000	0.0000
1870	9.4000	8.8500	7.8102	11	0	0.0000	1.5898	1.2200	0.0000	0.0000	0.0000
1871	10.3400	9.8400	8.7518	11	0	0.0000	1.5882	1.2200	0.0000	0.0000	0.0000
1872	10.8900	10.1750	9.6325	8	0	0.0000	1.2575	1.2200	0.0000	0.0000	0.0000
1873	52.1500	50.9550	50.6859	8	0	0.0000	1.4641	1.2200	0.0000	0.0000	0.0000
1874	52.4600	51.2400	50.9962	8	0	0.0000	1.4638	1.2200	0.0000	0.0000	0.0000
1878	58.5900	57.4300	56.9654	8	0	0.0000	1.6246	1.2200	0.0000	0.0000	0.0000
1879	55.3200	54.0700	53.7494	8	0	0.0000	1.5706	1.2200	0.0000	0.0000	0.0000
1880	55.6700	55.6700	54.1448	8	0	0.0000	1.5252	1.2200	0.0000	0.0000	0.0000
1881	61.9200	60.6200	60.2892	8	0	0.0000	1.6308	1.2200	0.0000	0.0000	0.0000
1883	62.4900	61.1250	60.9203	8	1	0.0000	1.5697	1.2200	0.0000	0.0000	0.0000
1884	62.9000	61.5250	61.3409	8	0	0.0000	1.5591	1.2200	0.0000	0.0000	0.0000
6001	5.8500	4.7100	4.2483	8	0	0.0000	1.6017	1.2200	0.0000	0.0000	0.0000
6002	5.4000	4.5900	4.0748	8	2	0.0000	1.3252	1.2200	0.0000	0.0000	0.0000
6003	55.7500	55.7500	54.2198	8	0	0.0000	1.5302	1.2200	0.0000	0.0000	0.0000
6004	51.2500	51.2500	49.6396	8	1	0.0000	1.6104	1.2200	0.0000	0.0000	0.0000
6005	11.7500	11.5000	9.2514	7	56	0.0000	2.4986	1.2200	0.0000	0.0000	0.0000
6006	11.5000	11.5000	9.4556	8	3	0.0000	2.0444	1.2200	0.0000	0.0000	0.0000
6008	5.2500	3.8000	3.5679	7	43	0.0000	1.6821	1.2200	0.0000	0.0000	0.0000
6014	50.0000	50.0000	48.5592	8	0	0.0000	1.4408	1.2200	0.0000	0.0000	0.0000
6017	6.5500	6.2000	5.1142	8	0	0.0000	1.4358	1.2200	0.0000	0.0000	0.0000
6019	51.0000	48.7500	47.2872	8	2	0.0000	3.7128	1.2200	0.0000	0.0000	0.0000
6020	48.4500	47.5500	46.9453	8	1	0.0000	1.5047	1.2200	0.0000	0.0000	0.0000
6021	47.3000	47.3000	46.1456	8	1	0.0000	1.1544	1.2200	0.0000	0.0000	0.0000
6022	47.5000	46.9800	45.5831	8	3	0.0000	1.9169	1.2200	0.0000	0.0000	0.0000
6023	8.7500	7.3750	7.1152	8	0	0.0000	1.6348	1.2200	0.0000	0.0000	0.0000
6027	11.2000	10.6500	9.5917	11	8	0.0000	1.6083	1.2200	0.0000	0.0000	0.0000
6031	5.5000	4.9100	4.0668	8	3	0.0000	1.4332	1.2200	0.0000	0.0000	0.0000
6032	4.1000	4.1000	2.3462	8	3	0.0000	1.7538	1.2200	0.0000	0.0000	0.0000
6034	2.9500	1.7920	1.4161	86	31	0.0000	1.5339	1.2200	0.0000	0.0000	0.0000
6035	1.7500	0.8000	1.4745	59	59	0.6745	0.2755	1.2200	0.0000	0.0000	0.0000
6038	5.6500	4.9400	4.0866	8	2	0.0000	1.5634	1.2200	0.0000	0.0000	0.0000
6039	5.3500	5.2000	3.6844	8	3	0.0000	1.6656	1.2200	0.0000	0.0000	0.0000
CR7	3.9000	3.9000	2.0598	8	3	0.0000	1.8402	1.2200	0.0000	0.0000	0.0000
6041	6.0000	4.7500	4.0428	8	2	0.0000	1.9572	1.2200	0.0000	0.0000	0.0000
6042	7.0000	5.3100	4.0551	8	28	0.0000	2.9449	1.2200	0.0000	0.0000	0.0000
6043	7.0000	5.2000	3.8717	8	29	0.0000	3.1283	1.2200	0.0000	0.0000	0.0000
6044	48.0000	47.5000	46.1982	8	1	0.0000	1.8018	1.2200	0.0000	0.0000	0.0000
6045	51.0000	51.0000	49.5917	8	0	0.0000	1.4083	1.2200	0.0000	0.0000	0.0000
6046	55.8000	55.7940	54.2335	8	0	0.0000	1.5665	1.2200	0.0000	0.0000	0.0000
6048	3.7500	3.0500	2.1127	8	1	0.0000	1.6373	1.2200	0.0000	0.0000	0.0000

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CR1	2.3000	1.1600	1.4000	0	0	0.2400	0.9000	1.2200	0.0000	0.0000	0.0000
CR2	1.8400	0.7100	1.4000	0	0	0.6900	0.4400	1.2200	0.0000	0.0000	0.0000
CR3	1.7500	0.5000	1.4000	0	0	0.9000	0.3500	1.2200	0.0000	0.0000	0.0000
CR4	1.7500	0.7400	1.4000	0	0	0.6600	0.3500	1.2200	0.0000	0.0000	0.0000
CR5	1.7500	0.4900	1.4000	0	0	0.9100	0.3500	1.2200	0.0000	0.0000	0.0000
CR6	1.8500	0.3000	1.4000	0	0	1.1000	0.4500	1.2200	0.0000	0.0000	0.0000
CR8	4.7500	3.3000	3.0620	7	44	0.0000	1.6880	1.2200	0.0000	0.0000	0.0000
CR9	1.7500	1.5000	1.4000	0	0	0.0000	0.3500	1.2200	0.0000	0.0000	0.0000
CR10	2.0000	1.2000	1.4000	0	0	0.2000	0.6000	1.2200	0.0000	0.0000	0.0000
Node274	47.5000	47.5000	46.0423	8	0	0.0000	1.4577	1.2200	0.0000	0.0000	0.0000
Node275	51.0000	51.0000	49.5934	8	0	0.0000	1.4066	1.2200	0.0000	0.0000	0.0000
Node279	47.0000	43.8000	42.2681	11	1	0.0000	4.7319	1.2200	0.0000	0.0000	0.0000
Node280	45.0000	41.8000	40.1003	11	2	0.0000	4.8997	1.2200	0.0000	0.0000	0.0000
Node282	66.0000	65.0500	65.1444	11	9	0.0944	0.8556	4800.0000	0.0000	0.0000	0.0000
Node284	60.0000	59.0000	58.0813	8	0	0.0000	1.9187	1.2200	0.0000	0.0000	0.0000
Node285	37.0000	36.2000	35.1043	8	2	0.0000	1.8957	1.2200	0.0000	0.0000	0.0000
Node286	25.0000	24.0500	23.9747	24	1	0.0000	1.0253	2800.0000	0.0000	0.0000	0.0000
Node289	34.0000	30.1000	29.1108	11	0	0.0000	4.8892	1.2200	0.0000	0.0000	0.0000
Diversion	34.0000	30.0000	29.4354	11	4	0.0000	4.5646	1.2200	0.0000	0.0000	0.0000
Node292	34.0000	30.0000	29.0578	11	5	0.0000	4.9422	1.2200	0.0000	0.0000	0.0000
Node295	66.0000	65.0500	64.1568	11	18	0.0000	1.8432	1.2200	0.0000	0.0000	0.0000
Node297	25.0000	24.0500	23.0267	24	7	0.0000	1.9733	1.2200	0.0000	0.0000	0.0000
Node298	47.0000	43.1000	43.1045	24	3	0.0045	3.8955	600.0000	0.0000	0.0000	0.0000
Node300	3.7500	3.0500	3.0546	17	2	0.0046	0.6954	1100.0000	0.0000	0.0000	0.0000
Node302	34.0000	30.1000	29.9989	24	20	0.0000	4.0011	1500.0000	0.0000	0.0000	0.0000
Node304	37.0000	36.0500	35.8265	24	11	0.0000	1.1735	600.0000	0.0000	0.0000	0.0000
Node306	37.0000	36.2000	36.0077	24	29	0.0000	0.9923	4500.0000	0.0000	0.0000	0.0000

```
*=====================================================*
|        Table E10 - CONDUIT SUMMARY STATISTICS        |
| Note: The peak flow may be less than the design flow |
| and the conduit may still surcharge because of the   |
| downstream boundary conditions.                      |
|                                                      |
| * denotes an open conduit that has been overtopped   |
|   this is a potential source of severe errors        |
*=====================================================*
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Conduit Name	Design Flow (cms)	Conduit Design Velocity (m/s)	Maximum Vertical Depth (mm)	Maximum Computed Flow (cms)	Time of Occurence Hr.	Min.	Maximum Computed Velocity (m/s)	Time of Occurence Hr.	Min.	Ratio of Max. to Design Flow	Maximum Water Elev at Pipe Ends Upstream (m)	Dwnstrm (m)	Ratio d/D US	DS
1686	0.2464	1.1382	525.0000	0.0122	8	0	0.0756	8	1	0.0495	1.4027	1.4018	0.672	1.070
1687	0.4054	1.3870	610.0000	0.0270	8	0	0.0955	8	0	0.0666	1.4019	1.4000	0.921	1.393
1691	0.1486	0.9342	450.0000	0.0393	8	1	0.2571	8	1	0.2644	1.4817	1.4739	0.915	1.564
1692	0.3450	1.1806	610.0000	0.0394	8	0	0.1321	8	0	0.1142	1.4739	1.4776	1.252	1.537
1693	0.2095	0.7170	610.0000	0.0582	8	0	0.1987	8	0	0.2780	1.4779	1.5006	1.537	1.673
1694	0.2795	0.9562	610.0000	0.0725	8	0	0.2472	8	0	0.2595	1.5005	1.4859	1.673	1.780

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1695	0.3123	1.0688	610.0000	0.0930	8	0	0.3169	8	0	0.2979	1.4861	1.4000	1.780	2.131	
1696	0.8164	2.2154	685.0000	0.3571	8	2	1.5265	9	34	0.4374	2.4597	2.2326	0.729	1.186	
1697	0.8937	1.9700	760.0000	0.4079	8	2	0.9360	11	15	0.4565	2.2326	2.0209	1.161	1.817	
1698	0.5402	1.1909	760.0000	0.4608	8	1	1.0097	8	1	0.8531	2.0209	1.6976	1.962	1.971	
1699	0.5536	0.8419	915.0000	0.4887	8	1	0.7402	8	1	0.8827	1.6976	1.5637	1.637	1.611	
1700	0.6932	1.2216	850.0000	0.4996	8	0	0.8763	8	0	0.7207	1.5637	1.4000	1.734	1.776	
1701	0.3380	1.1955	600.0000	0.0182	8	0	0.0642	8	0	0.0539	1.4350	1.4344	1.558	1.974	
1702	0.4103	1.4512	600.0000	0.0182	8	0	0.0643	8	0	0.0444	1.4172	1.4357	1.029	1.559	
1704	0.8005	2.7391	610.0000	0.2948	8	0	2.2178	8	1	0.3683	9.0833	7.6038	0.465	0.465	
1705	0.8300	2.8402	610.0000	0.3048	8	0	2.3102	8	1	0.3672	7.6038	5.8644	0.465	0.433	
1707	0.0670	0.2030	300.0000	0.0159	8	0	0.0481	8	0	0.2370	1.4057	1.4000	4.352	4.667	*
1709	0.0654	0.5765	380.0000	0.0242	8	0	0.5161	8	0	0.3698	7.3298	7.2003	0.447	0.290	
1710	0.2135	1.6991	400.0000	0.0299	8	0	1.0689	8	1	0.1403	7.1708	6.6310	0.277	0.252	
1711	0.1169	1.0583	375.0000	0.0173	8	0	0.6170	8	0	0.1481	7.1152	7.0232	0.307	0.249	
1712	0.9275	2.5919	675.0000	0.0473	7	44	1.2810	8	1	0.0510	6.6163	5.7507	0.158	0.179	
1713	0.8521	2.3813	675.0000	0.0596	8	0	1.3025	7	43	0.0700	5.7507	4.5662	0.179	0.246	
1715	0.5474	1.5296	675.0000	0.0716	8	0	0.9524	7	21	0.1308	4.5662	4.1403	0.246	0.415	
1716	1.0277	1.6155	900.0000	0.0979	7	52	0.5845	6	15	0.0953	4.1403	4.1046	0.311	0.461	
1718	0.0532	0.0000	900.0000	0.1155	7	52	0.4208	7	18	2.1721	4.1046	4.0748	0.461	0.428	
1719	0.2736	0.4301	900.0000	0.1815	8	2	0.7063	8	2	0.6635	3.9836	3.7294	0.448	0.188	
1720	2.4503	3.8516	900.0000	0.1888	8	1	1.9499	8	2	0.0770	3.7294	2.5690	0.188	0.377	
1726	0.1802	1.5885	380.0000	0.0260	8	0	1.0589	8	0	0.1444	3.1295	2.5518	0.262	0.347	
1727	0.1796	1.5837	380.0000	0.0410	7	29	1.1862	7	29	0.2280	2.5518	2.0209	0.347	0.529	
1736	0.0654	0.5770	380.0000	0.0000	0	0	0.0000	0	0	0.0000	5.4500	5.1473	.0000	.0000	
1737	0.1627	1.4345	380.0000	0.0262	8	0	1.0022	8	0	0.1610	5.1473	4.1529	0.282	0.271	
1738	0.3873	1.3252	610.0000	0.0262	8	0	0.7110	8	0	0.0676	4.0321	3.7201	0.184	0.180	
1739	0.3666	1.2545	610.0000	0.0507	8	0	0.7796	7	29	0.1382	3.7201	3.4009	0.279	0.231	
1742	2.1628	7.4004	610.0000	0.0507	8	0	1.7255	1	11	0.0234	3.2242	2.2326	0.105	1.332	
1746	0.8722	2.9846	610.0000	0.3047	8	1	2.4761	8	1	0.3493	5.8644	3.7519	0.433	0.478	
1747	0.8719	2.9833	610.0000	0.3428	8	0	2.3736	8	8	0.3932	3.7519	2.4597	0.478	0.655	
1767	0.1406	1.2727	375.0000	0.0604	8	0	1.0833	8	1	0.4296	61.3409	60.9217	0.509	0.458	
1768	0.1624	1.4700	375.0000	0.0603	8	1	1.1667	8	2	0.3712	60.9203	60.3481	0.481	0.422	
1770	0.6130	3.8545	450.0000	0.0819	8	0	2.4513	8	0	0.1337	60.2892	57.0910	0.265	0.247	
1772	0.5600	3.5211	450.0000	0.0949	8	0	2.4663	8	0	0.1695	56.9654	53.7494	0.279	0.399	
1773	0.2491	1.5662	450.0000	0.0843	8	0	1.0892	8	1	0.3384	54.1448	53.8004	0.500	0.401	
1774	0.5293	3.3281	450.0000	0.1877	8	0	2.7478	8	1	0.3546	53.7494	50.9962	0.443	0.458	
1775	0.9108	4.2072	525.0000	0.2078	8	0	1.8079	0	29	0.2282	50.9962	50.6859	0.545	0.487	
1776	0.6406	2.9593	525.0000	0.2078	8	1	1.8382	8	1	0.3244	50.6859	49.6396	0.545	0.266	
1779	5.1185	4.5257	1200.000	0.1626	11	0	1.9580	0	29	0.0318	8.7518	7.8102	0.135	0.133	
1780	0.4226	1.1808	675.0000	0.0289	7	45	0.6286	0	29	0.0683	9.6325	9.2425	0.196	0.152	
1781	0.0532	0.0000	900.0000	0.0264	11	1	0.3671	11	2	0.4963	7.8102	7.7290	0.178	0.088	
1782	0.2437	1.9394	400.0000	0.0124	7	43	1.0891	0	29	0.0508	7.9854	7.7290	0.163	0.198	
1783	2.1702	3.4113	900.0000	0.0340	9	0	1.1543	9	0	0.0157	7.7290	7.1168	0.088	0.130	
1784	0.2561	2.3184	375.0000	0.0163	8	0	2.4835	0	29	0.0637	7.5340	7.1168	0.171	0.312	
1785	1.6548	2.6012	900.0000	0.0498	8	0	1.0395	8	1	0.0301	7.1168	6.6328	0.130	0.114	
1786	1.7708	2.7835	900.0000	0.0497	8	1	1.1129	8	1	0.0281	6.6328	6.0490	0.114	0.188	
1787	0.9183	1.4434	900.0000	0.0575	8	2	0.7135	8	2	0.0626	6.0490	5.7445	0.188	0.149	
1789	2.9635	3.4224	1050.000	0.1362	11	1	1.6377	11	1	0.0459	7.8102	5.6818	0.153	0.145	
1790	2.9712	2.6271	1200.000	0.1416	11	1	1.2595	11	1	0.0477	5.5651	4.8210	0.154	0.167	

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1791	2.9846	2.6390	1200.000	0.1568	9	1	1.2864	9	2	0.0525	4.8210	4.1262	0.167	0.188
1792	2.2539	1.0435	1200.000	0.2552	8	3	0.4281	11	1	0.1132	4.1262	4.0866	0.280	0.289
1793	0.1885	0.6452	610.0000	-0.0620	11	5	-0.3353	12	21	-0.3289	4.0748	4.0826	0.631	0.709
1795	0.3023	1.3962	525.0000	-0.0499	8	0	-0.2480	8	0	-0.1651	4.5542	4.5104	0.408	1.201
1796	0.1540	1.3945	375.0000	0.0233	8	0	0.9714	8	0	0.1510	6.0211	4.6982	0.270	0.262
5005	0.0533	0.7547	300.0000	0.0097	69	44	0.1350	69	44	0.1810	1.4745	1.4000	3.248	4.000
5006	0.4732	1.6735	600.0000	0.0283	8	0	0.0993	8	0	0.0597	1.4344	1.4000	1.974	2.517
5009	0.4033	1.4264	600.0000	-0.0120	69	14	0.0709	86	32	-0.0297	1.4161	1.4171	0.373	1.029
5010	0.3744	2.3541	450.0000	0.0450	8	0	1.0831	7	38	0.1203	9.2514	9.0833	0.270	0.630
5011	0.8108	2.8676	600.0000	0.2439	8	3	1.7011	8	4	0.3009	9.4556	9.0833	0.509	0.472
5014	0.7426	5.9092	400.0000	0.0353	8	0	4.8371	0	29	0.0475	48.5592	46.1982	0.148	0.495
5015	1.3973	3.1628	750.0000	0.2075	8	2	1.3901	8	2	0.1485	47.2872	46.9949	0.383	0.260
5016	1.8870	4.2712	750.0000	0.2424	8	2	1.3303	8	6	0.1285	46.1456	45.5831	0.461	0.138
5018	9.2425	1.3204	1750.000	0.0802	8	0	0.3871	8	0	0.0087	54.2198	54.1448	0.126	0.128
5021	5.6825	5.0245	1200.000	0.1269	11	8	1.7195	11	8	0.0223	9.5917	8.7615	0.118	0.101
5022	1.2277	1.0231	1200.000	0.0618	8	3	0.4959	8	1	0.0504	5.7260	5.1142	0.105	0.095
5023	2.0806	1.7338	1200.000	0.0966	8	0	0.7709	8	0	0.0464	5.1142	4.1262	0.095	0.188
5024	0.0188	0.0000	610.0000	-0.0595	11	5	-0.3093	12	21	-3.1582	4.0826	4.0866	0.709	0.716
5026	0.7246	1.1390	900.0000	0.1374	8	3	0.7504	8	3	0.1897	4.0668	3.6844	0.352	0.094
5027	16.1398	5.6041	1600.000	0.2739	8	3	1.3753	8	3	0.0170	3.6844	2.3462	0.053	0.216
5029	1.2065	1.8965	900.0000	0.1936	8	1	0.9160	8	1	0.1605	2.5690	2.4434	0.377	0.270
5030	0.2291	1.0581	525.0000	0.0600	8	0	0.7632	8	1	0.2618	4.5104	4.3005	0.401	0.306
5031	0.5690	2.0124	600.0000	0.0600	8	0	1.0375	7	27	0.1054	4.2483	4.0428	0.231	0.488
5032	0.0669	0.9468	300.0000	0.0069	7	44	0.5815	8	0	0.1032	3.5679	3.0620	0.226	0.207
5033	5.8344	2.1609	1500.000	0.4112	8	29	0.9610	8	29	0.0705	4.0551	3.8717	0.163	0.114
5034	0.4674	0.7347	900.0000	0.1699	8	2	0.6659	8	3	0.3634	4.0748	3.9836	0.428	0.371
5035	1.9190	4.3438	750.0000	0.2076	8	2	1.7264	8	3	0.1082	46.9453	46.4660	0.327	0.221
Link232	2.1224	0.9826	1200.000	0.2094	8	3	0.3347	8	4	0.0987	4.0866	4.0668	0.289	0.297
Link233	0.0704	0.0000	1000.000	0.0727	8	5	0.3706	11	8	1.0320	4.0668	4.0428	0.317	0.293
5025	0.9887	1.2589	1000.000	0.1310	8	2	0.7452	8	3	0.1325	4.0428	3.6844	0.293	0.084
Link236	1.0533	2.7370	700.0000	0.0592	8	1	0.7935	8	1	0.0562	2.1127	1.4000	0.161	1.286
Link237	42.5308	6.3009	1500.000	0.0450	8	0	0.7605	0	28	0.0011	46.0423	10.0268	0.028	0.018
Link238	37.0144	4.7002	1750.000	0.2077	8	1	1.3061	0	29	0.0056	49.6396	47.2872	0.080	0.164
Link239	4.6551	1.2414	1500.000	0.0237	8	0	0.2592	0	28	0.0051	49.5917	48.5592	0.061	0.039
5028	14.4354	4.1677	2100.000	0.4751	8	3	1.3143	8	3	0.0329	2.3462	2.0598	0.165	0.124
Link242	9.1913	1.3130	1750.000	0.0365	8	0	0.2302	6	26	0.0040	54.2335	54.2198	0.108	0.126
Link243	42.2225	6.2552	1500.000	0.2439	8	3	2.0733	0	28	0.0058	45.5831	10.0982	0.069	0.065
Link244	18.6199	2.7585	1500.000	0.2424	8	1	1.0820	0	29	0.0130	46.1982	46.1456	0.132	0.230
Link245	8.7089	2.3224	1500.000	0.0413	8	0	0.9072	0	28	0.0047	49.5934	46.0423	0.062	0.028
Link252	18.7252	5.3500	1000.000	0.1270	11	5	1.0039	6	35	0.0068	29.0578	9.5917	0.058	0.142
Link253	11.0937	4.3596	1800.000	0.3398	11	1	6.5398	0	28	0.0306	42.2681	40.1003	0.149	0.056
Link257	8.3039	2.3725	1000.000	0.3020	11	18	0.7956	11	22	0.0364	64.1568	42.2681	0.157	0.268
Link258	19.8639	5.6754	1000.000	0.3398	11	2	1.0975	11	1	0.0171	40.1003	29.4354	0.100	0.435
Link259	10.8958	3.1131	1000.000	0.2205	11	0	1.5092	0	37	0.0202	29.1108	4.0551	0.111	0.245
Link260	9.7933	2.1763	1000.000	0.4529	8	29	0.5060	8	29	0.0462	3.8717	1.4000	0.172	0.900
Link261	14.1354	3.1412	1000.000	0.1865	8	0	0.9032	0	28	0.0132	58.0813	35.1043	0.081	0.104
Link262	10.9475	2.4328	1000.000	0.2191	8	2	0.5820	8	0	0.0200	35.1043	4.0551	0.104	0.245
Link263	10.3736	2.9639	1000.000	0.0193	24	7	0.2823	24	56	0.0019	23.0267	2.1127	0.027	0.113
Area 1 Out	0.0000	0.0000	1050.000	0.3022	11	9	0.6511	11	9	0.0000	65.1444	64.1568	1.090	0.149

Campbell River / Quinsam River ISMP
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Area 7 Out	0.0000	0.0000	1050.000	0.0193	24	1	0.5097	24	1	0.0000	23.9747	23.0267	0.928	0.025
Area 2 Out	0.0000	0.0000	1100.000	0.0037	24	29	0.5018	24	29	0.0000	43.1045	42.2681	1.004	0.244
Area 8 Out	0.0000	0.0000	1050.000	0.0191	17	10	0.5095	17	10	0.0000	3.0546	2.1127	1.004	0.107
Area 3 Out	0.0000	0.0000	1100.000	0.0022	30	53	0.5011	30	53	0.0000	29.9989	29.1108	0.908	0.101
Area 4 Out	0.0000	0.0000	1050.000	0.0006	26	40	0.5003	26	40	0.0000	35.8265	35.1043	0.787	0.099
Area 5 Out	0.0000	0.0000	1200.000	0.0073	26	11	0.5036	26	11	0.0000	36.0077	35.1043	0.840	0.087
Low Flow.1	0.2620	0.1467	300.0000	0.2127	11	5	1.2569	11	5	0.8118	29.4354	29.1108	1.451	0.380
High Flow.1	Undefnd	Undefnd	Undefn	0.1270	11	4								
FREE # 1	Undefnd	Undefnd	Undefn	0.4751	8	3								
FREE # 2	Undefnd	Undefnd	Undefn	0.0270	8	0								
FREE # 3	Undefnd	Undefnd	Undefn	0.0930	8	0								
FREE # 4	Undefnd	Undefnd	Undefn	0.0148	59	59								
FREE # 5	Undefnd	Undefnd	Undefn	0.4996	8	0								
FREE # 6	Undefnd	Undefnd	Undefn	0.0283	8	0								
FREE # 7	Undefnd	Undefnd	Undefn	0.0159	8	0								
FREE # 8	Undefnd	Undefnd	Undefn	0.0069	7	44								
FREE # 9	Undefnd	Undefnd	Undefn	0.4529	8	29								
FREE #10	Undefnd	Undefnd	Undefn	0.0592	8	1								

Campbell River / Quinsam River ISMP
XP-SWMM Modeling Results

XP-SWMM Output
Future Conditions (with ponds), 2 year 24 hour storm
Tables E4, E9 and E10

```
 *==================================================*
 |          Table E4 - Conduit Connectivity         |
 *==================================================*
```

Input Number	Conduit Name	Upstream Node	Downstream Node	Upstream Elevation	Downstream Elevation	
1	1686	1808	1809	1.0500	0.8400	No Design
2	1687	1809	CR1	0.8400	0.5500	No Design
3	1691	1802	1803	1.0700	0.7700	No Design
4	1692	1803	1804	0.7100	0.5400	No Design
5	1693	1804	1805	0.5400	0.4800	No Design
6	1694	1805	1806	0.4800	0.4000	No Design
7	1695	1806	CR2	0.4000	0.1000	No Design
8	1696	1824	1818	1.9600	1.4200	No Design
9	1697	1818	1815	1.3500	0.6400	No Design
10	1698	1815	1814	0.5300	0.2000	No Design
11	1699	1814	1811	0.2000	0.0900	No Design
12	1700	1811	CR4	0.0900	-0.1100	No Design
13	1701	1812	1810	0.5000	0.2500	No Design
14	1702	1813	1812	0.8000	0.5000	No Design
15	1704	1832	1831	8.8000	7.3200	No Design
16	1705	1831	1822	7.3200	5.6000	No Design
17	1707	1850	CR6	0.1000	0.0000	No Design
18	1709	1833	1834	7.1600	7.0900	No Design
19	1710	1834	1836	7.0600	6.5300	No Design
20	1711	6023	1836	7.0000	6.9300	No Design
21	1712	1836	1837	6.5100	5.6300	No Design
22	1713	1837	1844	5.6300	4.4000	No Design
23	1715	1844	1846	4.4000	3.8600	No Design
24	1716	1846	1847	3.8600	3.6900	No Design
25	1718	1847	6002	3.6900	3.6900	No Design
26	1719	1852	1853	3.5800	3.5600	No Design
27	1720	1853	1854	3.5600	2.2300	No Design
28	1726	1841	1840	3.0300	2.4200	No Design
29	1727	1840	1815	2.4200	1.8200	No Design
30	1736	1838	1839	5.4500	5.0900	No Design
31	1737	1839	1821	5.0400	4.0500	No Design
32	1738	1821	1820	3.9200	3.6100	No Design

Campbell River / Quinsam River ISMP
XP-SWMM Modeling Results

33	1739	1820	1819	3.5500	3.2600	No Design
34	1742	1819	1818	3.1600	1.4200	No Design
35	1746	1822	1823	5.6000	3.4600	No Design
36	1747	1823	1824	3.4600	2.0600	No Design
37	1767	1884	1883	61.1500	60.7500	No Design
38	1768	1883	1881	60.7400	60.1900	No Design
39	1770	1881	1878	60.1700	56.9800	No Design
40	1772	1878	1879	56.8400	53.5700	No Design
41	1773	1880	1879	53.9200	53.6200	No Design
42	1774	1879	1874	53.5500	50.7900	No Design
43	1775	1874	1873	50.7100	50.4300	No Design
44	1776	1873	6004	50.4000	49.5000	No Design
45	1779	1871	1870	8.5900	7.6500	No Design
46	1780	1872	1871	9.5000	9.1400	No Design
47	1781	1870	1869	7.6500	7.6500	No Design
48	1782	1868	1869	7.9200	7.6500	No Design
49	1783	1869	1866	7.6500	7.0000	No Design
50	1784	1867	1866	7.4700	7.0000	No Design
51	1785	1866	1865	7.0000	6.5300	No Design
52	1786	1865	1861	6.5300	5.8800	No Design
53	1787	1861	1860	5.8800	5.6100	No Design
54	1789	1870	1864	7.6500	5.5300	No Design
55	1790	1864	1862	5.3800	4.6200	No Design
56	1791	1862	1856	4.6200	3.9000	No Design
57	1792	1856	6038	3.7900	3.7400	No Design
58	1793	6002	1855	3.6900	3.6500	No Design
59	1795	1857	1858	4.3400	3.8800	No Design
60	1796	1859	1858	5.9200	4.6000	No Design
61	5005	6035	CR3	0.5000	0.2000	No Design
62	5006	1810	CR5	0.2500	-0.1100	No Design
63	5009	6034	1813	1.1920	0.8000	No Design
64	5010	6005	1832	9.1300	8.8000	No Design
65	5011	6006	1832	9.1500	8.8000	No Design
66	5014	6014	6044	48.5000	46.0000	No Design
67	5015	6019	6020	47.0000	46.8000	No Design
68	5016	6021	6022	45.8000	45.4800	No Design
69	5018	6003	1880	54.0000	53.9200	No Design
70	5021	6027	1871	9.4500	8.6400	No Design
71	5022	1860	6017	5.6000	5.0000	No Design
72	5023	6017	1856	5.0000	3.9000	No Design
73	5024	1855	6038	3.6500	3.6500	No Design
74	5026	6031	6039	3.7500	3.6000	No Design
75	5027	6039	6032	3.6000	2.0000	No Design
76	5029	1854	6032	2.2300	2.2000	No Design
77	5030	1857	6001	4.3000	4.1400	No Design
78	5031	6001	6041	4.1100	3.7500	No Design
79	5032	6008	CR8	3.5000	3.0000	No Design
80	5033	6042	6043	3.8100	3.7000	No Design
81	5034	6002	1852	3.6900	3.6500	No Design

Campbell River / Quinsam River ISMP
XP-SWMM Modeling Results

82	5035	6020	6044	46.7000	46.3000	No Design
83	Link232	6038	6031	3.7400	3.7100	No Design
84	Link233	6031	6041	3.7500	3.7500	No Design
85	5025	6041	6039	3.7500	3.6000	No Design
86	Link236	6048	CR10	2.0000	0.5000	No Design
87	Link237	Node274	6005	46.0000	10.0000	No Design
88	Link238	6004	6019	49.5000	47.0000	No Design
89	Link239	6045	6014	49.5000	48.5000	No Design
90	5028	6032	CR7	2.0000	1.8000	No Design
91	Link242	6046	6003	54.0440	54.0000	No Design
92	Link243	6022	6006	45.4800	10.0000	No Design
93	Link244	6044	6021	46.0000	45.8000	No Design
94	Link245	Node275	Node274	49.5000	46.0000	No Design
95	Link252	Node292	6027	29.0000	9.4500	No Design
96	Link253	Node279	Node280	42.0000	40.0000	No Design
97	Link257	Node295	Node279	64.0000	42.0000	No Design
98	Link258	Node280	Diversion	40.0000	29.0000	No Design
99	Link259	Node289	6042	29.0000	3.8100	No Design
100	Link260	6043	CR9	3.7000	0.5000	No Design
101	Link261	Node284	Node285	58.0000	35.0000	No Design
102	Link262	Node285	6042	35.0000	3.8100	No Design
103	Link263	Node297	6048	23.0000	2.0000	No Design
104	Area 1 Out	Node282	Node295	64.0000	64.0000	No Design
105	Area 7 Out	Node286	Node297	23.0000	23.0000	No Design
106	Area 2 Out	Node298	Node279	42.0000	42.0000	No Design
107	Area 8 Out	Node300	6048	2.0000	2.0000	No Design
108	Area 3 Out	Node302	Node289	29.0000	29.0000	No Design
109	Area 4 Out	Node304	Node285	35.0000	35.0000	No Design
110	Area 5 Out	Node306	Node285	35.0000	35.0000	No Design

```
*==========================================*
|          Storage Junction Data           |
*==========================================*
```

STORAGE JUNCTION NUMBER OR NAME	JUNCTION TYPE	MAXIMUM OR CONSTANT SURFACE AREA (M2)	PEAK OR CONSTANT VOLUME (CUBIC MET.)	CROWN ELEVATION (M)	DEPTH STARTS FROM
Node282	Constant	4800.0000	9600.0000	66.0000	Node Invert
Node286	Constant	2800.0000	5600.0000	25.0000	Node Invert
Node298	Constant	600.0000	3000.0000	47.0000	Node Invert
Node300	Constant	1100.0000	1925.0000	3.7500	Node Invert
Node302	Constant	1500.0000	7500.0000	34.0000	Node Invert
Node304	Constant	600.0000	1200.0000	37.0000	Node Invert
Node306	Constant	4500.0000	9000.0000	37.0000	Node Invert

```
*==========================================*
```

Campbell River / Quinsam River ISMP
XP-SWMM Modeling Results

```
|             Orifice Data                 |
*==========================================*

        Orifice            From              To                  Area      Depth      Discharge   Height Above
           Name        Junction        Junction       Type       (m2)        (m)    Coefficient  Junction  (m)
---------------- --------------- ---------------      ----      -----      -----    -----------  -------------
      Low Flow.1       Diversion         Node289 Rect Side       0.18       0.30          0.600          0.000

====> EQUIVALENT PIPE INFORMATION FOR ORIFICE           1
      CONDUIT NAME...........................       Low Flow.1
      Upstream node...........................       Diversion
      Downstream node.........................         Node289
      PIPE DIAMETER.......................               0.30
      PIPE LENGTH.........................             300.00
      MANNINGS ROUGHNESS..................             0.0047
      INVERT ELEVATION AT UPSTREAM END.....            29.0000
      INVERT ELEVATION AT DOWNSTREAM END...            28.9970

Note: For a Bottom-outlet orifice the invert elevation of the downstream node will be
      adjusted to accomodate the equivalent conduit.  Conduit grades are not affected.


*============================================*
|                 Weir Data                  |
*============================================*

           Weir            From              To           Crest       Weir       Weir    Discharge         Weir
           Name        Junction        Junction  Type  Height(ft)   Top (m)  Length (m) Coefficient        Power
---------------- --------------- ---------------  ----  ----------   -------  ---------- ----------- -----------
     High Flow.1       Diversion         Node292     1        0.30      5.00        1.50      1.7000      1.5000


*=================================================*
|          FREE OUTFALL DATA (DATA GROUP I1)      |
|         BOUNDARY CONDITION ON DATA GROUP J1     |
*=================================================*

Outfall at Junction....CR7              has boundary condition number...        1
Outfall at Junction....CR1              has boundary condition number...        2
Outfall at Junction....CR2              has boundary condition number...        3
Outfall at Junction....CR3              has boundary condition number...        4
Outfall at Junction....CR4              has boundary condition number...        5
Outfall at Junction....CR5              has boundary condition number...        6
Outfall at Junction....CR6              has boundary condition number...        7
Outfall at Junction....CR8              has boundary condition number...        8
Outfall at Junction....CR9              has boundary condition number...        9
Outfall at Junction....CR10             has boundary condition number...       10
```

Campbell River / Quinsam River ISMP
XP-SWMM Modeling Results

```
*=============================================*
|              Weir Outfall Data              |
|      Boundary Condition on data group J1    |
*=============================================*



*================================================*
|        INTERNAL CONNECTIVITY INFORMATION       |
*================================================*

         CONDUIT          JUNCTION         JUNCTION
---------------- ---------------- ----------------
      Low Flow.1        Diversion          Node289
     High Flow.1        Diversion          Node292
        FREE # 1              CR7         BOUNDARY
        FREE # 2              CR1         BOUNDARY
        FREE # 3              CR2         BOUNDARY
        FREE # 4              CR3         BOUNDARY
        FREE # 5              CR4         BOUNDARY
        FREE # 6              CR5         BOUNDARY
        FREE # 7              CR6         BOUNDARY
        FREE # 8              CR8         BOUNDARY
        FREE # 9              CR9         BOUNDARY
        FREE #10             CR10         BOUNDARY

*===================================================*
|        Boundary Condition Information             |
|                 Data Groups J1-J4                 |
*===================================================*


BC NUMBER..         1 Control water surface elevation is..     1.400 meters.
BC NUMBER..         2 Control water surface elevation is..     1.400 meters.
BC NUMBER..         3 Control water surface elevation is..     1.400 meters.
BC NUMBER..         4 Control water surface elevation is..     1.400 meters.
BC NUMBER..         5 Control water surface elevation is..     1.400 meters.
BC NUMBER..         6 Control water surface elevation is..     1.400 meters.
BC NUMBER..         7 Control water surface elevation is..     1.400 meters.
BC NUMBER..         8 Control water surface elevation is..     1.400 meters.
BC NUMBER..         9 Control water surface elevation is..     1.400 meters.
BC NUMBER..        10 Control water surface elevation is..     1.400 meters.


###########################################
# Header information from interface file: #
###########################################

Title from first computational layer:
```

Campbell River / Quinsam River ISMP
XP-SWMM Modeling Results

A1
Future Conditions Model

Title from immediately preceding computational layer
A1
Future Conditions Model

```
Name of preceding layer:................        Runoff Layer
Initial Julian date (IDATEZ).....................   2006001
Initial time of day in seconds (TZERO)............      0.0
No. Transfered input locations....................       76
No. Transfered pollutants.........................        0
Size of total catchment area (acres).............   1149.93
```

```
*=====================================================*
|        Table E9 - JUNCTION SUMMARY STATISTICS       |
| The Maximum area is only the area of the node, it   |
| does not include the area of the surrounding conduits|
*=====================================================*
```

Junction Name	Ground Elevation meters	Uppermost PipeCrown Elevation meters	Maximum Junction Elevation meters	Time of Occurence Hr.	Min.	Meters of Surcharge at Max Elevation	Freeboard of node meters	Maximum Junction Area m^2	Maximum Gutter Depth meters	Maximum Gutter Width meters	Maximum Gutter Velocity m/s
1802	2.8200	1.5200	1.5147	8	0	0.0000	1.3053	1.2200	0.0000	0.0000	0.0000
1803	2.4600	1.3200	1.4792	8	0	0.1592	0.9808	1.2200	0.0000	0.0000	0.0000
1804	2.2900	1.1500	1.4735	8	0	0.3235	0.8165	1.2200	0.0000	0.0000	0.0000
1805	2.2300	1.0900	1.5879	41	36	0.4979	0.6421	1.2200	0.0000	0.0000	0.0000
1806	2.1500	1.0100	1.5163	41	36	0.5063	0.6337	1.2200	0.0000	0.0000	0.0000
1808	2.8000	1.5750	1.4036	8	0	0.0000	1.3964	1.2200	0.0000	0.0000	0.0000
1809	2.5900	1.4500	1.4025	8	0	0.0000	1.1875	1.2200	0.0000	0.0000	0.0000
1810	1.7500	0.8500	1.4390	33	18	0.5890	0.3110	1.2200	0.0000	0.0000	0.0000
1811	1.8400	1.0050	1.6388	8	0	0.6338	0.2012	1.2200	0.0000	0.0000	0.0000
1812	1.7500	1.1000	1.4374	77	50	0.3374	0.3126	1.2200	0.0000	0.0000	0.0000
1813	1.7500	1.4000	1.4127	66	29	0.0127	0.3373	1.2200	0.0000	0.0000	0.0000
1814	1.9500	1.1150	1.8343	8	0	0.7193	0.1157	1.2200	0.0000	0.0000	0.0000
1815	2.9300	2.2000	2.3051	8	0	0.1051	0.6249	1.2200	0.0000	0.0000	0.0000
1818	3.1000	2.1100	2.6295	7	55	0.5195	0.4705	1.2200	0.0000	0.0000	0.0000
1819	4.9100	3.8700	3.2296	7	48	0.0000	1.6804	1.2200	0.0000	0.0000	0.0000
1820	5.3000	4.2200	3.7385	8	0	0.0000	1.5615	1.2200	0.0000	0.0000	0.0000
1821	5.6700	4.5300	4.0409	7	43	0.0000	1.6291	1.2200	0.0000	0.0000	0.0000
1822	8.3500	6.2100	5.8961	8	1	0.0000	2.4539	1.2200	0.0000	0.0000	0.0000
1823	5.2100	4.0700	3.8342	8	0	0.0000	1.3758	1.2200	0.0000	0.0000	0.0000
1824	3.7100	2.6700	2.9111	8	0	0.2411	0.7989	1.2200	0.0000	0.0000	0.0000
1831	9.0700	7.9300	7.6432	8	0	0.0000	1.4268	1.2200	0.0000	0.0000	0.0000

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1832	10.5500	9.4100	9.1226	8	0	0.0000	1.4274	1.2200	0.0000	0.0000	0.0000
1833	8.9100	7.5400	7.3450	8	0	0.0000	1.5650	1.2200	0.0000	0.0000	0.0000
1834	8.8100	7.4700	7.1812	8	0	0.0000	1.6288	1.2200	0.0000	0.0000	0.0000
1836	8.2600	7.3050	6.6255	8	0	0.0000	1.6345	1.2200	0.0000	0.0000	0.0000
1837	7.3800	6.3050	5.7606	8	0	0.0000	1.6194	1.2200	0.0000	0.0000	0.0000
1838	7.2000	5.8300	5.4500	0	0	0.0000	1.7500	1.2200	0.0000	0.0000	0.0000
1839	6.7900	5.4700	5.1570	8	0	0.0000	1.6330	1.2200	0.0000	0.0000	0.0000
1840	4.1700	2.8000	2.5644	8	0	0.0000	1.6056	1.2200	0.0000	0.0000	0.0000
1841	4.7800	3.4100	3.1381	7	47	0.0000	1.6419	1.2200	0.0000	0.0000	0.0000
1844	6.1500	5.0750	4.5816	7	34	0.0000	1.5684	1.2200	0.0000	0.0000	0.0000
1846	5.6100	4.7600	4.1812	8	0	0.0000	1.4288	1.2200	0.0000	0.0000	0.0000
1847	5.4400	4.5900	4.1478	8	1	0.0000	1.2922	1.2200	0.0000	0.0000	0.0000
1850	1.7500	0.4000	1.4078	8	0	1.0078	0.3422	1.2200	0.0000	0.0000	0.0000
1852	5.3300	4.5500	4.0225	8	1	0.0000	1.3075	1.2200	0.0000	0.0000	0.0000
1853	5.3100	4.4600	3.7483	8	1	0.0000	1.5617	1.2200	0.0000	0.0000	0.0000
1854	3.9800	3.1300	2.6054	8	1	0.0000	1.3746	1.2200	0.0000	0.0000	0.0000
1855	5.4000	4.2600	4.1272	8	2	0.0000	1.2728	1.2200	0.0000	0.0000	0.0000
1856	5.5900	5.1000	4.1882	10	1	0.0000	1.4018	1.2200	0.0000	0.0000	0.0000
1857	6.0300	4.8650	4.5305	8	0	0.0000	1.4995	1.2200	0.0000	0.0000	0.0000
1858	5.4900	4.9750	4.5842	8	0	0.0000	0.9058	1.2200	0.0000	0.0000	0.0000
1859	6.9200	6.2950	6.0301	8	0	0.0000	0.8899	1.2200	0.0000	0.0000	0.0000
1860	7.3600	6.8000	5.7579	10	1	0.0000	1.6021	1.2200	0.0000	0.0000	0.0000
1861	7.6300	6.7800	6.0790	10	0	0.0000	1.5510	1.2200	0.0000	0.0000	0.0000
1862	6.3700	5.8200	4.8802	10	0	0.0000	1.4898	1.2200	0.0000	0.0000	0.0000
1864	7.1300	6.5800	5.6309	10	0	0.0000	1.4991	1.2200	0.0000	0.0000	0.0000
1865	8.2800	7.4300	6.6560	10	0	0.0000	1.6240	1.2200	0.0000	0.0000	0.0000
1866	8.7500	7.9000	7.1421	10	0	0.0000	1.6079	1.2200	0.0000	0.0000	0.0000
1867	9.2200	7.8450	7.5393	7	25	0.0000	1.6807	1.2200	0.0000	0.0000	0.0000
1868	9.6700	8.3200	7.9907	7	22	0.0000	1.6793	1.2200	0.0000	0.0000	0.0000
1869	9.4000	8.5500	7.7586	10	0	0.0000	1.6414	1.2200	0.0000	0.0000	0.0000
1870	9.4000	8.8500	7.8663	10	0	0.0000	1.5337	1.2200	0.0000	0.0000	0.0000
1871	10.3400	9.8400	8.8179	10	0	0.0000	1.5221	1.2200	0.0000	0.0000	0.0000
1872	10.8900	10.1750	9.6440	8	0	0.0000	1.2460	1.2200	0.0000	0.0000	0.0000
1873	52.1500	50.9550	50.7325	8	0	0.0000	1.4175	1.2200	0.0000	0.0000	0.0000
1874	52.4600	51.2400	51.0475	8	0	0.0000	1.4125	1.2200	0.0000	0.0000	0.0000
1878	58.5900	57.4300	56.9827	8	0	0.0000	1.6073	1.2200	0.0000	0.0000	0.0000
1879	55.3200	54.0700	53.7763	8	0	0.0000	1.5437	1.2200	0.0000	0.0000	0.0000
1880	55.6700	55.6700	54.1781	8	0	0.0000	1.4919	1.2200	0.0000	0.0000	0.0000
1881	61.9200	60.6200	60.3064	8	0	0.0000	1.6136	1.2200	0.0000	0.0000	0.0000
1883	62.4900	61.1250	60.9521	8	1	0.0000	1.5379	1.2200	0.0000	0.0000	0.0000
1884	62.9000	61.5250	61.3738	8	0	0.0000	1.5262	1.2200	0.0000	0.0000	0.0000
6001	5.8500	4.7100	4.2631	8	0	0.0000	1.5869	1.2200	0.0000	0.0000	0.0000
6002	5.4000	4.5900	4.1177	8	1	0.0000	1.2823	1.2200	0.0000	0.0000	0.0000
6003	55.7500	55.7500	54.2472	8	0	0.0000	1.5028	1.2200	0.0000	0.0000	0.0000
6004	51.2500	51.2500	49.6577	8	1	0.0000	1.5923	1.2200	0.0000	0.0000	0.0000
6005	11.7500	11.5000	9.2644	8	0	0.0000	2.4856	1.2200	0.0000	0.0000	0.0000
6006	11.5000	11.5000	9.5072	8	2	0.0000	1.9928	1.2200	0.0000	0.0000	0.0000
6008	5.2500	3.8000	3.5738	8	0	0.0000	1.6762	1.2200	0.0000	0.0000	0.0000
6014	50.0000	50.0000	48.5642	8	0	0.0000	1.4358	1.2200	0.0000	0.0000	0.0000

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6017	6.5500	6.2000	5.1316	8	0	0.0000	1.4184	1.2200	0.0000	0.0000	0.0000
6019	51.0000	48.7500	47.3362	8	1	0.0000	3.6638	1.2200	0.0000	0.0000	0.0000
6020	48.4500	47.5500	46.9824	8	1	0.0000	1.4676	1.2200	0.0000	0.0000	0.0000
6021	47.3000	47.3000	46.1975	8	1	0.0000	1.1025	1.2200	0.0000	0.0000	0.0000
6022	47.5000	46.9800	45.5953	8	2	0.0000	1.9047	1.2200	0.0000	0.0000	0.0000
6023	8.7500	7.3750	7.1261	8	0	0.0000	1.6239	1.2200	0.0000	0.0000	0.0000
6027	11.2000	10.6500	9.6528	10	8	0.0000	1.5472	1.2200	0.0000	0.0000	0.0000
6031	5.5000	4.9100	4.1080	8	2	0.0000	1.3920	1.2200	0.0000	0.0000	0.0000
6032	4.1000	4.1000	2.3927	8	2	0.0000	1.7073	1.2200	0.0000	0.0000	0.0000
6034	2.9500	1.7920	1.4108	32	31	0.0000	1.5392	1.2200	0.0000	0.0000	0.0000
6035	1.7500	0.8000	1.4633	82	8	0.6633	0.2867	1.2200	0.0000	0.0000	0.0000
6038	5.6500	4.9400	4.1324	8	2	0.0000	1.5176	1.2200	0.0000	0.0000	0.0000
6039	5.3500	5.2000	3.6980	8	2	0.0000	1.6520	1.2200	0.0000	0.0000	0.0000
CR7	3.9000	3.9000	2.0866	8	2	0.0000	1.8134	1.2200	0.0000	0.0000	0.0000
6041	6.0000	4.7500	4.0800	8	2	0.0000	1.9200	1.2200	0.0000	0.0000	0.0000
6042	7.0000	5.3100	4.0763	8	24	0.0000	2.9237	1.2200	0.0000	0.0000	0.0000
6043	7.0000	5.2000	3.8847	8	23	0.0000	3.1153	1.2200	0.0000	0.0000	0.0000
6044	48.0000	47.5000	46.2372	8	1	0.0000	1.7628	1.2200	0.0000	0.0000	0.0000
6045	51.0000	51.0000	49.6013	8	0	0.0000	1.3987	1.2200	0.0000	0.0000	0.0000
6046	55.8000	55.7940	54.2587	8	0	0.0000	1.5413	1.2200	0.0000	0.0000	0.0000
6048	3.7500	3.0500	2.1239	14	1	0.0000	1.6261	1.2200	0.0000	0.0000	0.0000
CR1	2.3000	1.1600	1.4000	0	0	0.2400	0.9000	1.2200	0.0000	0.0000	0.0000
CR2	1.8400	0.7100	1.4000	0	0	0.6900	0.4400	1.2200	0.0000	0.0000	0.0000
CR3	1.7500	0.5000	1.4000	0	0	0.9000	0.3500	1.2200	0.0000	0.0000	0.0000
CR4	1.7500	0.7400	1.4000	0	0	0.6600	0.3500	1.2200	0.0000	0.0000	0.0000
CR5	1.7500	0.4900	1.4000	0	0	0.9100	0.3500	1.2200	0.0000	0.0000	0.0000
CR6	1.8500	0.3000	1.4000	0	0	1.1000	0.4500	1.2200	0.0000	0.0000	0.0000
CR8	4.7500	3.3000	3.0673	8	0	0.0000	1.6827	1.2200	0.0000	0.0000	0.0000
CR9	1.7500	1.5000	1.4000	0	0	0.0000	0.3500	1.2200	0.0000	0.0000	0.0000
CR10	2.0000	1.2000	1.4000	0	0	0.2000	0.6000	1.2200	0.0000	0.0000	0.0000
Node274	47.5000	47.5000	46.0457	8	0	0.0000	1.4543	1.2200	0.0000	0.0000	0.0000
Node275	51.0000	51.0000	49.6030	8	0	0.0000	1.3970	1.2200	0.0000	0.0000	0.0000
Node279	47.0000	43.8000	42.3225	10	0	0.0000	4.6775	1.2200	0.0000	0.0000	0.0000
Node280	45.0000	41.8000	40.1244	10	0	0.0000	4.8756	1.2200	0.0000	0.0000	0.0000
Node282	66.0000	65.0500	65.2304	9	32	0.1804	0.7696	4800.0000	0.0000	0.0000	0.0000
Node284	60.0000	59.0000	58.0896	8	0	0.0000	1.9104	1.2200	0.0000	0.0000	0.0000
Node285	37.0000	36.2000	35.1152	8	1	0.0000	1.8848	1.2200	0.0000	0.0000	0.0000
Node286	25.0000	24.0500	24.0834	18	3	0.0334	0.9166	2800.0000	0.0000	0.0000	0.0000
Node289	34.0000	30.1000	29.1192	10	0	0.0000	4.8808	1.2200	0.0000	0.0000	0.0000
Diversion	34.0000	30.0000	29.5124	10	1	0.0000	4.4876	1.2200	0.0000	0.0000	0.0000
Node292	34.0000	30.0000	29.0864	10	1	0.0000	4.9136	1.2200	0.0000	0.0000	0.0000
Node295	66.0000	65.0500	64.1949	9	37	0.0000	1.8051	1.2200	0.0000	0.0000	0.0000
Node297	25.0000	24.0500	23.0362	18	9	0.0000	1.9638	1.2200	0.0000	0.0000	0.0000
Node298	47.0000	43.1000	43.2578	23	8	0.1578	3.7422	600.0000	0.0000	0.0000	0.0000
Node300	3.7500	3.0500	3.1481	14	2	0.0981	0.6019	1100.0000	0.0000	0.0000	0.0000
Node302	34.0000	30.1000	30.1692	24	9	0.0692	3.8308	1500.0000	0.0000	0.0000	0.0000
Node304	37.0000	36.0500	35.9792	24	11	0.0000	1.0208	600.0000	0.0000	0.0000	0.0000
Node306	37.0000	36.2000	36.1740	24	15	0.0000	0.8260	4500.0000	0.0000	0.0000	0.0000

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|        Table E10 - CONDUIT SUMMARY STATISTICS        |
| Note: The peak flow may be less than the design flow |
| and the conduit may still surcharge because of the   |
| downstream boundary conditions.                      |
|                                                      |
| * denotes an open conduit that has been overtopped   |
|   this is a potential source of severe errors        |
*=====================================================*
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Conduit Name	Design Flow (cms)	Conduit Design Velocity (m/s)	Maximum Vertical Depth (mm)	Maximum Computed Flow (cms)	Time of Occurence Hr.	Time of Occurence Min.	Maximum Computed Velocity (m/s)	Time of Occurence Hr.	Time of Occurence Min.	Ratio of Max. to Design Flow	Maximum Water Elev at Pipe Ends Upstream (m)	Maximum Water Elev at Pipe Ends Dwnstrm (m)	Ratio d/D US	Ratio d/D DS	
1686	0.2464	1.1382	525.0000	0.0143	8	0	0.0886	8	1	0.0582	1.4036	1.4025	0.674	1.071	
1687	0.4054	1.3870	610.0000	0.0317	8	0	0.1122	8	0	0.0783	1.4025	1.4000	0.922	1.393	
1691	0.1486	0.9342	450.0000	0.0462	8	1	0.2921	8	1	0.3112	1.5147	1.4792	0.988	1.576	
1692	0.3450	1.1806	610.0000	0.0463	8	0	0.1582	8	0	0.1343	1.4792	1.4735	1.261	1.530	
1693	0.2095	0.7170	610.0000	0.0685	8	0	0.2336	8	0	0.3269	1.4735	1.5878	1.530	1.816	
1694	0.2795	0.9562	610.0000	0.0853	8	0	0.2908	8	0	0.3054	1.5879	1.5165	1.816	1.830	
1695	0.3123	1.0688	610.0000	0.1095	8	0	0.3728	8	0	0.3505	1.5163	1.4000	1.830	2.131	
1696	0.8164	2.2154	685.0000	0.4408	7	55	1.5287	11	12	0.5399	2.9111	2.6296	1.388	1.766	
1697	0.8937	1.9700	760.0000	0.4968	7	55	1.0903	7	55	0.5559	2.6295	2.3051	1.684	2.191	
1698	0.5402	1.1909	760.0000	0.5577	8	1	1.2192	8	1	1.0323	2.3051	1.8343	2.336	2.150	
1699	0.5536	0.8419	915.0000	0.5908	8	0	0.8940	8	0	1.0671	1.8343	1.6388	1.786	1.693	
1700	0.6932	1.2216	850.0000	0.6037	8	0	1.0583	8	0	0.8708	1.6388	1.4000	1.822	1.776	
1701	0.3380	1.1955	600.0000	0.0214	8	0	0.0756	8	0	0.0634	1.4344	1.4383	1.557	1.981	
1702	0.4103	1.4512	600.0000	0.0214	8	0	0.0755	8	0	0.0523	1.4127	1.4374	1.021	1.562	
1704	0.8005	2.7391	610.0000	0.3613	8	0	2.3031	8	1	0.4513	9.1226	7.6432	0.529	0.530	
1705	0.8300	2.8402	610.0000	0.3731	8	0	2.3989	8	1	0.4495	7.6432	5.8961	0.530	0.485	
1707	0.0670	0.2030	300.0000	0.0187	8	0	0.0566	8	0	0.2786	1.4078	1.4000	4.359	4.667	*
1709	0.0654	0.5765	380.0000	0.0284	8	0	0.5424	8	0	0.4347	7.3450	7.2100	0.487	0.316	
1710	0.2135	1.6991	400.0000	0.0352	8	0	1.1093	8	1	0.1649	7.1812	6.6398	0.303	0.274	
1711	0.1169	1.0583	375.0000	0.0203	8	0	0.6404	8	0	0.1740	7.1261	7.0313	0.336	0.270	
1712	0.9275	2.5919	675.0000	0.0555	8	0	1.3356	8	1	0.0599	6.6255	5.7606	0.171	0.193	
1713	0.8521	2.3813	675.0000	0.0701	8	0	1.3601	8	0	0.0823	5.7606	4.5816	0.193	0.269	
1715	0.5474	1.5296	675.0000	0.0841	8	0	0.9794	7	19	0.1537	4.5816	4.1812	0.269	0.476	
1716	1.0277	1.6155	900.0000	0.1151	8	0	0.5936	6	13	0.1120	4.1812	4.1478	0.357	0.509	
1718	0.0532	0.0000	900.0000	0.1358	8	0	0.4358	7	18	2.5537	4.1478	4.1177	0.509	0.475	
1719	0.2736	0.4301	900.0000	0.2186	8	1	0.7542	8	2	0.7990	4.0225	3.7483	0.492	0.209	
1720	2.4503	3.8516	900.0000	0.2272	8	1	2.0252	8	1	0.0927	3.7483	2.6054	0.209	0.417	
1726	0.1802	1.5885	380.0000	0.0306	8	0	1.0997	7	36	0.1699	3.1381	2.5644	0.285	0.380	
1727	0.1796	1.5837	380.0000	0.0477	7	49	1.1953	7	5	0.2658	2.5644	2.3051	0.380	1.277	
1736	0.0654	0.5770	380.0000	0.0000	0	0	0.0000	0	0	0.0000	5.4500	5.1570	.0000	.0000	
1737	0.1627	1.4345	380.0000	0.0308	8	0	1.0445	8	0	0.1893	5.1570	4.1618	0.308	0.294	
1738	0.3873	1.3252	610.0000	0.0308	7	44	0.7448	7	43	0.0795	4.0409	3.7385	0.198	0.211	
1739	0.3666	1.2545	610.0000	0.0601	7	55	0.8055	7	42	0.1638	3.7385	3.4138	0.309	0.252	
1742	2.1628	7.4004	610.0000	0.0727	7	47	3.7071	0	27	0.0336	3.2296	2.6296	0.114	1.983	

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1746	0.8722	2.9846	610.0000	0.3730	8	1	2.5661	8	2	0.4276	5.8961	3.8342	0.485	0.613
1747	0.8719	2.9833	610.0000	0.4177	8	1	2.3792	9	0	0.4790	3.8342	2.9111	0.613	1.395
1767	0.1406	1.2727	375.0000	0.0775	8	0	1.1441	8	1	0.5515	61.3738	60.9521	0.597	0.539
1768	0.1624	1.4700	375.0000	0.0773	8	1	1.2214	8	2	0.4760	60.9521	60.3722	0.566	0.486
1770	0.6130	3.8545	450.0000	0.1047	8	0	2.5981	8	0	0.1708	60.3064	57.1058	0.303	0.280
1772	0.5600	3.5211	450.0000	0.1208	8	0	2.6194	8	0	0.2156	56.9827	53.7763	0.317	0.458
1773	0.2491	1.5662	450.0000	0.1034	8	0	1.1267	8	1	0.4152	54.1781	53.8221	0.574	0.449
1774	0.5293	3.3281	450.0000	0.2346	8	0	2.8790	8	1	0.4431	53.7763	51.0475	0.503	0.572
1775	0.9108	4.2072	525.0000	0.2583	8	0	1.7779	8	0	0.2836	51.0475	50.7325	0.643	0.576
1776	0.6406	2.9593	525.0000	0.2583	8	0	1.9058	8	1	0.4031	50.7325	49.6577	0.633	0.300
1779	5.1185	4.5257	1200.000	0.2967	10	0	1.9948	10	1	0.0580	8.8179	7.8663	0.190	0.180
1780	0.4226	1.1808	675.0000	0.0339	8	0	0.6276	7	20	0.0803	9.6440	9.2516	0.213	0.165
1781	0.0532	0.0000	900.0000	0.0524	10	1	0.4752	10	1	0.9852	7.8663	7.7586	0.240	0.121
1782	0.2437	1.9394	400.0000	0.0146	8	0	0.9423	7	20	0.0597	7.9907	7.7586	0.177	0.272
1783	2.1702	3.4113	900.0000	0.0613	10	0	1.3394	10	0	0.0282	7.7586	7.1421	0.121	0.158
1784	0.2561	2.3184	375.0000	0.0192	8	0	1.2006	7	21	0.0748	7.5393	7.1421	0.185	0.379
1785	1.6548	2.6012	900.0000	0.0730	10	0	1.1489	10	1	0.0441	7.1421	6.6560	0.158	0.140
1786	1.7708	2.7835	900.0000	0.0730	10	0	1.2265	10	1	0.0412	6.6560	6.0790	0.140	0.221
1787	0.9183	1.4434	900.0000	0.0789	10	0	0.7753	10	1	0.0859	6.0790	5.7681	0.221	0.176
1789	2.9635	3.4224	1050.000	0.2443	10	0	1.9142	10	1	0.0824	7.8663	5.7333	0.206	0.194
1790	2.9712	2.6271	1200.000	0.2513	10	0	1.4554	10	1	0.0846	5.6309	4.8802	0.209	0.217
1791	2.9846	2.6390	1200.000	0.2690	10	0	1.4633	10	1	0.0901	4.8802	4.1882	0.217	0.240
1792	2.2539	1.0435	1200.000	0.3814	10	1	0.5331	10	1	0.1692	4.1882	4.1324	0.332	0.327
1793	0.1885	0.6452	610.0000	-0.0985	10	4	-0.4194	10	18	-0.5224	4.1177	4.1272	0.701	0.782
1795	0.3023	1.3962	525.0000	-0.0587	8	0	-0.2902	8	0	-0.1943	4.5842	4.5305	0.465	1.239
1796	0.1540	1.3945	375.0000	0.0274	8	0	1.0154	8	0	0.1777	6.0301	4.7069	0.294	0.285
5005	0.0533	0.7547	300.0000	0.0104	37	43	0.1448	37	43	0.1942	1.4632	1.4000	3.211	4.000
5006	0.4732	1.6735	600.0000	0.0332	8	0	0.1168	8	0	0.0702	1.4383	1.4000	1.981	2.517
5009	0.4033	1.4264	600.0000	-0.0086	79	59	0.0557	80	1	-0.0214	1.4108	1.4127	0.365	1.021
5010	0.3744	2.3541	450.0000	0.0530	8	0	1.1071	7	31	0.1414	9.2644	9.1226	0.299	0.717
5011	0.8108	2.8676	600.0000	0.3011	8	2	1.7367	8	4	0.3713	9.5072	9.1226	0.595	0.538
5014	0.7426	5.9092	400.0000	0.0415	8	0	4.0448	0	25	0.0559	48.5642	46.2372	0.160	0.593
5015	1.3973	3.1628	750.0000	0.2580	8	1	1.4079	7	15	0.1846	47.3362	47.0180	0.448	0.291
5016	1.8870	4.2712	750.0000	0.2990	8	1	1.3720	8	6	0.1585	46.1975	45.5953	0.530	0.154
5018	9.2425	1.3204	1750.000	0.0984	8	0	0.3977	8	0	0.0106	54.2472	54.1781	0.141	0.147
5021	5.6825	5.0245	1200.000	0.2495	10	0	2.0062	10	0	0.0439	9.6528	8.8179	0.169	0.148
5022	1.2277	1.0231	1200.000	0.0824	10	0	0.5364	8	1	0.0671	5.7579	5.1316	0.132	0.110
5023	2.0806	1.7338	1200.000	0.1202	8	0	0.8213	8	0	0.0578	5.1316	4.1882	0.110	0.240
5024	0.0188	0.0000	610.0000	-0.0952	10	4	-0.3891	10	17	-5.0546	4.1272	4.1324	0.782	0.791
5026	0.7246	1.1390	900.0000	0.1744	8	2	0.8068	8	2	0.2407	4.1080	3.6980	0.398	0.109
5027	16.1398	5.6041	1600.000	0.3480	8	2	1.5161	8	2	0.0216	3.6980	2.3927	0.061	0.245
5029	1.2065	1.8965	900.0000	0.2329	8	1	0.9624	8	1	0.1931	2.6054	2.4676	0.417	0.297
5030	0.2291	1.0581	525.0000	0.0705	8	0	0.7963	8	0	0.3080	4.5305	4.3146	0.439	0.333
5031	0.5690	2.0124	600.0000	0.0705	8	0	1.0592	7	22	0.1240	4.2631	4.0800	0.255	0.550
5032	0.0669	0.9468	300.0000	0.0081	8	0	0.6087	8	0	0.1213	3.5738	3.0673	0.246	0.224
5033	5.8344	2.1609	1500.000	0.4630	8	24	0.9966	8	24	0.0794	4.0763	3.8847	0.178	0.123
5034	0.4674	0.7347	900.0000	0.2047	8	2	0.6987	8	2	0.4381	4.1177	4.0225	0.475	0.414
5035	1.9190	4.3438	750.0000	0.2580	8	2	1.7752	8	3	0.1345	46.9824	46.4854	0.376	0.247
Link232	2.1224	0.9826	1200.000	0.2863	10	1	0.4067	10	1	0.1349	4.1324	4.1080	0.327	0.332

Campbell River / Quinsam River ISMP
XP-SWMM Modeling Results

Link233	0.0704	0.0000	1000.000	0.1162	10	3	0.4732	10	7	1.6498	4.1080	4.0800	0.358	0.330
5025	0.9887	1.2589	1000.000	0.1672	8	2	0.8053	8	2	0.1691	4.0800	3.6980	0.330	0.098
Link236	1.0533	2.7370	700.0000	0.0721	14	1	0.9004	14	1	0.0684	2.1239	1.4000	0.177	1.286
Link237	42.5308	6.3009	1500.000	0.0530	8	0	2.6588	0	23	0.0012	46.0457	10.0315	0.030	0.021
Link238	37.0144	4.7002	1750.000	0.2582	8	1	1.3838	0	24	0.0070	49.6577	47.3362	0.090	0.192
Link239	4.6551	1.2414	1500.000	0.0279	8	0	0.2598	8	0	0.0060	49.6013	48.5642	0.068	0.043
5028	14.4354	4.1677	2100.000	0.5900	8	2	1.3634	8	3	0.0409	2.3927	2.0866	0.187	0.136
Link242	9.1913	1.3130	1750.000	0.0429	8	0	0.2310	6	18	0.0047	54.2587	54.2472	0.123	0.141
Link243	42.2225	6.2552	1500.000	0.3011	8	2	2.3757	0	24	0.0071	45.5953	10.1134	0.077	0.076
Link244	18.6199	2.7585	1500.000	0.2990	8	1	1.6317	0	25	0.0161	46.2372	46.1975	0.158	0.265
Link245	8.7089	2.3224	1500.000	0.0486	8	0	0.8575	0	24	0.0056	49.6030	46.0457	0.069	0.030
Link252	18.7252	5.3500	1000.000	0.2496	10	1	1.1752	10	0	0.0133	29.0864	9.6528	0.086	0.203
Link253	11.0937	4.3596	1800.000	0.4882	10	0	1.6996	10	0	0.0440	42.3225	40.1244	0.179	0.069
Link257	8.3039	2.3725	1000.000	0.4372	9	37	0.9070	9	29	0.0526	64.1949	42.3225	0.195	0.323
Link258	19.8639	5.6754	1000.000	0.4882	10	0	1.2627	10	0	0.0246	40.1244	29.5124	0.124	0.512
Link259	10.8958	3.1131	1000.000	0.2493	10	0	0.8471	10	54	0.0229	29.1192	4.0763	0.119	0.266
Link260	9.7933	2.1763	1000.000	0.5122	8	23	0.5470	8	23	0.0523	3.8847	1.4000	0.185	0.900
Link261	14.1354	3.1412	1000.000	0.2192	8	0	2.2481	0	23	0.0155	58.0896	35.1152	0.090	0.115
Link262	10.9475	2.4328	1000.000	0.2590	8	1	0.6543	0	23	0.0237	35.1152	4.0763	0.115	0.266
Link263	10.3736	2.9639	1000.000	0.0322	18	9	0.3492	18	26	0.0031	23.0362	2.1239	0.036	0.124
Area 1 Out	0.0000	0.0000	1050.000	0.4376	9	23	0.7188	9	23	0.0000	65.2304	64.1949	1.172	0.186
Area 7 Out	0.0000	0.0000	1050.000	0.0323	18	2	0.5161	18	2	0.0000	24.0834	23.0362	1.032	0.034
Area 2 Out	0.0000	0.0000	1100.000	0.0069	24	6	0.5034	24	6	0.0000	43.2578	42.3225	1.143	0.293
Area 8 Out	0.0000	0.0000	1050.000	0.0328	14	8	0.5164	14	8	0.0000	3.1481	2.1239	1.093	0.118
Area 3 Out	0.0000	0.0000	1100.000	0.0054	24	16	0.5027	24	16	0.0000	30.1692	29.1192	1.063	0.108
Area 4 Out	0.0000	0.0000	1050.000	0.0008	26	21	0.5004	26	21	0.0000	35.9792	35.1152	0.933	0.110
Area 5 Out	0.0000	0.0000	1200.000	0.0161	25	17	0.5081	25	17	0.0000	36.1740	35.1152	0.978	0.096
Low Flow.1	0.2620	0.1467	300.0000	0.2386	10	1	1.4043	10	1	0.9108	29.5124	29.1192	1.708	0.408
High Flow.1	Undefnd	Undefnd	Undefn	0.2496	10	1								
FREE # 1	Undefnd	Undefnd	Undefn	0.5900	8	2								
FREE # 2	Undefnd	Undefnd	Undefn	0.0317	8	0								
FREE # 3	Undefnd	Undefnd	Undefn	0.1095	8	0								
FREE # 4	Undefnd	Undefnd	Undefn	-0.0133	37	44								
FREE # 5	Undefnd	Undefnd	Undefn	0.6037	8	0								
FREE # 6	Undefnd	Undefnd	Undefn	0.0332	8	0								
FREE # 7	Undefnd	Undefnd	Undefn	0.0187	8	0								
FREE # 8	Undefnd	Undefnd	Undefn	0.0081	8	0								
FREE # 9	Undefnd	Undefnd	Undefn	0.5122	8	23								
FREE #10	Undefnd	Undefnd	Undefn	0.0721	14	1								

APPENDIX E

WORKING GROUP MATERIALS

(Electronic Version on CD-ROM only)

City of Campbell River
Integrated Stormwater Management Plan
- Campbell River / Quinsam River -

Stakeholder's Working Group Meeting #1

Tuesday, June 20, 2006
10 a.m. – 12 p.m.
Enterprise Centre - East Wing (adjacent to City Hall)
900 Alder St
Campbell River, BC

Agenda

1. Introductions
2. General background and scope of ISMP's
3. Stakeholder's Working Group Business
    a. Terms of Reference
    b. Member Composition
    c. Chairperson
    d. Schedule
    e. Distribution of Information (email? fax? other?)
4. Project status to date
5. Brainstorming session on issues, concerns and challenges in each watershed
6. Other

2353 - 13353 Commerce Parkway, Richmond, BC V6V 3A1
Telephone: 604-273-8700 Fax: 604-273-8752

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MEETING NOTES

subject:	**Campbell River/Quinsam River ISMP Working Group Meeting #1**
date:	June 26, 2006
meeting date:	June 20, 2006
location:	Enterprise Centre, Campbell River
file:	1479.0009.01 M
prepared by:	Melanie Ross
distribution:	All Attendees and

attendees	company	e-mail
Ron Neufeld	City of Campbell River	ron.neufeld@campbellriver.ca
Rick Senger	Department of Fisheries & Oceans	sengerr@pac.dfo-mpo.gc.ca
Lawrie Bowles*	Biologist/Citizen	todspond@gicable.com
Barry Peters	Department of Fisheries & Oceans	petersb@pac.dfo-mpo.gc.ca
Kathy Campbell	City of Campbell River	Kathy.campbell@campbellriver.ca
Tony Roberts Jr.	CR Indian Band	troberts@crband.ca
Lesley Fell	Estuary Protection Group	zephyr52@telus.net
Melanie Ross	USL	mross@urban-systems.com
Jeff Rice	USL	jrice@urban-systems.com
Leona Adams	Estuary Protection Group	lowie@ccable.net
Luisa Richardson	Greenways Land Trust	executive@greenways.ca

*Observer only

ITEM DISCUSSION **ACTION BY**

1.0 Introductions

1.2 General Background and Scope of ISMP (PowerPoint presentation by Jeff Rice)

1.3 Working Group Business

a) *Terms of Reference:* — Info.

The Working Group Terms of Reference (ToR) was distributed and discussed with all attendees. Jeff and Ron explained that the ToR is meant to provide information about the role/expectations of a Working Group member.
Rick Senger, Tony Roberts and Lousia Richardson all stated that they were concerned over possible legal implication this agreement may link them to in the future. Jeff and Ron's response to their concern was that they would prefer a signed ToR by each participating member of the Working Group but that they would also allow those who could not sign it to remain on the committee.

b) *Member Composition:*

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ITEM	DISCUSSION	ACTION BY

Info.

The following people have indicated desire to participate on the Working Group:

Rick Senger	Department of Fisheries & Oceans
Barry Peters	Department of Fisheries & Oceans
Tony Roberts Jr.	Campbell River Indian Band
Lesley Fell	Estuary Protection Group
Leona Adams	Estuary Protection Group
Luisa Richardson	Greenways Land Trust
Alistair McLean	BC Hydro
Julie Sigurdson	Campbell River Environment Council
Mike Gage	Campbell River Gravel Committee
Gary Giese	Bonaventure Development Corp.
Jim Van Tine	Haig-Brown Kingfisher Corp.
Peter Law	MWLAP
Tim Ennis	Nature Conservancy of BC
Hubert Bunce	Q Coal Environmental Technical Review Committee
Dave Selent	Quinsam Coal Corporation
Dave Ewart	Quinsam Hatchery

Other possible members, who have not responded yet: Ministry of Transportation, Cape Mudge First Nation, and Tyee Club of BC

c) *Chairperson:* — Info.

Yet to be decided – must be decided during next meeting (September 5, 2006)

d) *Schedule:* — Info.

Jeff explained that things would probably be pretty quiet throughout the summer as far as information sharing with the public, but that there will be two more Working Group meetings as well as two Public open houses, scheduled for September 5 and October 23.

Working Group meetings will be held from 10:00 am to 12:00 pm.

e) *Distribution of Information:* — Info

All attendees agreed that email should be used as the main form of communication among Working Group members

f) *Project Status to date:* — Info.

Jeff explained that we are in the research stages of the Campbell River/Quinsam River ISMP.

- USL has met with the CoCR to discuss their concerns.
- USL has obtained GIS information from the City for the project area.
- Violet Komori (Biologist) from Komori Wong Environmental is in the process of collecting information and will be in touch with a few of the

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ITEM	DISCUSSION	ACTION BY
	Working Group members. • Andy Holmes from Piteau Associates will be within the Campbell River area in the near future to check out the project site.	
1.4	**Brainstorming session on issues, concerns and challenges in each watershed**: See attached sheets	
1.5	**Other:**	
	Tony Roberts Jr. stated that the Campbell River Indian Band has many concerns and issues with this stormwater project. He stated that although he was primarily concerned with the Nunn Creek watershed area there are still some issues that are transferable to the CR/QR project area: • Communication: Tony stated that the Campbell River Indian Band should not be addressed as Stakeholders but should be addressed as Land Owners or First Nations. • Tony stated that the CR Indian Band would prefer it if the CoCR and USL presented the CR/QR ISMP project to them much in the same way it will be presented to CoCR Council members. • Tony expressed concerns over flooding in the flats area. • Tony stated that bridges should be used wherever possible instead of culverts.	Info
	Melanie to email Louisa a digital copy of the ToR so that she can distribute it to members of the Greenways Land Trust.	Melanie
	Jeff will post a selection of PDFed resource documents to the USL Ftp site for everyone's review/use.	Jeff
	Leona stated that she is concerned about contaminants entering the watershed in the Campbellton area.	Info.
	For future, long-term financing, Jeff and Ron discussed the possibility of a Campbell River Stormwater uses charge. Ron noted that Campbell River currently uses a dedicated parcel tax for stormwater.	Info.
	Louisa agreed to get pastries/donuts for next meeting.	Louisa

The preceding is the writer's interpretation of the proceedings and any discrepancies and/or omissions should be reported to the writer.

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Brainstorming Session: Working Group members slipt into groups of three to discuss/brainstorm ideas around several questions. Responses are listed below for two sets of questions.

1. **How would you describe these streams and rivers? What makes them special?**
2. **How would you describe the watershed, the surrounding lands? What makes this area great?**

All living streams with natural habitat and enhanced salmon habitat.

Watersheds are Diverse

- Rural vs. urban development
- Size of streams – Detweiler Creek vs. Quinsam and Campbell Rivers
- Surrounding land is great
- Used for recreation
- Greenspace around Haig-Brown Kingfisher Creek is great
- Urban pressures are present

Detweiler Creek

- Limited value
- Heavily impacted already
- Little development pressure – active
- Limited opportunities for restoration
- Upper watershed offers best potential
- Fish bearing
- Wildlife corridor
- Access for enjoyment/recreation
- Low elevation

Haig-Brown Kingfisher Creek

- Development pressure in upper watershed
- For both branches – protection is important – stormwater management is critical
- Lower portion is well protected and offers good habitat and recreational value
- Historical/cultural ties to Haig Brown House
- Erosion Potential
- Threatened by golf course at headwaters and other development – but also freest of development throughout
- Fish bearing
- Wildlife corridor
- Access for enjoyment/recreation
- Low elevation
- Low flow summer issues

Quinsam River

- Erosion/Bank Stability
- Good recreational opportunities
- Utility vulnerability
- Low density
- Fish bearing
- Development pressure

- Wildlife corridor

Campbell River

- Erosion
- Recreational value
- Limited development pressure
- Property acquisition / protection
- Hydro influence (stable)
- Heritage River
- Fisheries value/ Fish bearing
- Nutrient-rich runoff
- Invasive aquatics
- Hard surface runoff
- Development pressure
- Wildlife corridor

2.a. If you could change anything in the area, what would it be? How would you make it better?

- Year round flow in Haig Brown Kingfisher
- +30m minimum of natural vegetation surrounding streams
- Investigate greater use of swales, ditches instead of culverts
- Catch basins to keep polluted water out of streams
- Oil/water separation before discharge to streams
- Monitor water quality
- Keep ditches/swales
- Return stormwater to ground where possible
- Alternate design standards to reduce impervious surface to < 10%.
- Effective impervious surface mapping
- Coordinate with Nunns Creek in flood reduction
- Catch basins that aren't breeding areas for West Nile Mosquitoes
- Maintain the natural flow regimes and water quality in the small streams and Campbell River
- Naturalization of riparian areas for all streams in the area
- Pesticide bans
- Better development controls on private lands
- Further improvements to logging practices to protect streams
- Change homeowners/business owner's attitude to any substances they release into water systems
- Improvements to flood-prone areas
- Replace culverts with bridges

2.b. What stands in the way of making these changes?

- Cost
- Community attitudes stand in the way
- Personal interests
- Lack of education – if we want compliance and cooperation from the public much more needs to be done as far as educating the public of the positive effects of stormwater management.

City of Campbell River
Integrated Stormwater Management Plan
- Campbell River/Quinsam River -

Working Group Meeting #2

Tuesday, September 12, 2006
10 a.m. – 12 p.m.
Enterprise Centre - East Wing (adjacent to City Hall)
900 Alder St
Campbell River, BC

Agenda

1. Re-introductions
2. Minutes of last meeting
3. Project status to date
4. Review of briefing paper
5. Discussion of environmental issues
6. Development of basis for draft plan
7. Other

2353 - 13353 Commerce Parkway, Richmond, BC V6V 3A1
Telephone: 604-273-8700 Fax: 604-273-8752

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MEETING NOTES

subject:	**Campbell River/Quinsam River ISMP**
date:	September 20, 2006
meeting date:	September 12, 2006
location:	Enterprise Centre
file:	1479.0009.01 M
prepared by:	Melanie Ross
distribution:	All Attendees, Ron Burrell, Mike Gage, Tony Roberts Jr., Allistair McLean, Derek Richmond, Bob Hall, Jim Van Tine, Dave Selent and Gary Giese and Brian Kelly

attendees	company	e-mail
Tim Ennis	Nature Conservancy Canada	tim.ennis@natureconservancy.ca
Violet Komori	Komori Wong Environmental	komorive@shaw.ca
Leona Adams	Estuary Protection Group	lowie@crcable.net
Luisa Richardson	Greenways Land Trust	executive@greenwaystrust.ca
Barry Peters	Stewardship Advisory Council	petersb@pac.dfo-mpo.gc.ca
Kathy Campbell	City of Campbell River	Kathy.campbell@campbellriver.ca
Lesley Fell	Estuary Protection Group	zephyr@telus.net
Shannon Anderson	Department of Fisheries & Oceans	andersonsh@pac.dfo.mpo.gc.ca
Dave Ewart	DFO – Quinsam Hatchery	ewartd@pac.dfo-mpo.gc.ca
Rick Senger	Department of Fisheries & Oceans	sengerr@pac.dfo-mpo.gc.ca

ITEM	DISCUSSION	ACTION BY
1.0	**Re-Introductions**	
2.0	**Reviewed last meeting's minutes**	
2.1	Group decided that the Working Group is functioning sufficiently without a chairperson and therefore no one will be elected or volunteer for the chair position.	Info.
3.0	**Project Status:**	
3.1	• Jeff reviewed project status. Currently at the half-way mark in the project. Slightly behind schedule (approximately 1 week) • Plan to complete Draft Report by mid October followed by our second open house and Working Group meeting • **Next Working Group session will be held November 1, 2006 at 10:00am. Paper will be made available for review 1 week prior.** • Final paper submitted to Council before December 1st	Info.
4.0	**Review of Briefing Paper**	
4.1	Tim enquired about the status of the Hydrogeology report. Jeff stated that a full copy of the Hydrogeology report will be included as an appendix of the draft and final reports. Although a draft report is currently available for viewing, Tim agreed to wait until the final version.	Info

ITEM	DISCUSSION	ACTION BY
4.2	The group studied and reviewed the 9 figures at the back of the report.	Info
4.3	Tim questioned the purple zone on Fig. 3. Jeff to check his data to see what the history of the area is for each purple zone. (ie. is it an underground river diverted through culverts – possibly old Willow Creek?)	Jeff
4.4	Jeff to compute the percentage of trees in each watershed and run comparisons.	Jeff
4.5	Jeff shared revised Figure 5 which displays the location of two Oil/water Separators and a Water Quality Pond that were installed after the highway was built. Updated figure to be used in future reports.	Info.
4.6	Jeff shared Figure #10 (not in original briefing paper) which showed the potential for future development, redevelopment and loss of forest.	Info
4.7	Leona questioned why the area near Walworth (wetland) was cleared? • Rick explained that it wasn't a natural wetland, that it was created by MoT during the construction of the Inland Island Hwy and that they have simply re-routed the culverts elsewhere.	Info
4.8	Violet inquired about the development plans for the Quinsam River/Detwieller areas? • Jeff responded that according to the OCP there will be low density residential development (acreage).	Info
4.9	Group discussed future bareland strata development between the highway and East Kingfisher. • Different rules apply to bareland strata • The City doesn't have control over what is done within the Strata community they only have control at the connection sites at the property boundaries • Needs to be addressed in the draft and final ISMP's. • Prescriptive vs. performance driven rules	Info
4.10	Dave questioned how low vs. high density housing would effect SWMPs? • Jeff explained that one isn't necessarily better; they just require different management tools/regulations (i.e. green roofs on high-rises, porous pavement driveways, etc.)	Info
4.11	Shannon stated that it would be helpful to know what types of development are being planned for different areas displayed on Fig. 10 so that the group can effectively plan this SWMP on the theory that the more you know, the more you're prepared you are, and the better you can fight for environmental protection.	Info

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ITEM	DISCUSSION	ACTION BY
4.12	Dave questioned the level of successful stormwater treatment technology in the Campbelton area. • Jeff stated that the level was very low – both in terms of the number of units installed and the sophistication of the units	Info
4.13	Tim cautioned that although the figures show ALR land as having no potential for development/redevelopment the land can be removed from this protected status.	Info
4.14	Jeff discussed pollutants - suspended solids • 20% of total project area produces the most pollutants (Campbellton). • Jeff suggested that cost effective treatment might focus first on this area.	Info
4.15	Jeff stated that suspended solids can be eliminated through stormwater treatment. Although this can be costly (especially if you wish remove heavy metals as well as sediment) it's extremely beneficial. ***Maintenance is key*** with water treatment systems however, this requires dedication of funds.	Info
4.16	Jeff noted that USL recommended 8 stormwater treatment systems in areas of the Foreshore ISMP.	Info
4.17	Tim questioned how areas outside of the project boundaries affect CR/QR ISMP?	Info
4.18	It was agreed that more research needs to be done on IR12's SW management practices. Once the CoCR advises USL how to proceed with the bands, USL will obtain any available information.	Jeff
4.19	Tim suggested that maybe a group member could contact the band for modeling information.	Info
4.20	Dave believes that IR12 implemented its own independent SW management system a couple of years back and that all SW is treated and routed on FN lands (i.e. doesn't enter project area).	Info
4.21	Jeff will try to account for what is going on in Detwieller – Silt and suspended particles may be a problem.	Jeff
5.0	**Discussion of Environmental Issues – Violet Komori**	
5.1	35% of the area is still forested.	Info
5.2	Very diverse terrain – lots of different SW management options.	Info
5.3	Not much opportunity to change Campbelton but lots of opportunity to protect Detweiller.	Info
5.4	Violet wishes to do some storm drain sampling.	Info

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ITEM	DISCUSSION	ACTION BY
5.5	HBK Creek – lots of issues: • Information may be difficult to obtain due to sometimes poor communication between CoCR and the Bands. USL will await CoCR direction on contact with the bands before approaching them for information. • Evidence of fish living in the pipes in lower areas – Violet to look for evidence for fish in pipes further up stream.	Violet
5.6	There's a tide gate located under the hwy near the HB house.	
5.7	Violet questioned whose responsibility is it to maintain the diversion wall? • No one knows – Jeff will question the CoCR • HB used to do fish counts there – but not anymore • Stewardship group was responsible for getting it built • Dave stated that it is imperative for structures like this to be maintained – if they're not maintained they're essentially a waste of money.	Info
5.8	Beavers – significant presence in HBK watershed. CoCR must acknowledge that one, single dam can't be removed; the effects would be detrimental. Must look at the whole problem. Violet suggested that city go out at high flow and look to see where the water is going. The beaver dams may have changed the course.	Info
5.9	Violet doesn't think the beaver dams should be removed.	Info
5.10	Violet to contact Rick Stevens at Highland Engineering and David Reid at Lanarc to discuss Beaver situation.	Violet
5.11	Kathy requested a copy of Violet's presentation to pass along to the Public Works department.	Violet
5.12	Jeff wanted to discuss issues that the group may have some control over: • Flows • Water quality • Maintenance • Enhancements • Protection	Info
5.13	Leonna stated that the CoCR really needs more monitoring programs. Perhaps another stewardship group can help.	Info
5.14	Dave raised concerns over pollutants entering the watershed during fires (i.e. foam and burnt materials). Questioned if USL could focus on this.	Jeff
5.15	Violet inquired about an Emergency response plan? If there is one she would like to review.	Kathy

ITEM	DISCUSSION	ACTION BY
5.16	Jeff asked the group what they're priority areas are: • Campbelton (Leonna, Violet and Kathy to do a site walk to pinpoint specific areas) • Barry is interested in groundwater (MoT may monitor). Questioned if springs are still producing water and if so are there fish? • Barry is concerned about fish in storm drains. • IR 12 Biologist info may be available – Violet has called but will follow-up • Quinsam River doesn't concern Violet at all – her observation was that future development may impact the area.	Jeff
5.17	Shannon stated that the river gets ramped up on the 15th of September. Campbell goes from aprrox. 32 cms to aprrox. 122 cms in October. Quinsam can be checked on-line	Info

The preceding is the writer's interpretation of the proceedings and any discrepancies and/or omissions should be reported to the writer.

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City of Campbell River
Integrated Stormwater Management Plan
- Campbell River / Quinsam River -

Working Group Meeting #3

Wednesday, November 15, 2006
10 a.m. – 12 p.m.
Campbell River City Hall (Committee Room)
301 St Ann's Road
Campbell River, BC

Agenda

1. Opening
2. Minutes of last meeting
3. Project status to date
4. Review of draft report
5. Discussion of recommendations
6. Other

MEETING NOTES

subject:	**Campbell River/Quinsam River ISMP**
date:	November 20, 2006
meeting date:	November 15, 2006, 10:00am – 12:00pm
location:	Campbell River City Hall
file:	1479.0009.01
prepared by:	Melanie Ross and Kathy Campbell
distribution:	All Attendees and Alistair McLean, Bob Hall, Brian Kelly, Dave Ewart, Dave Selent, Gary Giese, Hubert Bunce, Jim Van Tine, Lesley Fell, Mike Gage, Peter Law, Ron Burrell, Tony Roberts Jr., and Violet Komori

attendees	**company**	**e-mail**
Tim Ennis	Nature Conservancy Canada	tim.ennis@natureconservancy.ca
Leona Adams	Estuary Protection Group	lowie@crcable.net
Luisa Richardson	Greenways Land Trust	executive@greenwaystrust.ca
Barry Peters	Stewardship Advisory Council	petersb@pac.dfo-mpo.gc.ca
Shannon Anderson	Department of Fisheries & Oceans	andersonsh@pac.dfo.mpo.gc.ca
Rick Senger	Department of Fisheries & Oceans	sengerr@pac.dfo-mpo.gc.ca
Kathy Campbell	City of Campbell River (CCR)	Kathy.campbell@campbellriver.ca
Ron Neufeld	City of Campbell River (CCR)	ron.neufeld@campbellriver.ca
Melanie Ross	Urban Systems Ltd.	mross@urban-systems.com
Jeff Rice	Urban Systems Ltd.	jrice@urban-systems.com

ITEM	DISCUSSION	ACTION BY
1.0	**Opening** Melanie explained Jeff's absence due to weather. (Jeff to arrive within one hour)	Info
2.0	**Minutes of last meeting** Group approved last previous minutes	Info
3.0	**Project status to date** Melanie said that Jeff would brief the group re. project update upon his arrival.	Info
4.0	Ron took lead of the meeting at this point. He thanked the group for their involvement with this ISMP (and any prior ones).	Info
4.1	Ron gave a brief explanation of the reason CCR is conducting ISMPs. He further explained that now that the final ISMP for the Campbell River area is nearing completion the next step is to put together an implementation plan. This implementation plan will; prioritize the ISMP recommendations, plan the development and the maintenance of future work.	Info
4.2	The City has asked Jeff Rice, USL to begin working on the implementation plan.	Info
4.3	Once the work plan has been completed the City will have to decide how to fund	Info

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ITEM	DISCUSSION	ACTION BY
	the work. At this time the City is leaning towards the implementation of a self funded Utility with a user fee.	
4.4	Ron stated that an information program will be needed to explain the stormwater utility to the public.	Info
4.5	Ron said that this process will take time, current plan is go to Council with the Implementation Plan early 2007 and proposed to introduce fee in 2008.	Info
4.6	Rick said that he was happy with the City's plans; however he and others in the group share a concern that if the alternative design regulations/fees aren't introduced to the public until 2008, that the City would suffer as there is a major development boom happening now and anticipated for the next year.	Info
4.7	Ron said that the City needs to change the Bylaw (which is a timely process) before they could enforce any of the new regulations. City staff is currently recommending new design standards, but can't enforce.	Info
4.8	Leona questioned what the cost would be to speed things up so that the bylaw is passed immediately? Ron explained that it's not money, that the process takes time.	Info
4.9	Rick questioned if developers who follow the new design suggestion would benefit later on once the new by-laws are enforced. Ron answered that there would be no financial benefit from the City	Info
4.10	Rick suggested a financial compensation to developers if they build according to new standards. He thought I might encourage people follow new rules. Ron explained that although it may entice builders/developers to follow rules, the fee would ultimately be up to the owner – not the developer - to pay.	Info
4.11	Tim asked if there would be a possibility to reward home owners and builders for keeping wooded space on their property. Would people be able to have a fee "break" if they kept a certain percentage of their property wooded?	Info
4.12	Rick stated that the report suggested that roof leaders be removed, but according to current CoCR bylaws they are required and necessary to pass inspection. What would happen with this? Ron stated that this would be one of the changes to the by-laws based on the new ISMP recommendations.	Info
4.13	Rick asked if there would be design standards for water infiltration systems. Ron answered by saying that the goal is to have a performance driven by-law	Info

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ITEM	DISCUSSION	ACTION BY
	rather then a prescriptive bylaw. He said that there may be prescriptive standards available for smaller businesses but that larger companies would opt for the performance driven standards.	
4.14	Leona said that she recently heard something about Ucluelet receiving reward money for a recent green space project. She questioned whether this would be a funding option for the ISMP plans. Ron said that he would definitely be seeking funding. (Government, grants, awards)	Info
4.16	Tim questioned if there was a way to quantify the value of pervious area of property? If so could the fee be based on a percent of pervious area per property? Ron was uncertain, Melanie to present question to Jeff. (Ron left he meeting and Kathy Campbell took over)	Melanie
5.0	**Review of draft report / Discussion of recommendations**	
5.1	The group reviewed the recommendations listed in the Draft ISMP. Kathy Campbell's recommendation notes are attached.	Info
5.2	(Jeff Rice joined meeting at 11:15. Participated in review of Draft document.)	Info
6.0	Jeff discussed possible dates for the completion of the Final Report (early December 2006)	Info
7.0	Meeting Adjourned.	

The preceding is the writer's interpretation of the proceedings and any discrepancies and/or omissions should be reported to the writer.

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Melanie Ross

/MR

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Recommendation Notes taken by Kathy Campbell

9.1 Guiding Principles

Encourage the retention of vegetation
Encourage use of permeable paving
Encourage reduction of impervious area
CCR to initiate a Public Education Program prior to implementation of LID design standards
Link cost of Stormwater Utility to % imperviousness of properties
Change "Alternative" Design Standards to "Low Impact" or "Recommended" Design Standards

9.2 Performance Targets

Difficult to monitor TSS removal standards
It should be a required, not recommended that oil & grease are removed before discharge to creek
Are their private oil/water separators in parking lots?
Who is responsible for cleaning out of privately-owned oil/grease separators?
City to publicize BMPs for stormwater

9.3 Municipal Systems Upgrades

Tide gates may not be appropriate for the system
Catch basin changes should be coordinated with CCR West Nile Virus Prevention Program
Concerns expressed about CCR street sweepers dump their debris, how toxic is debris.

9.4 Stormwater Quality Treatment Facilities

Commercial and industrial users should be required to remove oil & grease before discharge
Private landowners to maintain oil water separators
Develop a ticketing system for users who adversely affect stormwater quality
Check Quinsam Hatchery Weather station for local weather information

9.5 Environmental Monitoring

City should initiate a pilot program to monitor stormwater quality in Campbellton
Have a consultant design a stormwater quality study
Increase sampling frequency from semi-annually at major outfalls
Complete a stronger baseline study
Long-term monitoring is important to maintaining stormwater quality
Compare CCR stormwater with other communities
DFO has some data on metals concentrations in local streams
Greenways does not presently have capacity to conduct outfall monitoring

9.6 Field Verification of Soil Infiltration Properties

Perc test data should be kept by CCR and included in GIS database
Infiltration tests should be completed by proponents of development projects
CCR to define methodology for soil perc tests to be done by developers

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Recommendation Notes taken by Kathy Campbell continued….

9.7 Topographic Database Updates
GIS study to update as built sewer and stormwater system supported

9.8 Continuous Modeling
Jeff to confirm XPSWMM acronym definition
More information on local stream flows needed to improve stormwater monitoring

9.9 Operations and Maintenance Schedule
City to formalize program of stormwater system operations and maintenance
Review performance of detention ponds re flow attenuation and water quality
Low Impact Design Standards to be incorporated in all new developments

9.10 Habitat Protection, Restoration and Enhancement Opportunities
Greenways Land Trust working on acquiring stewardship of Kingfisher Creek watershed
CCR to coordinate with Cape Mudge Band for watershed restoration
There is lots of restoration work needed on HB Kingfisher Creek

9.11 Erosion and Sediment Control (ESC) Practices on Construction Sites
CCR to develop Erosion and Sediment Control bylaw
Developers and builders must meet CCR defined erosion and control standards
Construction windows to be defined to reduce sediment & erosion incidents
Fines to be used as penalties for those not meeting performance standards

9.12 Public Outreach and Education Initiatives
CCR to conduct public outreach program with developers, city staff and building suppliers
City Hall to become a model site for stormwater management
Sign to be placed at Tyee Spit outlining positive stormwater management techniques
Rotary Beach sign could be used to communicate stormwater controls
Promote raingardens and naturescaping
Encourage a positive tax strategy for properties that control stormwater on site

9.13 GIS Database
Abbreviated UTMs to be used with two letter watershed codes to identify manholes and outfalls
Online atlas of outfalls and manholes could be produced with notes on attributes

9.14 City Bylaw and Policy Revisions
Environmental Advisory Commission will discuss Tree Protection, & ESC in 2008
Sub-basin level for determining % impervious areas of a watershed
% imperviousness to be considered for developments on a property level (building department)
Sara to contact Paul Stanton re zoning bylaws, DP guidelines
CCR needs policy to protect trees on City lands.
Environmental Advisory Commission will discuss Pesticide Bylaw in 2008

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Recommendation Notes taken by Kathy Campbell continued....

9.15 Updates to City Engineering Standards & Specifications

"Alternate" Design Standards to be renamed as Low Impact Design Standards
Stormwater controls alternative to piping to smaller streams should be encouraged
City standards to include sediment and water quality

9.16 Funding Mechanisms

Stormwater Utility costs to reward property owners that use LID standards for stormwater control
Tree Planting to be encouraged to hold back rainwater

Campbell River/Quinsam River Area ISMP Stakeholder Contact List

Contact	Organization	Phone #	Fax #	E-mail
Ron Burrell	Advisory Planning Commission	250-923-1914		rburrell@oberon.ark.com
Allistair McLean	BC Hydro	250-850-5906		Al.McLean@bchydro.bc.ca
Julie Sigurdson	Campbell River Environment Council	250-923-9969		jcs0214@telus.net
	Campbell River Fish and Game Association	250-287-8277		
Mike Gage	Campbell River Gravel Committee	250-287-4368		
Barry Peters	Campbell River Stewardship Advisory Council	250-203-2113		petersb@pac.dfo-mpo.gc.ca
Brian Kelley	Cape Mudge First Nation	250-285-3316		bkelly@connected.bc.ca
Derek Richmond	City of Campbell River	250-286-5734		derek.richmond@campbellriver.ca
Graham Stewart	City of Campbell River	250-286-4041	250-286-5762	graham.stewart@dcr.ca
Paul Stanton	City of Campbell River	250-286-5730		paul.stanton@dcr.ca
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Gary Giese	Development Liaison Group (Bonaventure Development Corp)	250-287-8130		giese@oberon.ark.com
Rick Senger	DFO, Area Habitat Technologist	250-850-5703		SengerR@pac.dfo-mpo.gc.ca
Shannon Anderson	DFO, Habitat Biologist	250-286-5807	250-286-5898	andersonsh@pac.dfo-mpo.gc.ca
Lesley Fell	Discovery Coast Greenways Land Trust	250-287-3785		executive@greenwaystrust.ca
Luisa Richardson	Discovery Coast Greenways Land Trust	250-287-3785		executive@greenwaystrust.ca
Leona Adams	Estuary Protection Group			lowie@crcable.net
Jim Van Tine	Haig-Brown Kingfisher Creek	250-923-1873		jvantine@telus.net
Violet Komori	Komori Wong			komoriv@shaw.ca
Bob Hall	MoT			bob.a.hall@gov.bc.ca
Peter Law	MWLAP / Urban Biologist & Provincial Ministry of Environment	250-751-3229	250-751-3103	Peter.Law@gov.bc.ca
Tim Ennis	Nature Conservancy of British Columbia	250-686-8540		time@telus.net
Hubert Bunce	Q Coal Environmental Technical Review Committee	250-751-3254	250-751-3103	Hubert.Bunce@gov.bc.ca
Dave Selent P.Eng	Quinsam Coal Corporation	250-286-3224		dhs35@hotmail.com
Dave Ewart	Quinsam Hatchery	250-287-9564		ewartd@pac.dfo-mpo.gc.ca
Barry Peters	Stewardship Advisory Council	250-286-5823		petersb@pac.dfo-mpo.gc.ca

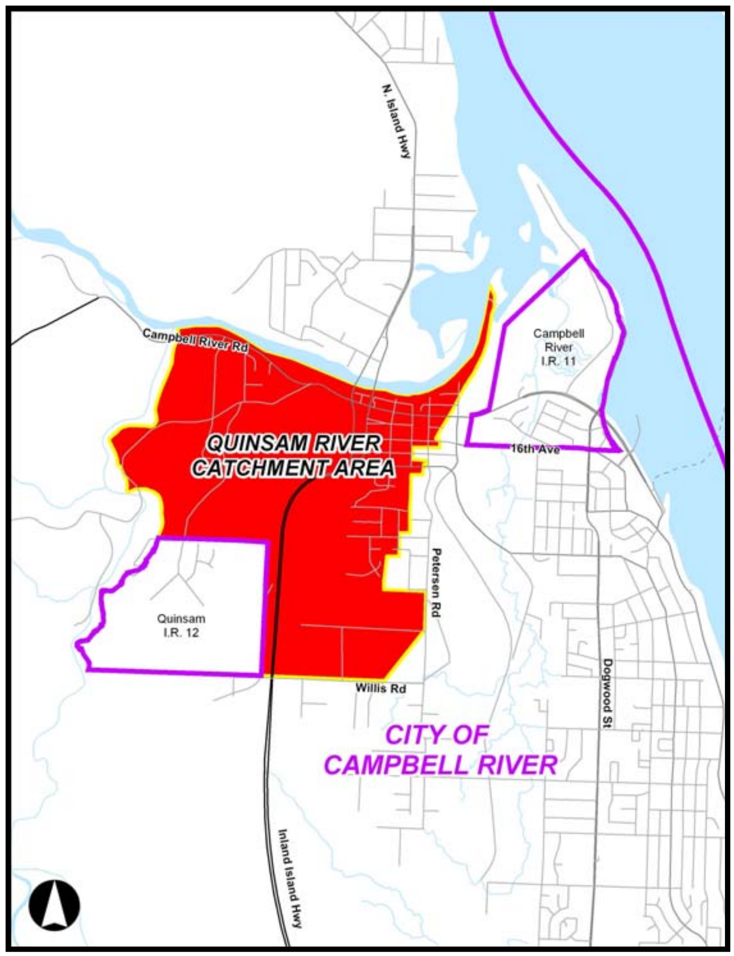
APPENDIX F

PUBLIC CONSULTATION MATERIALS

(Electronic Version on CD-ROM only)

INTEGRATED STORMWATER MANAGEMENT PLAN FOR THE CAMPBELL RIVER/QUINSAM RIVER AREA OF CAMPBELL RIVER

The City of Campbell River has retained Urban Systems Ltd, a municipal consulting firm based in Richmond BC, to develop an Integrated Stormwater Management Plan (ISMP) for the Campbell River/Quinsam River area of Campbell River. The location of the Campbell River/Quinsam River areas is shown in the map below.



The purposes of this ISMP are to assess the existing conditions of the Campbell River/Quinsam River area, to provide recommendations on capital works improvements, to identify preferred best management practices, and to set policies to direct future stormwater practices which emphasize integrated, sustainable approaches. An interdisciplinary team has been assembled to complete the plans including engineers, planners, landscape architects, habitat biologists and hydrogeologists. During September and October, public open houses will be held to present information on the ISMP and offer the public an opportunity to provide input to the process. A Stakeholders Working Group is being established to provide information to the consulting team and to assist in the development of the ISMP.

If you would like further information on this project, please contact:

Derek Richmond, M. Eng., P. Eng.
Engineering Department
City of Campbell River
(250) 286-5734

Kathy Campbell, R. P. Bio.
Environmental Coordinator
City of Campbell River
(250) 286-5711

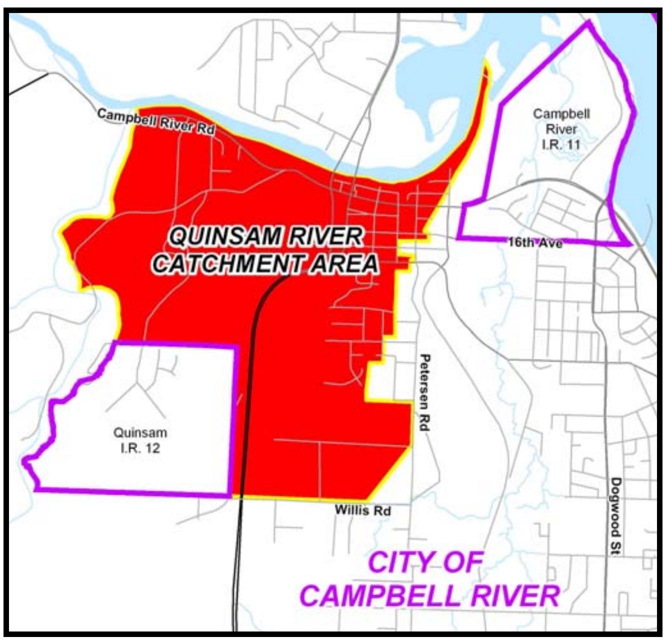
Jeffrey Rice, P. Eng.
Project Manager
Urban Systems Ltd.
(604) 273-8700

NOTICE OF PUBLIC OPEN HOUSE

INTEGRATED STORMWATER MANAGEMENT PLAN FOR THE CAMPBELL RIVER/QUINSAM RIVER AREA

TUESDAY, SEPTEMBER 12TH, 2006
7:00 p.m. – 9:00 p.m.
CAMPBELL RIVER COUNCIL CHAMBERS, 301 ST. ANN'S ROAD

The City of Campbell River has retained Urban Systems Ltd, a municipal consulting firm based in Richmond BC, to develop an Integrated Stormwater Management Plan (ISMP) for the Campbell River/Quinsam River area of Campbell River. The location of the Campbell River/Quinsam River areas is shown in the map below.



The purposes of this ISMP are to assess the existing conditions of the Campbell River/Quinsam River area, to provide recommendations on capital works improvements, to identify preferred best management practices, and to set policies to direct future stormwater practices which emphasize integrated, sustainable approaches. An interdisciplinary team has been assembled to complete the plans including engineers, planners, landscape architects, habitat biologists and hydrogeologists. In addition, a Working Group has been established to provide technical information to the consulting team and to assist in the development of the ISMP. During September and October, public open houses will be held to present information on the ISMP and offer the public an opportunity to provide input to the process.

At this first open house on September 12th, the City's consultant will provide general information on stormwater management in the City as well as an overview of the work completed to date for this project. The City would also like to solicit further information from the public at the meeting regarding stormwater issues or concerns specific to the project area.

If you would like further information on this project, please contact:

Derek Richmond, M. Eng., P. Eng.
Engineering Department
City of Campbell River
(250) 286-5734

Kathy Campbell, R. P. Bio.
Environmental Coordinator
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PLANNERS • ENGINEERS • LANDSCAPE ARCHITECTS

Tonight's Open House

Open Discussion
Formal Presentation (around 7:30pm)
More Open Discussion / Feedback

Quinsam River / Campbell River ISMP

Formal Presentation

- Overview of stormwater management
- Stormwater management in Campbell River
- Stormwater management in the Study Area
- Issues, Challenges and Opportunities
- Next Steps

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September 12, 2006
City of Campbell River

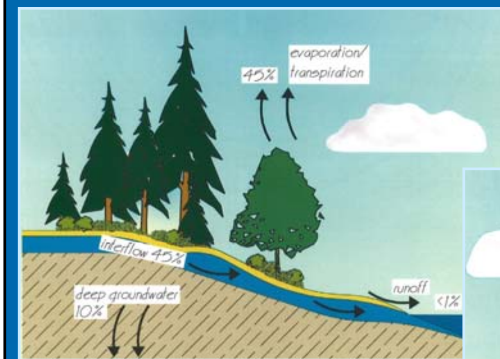
Stormwater Management Overview

- Natural water balance
- Undeveloped & developed conditions
- Impervious area
- Healthy watersheds
- Big and little storms

Natural Water Balance

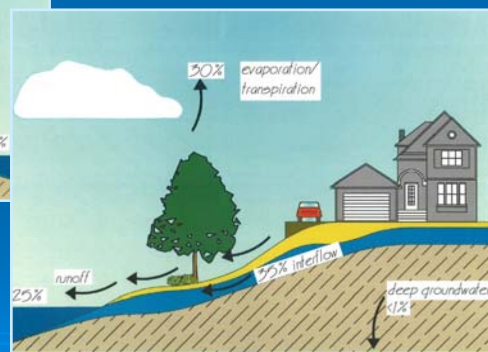
- Evaporation
- Transpiration
- Shallow infiltration (Interflow)
- Deep infiltration (base flow / groundwater)
- Surface runoff

Quinsam River / Campbell River ISMP



Pre-Development

Post-Development



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Quinsam River / Campbell River ISMP

- Total Impervious Area
  - Sum of all paved and other built surfaces
- Effective (or Connected) Impervious Area
  - Impervious areas directly connected to watercourses via pipes

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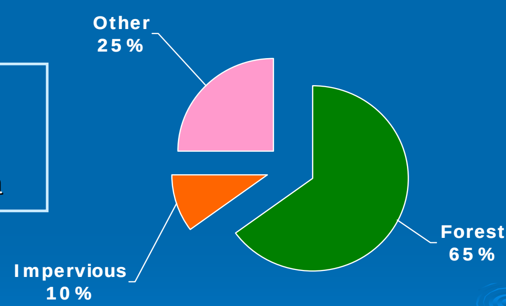
Quinsam River / Campbell River ISMP

Healthy Watersheds

> 65% Forested Area
&
< 10% Impervious Area



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Quinsam River / Campbell River ISMP

Big & Little Storms

- Average Total Annual Rainfall = 1335 mm
- Mean Annual Rainfall = 55 mm in 24 hours
- Typical “design” Rainfall > 75 mm in 24 hours

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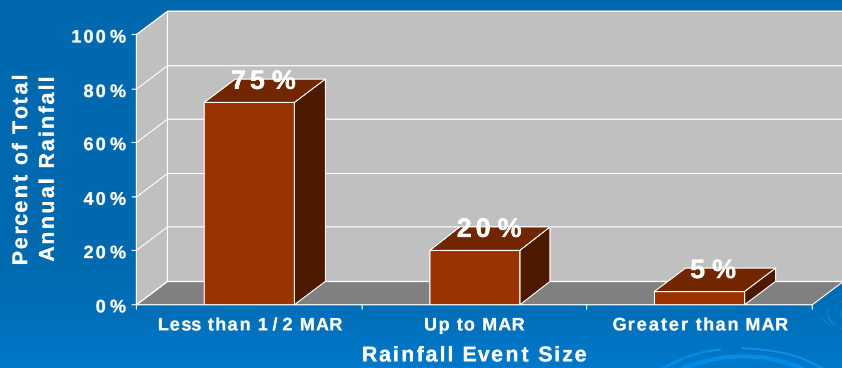
Quinsam River / Campbell River ISMP

Big and Little Storms



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Quinsam River / Campbell River ISMP

Change in the Natural Water Balance leads to…

- Property impacts
- Ecologic impacts
- Water quality impacts
- Financial/political impacts

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Quinsam River / Campbell River ISMP

We can minimize our impact on the Natural Water Balance…

- By changing our development patterns
- By changing our development practices

Integrated Stormwater Management!

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City of Campbell River

Quinsam River / Campbell River ISMP

Stormwater Quality

- More surface runoff, more contaminants likely
- More impervious area, more contaminants likely
- Stormwater quality highly variable--
  - Land use
  - Overall impervious fraction
  - Size and duration of storm
  - Time between storm events
  - Mitigating factors, including treatment

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City of Campbell River

Typical Stormwater Contaminants

- Sediments
- Heavy metals (copper, zinc, cadmium, etc)
- Pathogens
- Hydrocarbons
- Pesticides & herbicides
- Organic matter
- Nutrients (nitrogen, phosphorous)

Types, Sources and Effects of Pollutants

Type	Source (examples)	Effect
Sediments	•Roadways •Construction sites •Urban areas •vehicles	•Habitat alteration •Aesthetic alteration •Contaminant transport •Bank erosion
Nutrients (phosphorus, nitrogen, etc)	•Agriculture •Lawn & garden fertilizer (natural and artificial) •Atmospheric deposition •Urban wildlife and pets •Litter and leaf fall	•Water chemistry alteration •Algal blooms
Metals (lead, copper, zinc, etc)	•Pesticides •Roadways •Commercial & industrial sites (specific on site usage) •Underground storage tanks •Transportation vehicles	•Toxicity •Habitat alteration •Bio-accumulation

How have we managed runoff in the past?

- Remove runoff as quickly as possible
- Fix erosion problems
- Detain runoff in ponds
- Keep out gross pollution
- Think about the fish
- Stormwater as a resource

Stormwater Management in Campbell River

Quinsam River / Campbell River ISMP

In the City's past

- Storm drains in developed areas
  - Ditches in lower density areas
- Control peak flows with detention ponds
  - Some water quality controls
- Sustainable stormwater controls

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City of Campbell River

Quinsam River / Campbell River ISMP

Integrated Stormwater Management Plans

- Water is a resource
- Long-term
- Proactive
- Adaptive
- Interdisciplinary

Goal:
Sustainable Stormwater Management

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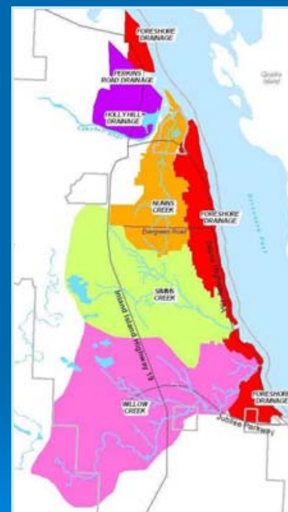
September 12, 2006

City of Campbell River

ISMPs To Date

- Perkins Road Drainage
- Holly Hills Drainage
- Nunns Creek Watershed
- Simms Creek Watershed
- Willow Creek Watershed
- Foreshore Area



Quinsam River / Campbell River ISMP

Goals for the ISMP Process

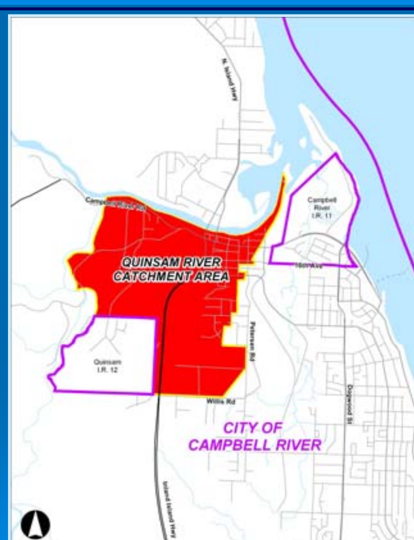
- Implement sustainable stormwater management solutions and policies that maintain, restore and enhance natural watershed characteristics
- Protect the community from destructive flooding and erosion
- Promote community development within a sustainable framework
- Integrate engineering, planning and environmental solutions

Public Open House

Stormwater Management for the Quinsam River and Campbell River Catchment Areas

Tuesday, September 12, 2006
7:00 p.m. – 9:00 p.m.

Quinsam River / Campbell River ISMP



September 12, 2006

Quinsam River / Campbell River ISMP

Objectives for the ISMP

- Document existing conditions within study area
- Identify infrastructure and land use policies to meet goals
- Ensure stakeholder and senior environmental agency support
- Develop decision matrices for analyzing and evaluating options
- Recommend a cost effective, integrated stormwater management strategy
- Provide City with sound basis for sustainable financial support of the plan

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September 12, 2006

City of Campbell River

Quinsam River / Campbell River ISMP

Main Tasks

1. Communicate with the City and stakeholders
2. Inventory existing stormwater, watercourse and biophysical systems
3. Define land use issues
4. Perform hydrologic and hydraulic analysis
5. Evaluate alternatives and develop recommendations

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City of Campbell River

Quinsam River / Campbell River ISMP

Project Status

- Completed Tasks 1 & 2
  - City staff; stakeholders group
  - Open house (tonight!)
  - Review existing data and background materials; some field reconnaissance
- Tasks 3 & 4 in progress
  - Additional field work in September
  - Modeling nearly complete
- Task 5 just starting

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Quinsam River / Campbell River ISMP

Campbell River & Quinsam River Study Area

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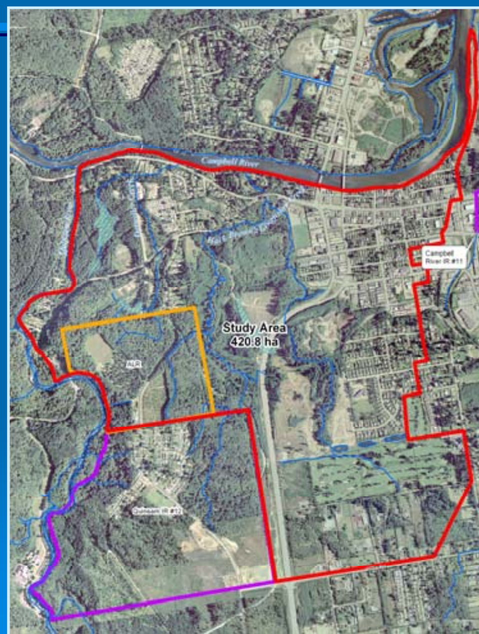
Quinsam River / Campbell River ISMP



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City of Campbell River

Quinsam River / Campbell River ISMP

The Study Area

- Four catchments; 421 hectares
  - Haig Brown's Kingfisher Creek
  - Detweiler Creek
  - Quinsam River upland
  - Campbell River uplands
- Land Use:
  - Highly developed eastern third
  - Significant open/wooded areas / ALR
  - Development pressure

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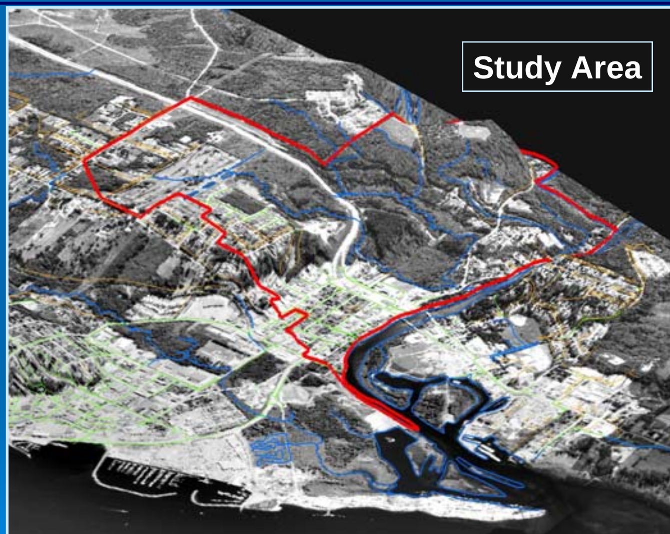
City of Campbell River

Quinsam River / Campbell River ISMP



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City of Campbell River

Quinsam River / Campbell River ISMP

Parameter	Value	
Study Area	421 ha	
Impervious Surface	119 ha	28%
Wooded Area*	145 ha	35%
Stream Length**	9.7 km	
Riparian Area***	58 ha	14%
Open Channel Length (Ditches)	8.0 km	
Storm Drain Length	7.5 km	

* Covers significant contiguous areas only

** Does not include Quinsam and Campbell Rivers

***Based on 60m corridor around all streams

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Quinsam River / Campbell River ISMP

Existing
Wooded/Forest
Areas

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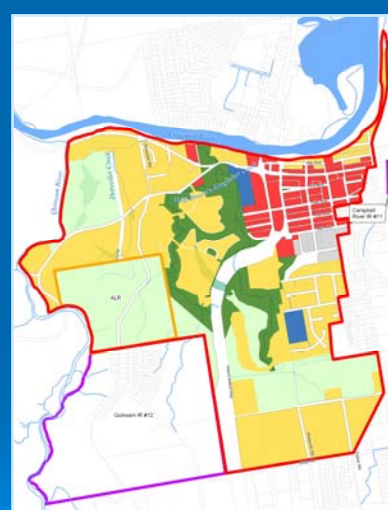
City of Campbell River

Quinsam River / Campbell River ISMP

Official
Community
Plan



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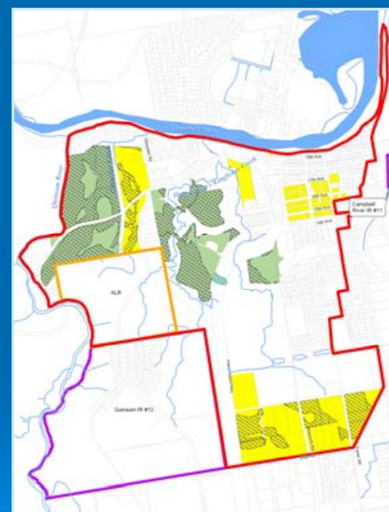
City of Campbell River

Quinsam River / Campbell River ISMP

Potential long-term changes:

- 63 ha new development (green)
- 62 ha redeveloped (yellow)
- 61 ha woods lost (hatched)



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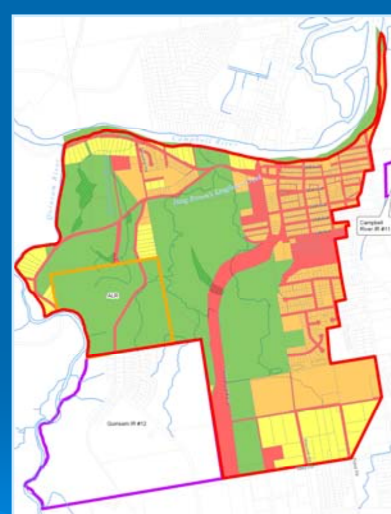
Quinsam River / Campbell River ISMP

Areas with potential for high runoff pollutant loadings - CURRENT

Red = “Hot Spots”
Green = “Low Potential”



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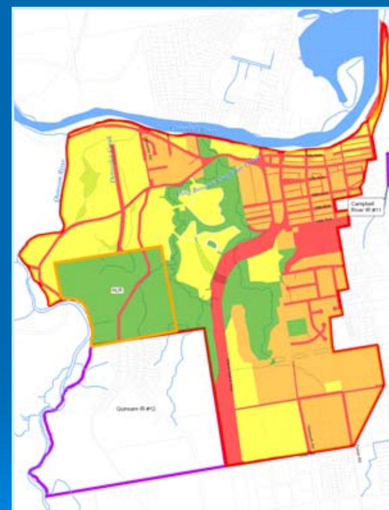
Quinsam River / Campbell River ISMP

Areas with potential for high runoff pollutant loadings - FUTURE

Red = “Hot Spots”
Green = “Low Potential”



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Quinsam River / Campbell River ISMP

Issues, Challenges and Opportunities

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City of Campbell River

Key Issues

- Long-term maintenance of drainage infrastructure
- Control of runoff quality, esp. in "hot spot" areas
- Maintenance / enhancement of riparian areas
- Maintenance / enhancement of fish passage & spawning areas

Quinsam River / Campbell River ISMP

More Key Issues

- Development construction practices
  - Retention / protection of vegetation and soils
  - Sediment control during construction
- Stormwater controls in new development
  - Public vs. private
  - Source vs. end-of-pipe

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September 12, 2006
City of Campbell River

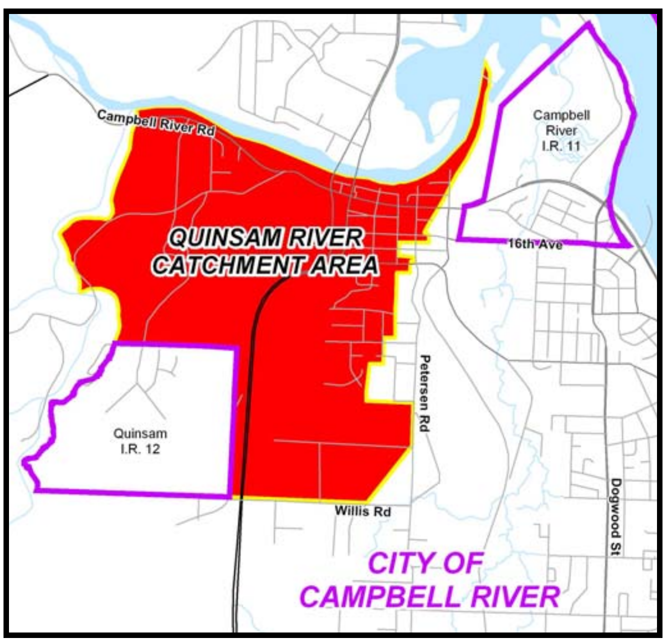
NOTICE OF PUBLIC OPEN HOUSE

TO REVIEW DRAFT REPORT

INTEGRATED STORMWATER MANAGEMENT PLAN FOR THE CAMPBELL RIVER/QUINSAM RIVER AREA

WEDNESDAY, NOVEMBER 15th, 2006
7:00 p.m. – 9:00 p.m.
CAMPBELL RIVER COUNCIL CHAMBERS, 301 ST. ANN'S ROAD

The City of Campbell River has retained Urban Systems Ltd, a municipal consulting firm based in Richmond BC, to develop an Integrated Stormwater Management Plan (ISMP) for the Campbell River / Quinsam River Area of Campbell River. The Campbell River / Quinsam River Area is shown on the map below.



The purposes of this ISMP are to assess the existing conditions of the Campbell River / Quinsam River Area, to provide recommendations on capital works improvements, to identify feasible stormwater best management practices for use in the area, and to set policies to direct future stormwater practices that emphasize integrated, sustainable approaches.

Results and recommendations from the Draft Report on the Integrated Stormwater Management Plan will be discussed at the Open House. A 30-minute formal presentation will be made at about 7:30 p.m., with the remainder of the time before and after the presentation available for conversation with the Project Consultant and City Staff.

If you would like further information on this project, please contact:

Kathy Campbell, R. P. Bio.
Environmental Coordinator
City of Campbell River
(250) 286-5711

Jeffrey Rice, P. Eng.
Project Manager
Urban Systems Ltd.
(604) 273-8700

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City of Campbell River

Public Open House

Stormwater Management for the Quinsam River and Campbell River Catchment Areas

Wedensday, November 15, 2006

7:00 p.m. – 9:00 p.m.

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Campbell River / Quinsam River ISMP

Here's how you can help us tonight…

- Sign in
- Look over the exhibits
- Ask questions
- Complete an "exit interview"…leave it here or send it later

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More Key Issues

- Public education, outreach and support mechanisms
- Implementation and enforcement of ISMP recommendations
- Long-term monitoring programs

Quinsam River / Campbell River ISMP

Challenges

- Developing objectives to meet specific needs of varied study area environments
- Sustainable retrofits in developed areas
- Long-term assessment of management success
- Acceptance of new stormwater practices

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Opportunities

- To maintain & enhance local streams
- To implement innovative stormwater quality controls
- To implement public/private partnerships
- To implement pilot projects
- To engage the public in support

Examples of Sustainable Stormwater Management Practices

Quinsam River / Campbell River ISMP

Terms

- Sustainable Stormwater Controls
- Best management practices (BMPs)
- Low Impact Development (LID) or Stormwater Source Controls

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Quinsam River / Campbell River ISMP

Examples of BMP / LID

Street Edge Alternative (SEA) Program, Seattle, WA

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Quinsam River / Campbell River ISMP

Examples of BMP / LID

Porous Paver System

Portland, OR

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Quinsam River / Campbell River ISMP

Examples of BMP / LID

Reinforced Grass / Gravel System,

University of British Columbia

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Quinsam River / Campbell River ISMP

Examples of BMP / LID

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Quinsam River / Campbell River ISMP

Examples of BMP / LID

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Quinsam River / Campbell River ISMP

Examples of BMP / LID

Vegetated Bioswale

Portland, OR

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Quinsam River / Campbell River ISMP

Examples of BMP / LID

Rain Garden

King County, MD

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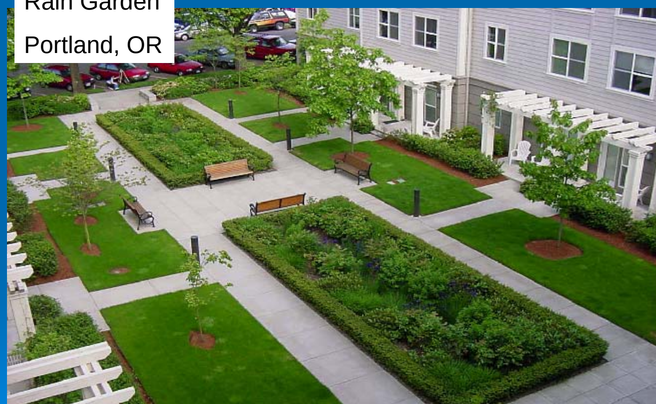
Quinsam River / Campbell River ISMP

Examples of BMP / LID

Rain Garden

Portland, OR



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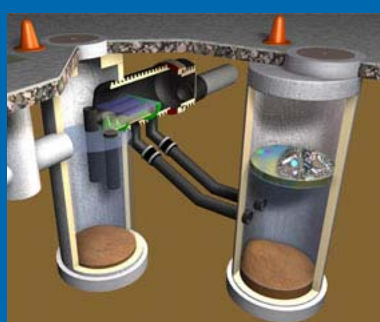
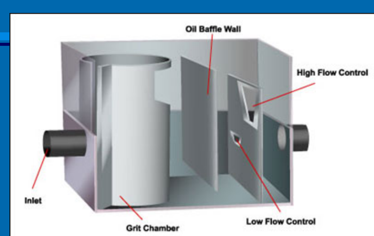
City of Campbell River

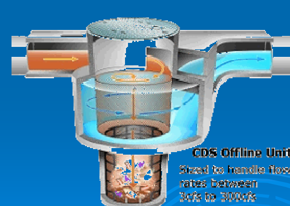
Quinsam River / Campbell River ISMP



Baysaver



Vortechnics



CDS

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City of Campbell River

Quinsam River / Campbell River ISMP

Next Steps

- Identify appropriate sustainable practices
- Determine impacts of future development
- Develop recommendations to address key issues
- Draft report – early October
- Open House #2 – late October

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Quinsam River / Campbell River ISMP

Here's how you can help us tonight…

- Sign in
- Look over the exhibits…ask questions
- Tell us what you know about the Study Area
- Complete an "exit interview"…leave it here or send it later

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City of Campbell River

Thanks for coming tonight!

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City of Campbell River

Quinsam River / Campbell River ISMP

Urban Systems Ltd
Richmond, BC
604-273-8700

Jeffrey Rice, P.Eng.
Project Manager

Melanie Ross
Project Coordinator

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City of Campbell River

Campbell River / Quinsam River ISMP

Formal Presentation

- Project Overview
- Issues & Findings
- Recommendations
- Next Steps

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November 15, 2006

City of Campbell River

City of Campbell River

Project Overview

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Campbell River / Quinsam River ISMP

Goals for the ISMP Process

- Implement sustainable stormwater management solutions and policies that maintain, restore and enhance natural watershed characteristics
- Protect the community from destructive flooding and erosion
- Promote community development within a sustainable framework
- Integrate engineering, planning and environmental solutions

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Campbell River / Quinsam River ISMP

Main Tasks

1. Communicate with the City and stakeholders
2. Inventory existing stormwater, watercourse and biophysical systems
3. Define land use issues
4. Perform hydrologic and hydraulic analysis
5. Evaluate alternatives and develop recommendations

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Campbell River / Quinsam River ISMP

Project Status

- Completed Tasks 1 through 5
- Draft report has been issued
- Final report due in about 1 month
- Present to Council

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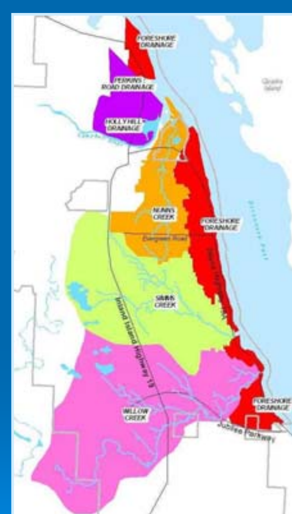
Campbell River / Quinsam River ISMP

ISMPs To Date

- Perkins Road Drainage
- Holly Hills Drainage
- Nunns Creek Watershed
- Simms Creek Watershed
- Willow Creek Watershed
- Foreshore Area



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Campbell River / Quinsam River ISMP

Study Findings

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Campbell River / Quinsam River ISMP

The Study Area

- Four catchments; 416 hectares
  - Detweiler Creek
  - Haig Brown’s Kingfisher Creek
  - Campbellton Area
  - River Bank Drainages
- Land Use:
  - Highly developed eastern third
  - Significant open/wooded areas / ALR
  - Development pressure

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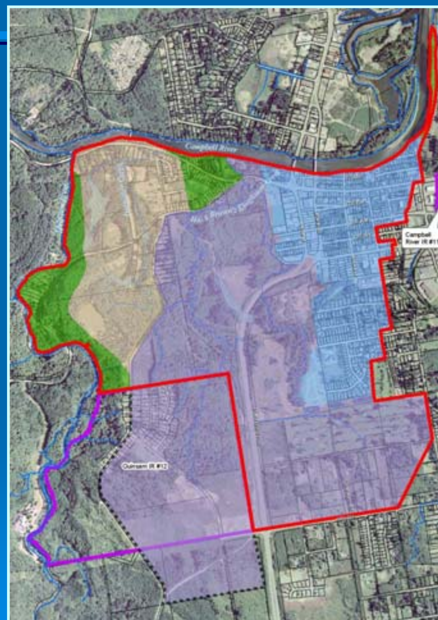
City of Campbell River

Campbell River / Quinsam River ISMP



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Campbell River / Quinsam River ISMP

Parameter	Value	
Study Area	416 ha	
Impervious Surface	110 ha	26%
Wooded Area*	162 ha	39%
Stream Length**	9.9 km	
Riparian Area***	73 ha	18%
Open Channel Length (Ditches)	7.8 km	
Storm Drain Length	7.5 km	

* Covers significant contiguous areas only

** Does not include Quinsam and Campbell Rivers

***Based on 60m corridor around all streams

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Campbell River / Quinsam River ISMP

Main Catchments

- Detweiler Creek – 9% impervious; 58% wooded
- Haig Brown's Kingfisher Creek – 23% impervious; 45% wooded
- Campbellton Area – 60% impervious; 4% wooded

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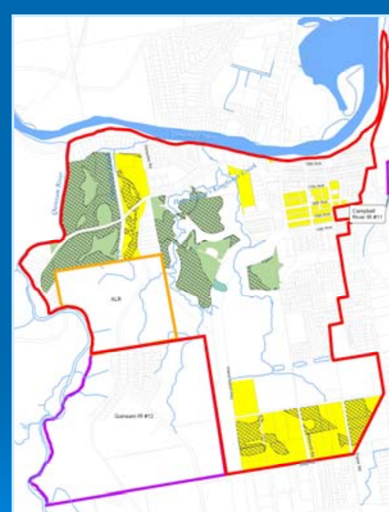
Potential long-term changes:

• 63 ha new development (green)
• 62 ha redeveloped (yellow)
• 61 ha woods lost (hatched)



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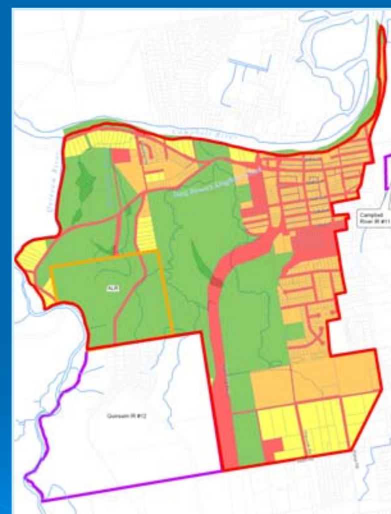
Campbell River / Quinsam River ISMP

Areas with potential for high runoff pollutant loadings - CURRENT

Red = “Hot Spots”
Green = “Low Potential”

170,000 Kg of sediment washoff annually



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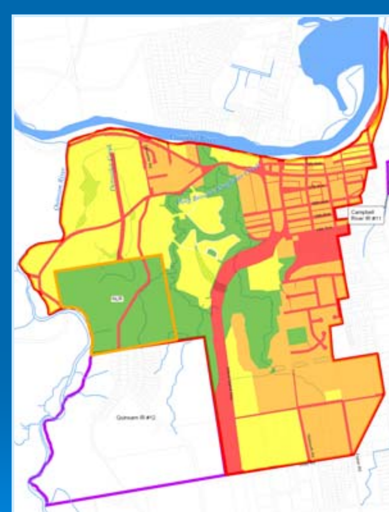
Areas with potential for high runoff pollutant loadings - FUTURE

Red = “Hot Spots”
Green = “Low Potential”

210,000 Kg of sediment washoff annually



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Campbell River / Quinsam River ISMP

Key Issues

- Long-term maintenance of drainage infrastructure
- Control of runoff quality, esp. in "hot spot" areas
- Maintenance / enhancement of riparian areas
- Maintenance / enhancement of fish passage & spawning areas

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Campbell River / Quinsam River ISMP

More Key Issues

- Development construction practices
  - Retention / protection of vegetation and soils
  - Sediment control during construction
- Stormwater controls in new development
  - Public vs. private
  - Source vs. end-of-pipe

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Campbell River / Quinsam River ISMP

More Key Issues

- Public education, outreach and support mechanisms
- Implementation and enforcement of ISMP recommendations
- Long-term monitoring programs

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Campbell River / Quinsam River ISMP

Opportunities

- To maintain & enhance local streams
- To implement innovative stormwater quality controls
- To implement public/private partnerships
- To implement pilot projects
- To engage the public in support

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Recommendations

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Policy Recommendations

- Adopt performance targets for stormwater peak, volume and quality
- Require use of stormwater source control methods (“Low Impact Development”)
- Adopt related bylaws:
  - Erosion and Sediment Control
  - Tree Protection/Retention
  - Pesticide Use

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Campbell River / Quinsam River ISMP

Policy Recommendations, cont'd

- Update zoning bylaw to support integrated stormwater management
- Adopt updated engineering design standards ("alternate design standards" initiative)

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Campbell River / Quinsam River ISMP

Environmental Recommendations

- Enhance key fish & fish habitat sites
- Perform hydrologic, water quality, soils and biophysical monitoring
- Enhance hydrologic & hydraulic computer modeling

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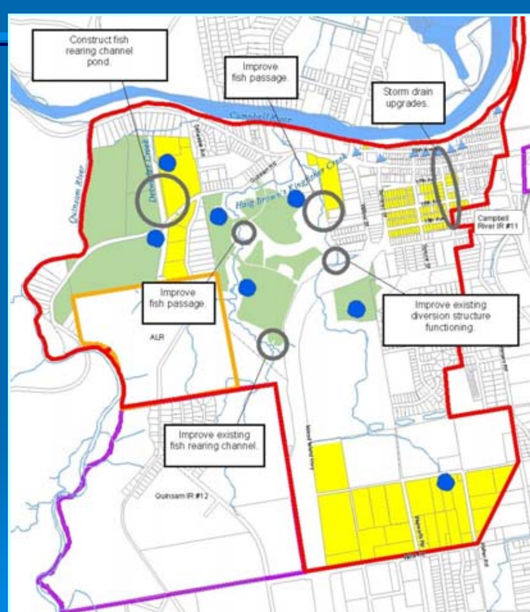
Infrastructure Recommendations

- Upgrade storm drains in Campbellton Area
- Construct detention ponds (7 total)
- Install water quality treatment facilities on existing storm outfalls (9 total)
- Total capital cost = $12.6 million



Campbell River / Quinsam River ISMP

Public Education/Outreach

- Implement long-term public education and outreach program
- Publicize innovative stormwater pilot projects

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Campbell River / Quinsam River ISMP

Next Steps

- Final report – late November
- Council presentation – December

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Campbell River / Quinsam River ISMP

Thanks for coming tonight!

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November 15, 2006

City of Campbell River

Campbell River / Quinsam River ISMP

Urban Systems Ltd
Richmond, BC
604-273-8700

Jeffrey Rice, P.Eng.
Project Manager

Melanie Ross
Project Coordinator

URBANSYSTEMS

November 15, 2006

City of Campbell River

City of Campbell River

INTEGRATED STORMWATER MANAGEMENT PLAN
CAMPBELL RIVER/QUINSAM RIVER

PUBLIC OPEN HOUSE
TUESDAY SEPTEMBER 12, 2006
MUNICIPAL HALL – COUNCIL CHAMBERS
7:00 PM – 9:00 PM

GUEST SIGN-IN SHEET

Name	Address	Telephone	Email
Rick Boland	142 Munson	287-8993	
BRIAN NOREN	675 OLD PETERSEN RD.	337-1719.	
SUSAN BOLAND	2691 CAMPBELL RIVER RD.	287.2864	sharpei@uniserve.com.
Adam Fitch	104-451 9th Avenue	286 5742.	

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CITY OF CAMPBELL RIVER

Integrated Stormwater Management Plan

- Campbell River / Quinsam River Catchment Areas -

City of Campbell River

OPEN HOUSE FEEDBACK

September 12, 2006

As was discussed during the Open House presentation, we welcome and encourage your input into the planning process. Please use this form as one way to provide input.

1. If you are a resident of the area, how long have you lived here? Over the time you've lived here, what changes have you seen in the watersheds and streams? (Detweiler Creek; Haig Brown's Kingfisher Creek; and the riparian areas for Campbell River and Lower Quinsam River.)

2. Are you aware of any particular stormwater / drainage / erosion problems or concerns in your area? If yes, what are they? What concerns do you have with regard to water quality in the ditches and beaches in your area?

3. Are there other people or organizations in the area that you feel we should contact to get their input? Please list them.

4. Is there anything else you would like to add to the discussion? (Use reverse side, if needed)

Name: ________________________________

Address: ______________________________

Phone (day): __________________________

(evening): ____________________________

E-mail: _______________________________

Fill this out tonight, or fill it out at home and send it to this address by September 19, 2006:

Urban Systems Ltd.
2353-13353 Commerce Parkway
Richmond, BC V6V 3A1
Attn: Melanie Ross
(Ph: 604-273-8700)
(Fax: 604-273-8752)

APPENDIX G

CAMPBELL RIVER DRAINAGE COMPLAINT SUMMARY
(2000 – 2004)

(Electronic Version on CD-ROM only)

frmService Requests				
Ref No	**Date Received:**	**Callers Name**	**Location**	**Request**
20020031	Monday, January 07, 2002	Mike Golicz	Island Highway	Caller reports drainage problem - could someone please assist.
20020371	Monday, March 04, 2002	Johanna DeHaas	Mo Road	The ditches on the corner of Mo Road and Greta Road don't drain very well. Can we investigate and fix?
20020571	Tuesday, April 16, 2002	Wayne Morley	1500 20th Ave	Drainage problem at 1500 - 20th Ave - Kathy McCartenay 286-6466. Puddle in street now flowing into basement.
20020577	Tuesday, April 16, 2002	Shaune - Windsor Plywood	14th Ave	Drainage problem at Windsor Plywood - 1680 14th Ave - flooding into store.
20020580	Tuesday, April 16, 2002	Al - Ican Transport	16th Ave	Drainage problem at 1469 - 16th Ave. Water is at his door and he is requesting sandbags.
20020582	Tuesday, April 16, 2002	Wendy Riedl	Northmore Rd	Ditch across from 905 Northmore Rd is starting to overflow. Could possibly run into because they are at the bottom.
20020591	Tuesday, April 16, 2002	Bernie Scholti	Spruce St - alley	Ditch behind property 1630 & 1620 (he owns both) is flooding. Water is draining towards 16th Ave very slowly. He is going to more some of the debris himself at drain.
20020622	Friday, April 19, 2002	Len McAlpine	Road in front of 1941 15th Ave	Water pools into a huge puddle on the road in front of house and then drains into his yard. He was wondering if the drain is plugged.
20020644	Monday, April 22, 2002	Mike Henderson	Spruce Street Alley	Ditch is deeper than outflow pipe at 16th Avenue - Needs to be lowered as per attached Service Request No. 20020591.
20020682	Friday, April 26, 2002	Len McAlpine	15th Ave	Please see SR#20020622. Len is wondering if something could be done about the pooling infront of 1941 15th Ave. Will it be at his expense? Please call him at work Mon to Fri (9to5) 923-2288
20030028	Thursday, January 02, 2003	Mainroad Contracting	Island Highway	Very large puddle in front of Discovery Speciality Advertising on Island Highway across from Acklands by the Quinsam Hotel as per attached Log Sheet dated Jan 2/03 5:24 am.
20030038	Thursday, January 02, 2003	Shelly Craven	1871 O'Leary	Ditch in front of their house is full and the downstream culvert is too high to drain it. There is a spring in their front yard and it is flooding their family room. She feels that the poor drainage in the ditch could be resolved by lowering the downstream culvert.

frmService Requests

Ref No	Date Received:	Callers Name	Location	Request
				Could somebody please check this. (Email attached.)
20030490	Thursday, March 20, 2003	Mr. Shulte	Alley behind 1620 Spruce	The ditch in the alley behind 1620 Spruce is not working and is causing some flooding at this property
20030622	Tuesday, April 08, 2003	Barry Brown	Shetland Road	Please inspect drainage ditches as per attached e-mail from Ron Neufeld dated April 8, 2003.
20031217	Friday, June 20, 2003	Brian Skuse	Robinson Road	there is a puddle approximately 30 feet from the catch basin just off the highway. Can something be done to take care of this problem. It is marked in spray paint.
20032301	Tuesday, December 16, 2003	Mark Makosiej	Willis Rd at Fisher	Mark reports the ditches on Willis Road at Fisher are very full.
20040638	Monday, April 26, 2004	Brian Perrault	1980 Island Hwy	Brian requests someone to come and scope out his storm sewer lines at 1980 Island Hwy. Al Hinch has already attended this site in the past, and will go back today.
20050106	Monday, January 17, 2005	Richard Mailloux	1481 Nursery Rd	Richard has a lot of water running down his driveway and into his carport, from the drainage ditch across the road. He is concerned that it will start to drain into his basement. This has gotten worse since his neighbours had sani installed in 2004. Would someone please come and check this out. W: 286-0045
20050728	Monday, April 25, 2005	Cindy Longland	2261 Steelhead	A couple of years ago a new sani system was put in and curbs were installed in front of all the homes except hers. She said tha all the water drains from the street into her boulevard. She wonders if a curb or lip could be installed in front of her residence.
20050840	Friday, May 13, 2005	Jan Clark	17th & Spruce	Jan Clark owns the CR Home Plumbing & Clark's Water Shop and she is concerned about the lack of drainage in the ditch at the corner of 17th & Spruce. There are weeds growing in it, and sludge has settled, which is impeding the drainage. Would someone please come and clean this ditch out, so that the drainage water can flow again.
20051083	Thursday, June 23, 2005	Chris Reise	2005 Treelane Rd	Chris Reise call to say that since the City did work in the ditch at her house a while ago, the sandbags have started falling out from around the culvert. Could we please go and have a look at it.
20051097	Monday, June 27, 2005	Jeff Goodwin - CRTV	1820 & 1820 19th Ave	CRTV has just purchased 181-/1820 19th Ave. When they get a medium rain, the water bubbles up out of the cbs, which results in approx 1' of water in the parking lot. Would someone please take a look at this and offer some suggestions. Jeff would like to be onsite. Please call him, and give him an hour's notice, and he will meet up with us at the site.

frmService Requests				
Ref No	**Date Received:**	**Callers Name**	**Location**	**Request**
20060202	Friday, January 27, 2006	Bob Jones	2311 Steelhead Road	Bob has a small lake in front of his property, and he would like someone to look at it, to recommend an action to fix.
20051812	Wednesday, October 26, 2005	Susan Thompson	1880 15th Avenue	Request to investigate large deep puddle forming in front of the residence at 1880 15th Ave. Resident advises that the puddle is causing her trouble with her vehicle as it makes brake lines etc. wet.
20051885	Thursday, November 03, 2005	Dorothy Young	2305 Campbell River Road	Mrs. Young was very agitated that no one had come to deal with her drainage issue. Gord Brown and a representative from EMCON had been to the property 2 weeks ago and Hwys came out and did their repair, and the City never came. Now her front lawn is a swimming pool.
20060007	Wednesday, January 04, 2006	Dorothy Young	2305 Campbell River Rd	Report that the culvert in front of the house is plugged and the water has backed up and is flooding her out. Paged PW and provided information to Lorne
20060115	Monday, January 16, 2006	Mike Haynes	1765 Willis Road	Mike reports that a culvert across from 1765 Willis Road seems to be plugged, and it looks like flooding in the area could occur. Please check.
20060521	Friday, March 10, 2006	Stan Nichol	1837 15th Avenue	Complaint that the storm drain at the location is plugged and he is concerned about further flooding. Please investigate if the problem is the city's responsibility or the homeowner. He was told that we would not action his complaint until after the snow removal was complete. Locate is 7 m. E/W
20060731	Tuesday, April 11, 2006	Kim Garety	2351 Steelhead Drive	Request to investigate drainage problems at location. Caller indicates water is not going into ditch but is streaming across property. Please knock on door and speak to homeowner when you are there. If no one home, please call cell at 287-1673.
20060764	Thursday, April 20, 2006	Joel Richards	1951 19th Ave	Joel has some drainage problems at his house, and wants to connect to our storm drain. There is no storm drain on this block of 19th. Would someone please check this out, and make any suggestions to Joel. Cell 203-7161
20061135	Friday, June 09, 2006	Paul Burgoyne	Willis Rd - Carolyn to Walworth	Pual is concerned about the lack of drainage in the ditch on Willis Rd between Carolyne & Walworth. Could we please ditch it? He says there is also a small culvert which he believes is illegal - due to its size. Would someone please check this out?

APPENDIX H

COST ESTIMATES

City of Campbell River
Campbell River / Quinsam River Integrated Stormwater Management Plan
Basis of Costs

CAPITAL COSTS

Pipe Size (mm dia)	$/lin.m.* Storm Drains
300	$270
375	$340
450	$420
525	$500
600	$570
675	$640
750	$720
900	$860
1050	$1,010
1200	$1,160
1350	$1,310
1500	$1,450

Manholes (mm dia)	$/each	$/metre**
1050 (for <900mm pipe)	$3,000	$25
1200 (for 1050 mm pipe)	$4,000	$30
1350 (for 1200 mm pipe)	$5,500	$40
1500 (for 1350 mm pipe)	$6,500	$45
1800 (for 1500 mm pipe)	$7,750	$55

Detention Ponds	$360	per cu.m. storage volume
Riparian Planting	$25	per sq.m.
Road Removal / Restoration	$40	per sq.m.

* Price includes installation and imported bedding / backfill.
** Assumes 155 metre spacing between manholes.

Other Unit Costs

Top inlet catch basin	$2,100	per each
Service Connections		
100 mm	$140	per lin.m.
150 mm	$165	per lin.m.
200 mm	$185	per lin.m.
Inspection Chambers	$700	per each
Rip Rap	$50	per cu.m.
Oil / Sediment Removal Structure	$66,700	per each (minimum) (see attached sheet for additional data)
Disconnection of Roof Leaders	$700	per lot
Swales	$30	per lin.m.
Swales with Perforated Underdrain	$250	per lin.m.
Ditch Excavation	$100	per lin.m.
Wetland Vegetation Planting	$65	per sq.m.
Check Dams	$350	per each
Rock Liners	$112	per lin.m.
Porous Pavement (Asphalt)	$56	per sq.m.
Large Woody Debris (LWD)	$210	per each
Gravel / Cobble Stream Substrate	$120	per sq.m.
Bioengineered Slope Stabilization:		
Live Reinforced Earth Walls	$210	per lin.m.
Wattle Fences	$126	per lin.m.
Live Stakes	$8	per sq.m. (based on 1 m spacing)
Ditch Habitat Enhancement	$365	per lin.m.

O&M COSTS

Detention Ponds	4%	of Capital Cost
Storm Drain Systems	1%	of Capital Cost
Water Quality Structures	4%	of Capital Cost
Environmental / Fisheries	5%	of Capital Cost

Present Worth of O&M Costs

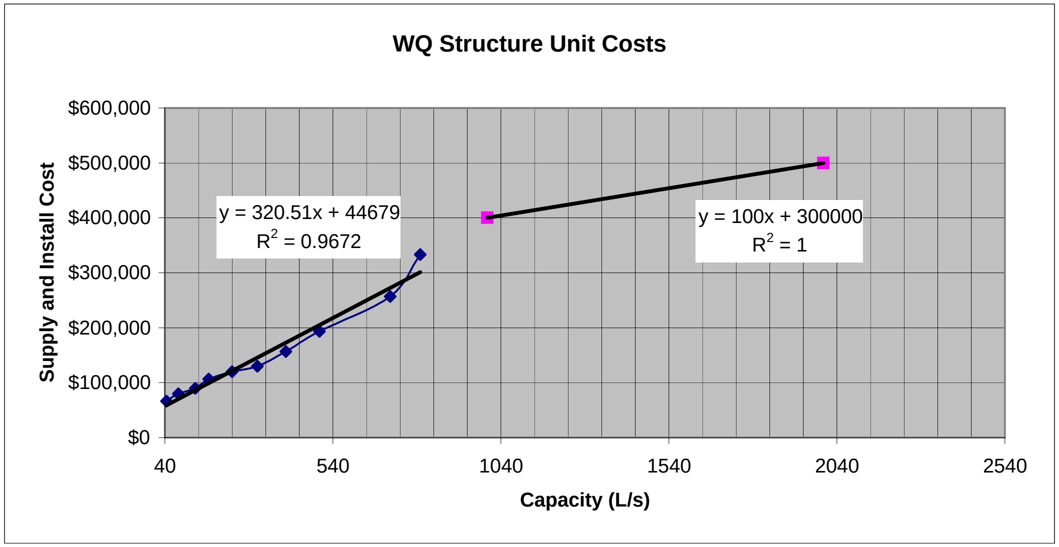
$$PW = \frac{1-(1+i)^{-n}}{i}$$

where $i = 5.50\%$
$n = 30$ years

Unit Price Estimates for Sediment Removal Structures
Based on ConTech Vortex systems; Prices from 2006

Capacity (l/s)	Cost $	Build $	Ratio	
0	20000	$66,667	3.333	
45	24000	$80,000	3.333	"Off the shelf" system
80	27000	$90,000	3.333	"Off the shelf" system
130	32000	$106,667	3.333	"Off the shelf" system
170	36000	$120,000	3.333	"Off the shelf" system
240	39000	$130,000	3.333	"Off the shelf" system
315	47000	$156,667	3.333	"Off the shelf" system
400	58000	$193,333	3.333	"Off the shelf" system
500	77000	$256,667	3.333	"Off the shelf" system
710	100000	$333,333	3.333	"Off the shelf" system
800	120000	$400,000	3.333	"Off the shelf" system
1000	120000	$500,000	4.167	Custom-built system
2000				Custom-built system

NOTE: CAPACITY COLUMN SHIFTED DOWNWARD IN ORDER FOR VLOOKUP FUNCTION TO BE CONSERVATIVE. IT SELECTS THE VALUE THAT IS CLOSEST AND LOWER AUTOMATICALLY. HENCE THE SHIFT.



City of Campbell River
Campbell River / Quinsam River ISMP
Class D Construction Cost Estimate

Costs for Recommended Municipal Storm Sewer Upgrades (To Upgrade for Existing Conditions)

Model ID	Location	Proposed Pipe Size (mm dia.)	Pipe Cost ($/m) [1]	Length (m)	Capital Cost ($) [2]	O&M Cost ($/yr)	Present Worth of O&M Cost ($)[3]
1696	Redwood Street and 14 Avenue	900	885	86.5	$ 92,200	$ 1,000	$ 14,600
1697	Redwood Street and 15 Avenue	1050	1040	102	$ 124,500	$ 1,300	$ 18,900
1698	Redwood Street and 16 Avenue	1050	1040	129.7	$ 158,300	$ 1,600	$ 23,300
1699	Redwood Street and Island Hwy 19A	1200	1200	110.8	$ 153,000	$ 1,600	$ 23,300
1700	Redwood Street and 19 Avenue	1200	1200	86.7	$ 119,700	$ 1,200	$ 17,500
1746	14 Avenue and Spruce Street	675	665	99.9	$ 84,500	$ 900	$ 13,100
1747	14 Avenue and Redwood Street	750	745	65.4	$ 60,500	$ 700	$ 10,200
				Sub-Total	$ 792,700	$ 8,300	$ 120,900
				+35% Contingency	$ 277,500	$ 3,000	$ 42,400
				+15% Engineering	$ 119,000		
				Total	$ 1,189,200	$ 11,300	$ 163,300
						Grand Total (Capital + O&M)	**$ 1,353,000**

Costs for Recommended Municipal Storm Sewer Upgrades (To Meet Future Conditions)

Model ID	Location	Proposed Pipe Size (mm dia.)	Pipe Cost ($/m) [1]	Length (m)	Capital Cost ($) [2]	O&M Cost ($/yr)	Present Worth of O&M Cost ($)[3]
1696	Redwood Street and 14 Avenue	900	885	86.5	$ 92,200	$ 1,000	$ 14,600
1697	Redwood Street and 15 Avenue	1050	1040	102	$ 124,500	$ 1,300	$ 18,900
1698	Redwood Street and 16 Avenue	1050	1040	129.7	$ 158,300	$ 1,600	$ 23,300
1699	Redwood Street and Island Hwy 19A	1350	1355	110.8	$ 170,100	$ 1,800	$ 26,200
1700	Redwood Street and 19 Avenue	1350	1355	86.7	$ 133,100	$ 1,400	$ 20,400
1746	14 Avenue and Spruce Street	675	665	99.9	$ 84,500	$ 900	$ 13,100
1747	14 Avenue and Redwood Street	750	745	65.4	$ 60,500	$ 700	$ 10,200
				Sub-Total	$ 823,200	$ 8,700	$ 126,700
				+35% Contingency	$ 288,200	$ 3,100	$ 44,400
				+15% Engineering	$ 123,500		
				Total	$ 1,234,900	$ 11,800	$ 171,100
						Grand Total (Capital + O&M)	**$ 1,406,000**

NOTES:

1 Pipe cost includes manholes at 155 metre spacing.

2 Capital cost assumes road removal and restoration for top of trench width (width based on 1.5 m cover on sewer and 1.5:1 excavated side slopes on trench).

3 Present worth based on 30 year life with 5.5% interest rate

City of Campbell River
Campbell River / Quinsam River ISMP
Class D Construction Cost Estimate

Costs for Detention Facilities to Service Future Development

Development	Catchment	Catchment Area (ha)	Active Storage Volume (m^3)	Perimeter (m) [1]	Capital Cost ($) [2]	O&M Cost ($/yr)	Present Worth of O&M Cost ($)[3]
1	Kingfisher Creek (Upper Reach)	42.8	5,100	240	$ 1,854,000	$ 74,200	$ 1,078,500
2	Kingfisher Creek (Middle Reach)	6.2	1,300	120	$ 477,000	$ 19,100	$ 277,600
3	Kingfisher Creek (Middle Reach)	12.4	4,000	210	$ 1,455,750	$ 58,300	$ 847,400
4	Kingfisher Creek (Lower Reach)	6.9	2,200	160	$ 804,000	$ 32,200	$ 468,000
5	Kingfisher Creek (Lower Reach)	5.2	1,700	140	$ 622,500	$ 24,900	$ 361,900
6	Detweiler Creek (Upper Reach)	12.2	3,000	180	$ 1,093,500	$ 43,800	$ 636,600
7	Detweiler Creek (Lower Reach)	7.7	1,200	120	$ 441,000	$ 17,700	$ 257,300
				Sub-Total	$ 6,747,750	$ 270,200	$ 3,927,300
				+35% Contingency	$ 2,361,800	$ 94,600	$ 1,374,600
				+15% Engineering	$ 1,012,200		
				Total	$ 10,121,750	$ 364,800	$ 5,301,900
						Grand Total (Capital + O&M) [4]	**$ 15,424,000**

NOTES:

1 Perimeter calculation assumes a square pond at 1.5 metre depth.

2 Capital cost assumes a 3 metre wide riparian planting buffer around perimeter of pond; cost is sum of cost for storage volume plus riparian planting.

3 Present worth based on 30 year life with 5.5% interest rate

4 Costs assume a dry pond, i.e. no additional storage volume for a permanent pool.

USL Job No. 1479.0009.01

City of Campbell River
Campbell River / Quinsam River ISMP
Class D Construction Cost Estimate

Costs to Treat Runoff at Campbellton Outfalls

Outfall(s) Name	Capital Cost ($)	O&M Cost ($/yr)[1]	Present Worth of O&M Cost ($)[2]
CR1	$ 66,700	$ 2,700	$ 39,300
CR2	$ 80,000	$ 3,200	$ 46,600
CR3	$ 66,700	$ 2,700	$ 39,300
CR4	$ 193,300	$ 7,800	$ 113,400
CR5	$ 66,700	$ 2,700	$ 39,300
CR6	$ 66,700	$ 2,700	$ 39,300
CR6.5[3]	$ 130,000	$ 5,200	$ 75,600
CR7	$ 130,000	$ 5,200	$ 75,600
CR8	$ 66,700	$ 2,700	$ 39,300
Sub-Total	$ 866,800	$ 34,900	$ 507,700
+35% Contingency	$ 303,400	$ 12,300	$ 177,700
+15% Engineering	$ 130,100		
Total	$ 1,300,300	$ 47,200	$ 685,400
	Grand Total (Capital + O&M)		**$ 1,990,000**

NOTES:

1. O&M Cost based on 4% of construction cost, to cover required sediment removals and cleanings

2 Present worth based on 30 year life with 5.5% interest rate

3 Total at CR7 has been split 50/50 with CR6.5

APPENDIX I

PHOTO INVENTORY

Campbell River / Quinsam River Integrated Stormwater Management Plan
Reconnaissance Photos

Diversion (bifurcation) structure on Haig Brown's Kingfisher Creek; low flows pass through the orifice on the left and high flows pass over the concrete weir to the rock-lined channel to the right

Outlet structure for water quality pond along Highway 19, near 14th and Willow

Campbell River / Quinsam River Integrated Stormwater Management Plan
Reconnaissance Photos

Water quality pond along Highway 19, near 14th and Willow

Outfall CR7; 2000mm diameter CMP

Campbell River / Quinsam River Integrated Stormwater Management Plan
Reconnaissance Photos

Box culvert under Campbell River Road; Haig Brown's Kingfisher Creek

Beaver pond in Pease Marsh

Campbell River / Quinsam River Integrated Stormwater Management Plan
Reconnaissance Photos

Small, riffle pool on Haig Brown's Kingfisher Creek

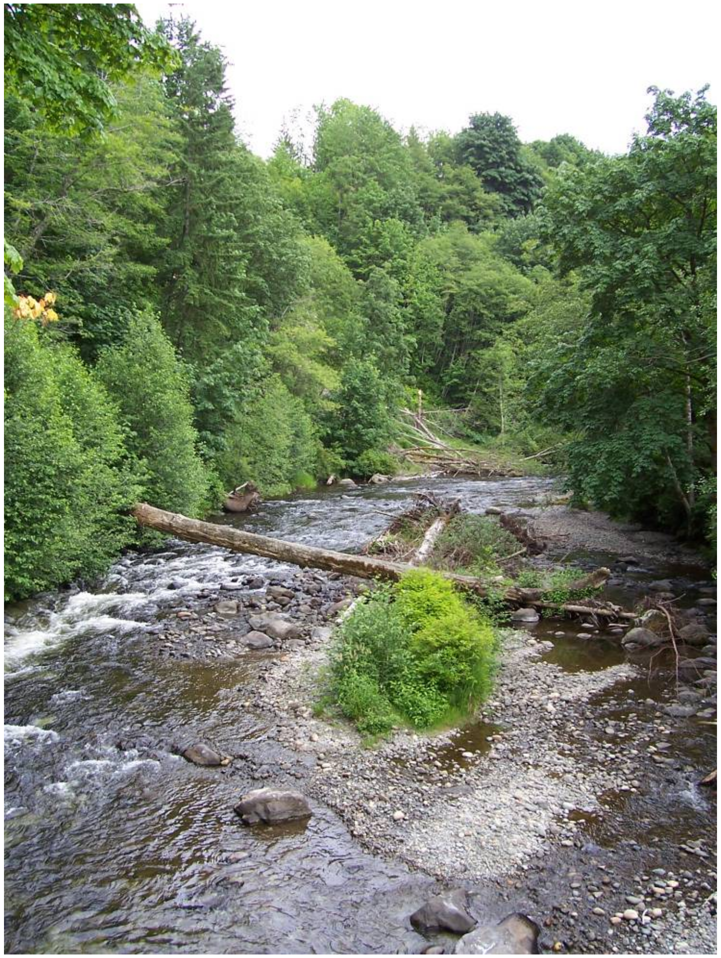
New headwall with trash rack on west end of Treelane Road

Campbell River / Quinsam River Integrated Stormwater Management Plan
Reconnaissance Photos

Outlet of 750 mm diameter CMP under Treelane Road; services new development

Riprap-lined channel servicing new Sequoia Springs development in upper Haig Brown's Kingfisher Creek watershed

Horse farm along Shetland Road



Quinsam River, upstream from Quinsam Road bridge

Campbell River / Quinsam River Integrated Stormwater Management Plan
Reconnaissance Photos

Eroding silt banks along Quinsam River

Shetland Road, south of the golf course, in upper Haig Brown's Kingfisher Creek watershed

Typical residential streets in upper Campbellton Area; note ditch which could be converted to a bioswale for runoff treatment

Campbell River / Quinsam River Integrated Stormwater Management Plan
Reconnaissance Photos

Typical commercial / industrial area in Campbellton; note wide streets and extensive impervious surfaces

Campbell River / Quinsam River Integrated Stormwater Management Plan
Reconnaissance Photos

Typical single family residential area, with rural street section; note ditches which could be used as bioswales for runoff treatment

Campbell River / Quinsam River Integrated Stormwater Management Plan
Reconnaissance Photos

Campbell River, looking upstream from Outfall CR2

Campbell River and estuary, looking downstream from Outfall CR2

Campbell River / Quinsam River Integrated Stormwater Management Plan
Reconnaissance Photos

Typical Campbellton residential area along the river

Typical Campbellton residential area, along 17th Avenue; note use of ditches and culverts

APPENDIX J

SUMMARY OF EXISTING CITY OF CAMPBELL RIVER POLICIES

Summary of Existing City of Campbell River Documents
Which Address Stormwater Management

Reference	Title (Date)	Comments
OCP Bylaw 3150	Official Community Plan (October 2005)	• Defines broad principles, goals, objectives and implementation strategies for community growth and development • Four overall key principles / values: (1) enhance economic diversity; (2) celebrate the City's cultural fabric; (3) ensure quality of life; and (4) promote environmental sustainability • Four specific goals related to environmentally sensitive areas: (1) protect sensitive areas; (2) minimize air, land and water pollution; (3) protect and conserve the quality and quantity of groundwater and surface water; and (4) minimize loss of life and damage to property in areas with flooding risk or slope instability • Strong environmental protection and sustainability components in many provisions • Commits to encouraging and supporting growth and development in the District that is in accordance with the Integrated Stormwater Management Plans (ISMP's) • Encourages the use of alternative design standards where appropriate to mitigate stormwater impacts • Encourages increased densities and cluster development instead of urban sprawl • Identifies current and future commercial, industrial and residential development areas • Stormwater management goals are to maintain pre-development flows to downstream systems and to capture, convey and treat water that flows through a site from upstream areas
Bylaw 3060	Building Bylaw (2003)	• Requirements for plans and specifications for buildings • Permits for installing culverts
Bylaw 1802	Soil Removal and Deposition Bylaw (1989)	• Basis for permits to move soil • Prohibits adverse affects from soils movement, including siltation of streams • Fines up to $2000 for contravention (set by companion Bylaw 2429)
Bylaw 1340	Subdivision Bylaw (1983)	• Requires engineering studies and mitigation for flooding, settlement or unusual soil or drainage conditions • References Engineering Design Standards (Appendix A) (see below) • Requires servicing developments with storm drainage systems, based on broad land use types, including storm drains in all but "rural" and "resource" zones • Cost sharing for "higher standard" of service for storm drains disallowed, except where a Development Cost Charge (DCC) has been established • Establishes basis for cost sharing
Bylaw 2957	Development Cost Charges Bylaw (2003)	• Establishes purpose and basis for Development Cost Charges (DCCs) • Specifies DCCs for stormwater drainage in the Quinsam Heights Area, but not for other areas of City • DCCs in Quinsam Heights typically based on number of units (residential) or gross building square footage (multiplex, commercial, industrial and institutional)
Bylaw 2700 (and amend-ments)	Zoning Bylaw (November 2006)	• Regulates use of land and structures within District • Siting adjacent to lakes and watercourses • Siting in floodplains • Landscaping requirements in certain zones • Parking requirements • For each zone, typical requirements relate to: permitted uses; lot size; lot coverage/density; minimum dimensions for yards; building heights; usable open space; conditions of use • Establishes streamside protection and enhancement areas

Reference	Title (Date)	Comments
Bylaw 2709	Frontage Improvement Bylaw (1998)	• Requires certain improvements to serve developments, including stormwater-related • Extent of improvements based on general zoning uses (rural/resource; industrial; all others) • Establishes unit costs to be charged for the improvements, including specifically for storm drains, storm drain connections, and trees
CREMP	Campbell River Estuary Management Plan (1995)	• The Plan addresses long-term protection and enhancement of the Estuary including recommendations related to habitat restoration, dredging, industrial relocation and upland development. Among the proposed overall policies are several directly relating to stormwater: • Develop and manage land per Provincial Land Development Guidelines • Minimize water contamination from runoff per Provincial Urban Water Runoff Guidelines • Complete a stormwater management plan for the estuary and surrounding lands Other policies relate to shoreline erosion, upland development clustering to encourage open space and development of greenways
CREMP (rev)	Campbell River Estuary Management Plan Update (2002)	• Reviews actions undertaken since adoption of 1995 CREMP and provides direction on priorities over next 5 years • Recommends establishing performance standards for stormwater runoff quality and habitat protection • Recommends establishing stormwater management plans for watercourses flowing into the estuary
Bylaw 2864	Storm Water Management Parcel Tax Assessment Roll Bylaw (2000)	• Directs preparation of assessment roll for purposes of imposing a parcel tax to cover costs related to stormwater management • Parcel tax to be an amount for each parcel
Bylaw 3197	Storm Water Management Parcel Tax Bylaw (2005)	• Extends the original stormwater parcel tax adopted in 2000 • Tax to be imposed on all parcels (except exempt properties) within District • Revenues identified for stormwater management purposes • $12/year for five years (2006-2010)
Bylaw 2871	Local Improvement Charges Bylaw (2000)	• Establishes annual charges per frontage foot for various local improvements • Improvements include: curb & gutter; roads; storm sewers; sidewalks and landscaping
Bylaw 2926	Storm Drain System Connections Bylaw (2001)	• Storm drain connections required under a variety of conditions • Establishes connection charges • Not required when adjacent to certain water courses (including Campbell River and Discovery Passage)

Reference	Title (Date)	Comments
Appendix A, Bylaws 1340 & 2709	Engineering Design Standards (November 2000)	Part I sets standards for roadway designs that affect impervious area and hydraulic connection of impervious area: • Tables I & IA – minimum pavement widths with curb types for various land uses • Table III – sidewalk requirements • Table V – sets pavement designs (materials, etc .) • Sec 13.1 thru 13.7 – requires tree planting along roadways and sets standards Part III directly concerns storm drainage: • Sec 1.1 – systems must meet District's "stormwater management plans" • Sec 1.4.1 – design minor systems for 5-year event, except 10-year for commercial / industrial • Sec 1.4.2 – design major systems for 100-year event; allows flow paths in roadways and walkways • Sec 3 – requires sediment control plans for developments during construction; sets limits on discharge of total suspended solids (TSS) in runoff; requires slope protection; establishes other requirements for sediment controls during construction • Sec 4 – requires conformance with District's approved stormwater management plan where applicable; shows preference for regional stormwater detention facilities and for wet ponds; sets requirements for design of detention facilities
Appendix B, Bylaws 1340 & 2709	Specifications (November 2000)	• References "Master Municipal Construction Documents: Specifications and Standard Detail Drawings" • Includes a variety of items related to construction of stormwater facilities, including erosion control
Appendix, Bylaws 1340 & 2709	Approved Product List (November 2000)	• Describes approved suppliers of certain storm drainage features • Includes: pipe, culverts, fittings, manholes, catch basins and headwalls
EAP	Environmental Action Plan (December 2003)	• Outlines District's environmental goals and objectives, projects to complete over next 5 years, departments responsible for undertaking projects, funding sources and partnership opportunities • Projects include future ISMP studies, environmental monitoring, guidelines and bylaws for runoff and erosion control, design guidelines for BMP's, acquiring dedicated property or restrictive covenants for sensitive areas
MPP	Master Parks Plan (2005)	• Not reviewed because draft report not completed
ADS	Draft Alternative Design Standards (2006)	• Proposes use of "sustainable" or "low impact" standards for City infrastructure, as regulated through the Subdivision Bylaw, including (1) street systems; (2) stormwater management; and (3) erosion and sediment control • Includes a draft bylaw • Proposes a dual system of "performance" and "prescriptive" standards, depending on project size and complexity • Compatible with recommendations of the City's ISMPs, including use of target performance standards for stormwater control
MTP	Master Transportation Plan (May 2004)	• Outlines current conditions of District's road network and provides recommendations for future improvements • Recommends that all residential collector roads be upgraded to full urban standard (curb, gutter and sidewalk) • Recommends 2 sidewalks on residential collector roads and 1 sidewalk in commercial / industrial collector roads • Some new roads suggested for Willow and Simms Creek watersheds, upgrades to existing roads for Nunns Creek watershed
CPM	Council Policy Manual (February 2004)	• Policies for administrative, finance, parks/recreation, property, public works and purchasing • Provides timing schedules for inspection of utilities, roads, etc and outlines

Reference	Title (Date)	Comments
		recording and action procedures by public works department
Bylaw 3230	Advisory Commissions Bylaw (2006)	• Establishes advisory commissions for several City functions, including a Development Advisory Commission and an Environmental Advisory Commission • Eliminated the CR Estuary Management Commission • Defines roles and duties of the commissions

Adapted and amended from the Integrated Stormwater Management Plan for the Foreshore Area, prepared by Urban Systems Ltd, October 2005.

APPENDIX K

CAMPBELL RIVER/QUINSAM RIVER AREA
INTEGRATED STORMWATER MANAGEMENT PLAN
TERMS OF REFERENCE

A. INTRODUCTION

The City of Campbell River (the City), a community of approximately 30,000 people, is located 150 kilometers north of Nanaimo on the east coast of Vancouver Island. Development in the community has primarily taken place in a two to three kilometer wide strip of land, which rises up from Discovery Passage at the northern tip of the Georgia Basin and stretches along the coastline for over 14 kilometers.

The City is requesting proposals for the completion of an Integrated Stormwater Management Plan (ISMP). The ISMP is to be developed for portions of the Campbell River Watershed, which include areas of agricultural (forestry), rural, and urban development. The ISMP is to be undertaken using the methodology outlined below.

The Campbell River ISMP is to include only the south bank of the river from the Tyee Spit approximately 1.8 km upstream to the base of Elk Falls. An ISMP study for the Holly Hills drainage, undertaken in 2004, has already considered the upland drainage and its influence on the north bank of the river, but should be reviewed as part of this assignment. The study will also include the Quinsam River from its confluence with the Campbell River upstream to the bridge crossing (Campbell River) at the Argonaught Road including any associated upland road drainages. In addition, Detweiler Creek located between the Haig-Brown Kingfisher Creek and Quinsam River will also form part of this study.

Background

From the 1960's through the mid 1990's, the City completed various studies to address stormwater management issues. These studies were often associated with site-specific development, projects or problem areas. In some cases, these studies did not address the larger strategic stormwater issues associated with an entire watershed. In 2000, the City of Campbell River initiated a 5-year program to complete a series of integrated stormwater management plans (ISMP). To date ISMP studies have been successfully completed for the Holly Hills and Perkins Road drainages, Willow, Simms & Nunns Creek Watersheds, and the Foreshore between the Jubilee Parkway and Orange Point Road.

The City did initiate a series of overall watershed master drainage plans in 1995 and 1996. Master drainage plans were completed for the Willow Creek (1996), Simms Creek (1995) and the west and lower sections of the Nunns Creek catchments in 1995 and 2002 respectively. Specific recommendations were made in these studies to address the impact of future land development, with the goal to preserve the pre-development flow characteristics of the stream as urbanization proceeds. The plans were consistent with the Federal Department of Fisheries Land Development Guidelines and relevant Provincial guidelines, which ultimately led to revisions to the City's Design Standards and Specifications between 1997 and 2000. The City will through 2005 & 2006 undertake another review of its current design standards. The goal of this two-phase study will be to identify and develop alternative storm-water design standards for area specific neighbourhoods and catchment areas.

Recently, engineering, planning and environmental specialists have come to agree that an integrated approach to stormwater management is required to protect watersheds. This approach is science based, addressing the impacts of urbanization on fish habitat, flooding and property damage. The ISMP will bring together land use planners, stormwater engineers and ecological specialists in an interdisciplinary approach to develop proactive solutions to the changes that urbanization brings to the City's stormwater system and natural habitat.

A number of issues are driving the need to complete a comprehensive citywide stormwater management strategy including: the reconstruction of Island Highway 19A from the Jubilee Parkway to Hidden Harbour and upgrading of the sanitary sewer collection system. Other factors that have been considered include the City's concern over existing undersized stormwater infrastructure. Up to the mid 1990's rainfall estimates were based on data from the Comox Valley. These estimates have proven to be considerably lower than actual Campbell River rainfall events. With historic urban development concentrated along the Campbell River foreshore and new urban development now moving in a westerly direction away from the foreshore, downstream pipe capacity for new upland developments may as a result of the early estimates have capacity limitations.

In addition, it will also be necessary to coordinate any proposed stormwater drainage improvements with other long-range management plans. The list includes: the City's Official Community Plan (adopted in October 2005); Long Range Road Reconstruction Plan (LIP); Utility Renewal Plans; Capital Works Plan; Long Range Plan for Road Overlays; and Estuary Management Plan. Coordination with these other plans is critical to cost effective implementation of each plan. Other planning exercises underway that may be considered include Phase One of a Master Parks Plan and Phase Two of a review of Alternative Design Standards.

B. STUDY AREA

Physical Setting

The Campbell River is a designated Heritage River and drains an area of significant geographic variety. For the purposes of this study only the river sections located within the lower reaches of the watershed are to be assessed, as per the attached map. Within the defined study area it is expected that all drainages that flow into the Campbell River will form part of the ISMP. The designated study area should be reviewed by the consultant and updated if deemed appropriate to include the Kingfisher Creek.

Located within the Coastal Western Hemlock Biogeoclimatic zone, the predominant tree species include Western hemlock, Douglas fir, Red cedar, Sitka spruce, Grand fir, Big Leaf maple and Red alder. Invasive plant communities have recently been identified that if left unchecked may lead to changes in vegetation ground cover and loss of species diversity.

Climate

Average winter temperatures range from 0.9 C to 2.7 C. Average summer temperatures are 16.7 C. (C.R. Climate station). The prevailing wind is from the southeast, especially during the winter months, and westerly during the summer months.

Soils

The watersheds lie within the Coastal Western Hemlock (CWHxm) Biogeoclimatic zone. Valentine et al. notes that the soils are within this region are typically humo-ferric podzols, imperfectly drained and leached soils with a mixture of dry brunisols, rapidly draining brown soil.

Watershed Profile

The Campbell River Watershed has very high fisheries values as a Chinook Salmon (*Oncorhynchus tshawytsch),* Pink (*Oncorhynchus gorbuscha*), Chum (*Oncorhynchus keta*) Coho (*Oncorhynchus kisutch*), limited but historical runs of Steelhead (*Oncorhynchus mykiss*) and various Trout & Char species. The Campbell River is designated as a Heritage River.

The Campbell River is a hydro managed system with the John Hart Generating Station located approximately 1.8 km upstream of the estuary. An impassable fish barrier is located at approximately 2.5 km (Elk Falls) and the John Hart, Lador and Strathcona dams are located beyond the falls that feed the Hydro generating station and is also the City's drinking water source. BC Hydro has completed an extensive Water Use Planning process and has committed to maintaining base flows in the lower river that meet fisheries' rearing and life cycle requirements for anadromous and non-anadromous fish. In 2001 the City also completed a Watershed Management Plan that forms the backbone of its drinking water strategy.

Fisheries and Oceans Canada maintain a highly productive and successful federally operated hatchery operation on the Quinsam River. Numerous habitat enhancement works have been completed on both the Campbell and Quinsam rivers. Extensive data has been collected including habitat assessments, flow monitoring and fish population estimates. In addition, the provincial Ministry of Environment has worked to improve the rivers' Steelhead population which in recent years has begun to see signs of improvement.

While historically development has occurred along the lower reaches of the river, the study area is not highly urbanized and is home to numerous terrestrial wildlife including ungulates, large mammals, amphibians, avian and waterfowl populations. This diversity is critical to the ecosystem which the river supports and draws nutrients from.

Community Profile

Local non-government organizations that participate in partnership projects include but are not limited to the: Campbell River Gravel Committee; Tyee Club of British Columbia; Greenways Land Trust; Campbell River Fish and Game Association; Nature Conservancy of British Columbia, and BC Hydro. Other organizations that have participated in governance of the subject watersheds include: Provincial Ministry of Environment, the Campbell River Indian Band, and Campbell River Stewardship Advisory Council.

It is expected that the successful consultant team will be able to utilize the biological and anecdotal information these stakeholders have developed through their own resources. Each stewardship group is active in its respective watershed and has varying capabilities. Opportunities for enhancement and restoration activities that compliment the ISMP for the study area should be seen as a key objective in building community capacity and education for the protection of the natural environment.
The study area includes the Campbellton neighbourhood. This area was one of the City's first settled areas. Buildings were constructed along the riverbank, which today is exhibiting signs of

instability. In 2003 the City, at the request of and on behalf of the local residents applied for provincial funding to study the rivers' bank stability between Maple Street and the Willow Street Bridge. Following the consultant's recommendations the City applied for funding from the Provincial Flood Protection program to implement bank stabilization works. The City's application to the province for funding to complete the works was not successful and as a result, no improvements have taken place.

It should be noted that the existing stormwater infrastructure not only collects localized runoff from roads, and buildings but also some upland portions of the Nunns, Haig-Brown and Detweiler creek watersheds. Some storm drains were updated during the Ministry of Highways construction of the Inland Island Highway but most of the remaining storm system has little or no existing treatment for sediments, or hydrocarbons.

C. GOALS & OBJECTIVES

The goals of the ISMP are:

I. To establish an achievable and supportable vision for the watershed that will result in development of stormwater management solutions and policies that maintain, restore and enhance the natural watershed characteristics while meeting engineering, environmental and land use needs;
II. To protect the community from flooding, erosion and destruction of private and public property;
III. To promote community development while recognizing neighborhood values and unique characteristics of the area, and
IV. To integrate engineering, planning and environmental solutions to the benefit of each watershed.

The objectives of this ISMP are:

I. To document the existing condition of the watershed including the stormwater infrastructure, biophysical inventory, and existing and future land use patterns;
II. To identify the required stormwater management infrastructure and land use policies necessary to ensure the protection of residents and property with protection of the aquatic habitat;
III. To ensure stakeholder interests and senior environmental agency support for the study recommendations is balanced with the social and economic interests of the community;
IV. To develop a decision matrix that will allow the City to analyze and evaluate options that meet the multiple needs of the community;
V. To recommend an integrated approach to achieving cost effective solutions which will assist the City and its partners in establishing watershed based stormwater policies, a stormwater infrastructure program; and
VI. Provide the City with an evaluation and recommendation(s) that will lead to the development of sustainable financial tools that support the City's land use plan and capital works program, including but not limited to the establishment of a stormwater utility and development cost charges.

D. METHODOLOGY

The proposal should clearly outline the methodology the consultant will use in achieving the objectives of this Proposal Call. In meeting the above objectives, the consultant should, as a minimum, carry out the following tasks:

1. Within 1 week of acceptance of your proposal facilitate and chair a project initiation meeting with appropriate City attendees to confirm the scope of work and to gather input. As a minimum, City staff to be invited includes representatives from the Engineering, Planning, Finance, Parks and Public Works departments.

2. The Consultant will meet with and gather information from key stakeholders including but not limited to: the Senior Environmental Agencies, landowners (including Forestry Industry Sector), First Nations, MoT, Non-Government Organizations, area residents and businesses. The consultant shall pursue the formation of a stakeholder-working group that includes representation from the various parties, including the City. The working group would act as a resource pool for input and feedback on various land use and environmental issues. The stakeholder/working group should meet on a regular basis, as required, to provide input on the development and review of the studies recommendations.

3. Host a minimum of at least two community open houses. The purpose of the open houses will be to gather community comment to judge the recommendations of the studies and to determine if further revisions are required.

4. Arrange and chair a 50% project completion review meeting with City staff as well as any other relevant stakeholders/working group to confirm project status and identify potential conflicts.

5. Arrange and chair a 90% project review meeting with City staff as well as any other relevant stakeholders/working group to review the draft final report.

6. The Consultant will be responsible for promotion, facilitation and preparation of minutes from all open houses, working group, stakeholder and City meetings.

<u>Existing Stormwater and Watercourse System</u>

7. Review existing engineering studies and related reports for each study area.

8. Review and identify existing rainfall and runoff data. In consultation with City engineering staff recommend additional information or data gaps to be filled.

9. Verify watershed catchments and drainage areas.

10. Gather and review existing biological and flow studies and watershed reports prepared by the City, senior environmental agencies and watershed stewardship groups.

11. Review the City's Engineering Standards and Specifications; identify gaps or deficiencies and make recommendations where appropriate changes might facilitate better use of current Best Management Practices for ISMP's.

12. Map soil conditions and review existing groundwater data.

13. Inventory and evaluate the capacity of the existing stormwater system including ditches, creeks, pipes and overland flow paths. Special attention should be paid to piped systems constructed prior to the mid 1990's. Where required, cross sectional data should be obtained at critical points, specific anthropogenic features and representative segments of identified drainages and catchment areas.

14. Identify known habitat issues in the watershed through discussion with City staff and stakeholders/working group.

15. Where critical habitat concerns are identified during the review of existing studies and stakeholder input, undertake a preliminary site assessment of any significant elements of the noted biophysical features, habitat use, fish and wildlife presence.

16. Delineate and prepare plans showing the watershed and sub-basin boundaries and key site-specific areas of concern.

17. Develop a database of existing and new data for integration with the City's GIS database. Data should include but not be limited to: Geometric, Land Use, Soils, Rainfall, Runoff, Watershed catchments, Contour, Legal address, Utility, Existing mapping, and Survey information as necessary (Arc View GIS and AutoCAD compatible for future use).

Land Use

18. Review the OCP, neighborhood studies and other land use documentation to identify the existing and proposed land use pattern in the area.

19. Identify any special land use designations in the catchments and identify how this information may affect the ISMP (First Nations, forestry, land, wildlife and agricultural reserves, etc.).

20. Map the existing and future land use designations and zoning on each parcel in the catchments.

21. Document and identify gaps in the land use and development policies and regulations for the area.

Hydrologic and Hydraulic Analysis

The City intends to develop the long-term capabilities to accurately model hydrologic and hydraulic data and recognizes that existing data may be limited. It also understands that continuous modeling requires ongoing data collection. The City intends to work towards modeling capabilities using XP-SWMM. It is expected that any input and output files developed under this assignment will remain the property of the City.

While the City does not currently have the in-house software to model hydrologic and hydraulic data using XP-SWMM it will be considering a short-term agreement to contract these services out as needed, and will explore this option under a separate arrangement.

To assist in modeling of various flow rates the City will attempt to provide the following information: an inventory of all available storm drain infrastructure including pipes, sizes, lengths, date of installation, composite materials, grades, invert sizes, and contour mapping associated with inlet rims.

Therefore all modeling should be completed using XP-SWMM as proposed:

22. Develop concept model of the groundwater system of each watershed, including determining areas of potential infiltration and groundwater recharge.

23. Identify base flows for streams and ditches that may have direct influence on the streams.

24. Develop an integrated model of the hydrologic and hydraulic conditions for the watershed using the available rainfall and runoff data.

25. Perform a sensitivity analysis and calibrate and verify the model. Modeling should include but not be limited to: total area, impervious area, impervious and pervious roughness coefficients, impervious and pervious depression storage, and infiltration parameters. In addition, for those models simulating pipes, ditches, swales or natural channel(s), perform sensitivity analysis on key hydraulic parameters that may affect routing and the calculation of flow velocity and depth, including roughness coefficients, expansion and contraction coefficients, loss coefficients, detention volumes and boundary water surface conditions. Parameters must be varied individually by plus or minus 20% as part of the analysis.

26. Evaluate the existing and future land use conditions for various return periods including the 2-, 5- 10- 25- and 100- year storms.

27. Compare and contrast the results of modeling existing and future land use conditions with and without various low impact development designs.

Alternatives, Evaluation and Recommendations

28. Identify alternatives that should be considered to move from event based modeling to continuous based modeling including but not limited to: possible locations of flow meters, additional rain gauges and surveying needs. Any recommendations must also include a discussion on the implications of such alternatives and estimated costs for of such activities.

29. Identify and evaluate innovative stormwater management solutions that consider sustainability, long-term operation and maintenance, capital and operating costs, community amenities, and the health of the watercourses.

30. Review options for stormwater management alternatives at the watershed level and recommend modeling tools that can be used to direct site-specific developments in maintaining post development flows to mimic predevelopment flows.

31. Establish the drainage and biological benefits of various solutions and the level of protection supported by each solution. Determine the future condition of the watercourses using existing and proposed future land use plans.

32. Prioritize critical habitat protection, restoration and or enhancement opportunities that require either immediate mitigation or that might pose a risk to adjacent upland residential, commercial or industrial property in the long-term.

33. Recommend best management practices (BMP's) in a comprehensive strategy that outlines the integrated goals and objectives and which level of protection is possible for the watershed. BMP's such as ground infiltration, detention, stormwater treatment and surface flows, etc. will be considered. Determine which BMP's are best constructed by the private sector or by public sector.

34. Report on new and innovative solutions that may be appropriate as a pilot project or policy and the implications of such a solution.

35. Identify the specific type, size and location of the required drainage and watercourse works including any modifications to existing facilities or the recommendations of existing studies. Indicate whether implementation should be by the public or private sectors.

36. Present the options, evaluation and recommendations to the working group for comments and direction.

37. Develop short and long-term evaluation methods the City may employ to measure the success of the recommended solutions.

38. Provide a cost estimate of the recommended solutions.

39. Identify preliminarily changes necessary to the City's Engineering Standards and Specifications, Official Community Plan as well as other documents to implement the recommended solutions.

40. Recommend alternative legislative tools such as relevant sections of the Local Government Act or Community Charter that can be utilized to ensure land use decisions be managed to meet water resource needs.

41. Develop and recommend a long-term monitoring program that can be used to evaluate the effectiveness of the stormwater management program. The program should include a discussion of target limits and mechanisms for making future adjustments to the program, as needed.

42. Identify funding mechanisms that could be used to implement recommendations (DCC's, Stormwater Utilities, GMF, GEF, etc.). Where DCC's and utility charges may be applied identify the eligible items.

Communications Strategy

43. The Consultant will report to the City's Project Manager (Engineering Services Manager). Using Microsoft Project and summary memos the Consultant will provide a project status report and list of accomplishments, at a minimum, every 3 weeks. The Consultant will be responsible for the compilation and distribution of minutes to the Project Manager for all meetings and open houses.

44. Prepare and distribute media releases promoting the City's ISMP process. Ensure that regular updates are distributed to the local newspapers. Any media articles must be approved by the Project Manager prior to their release.

45. The Consultant will provide the working group with copies of any draft version of the ISMP report and maps for use by City staff and stakeholders. In addition, the Consultant will provide a separate and comprehensive ISMP study for Campbell River Watersheds. The Consultant will provide the City 15 bound copies plus a digital CD-Rom version of the final ISMP report. The digital files are to be compatible with (MS-Word and PDF) and the City's Arc View GIS and AutoCAD systems. In addition, for each report an executive summary to a maximum of 3 pages is required.

E. DELIVERABLES

46. Document existing watershed conditions and predict future needs including infrastructure requirements, land use considerations and alternative legislative policies necessary to meet the recommendations.

47. Ensure that all stakeholders and interest groups have been afforded an opportunity for input into the development of the ISMP.

48. Develop a cost effective baseline model that can be adapted to meet the future needs of the City.

49. Prepare separately bound integrated stormwater management plan for the Campbell River Watershed that establish an achievable vision, which includes protection of private and public properties and integrates engineering, planning and environmental values for each distinctive neighborhood.

50. Present a summary report of the study to Mayor and Council providing an overview of the study and its recommendations.

F. TIMING

Works under this project shall be completed as follows:

March 28th 2006:	Project Start up and initial meeting.
June 20th 2006:	50 % completion review.
August 30th 2006:	Review final draft and project completion.

G. QUALIFICATIONS

The proposal will include the names of all team members proposed to carry out the work assignment. Included should be their specific roles in the assignment and a detailed summary of qualifications and experience on similar projects.

The corporate qualifications and experience in similar work should be included.

H. BUDGET

To aid you in preparing your budget it should be noted that a maximum of $50,000 (taxes included) would be provided to complete this study.

The proposal for provision of services for this assignment shall include an estimate of fees with an appropriate breakdown in spreadsheet form. A cost breakdown for each team member, including City staff, which will be utilized, must be provided. The proposal shall detail individual charge-out rates and number of hours to be spent on each of the specified work tasks.

All disbursements including sub-consultant services, travel, printing, courier services, computer costs, long distance calls and any other legitimate expenses are to be identified. The proposal shall include a maximum fee including disbursements (upset price) for all services rendered during the proper execution of the assignment. Payment will be made for the actual time spent to complete the various tasks plus actual disbursements and applicable taxes up to the limit of the quoted maximum fee.

Invoices for work completed must clearly identify the service provided and the percentage completed, and must show the approved budget fees and disbursements, amount billed to date and remaining balance. The invoice amount shall not exceed the quoted maximum without prior written authorization from the City.

I. INFORMATION

The following reports are available for viewing in the Municipal Engineering Department along with reference and construction drawings. Documents in italics can also be viewed at the City website www.campbellriver.ca

Campbell River's Official Community Plan, 2005
Zoning Bylaw No. 2700
City of Campbell River Design Standards and Specifications (Bylaw 1340)
Floodplain Mapping Program Campbell & Quinsam Rivers – Klohn Leonoff, 1989
Campbell River Estuary Management Plan, 2003
Watershed Maps
Various stream reports and data for low flow riffle crest studies for the Campbell and Quinsam Rivers.
South Bank Erosion Study (2003) Kerr Wood Leidel