# Final REPORT

City of Campbell River

# Integrated Stormwater Management Plan

## Foreshore Area



1479.0007.01 / October 18, 2005

URBANSYSTEMS®
2353 - 13353 Commerce Parkway
Richmond BC V6V 3A1
Telephone: 604-273-8700
Fax: 604-273-8752

2353 - 13353 Commerce Parkway, Richmond, BC V6V 3A1
Telephone: 604-273-8700 Fax: 604-273-8752

**URBANSYSTEMS.**

October 18, 2005

File: 1479.0007.01 – C1

City of Campbell River
301 St. Ann's Road
Campbell River, BC V9W 4C7

**Attention: Mr. Michael Roth**
**Environmental Coordinator**

**RE: FORESHORE AREA INTEGRATED STORMWATER MANAGEMENT PLAN**
**FINAL REPORT**

We are pleased to submit to you this Final Report for the Foreshore Area Integrated Stormwater Management Plan (ISMP). We have enclosed fifteen (15) copies of the report; each copy is accompanied by a CD-ROM that contains the entire report, including all appendix materials, in electronic format (PDF). In order to keep the report to a reasonable size, Appendices E through G are found only on the CD-ROM; XP-SWMM output (Appendix D) is also on the CD-ROM, although model schematics are included in hardcopy.

Thank you for the opportunity to work with you on this latest ISMP. It is gratifying to know that we are assisting the City as it finds a sustainable balance between urban development and growth and environmental protection and enhancement. It has been especially exciting to be part of the City's exploration of urban runoff quality issues during this ISMP.

If you have questions, please call us.

Yours truly,

**URBAN SYSTEMS LTD.**

PROFESSIONAL PROVINCE OF J.M. RICE 25725 BRITISH COLUMBIA ENGINEER

10/18/05

Jeffrey M. Rice, P.Eng.
Senior Water Resources Engineer

Andrew Ling, E.I.T.
Project Engineer

Enclosures (15 copies of report c/w CD-ROM)

/jmr

*U:\Projects_VAN\1479\0007\01\R-Reports-Studies-Documents\Final\2005-10-18-LTR-mroth-ISMP submittal.doc*

30 YEARS integrity. longevity. diversity.

## TABLE OF CONTENTS

**APPENDICES**

## LIST OF TABLES



## LIST OF FIGURES IN TEXT

## LIST OF FIGURES IN APPENDIX A



## ABBREVIATIONS AND ACRONYMS

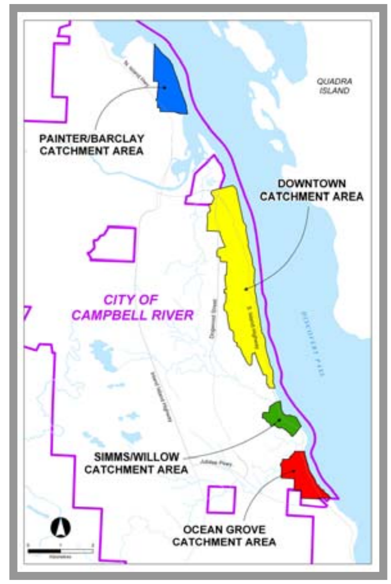
| | |
|---|---|
| BMP | Best Management Practices |
| DFO | Fisheries and Oceans Canada |
| ha | hectares |
| hr | hour |
| ISMP | Integrated Stormwater Management Plan |
| LID | Low Impact Development |
| L/s | liters per second |
| m | meters |
| mm | millimetres |
| m/m | meter per meter |
| m/s | 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 |
| 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 will eventually encompass the entire City, though this study addresses the City's **Foreshore Area** only. The area covers a little more than 900 hectares along the eastern part of Campbell River (see map; a small area of the southernmost part of the Foreshore Area is outside the City). The City is responsible for the construction, operation, maintenance and enhancement of stormwater systems in the Foreshore Area.

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. A Stakeholders Working Group met three times to discuss the issues facing the Foreshore 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.

The Foreshore Area is unique among the City's watersheds as there are essentially no natural streams present and most runoff drains directly into marine waters via either ditches or storm drain systems. More than 50 outfalls from these ditch and storm drain systems deliver runoff, along with any contaminants carried by the runoff, into Discovery Passage. As a result, stream flooding and stream erosion, often issues in urban or urbanizing watersheds, are not generally issues for the Foreshore Area.

Current stormwater wisdom is that healthy watersheds are characterized by greater than 65% forest cover and less than about 10% impervious surfaces (pavement, buildings and other hard surfaces). With the exception of the upper parts of the Ocean Grove Catchment, forest cover is minimal throughout the Foreshore Area with as much as 90% or higher impervious cover in areas such as the Campbell River downtown core. Runoff from such highly developed lands typically carries heavy loads of suspended solids, excess nutrients, heavy metals and other contaminants that are picked up from impervious surfaces. Computations performed for the study show that very high pollutant loading rates are especially associated with the downtown core area and nearby industrial activities (such as the marinas and harbors). Retrofitting runoff treatment in areas with the highest loadings is a cost effective method for improving water quality.

The marine riparian corridor and environment along the Foreshore are home or passageway for a variety of fish and wildlife. Field work undertaken for this ISMP found that pockets of intertidal fish habitat have developed at many of the storm sewer outfalls; some of these pockets represent thriving biotic communities. A number of opportunities for enhancing these habitat areas were identified.

Key issues identified for the Foreshore Area are:

- Remedial treatment of runoff from the highly developed downtown core
- Maintenance of base flows
- Pressure to develop areas in upper Ocean Grove catchment and need for stormwater controls
- Protection and enhancement of the shoreline and marine riparian corridor, including intertidal fish habitat areas
- Erosion and sediment control during construction
- Public education and outreach

To address these issues, three guiding principles for stormwater management in the Foreshore Area were formulated:

- Minimize impact of new development on runoff
    - Meet performance targets
    - Require BMP's for new development
    - Encourage BMP's for infill / redevelopment

- Improve runoff water quality from developed areas, when feasible
- Enhance intertidal fish habitat in conjunction with other City programs and infrastructure improvements

The overall intent is to accommodate new development in an environmentally sustainable manner, reduce the impact on water quality from existing development through application of cost effective stormwater BMP's, and preserve and improve the entire foreshore marine riparian corridor for the community and for fish and wildlife.

Performance targets for stormwater control are recommended that will implement these guiding principles:

- *Small storm goal* – No discharge of runoff from new impervious surfaces
- *Large storm goal* – Limit post-development runoff to the following pre-development levels in new areas of development:
    - 50% of the 2-year event
    - 100% of the 5-year event
- *Extreme storm goal* – Safe conveyance of runoff
- *Water quality goal* – Provide treatment of runoff from new impervious surfaces for storms up to 55 mm in 24 hours, with specific targets for:
    - Total Suspended Solids – Remove 80% of annual average load
    - Oil & Grease – Remove from runoff from commercial and industrial areas

The table on the next page summarizes other recommendations. Among these are recommendations for constructing stormwater treatment systems for the downtown core and for outfalls with priority habitat enhancement opportunities. The total estimated construction cost for these improvements is $1.4 million. Construction costs for other infrastructure improvements (replacing undersized storm drains) total about $0.9 million. The recommendations also include new or revised bylaws and standards to enhance overall stormwater management in the City and an extensive environmental monitoring program.

This Page Left Blank

**Table E.1**
**Summary of Recommendations for Foreshore Area Stormwater Management**

| Category | Recommendation | Priority Level | | |
|---|---|---|---|---|
| | | 1 | 2 | 3 |
| Municipal Infrastructure | Upgrade deficient municipal drainage infrastructure (storm drains) | | X | |
| | Construct runoff water quality treatment facilities for downtown core area (4 total) | X | | |
| | Construct runoff water quality treatment facilities at habitat enhancement sites (4 total) | | X | |
| | Upgrade existing catch basins with deeper sumps and trapping hoods | | | X |
| | Prepare operations and maintenance schedule for stormwater system, incl street cleaning | X | | |
| Environmental | 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 inventory program at 2 or more sites | X | | |
| | Initiate soils property verfication program | | X | |
| | Re-establish digital recording of continuous rainfall measurements at the airport rain gauge | | X | |
| | Enhance foreshore habitat in conjunction with other City initiatives (15 key, potential sites) | X | | |
| Pilot Projects | "Green" parking lot with pervious pavement and bioswales | X | | |
| Data Management | Obtain updated, detailed aerial contour mapping of area (supplemented by ground survey) | | X | |
| | Compile manhole rim data throughout the area | | X | |
| | Refine the current XP-SWMM model to perform extended period (continuous) simulations | | | 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 | |
| | Prepare and distribute to builders an Erosion and Sediment Control Brochure | X | | |
| | Adopt measureable targets in OCP for preserving tree cover and limiting impervious area | X | | |
| | Update zoning bylaw to include maximum parking space and impervious area limits, encourage vegetation retention and native species plants, and encourage cluster development | | 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 | Conduct a long term public eduation and outreach program | X | | |
| | Publicize stormwater pilot projects | X | | |
| | Develop a stewardship award for the development community | | X | |

This Page Left Blank

# 1.0 INTRODUCTION

## 1.1 Stormwater Management Vision for Campbell River

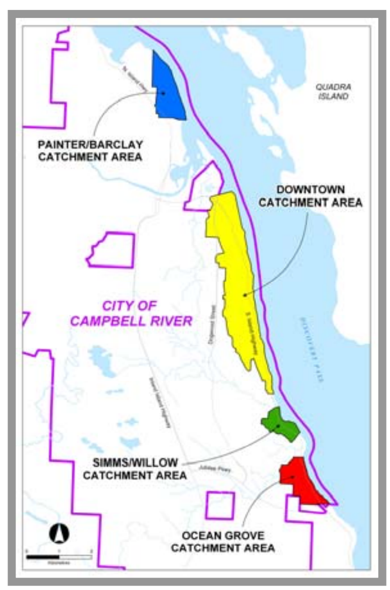
Over the past forty years, approaches to managing stormwater in urban and urbanizing communities have undergone a significant and rapid evolution. Increasingly more than just basic engineering perspectives on flood control are guiding communities as they attend to the impacts of urban development on 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 **Foreshore Area** of the City (see Figure 1.1); it is the fifth in the series comprising the overall five-year stormwater program. Previous ISMP's have been completed for these drainages and watersheds:

- Holly Hills drainage
- Perkins Road drainage
- Nunns Creek watershed
- Simms Creek watershed
- Willow Creek watershed

**Figure 1.1**
**General Location Map**




The plan for the two drainages was approved by City Council in April 2004 and separate plans for each of the three watersheds were approved in June 2005. At least one more ISMP (for the Quinsam River watershed) will be pursued when this Foreshore Area ISMP is completed.

It is the vision of the City and this project team to create living documents for each watershed, which recommend stormwater management strategies that are *long-term*, *proactive* and *adaptable*.



URBANSYSTEMS®

### 1.2 Goals and Objectives of the ISMP Studies

The Terms of Reference issued by the City for the Foreshore 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 utility and development cost charges.

## 1.3 Communications Strategy

To ensure that the ISMP process is a successful one, involvement and support from a variety of interest groups is 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 Stakeholders Working Group*

One of the objectives of the ISMP study was the formation of a stakeholders working group. This group included representatives from a variety of interest groups, including provincial and federal environmental agencies, and City staff. The main purpose of the group was to provide background information on the Foreshore, 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 stakeholders working group. Additional information related to the group can be found in Appendix E.

**Stakeholders Working Group Meeting**

**Table 1.1**
**Stakeholders Working Group Participants**

| Name | Organization |
|---|---|
| Shannon Anderson | DFO, Habitat Biologist |
| Gord Brown | City of Campbell River |
| Ron Burrell | Advisory Planning Commission |
| Ivan Charette | Resident |
| Danielle Cryderman | Greenways Land Trust |
| Linda Franz | Campbell River Harbour Authority (Fisherman's Wharf) |
| Peter Law | BC Ministry of Environment |
| Ted Maxwell | Resident / Developer |
| Ron Neufeld | City of Campbell River |
| Michael Roth | City of Campbell River |
| Rick Senger | DFO, Area Habitat Technologist |
| Graham Stewart | City of Campbell River |
| Jim Van Tine | Resident / Fisheries Consultant |

### *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.

**Presentation Boards Used at Open House**


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, August 30, 2005 and Tuesday, October 4, 2005. A brief presentation was given by the project team at the start of each open house, which was then followed by an open discussion and question period. Presentation materials, sign-in sheets and feedback forms for both open houses are located in Appendix F.

### 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 stakeholder 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

A comprehensive 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 and has prior experience in developing ISMPs. 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<br>Andrew Ling, EIT | 604-273-8700 |
| GIS | Urban Systems | Craig Polzen, GIS Specialist | 604-273-8700 |
| Planning / Land Use | Urban Systems | Sara Stevens, M.Pl. | 604-273-8700 |
| Habitat Biology | Komori Wong Environmental / AXYS Environmental | Violet Komori | 250-339-7613 |
| Hydrogeology | Piteau Associates | David Tiplady, P.Eng.<br>Arnd Burgert, GIT | 604-986-8551 |

This Page Left Blank

# 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.

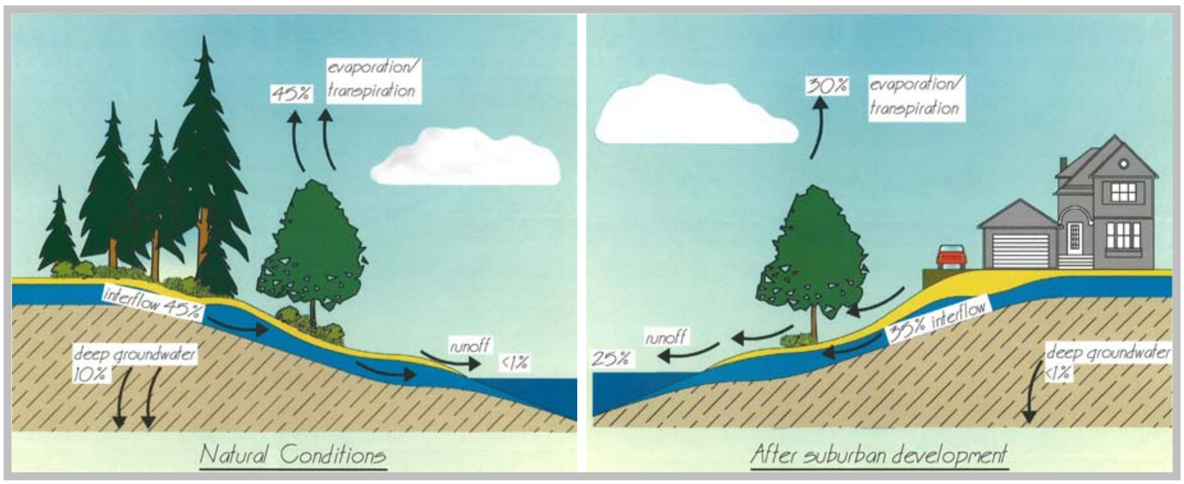
## 2.1 The Hydrologic Cycle

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[1] (University of Washington) 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.

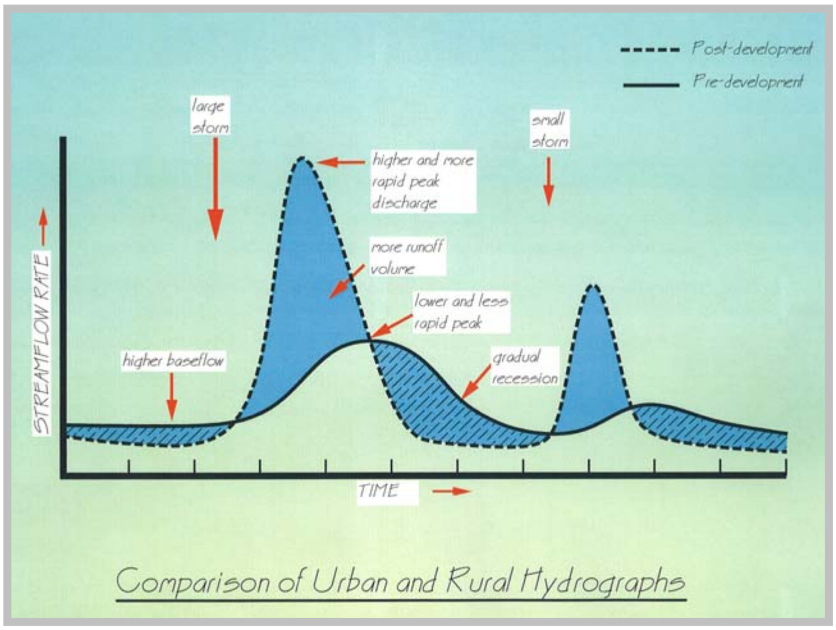
---

[1] Integrated Stormwater and Stream Corridor Management forums, 2001

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 Foreshore 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.

This Page Left Blank

# 3.0 FORESHORE 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 Foreshore Area. Anecdotal information on fish habitat along the shoreline was provided by members of Stakeholders Working Groups.

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 2002 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 foreshore 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 on July 13th and again on August 16th, 2005, 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 these visits, 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
- Visually observing tidal influences
- Gaining an understanding of the overall configuration of the Foreshore Area and how runoff is conveyed within it

Fisheries biologists undertook field reconnaissance on August 18th and again on September 11th. Most of the existing storm drain outfalls were visited and a general assessment of habitat conditions was made. Data such as backshore and foreshore type were noted and numerous photographs were taken to document conditions. The team also made estimates of base flows in the storm drains. Appendix B contains a complete report.

The project team's hydrogeologist visited the Foreshore Area on August 23, 2005, to confirm lithology and spring data obtained from interviews with knowledgeable individuals 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

Campbell River is drained by several significant streams (Willow, Nunns, Simms, Quisam River) however a number of areas do not lie within any of these watersheds. Instead these areas drain directly into Discovery Passage. Collectively, the City is calling these areas the Foreshore Area (see Figure 3.1; in Appendix A[2] – Oversize Figures).

Four catchments comprise the Foreshore Area:

- Painter/Barclay Catchment – located at the north end of the City
- Downtown Catchment – including the marinas and core business district, as well as significant residential areas as far south as the mouth of Simms Creek

2 All oversize (11 x 17) figures can be found in Appendix A.

- Simms-Willow Catchment – lying between the mouths of Simms and Willow Creeks
- Ocean Grove Catchment – located at the south end of the City

Areas between the Painter/Barclay and Downtown Catchments that generally drain into the Campbell River Estuary were previously studied as part of the Holly Hills / Perkins Road Drainages ISMP.

At one time some of these catchments likely had small streams, but development has replaced these with storm drains. Forty-five (45) significant storm drain outfalls (greater than 300mm diameter) line the length of the Foreshore Area.[3] With the exception of the upper areas of the Ocean Grove Catchment, the Foreshore Area is essentially entirely developed.

The Foreshore Area can also be seen as a series of topographic zones:

- Zone 1 – Land between the high tide line and Highway 19A (old Island Highway)
- Zone 2 – Land between Highway 19A and an escarpment that runs from about Hilchey Road north to the beyond the downtown core
- Zone 3 – Lands above the escarpment, to the ridge line
- Zone 4 – Lowlands between Erickson Road and Jubilee Parkway at the City's southern border

Within its generally narrow strip, *Zone 1* includes significant features such as the highway, recreation opportunities (e.g. the Rotary Seawalk), some mixed residential uses and some landmark hotels and motels. Runoff from this area generally drains directly to Discovery Passage, with little opportunity for water quality controls. All upland runoff, whether overland flow or confined to a storm sewer, must pass through this zone. While there are generally no streams for fish, storm outfalls have created opportunities for development of fish habitat.

*Zone 2* has single family residences, condominiums and apartments, and commercial businesses. Much of the commercial community is oriented towards seasonal tourism, via hotels, motels, restaurants and service industries. Pressure to redevelop single family lots and accommodate multifamily housing presents the challenge of controlling runoff responsibly and providing some form of water quality treatment.

*Zone 3* is developed, generally with exclusively residential uses, with few infill opportunities remaining. The zone is entirely served by storm sewers, or in the case of the Painter/Barclay Catchment, by open ditches and culverts. Even the open ditches of Painter/Barclay area do not support salmonid as the escarpment at the water's edge is too high and steep for migration into the area.

The lowlands of *Zone 4* are experiencing intense pressure from new subdivision development. A sandy beach at the end of Ocean Grove is a significant and rare location for marine contact recreation, as well as providing fish habitat. Some of the drainage in this zone actually originates in the Regional District of Comox-Strathcona.

Boundaries for all four catchments were initially established by the City and confirmed (or revised) during this project. The boundaries were confirmed 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 3.2 in Appendix A). The resultant catchment boundaries are slightly different than originally provided by the City and also reflect the watershed boundaries established for Willow, Simms and Nunns Creek watersheds as apart of those previous ISMPs. The study area of the Foreshore Area, as set forth in the project Terms of Reference, totals 915 hectares (ha), including a significant strip of Discovery Passage from the shoreline to the City boundary. The total drainage area for analysis purposes is only 666 ha. Separate subcatchments were subsequently set for each outfall within the Foreshore Area.

Table 3.1 summarizes several basic parameters which are useful in measuring the extent of urban disturbance and its associated risk within a watershed. These parameters are also shown graphically in Figure 3.3 (see Appendix A). The parameters were calculated based on the 2002 aerial photography supplied by the City. The basis for delineating the areas is:

**Drainage Area** – Land that drains directly towards Discovery Passage was measured as the drainage area for each catchment. This total (in hectares) is less than the total for the Study Area since catchment boundaries account for site topography and the total Study Area includes a significant portion of Discovery Passage itself.

---

[3] The City's GIS database lists another seven (7) outfalls, all less than 300 mm diameter. Undoubtedly, other small outfalls exist but are not included in the current database.

**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 2002 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 2002 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**[4]

| | Catchment | | | |
|---|---|---|---|---|
| **Parameter** | **Painter / Barclay** | **Downtown** | **Simms/Willow** | **Ocean Grove** |
| Study Area (ha) | 128 | 558 | 69 | 160 |
| Drainage Area (ha) | 59 | 389 | 53 | 165 |
| Impervious Area (%) * | 22% | 48% | 34% | 22% |
| Wooded Area (%) ** | 13% | 7% | 4% | 39% |
| Freshwater Riparian Area (%) | 0% | 0% | <1% | 0% |
| Shoreline Length (km) | 2.1 | 7.4 | 1.7 | 1.9 |
| Open Channels (km) *** | 9.6 | 3.4 | 0.8 | 1.1 |
| Closed Pipes (km) | 1.7 | 37.9 | 3.4 | 7.8 |

* % of drainage area
** Covers significant contiguous areas only
*** Streams and 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 Foreshore Area is

[4] These parameter values were 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.

severely altered by urban development and can not be considered a healthy watershed. The notable exception is the upper portions of the Ocean Grove Catchment which is currently undeveloped, though experiencing pressure to be developed. Stream flooding, stream erosion and "stream health" in general are thus not issues for the study 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.

### 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. The Painter / Barclay Drainage was developed in the early 1950's in conjunction with the Elk Falls Pulp and Paper Mill, now owned by Norske Skog Canada.

### 3.5 Watercourse Characteristics

Most of the Foreshore Area has no natural open channel watercourses, with ditches being the predominant type of open channel in areas not served by storm sewers. These ditches are associated with the Old Island Highway, as well as with older residential areas in the Painter/Barclay Catchment. Ditches are generally shallow (less than 1 meter deep) with narrow bottoms and moderate side slopes. Most are lined with grass. A single stream is shown on the City's GIS database, in Simms-Willow Catchment; it is an ephemeral wetland with no defined channel banks. Figure 3.3 (see Appendix A) shows the existing storm drains, culverts, ditches and streams in the area.

The nearshore marine environment is Discovery Passage, a tidal marine water body. The shoreline through the Foreshore Area varies, but generally consists of a sand, gravel and boulder or bedrock shelf with two to three meter high banks south of the river. An escarpment, lying approximately 50 meters in from the shoreline, runs most of the length of the Simms-Willow and Downtown Catchments. In the Painter/Barclay Catchment, a 10-15 meter high escarpment generally sits right above the high tide line. A similar feature lies within the Downtown Catchment, between Evergreen Road on the south and the Government Wharf on the north.

### 3.6 Hydrologic Conditions

As noted, there are no streams of significance within the Foreshore Area. Thus, there is no data on stream flow. Most areas within the Foreshore are serviced by storm sewers. Based on field reconnaissance observations that occurred during late summer, many of these have base flows, estimated at 1-4 L/s.

## 3.7 Tidal Conditions

As with most areas of the west coast of North America, Discovery Passage has a diurnal tidal pattern, with a typical tidal range of about 300 cm at Campbell River. Low-lying areas such as the downtown core are often directly affected by high tide conditions especially in winter, which can prevent adequate drainage of roads, parking lots, open spaces and other surfaces.

A unique tidal phenomenon of the Campbell River area is that southward tidal flows meet the northward tidal flows at the $50^{th}$ parallel off Cape Mudge. The maximum measured velocities for tidal currents between Duncan Bay and Willow point are 11 km/hr (3 m/s) on the flood tide and 9 km/hr (2.5 m/s) on the ebb tide. To the north of Campbell River, at a narrower part of Discovery Passage called Seymour Narrows, typical tidal currents are in the range of 8-12 knots (4 to 6 m/s). These velocities are indicative of the strong currents that are present throughout the area. Discharges to Discovery Passage are likely dissipated quickly due to regular tidal flushing with strong currents.

## 3.8 Biophysical Inventory

The results of the shoreline survey are summarized in the paragraphs that follow and in Table 3.2; full details are provided in Appendix B.

### *3.8.1 Ocean Grove Catchment*

The upper foreshore habitat is relatively stable and largely unaltered with an extensive 150 m+ bedrock with boulder shelf and a gravel cobble beach. Offshore kelp beds in combination with an extensive intertidal shelf provides valuable rearing and holding habitat for fish and birds as well as dissipating wave energy. As with many areas along the shoreline, the seawalk is located within close proximity to the foreshore habitat, representing a significant human addition to the landscape.

Groundwater flows were observed during August 2005 at most outfall sites with an average flow of 1-2 L/s. There were two outfall sites with foreshore habitat capable of supporting fish and sampling verified salmonid use at Outfall OG01.

This Page Left Blank

**Table 3.2**
**Summary of Foreshore Reconnaissance Study Results**

| Catchment Area | Sites Assessed* | Backshore Type | Foreshore Type | Groundwater or Summer Base Flows (Est) | Comments |
|---|---|---|---|---|---|
| Ocean Grove (5 sites) | 01, 02, 03/04, 06, 07 | Low profile shrub dominated with isolated conifers and deciduous vegetation. Seawalk located between 2-10 m from the HHW mark. | Extensive 150 m+ bedrock with boulder shelf with bull kelp forests along 50% of sites sampled, gravel cobble beach with largely unaltered upper foreshore habitat | Average of 1-2 L/sec at most sites viewed | Moderate exposure and largely sediment transport zone. At OG06 (Dahl Rd), good groundwater flow obs with 19 m long channel in upper foreshore that is not supporting fish. Fish presence confirmed at OG 01. The only catchment where the upper drainage area is undeveloped and therefore good opportunities for onsite treatment of stormwater. Offshore kelp and extensive intertidal shelf provides valuable rearing and holding habitat for fish and feeding habitat for birds as well as dissipating wave energy. |
| Simms Willow (6 sites) | 01/02, 03, 04/05, 06, 07, 09 | Low profile shrub dominated backshore with residential and linear development increasing | Altered upper foreshore area (riprap seawalls) over 50% of the catchment. Extensive intertidal shelf continues with cobble/gravel substrates dominant | Marginal groundwater observed with exception of SW07 where 3-4 L/sec flows observed | Moderate to low exposure foreshore with prevalence of cobble/gravel substrates. Low profile beach similar to OG, outfalls difficult to locate due to recent stormwater upgrades. At SW07 (Hilchey Rd) good groundwater flows observed with an open foreshore channel obstructed by beach logs potentially supports salmonids. Opportunity for improving shoreline vegetation throughout the upper foreshore area. |
| Painter Barclay (5 sites) | 00, 01, 02, 03, 06 | Steep but stable escarpment to foreshore, well vegetated with Native shrub and tree species | Rock groynes over much of foreshore to trap sediments moving north from Campbell River estuary, sand and gravel beaches, kelp beds over most of catchment 60 m from HHW mark | seepage flows observed | Older residential area with large treed properties, open vegetated ditches providing good example of natural onsite SW treatment, steep escarpment to well vegetated foreshore with rock groynes constructed for erosion protection. No bank erosion sites observed. Sites observed during high tide at the end of the day. Collapsed wooden culvert at upslope from PB06 needs maintenance. Offshore kelp beds provides valuable rearing and holding habitat for fish and feeding habitat for birds. |
| Downtown (10 sites) | 01, 04, 05, 06, 08, 13, 17, 19, 20, 27 | Largely altered low profile backshore area dominated by shrub/grass south of DT 13 near 1st St with increasing backshore slope observed at sites to the Discovery Pass fishing pier | Upper foreshore area predominated altered by riprap seawalls, cobble/boulder or cobble /gravel beaches with intertidal shelves in southern section. Highest concentration of kelp beds varying from 50-150 m from the HWM | Good summer baseflows or groundwater flows ~ 2 L/sec | Most commercial, residential and industrial development inland and along foreshore relative to other catchment areas in study with corresponding degree of alteration of natural foreshore and backshore features. Best foreshore fish habitat observed at DT 13 (1st st): 8 m x 4 m x 0.8 m deep plunge pool leading into 17 m long channel. Several city owned shoreline properties with potential for stormwater treatment. Altered nearshore features include docks, extensive (100 m) rock protection berms at marina's and boat launch facilities, intertidal pools that all increase habitat complexity and provide refuge and rearing habitat for marine bird and fish species. Offshore kelp beds provides valuable rearing and holding habitat for fish |

* Site numbers refer to outfall numbers shown on Figure 3.5 (Appendix A).

This Page Left Blank

### *3.8.2 Simms / Willow Catchment*

The Simms Willow foreshore area has a low beach profile similar to Ocean Grove with the extensive intertidal shelf continuing to the north with finer cobble/gravel substrates located in the less exposed northern section. Residential properties and linear development border the foreshore with over 50% of the natural shoreline features altered by erosion protection features including rip rap seawall construction. The riparian and backshore vegetation is predominantly grass and shrubs with colonization of invasive species. There have been recent upgrades to the stormwater systems in the Hilchey Road area and groundwater or summer base flows throughout the catchment were absent with exception of outfall SW 07 where flows of 3-4 L/sec were observed. Potential foreshore fish habitat was observed at the SW 07 outfall, where an open foreshore channel is partially obstructed by beach logs.

### *3.8.3 Downtown Catchment*

The Downtown catchment supports the highest commercial, residential and industrial development inland and along the foreshore relative to other catchment areas with a corresponding degree of alteration of natural foreshore and backshore features. Much of the shoreline has been altered by construction of shoreline protection features including breakwaters and seawalls as well as docks, piers and areas of landfill. Between Hidden Harbour and the Discovery Pier, 60% of shoreline has been altered for shoreline protection and includes riprap seawalls, concrete blocks, cement retaining walls and log cribbing.

Altered nearshore features also include docks, extensive (100 m) rock protection berms at marinas and boat launch facilities. In conjunction with intertidal pools, these features can increase habitat complexity and thereby improve the quality of refuge/rearing habitat for marine bird and fish species. Juvenile salmonids and herring are known to utilize the altered nearshore areas in the Downtown catchment as rearing and migration habitat.

The southern Downtown foreshore area is dominated by boulder cobble or cobble gravel substrates with large kelp beds starting near the "big rock" and extending northwards into the city core area. As noted above, kelp forests provide critical nearshore holding, rearing and refuge habitat during high winds.

Potential foreshore fish habitat was observed at several outfalls (DT 13; DT 20). Fish presence was confirmed at the DT 13 site with at least 15 large (120 mm) coho juveniles observed in September 2005.

The backshore varies from low in the southern section of the catchment with an increasing backshore slope from Hidden Harbour north to the Discovery Pier. Natural backshore and riparian features have been replaced with a largely shrub/grass vegetation type.

### *3.8.4 Painter / Barclay Catchment*

The Painter Barclay Catchment is an older (50 year) residential area with large treed properties and open vegetated ditches that function much like bioswales and in combination with gravel shoulders sustain a more natural rainfall run off pattern compared to typical curb/gutter and piped stormwater features. The open ditches deliver flows into a series of stormwater pipes that convey flows down a steep but largely stable escarpment. Outflows are released into a well vegetated low profile benched backshore area vegetated with native species including elderberry, willow, maple, alder, salmonberry and Elymus along the foreshore interface.

The foreshore is dominated by cobble/gravel and cobble/boulder substrates with rock groynes constructed over much of the foreshore to increase shoreline stability and to trap sediments moving north from the Campbell River estuary. Nearshore kelp beds were abundant and provide valuable rearing and holding habitat for fish and feeding habitat for birds.

## 3.9 Geology

The Foreshore study area is underlain primarily by glaciomarine deposits consisting mainly of silty sand and pebbly sand near the ground surface, and silts and clays below. This marine layer does not often exceed 12 m in thickness and is further underlain by either sedimentary bedrock, or glacial outwash sand (called Quadra Sand). The marine deposits can be considered to have low permeability while Quadra Sand unit is moderately permeable.

Although there are a number of shallow dug wells in the area, there are only a few deep drilled wells from which to develop a more complete picture of the geology of the watershed. Drilled wells ranged up to 41 m deep, averaging 23 m. Depth to water ranged between about 1.2 m and 13 m, with an average of about 3 m (includes data from shallow dug wells). Reported well yields were as high as 12 L/s with a median value of 4.2 L/s.

From the available well records, supplemented by extensive well records in geologically similar Quadra Island, the underlying Quadra Sand unit becomes increasingly thin towards the south. While mostly consisting of sands, this unit also displays beds of clay, silt and gravel. Typically the silts are on the lower parts of the unit, while gravels lie towards the upper parts.

Appendix C contains additional detail in the complete hydrogeological report.

### 3.10 Surficial Soils and Groundwater Conditions

Precipitation falling outside of the topographic Foreshore boundary likely infiltrates deeply to the aforementioned restrictive clay or bedrock units. As such, it is recognized that deep groundwater systems do not always follow surface topographic slopes. The flow from deep groundwater either seeps into the Quadra sand unit, discharges back onto the ground surface as springs or deeps, or directly to the inter-tidal zone. The relatively high water tables and piezometric heads, and moderate permeability make ground water infiltration practical only in portions of the Foreshore (see Figure 3.6 in Appendix A).

#### *3.10.1 Painter Barclay*

The Painter-Barclay catchment consists mainly of Shawnigan gravely sand loam. It is a well-drained unit that forms a bench extending north from Campbell River. The Shawnigan unit has the potential for an infiltration of 3 mm/hr. This is an estimate based on soil grain size analysis, and experience conducting percolation tests in similar soils.

Moreover, observed bedrock exposures along Orange Point Road near Barclay Road suggest that shallow bedrock may behave as a restrictive layer in this portion of the catchment. However, as no bedrock exposures were seen elsewhere, it is expected that the bedrock surface is irregular. While some standing water was observed in localized areas indicating a shallow confining layer, stands of Douglas Fir and Maple indicate a well-drained soil.

#### *3.10.2 Downtown*

The Downtown catchment consists primarily of Dashwood gravely loamy sand (Dgls) which covers the more steeply sloping portions while the Cassidy soil (Ca) covers the lower-lying northern portions. The Cassidy unit is a variable unit possibly consisting of gravely loamy sand, loamy sand, or sandy loam; as such, its permeability varies correspondingly. Dashwood soils have long term infiltration potentials of up to 250 mm/hr.

The north tip of the Downtown catchment lies over the deltaic spit formed by Campbell River where coastal beach deposits of sand and gravel likely permit a well to freely drained soil.

Bordered by 6$^{th}$ Avenue in the north and Simms Creek in the south a 20 m high scarp rises steeply approximately 80 m west of the low-lying zone along Discovery Passage. A series of springs have been observed issuing from the scarp contributing baseflows to the intertidal zone.

In localized areas along the scarp there have been historical slope stability problems noted due to the seepage flow of water which in some areas is observed year around. It has been suggested that a considerable portion of summer baseflow is a result of upland irrigation.

As discussed previously, it should be noted that the Downtown catchment groundwater flows are sourced not only from precipitation falling within the catchment boundaries but also from upland areas west of the boundary and topographic divide. This groundwater outflows from observed seeps and springs along the scarp, and likely underneath Highway 19A directly to the inter-tidal zone.

### *3.10.3 Simms / Willow*

The Simms / Willow catchment consists mainly of two soil types, the well-drained Neptune unit running along the coast, and the imperfectly drained Bowser loamy sand unit (B) in the areas upland. The potential infiltration potentials are 300 mm/hr and 8 mm/hr respectively.

An open construction trench at the intersection of Westgate Rd and Highway 19A exposed a sequence of sandy silt overlying an approximately 2 m thick layer of gravel and sand which was further underlain by an additional layer of silt. Conversations with construction staff indicated that similar lithology extends south as far as Erickson Road where depth to the water table is approximately 3m.

Similar to the Downtown catchment, the Simms / Willow catchment groundwater flows are sourced by precipitation within the catchment as well as upland areas to the west. However, as the topography is fairly gentle in these areas, the flow is less likely to appear as seeps or springs, but more likely as discharge directly to the inter-tidal zone.

### *3.10.4 Ocean Grove*

Similar to the Simms / Willow catchment, the bands of Neptune and Bowser units extend south where another occurance of the Dashwood unit is found.

Construction at Twillingate Road and Willow Creek Road, exposed soils in a construction trench which comprised silt with traces of clay and fine sand. At the subdivision currently under development at the west end of Maryland Road, temporary ponding was observed, however the mixed conifers among the remaining trees indicates a moderately well-drained site.

### 3.11 Inter-tidal Baseflow

The hydrogeological work performed as a part of the previous ISMP studies indicated that baseflows for Willow, Simms and Nunns Creek are provided by groundwater discharging from the underlying Quadra sand unit. It was shown that development has impinged on the baseflows of the three Creeks. It is anticipated that the calculated groundwater fluxs, or flow per unit area, maybe be comparable to that of the Foreshore area.

While no significant watercourses are mapped within the Foreshore area, groundwater discharging as seeps and springs in the lowland flats at or near the tidewater likely plays a role in controlling the temperature and salinity of the inter-tidal zone. Development of the upland area and interception of stormwater into closed conduits has likely reduced the volume of infiltration which under undeveloped conditions would flow as groundwater months later. As a result, variations in temperature and salinity during the drier summer months has likely increased due to the lessening of the buffering effect of slow release groundwater.

### 3.12 Municipal Drainage Infrastructure

Except for the Painter-Barclay catchment the majority of the Foreshore is serviced by a large number of individual storm sewer networks that discharge directly to Discovery Passage through culverts under Highway 19A. These networks service relatively small areas before discharge to Discovery Passage. In total there are 52 known storm sewer outfalls to Discovery Passage. Much of the pipes are less than 525 mm in diameter. (See Figure 3.4 in Appendix A.)

The Painter-Barclay area is unique within the Foreshore as its drainage system consists mostly of open ditches and culverts at road intersections which collect runoff and direct it east towards outfalls to Discovery Passage. The length of closed conduit within the system is low compared with the other catchments. Our site assessment of these ditches shows that they are in generally good condition; they appear well-maintained, vegetated and show only minor sloughing in few steeper sections. On average, they have a 0.5 m bottom with gentle side slopes (~2:1) and 0.6+ m of freeboard.

**Typical Ditch Condition in Painter-Barclay Area**

**Water Quality Structure at Maryland Road Outfall**

According to the City's GIS database there are no stormwater detention ponds in the Foreshore area. All stormwater is discharged directly to Discovery Passage with no attenuation or treatment with the exception of a water quality structure at outfall of the Maryland Rd. sewer.

The majority of the core business district of the Downtown Catchment is serviced by two outfalls (DT27 and DT31). Site assessment of this portion of the network revealed the presence of a tide gate, located approximately at the intersection of 11th Avenue and Shoppers Row, upstream of one outfall (DT27). As confirmed with City operations staff, the age and condition of this portion of storm sewer network is deemed relatively poor.

### 3.13 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). 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.

Only one underground sediment removal system was shown on the City's current GIS database; no details were available on this system but it is likely a large settling tank with baffles (or similar system) for capturing oils and greases. Undoubtedly some commercial enterprises have stormwater treatment systems for their private sites; for example, most gas stations have systems to capture spills.

Ditches that are well maintained, are grassed and have reasonably shallow profile slopes (such as the north/south ditches in the Painter-Barclay catchment) will provide some runoff treatment by allowing solids to settle and enhancing contact between soil and runoff.

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 Downtown core are unlikely to be receiving any significant treatment of the runoff generated within its subcatchments.

## 3.14 Land Use

### *3.14.1 Existing Land Use Pattern*

The existing land use pattern within the Campbell River Foreshore Area is largely determined by the City of Campbell River's Zoning Bylaw No. 2700, which regulates the use of land and structures in the City (see Figure 3.7 in Appendix A). As shown on the Zoning map, over a third of the land (34%) in the Foreshore Area 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[5] of all buildings, including driveways and parking areas, is 35%. Aerial photographs show that nearly all of the land in this zone has already been developed.

While single-family residential development on city-sized lots is the predominant land use type within the Foreshore Area, the study area also includes a variety of other land uses. For example, the northernmost part of the study area near the Painter/Barclay Catchment Zone, includes a substantial **Residential Four (R-4) Zone** along the shore. This permits single-family residential development on large lots with the option of a second dwelling structure. The R-4 Zone permits 40% lot coverage on a lot with a minimum size of 1,000 $m^2$.

In addition to single-family uses, the Downtown Catchment Zone includes multi-family residential development within the **Residential Multiple (RM-3) Zone**, which permits mid-rise apartments with lot coverage of 50% on 1,000 $m^2$ lots. A substantial portion of commercial development (**Commercial Two** and **Commercial Four Zones**) is located at the northern tip near the Campbell River Reserve #11; these zones allow service commercial and marine-oriented commercial uses. The Simms/Willow Catchment Zone, which adjoins the Downtown Catchment Zone, also includes a service commercial node.

---

5 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.

The Ocean Grove Catchment Area includes a substantial portion of **Residential Four (R-4)** development as well as a portion of the Willow Creek Conservation Area. The entire Foreshore Area is bordered by a strip of **Public Assembly (PA-1) Zone** along the shoreline; this is a broadly defined zone that permits buildings and uses that provide social, educational, recreational, and other public services to the community.

The southernmost part of the Foreshore Area lies outside of the City of Campbell River's municipal boundaries and within Electoral Area D of the Comox-Strathcona Regional District (CSRD). Development in this area is regulated by the CSRD's land use policies and falls within the **Rural One (RU-1) Zone** of the Campbell River Area Zoning Bylaw. This zone permits a variety of uses such as forestry, agriculture, single family residential (one dwelling allowed on any lot, and two dwellings allowed on lots over 8 ha), as well as gravel or mineral extraction (provided the lot is at least 10 ha). The minimum parcel size for subdivision in this zone is 8 ha. The lands lying outside of City boundaries are currently forested and undeveloped.

As most of the Foreshore Area is developed for residential and commercial uses, the area includes a substantial number of roadways, which are, themselves, an important land use in terms of stormwater management. Road rights-of-way (which are not zoned) account for a total of 161 ha or 17% of the Foreshore Area.

Since the Foreshore Area extends into Discovery Passage, activities within the study area also include water uses such as boating, kayaking, fishing, as well as swimming at the south end in the Ocean Grove Catchment Zone.

### *3.14.2 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[6]. The future land use designations within the OCP are shown on the Official Community Plan map (see Figure 3.8 in Appendix A). The majority of land within the Foreshore Area is designated for the following type of development:

- **Residential**
  Most of the study area is already developed for residential uses. The Residential OCP designation encourages residential infill, and supports cluster housing near Environmentally

[6] At the direction of the City, the Draft OCP rather than the current OCP was used as the basis for this study.

Sensitive Areas. The residential area within the Foreshore Area is designated for low density residential development (up to 30 dwelling units per hectare) as well as medium density residential development (31 to 65 dwelling units per hectare) in the central area of the study area near the intersection of Willis Road and Petersen Road.

The Foreshore Area also includes a number of other land use designations to provide for commercial uses, especially near the Campbell River Reserve in the Downtown Catchment Area, as well as institutional land uses (e.g. schools, churches, hospitals and medical facilities, parks and natural areas).

The area in the southernmost section of the Ocean Grove Catchment Zone, which falls within the Electoral Area D of the Comox-Strathcona Regional District, does not have an OCP designation.

**South Island Highway Redevelopment**

The redevelopment of the South Island Highway 19A), which runs parallel to the shoreline through the Foreshore Area, is one of the largest projects proposed for the study area. Construction is already underway in the vicinity of the Simms-Willow Foreshore Catchment Zone (Kilchey Road to Willow Point), and the *South Island Highway–Conceptual Design* report outlines potential changes for the remainder of the highway.

Currently, the South Island Highway is a two-lane highway with one lane of traffic in each direction; there are very few left-turn lanes. The proposed design sees the highway remaining at two driving lanes, but includes the widening of the paved surface for a bicycle lane as well as for more dedicated turning lanes. Improvements are also proposed for the "multi-use trail" running alongside the highway, which will involve some widening and realignment. The addition of roadside swales and detention chambers for stormwater are mentioned in the plan and referenced in conceptual design.

Overall, the upgrading of the highway will result in an increase in paved surface. However, the plan also recommends improvements to drainage infrastructure, which should properly manage any additional stormwater runoff. The plan also promotes water quality by recommending that stormwater be managed for the removal of coarse sediments and oil and grease prior to discharge to the natural environment.

### Campbell River Foreshore Acquisition Plan

Future land use along the Campbell River foreshore will also be affected by the City's plans to acquire a continuous strip of land along the City's waterfront for a public seawalk. While the City's intent is to acquire as much shoreline land as possible, it is difficult to estimate how much land will actually be acquired within the next 5 to 10 years. The "shoreline land acquisition plan" will be presented to Council in October 2005 and is expected to be adopted as City policy. Ownership of this land may provide opportunities for enhancements to the marine riparian zone, including locations for stormwater treatment systems.

### Maryland Estates Conceptual Development Plan

The Draft OCP also includes a more detailed neighbourhood plan for the Maryland Estates area, most of which (38.8 ha of a total of 40.4 ha) is located in the Ocean Grove Catchment Zone near the southern boundary of the City. The Maryland Estates Conceptual Development Plan proposes single-family residential development (e.g. R-1 zoning) and supports secondary suites and duplexes subject to re-zoning. The Development Plan also supports low-density strata development that is consistent with the R-1 Zone. As permitted in the *Local Government Act*, 5% of the development will be dedicated as parkland, and will provide for a future neighbourhood park as well as a linear park, which will provide a pedestrian connection to the Willow Creek Conservation Area just north of the Maryland Estates area.

### Urban Residential Containment Boundary

The Draft OCP contains an Urban Residential Containment Boundary (URCB) to control residential development and prevent urban sprawl. As shown on Figure 3.8 (see Appendix A) all of the Foreshore Area lies within the Urban Residential Containment Boundary, which means the City plans to direct future residential development to this area.

### Environmentally Sensitive Areas

The Draft 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 Draft OCP designates these areas as Environmental Development Permit Areas. In addition to the oceanfront and foreshore areas, all lands within 30 metres from the top of the bank of any watercourse falls within the Environmental Development Permit Area.

The development permit guidelines for streamside, oceanfront, and foreshore 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

### 3.14.3 Short Term Development Potential

Because most of the Foreshore Area is already developed, relatively few major land developments are expected in the short term. The only identifiable major developments are the Maryland Estates residential development in the Ocean Grove Catchment Zone, and potential development on the Campbell River First Nation Reserve. However, the Foreshore Area is expected to experience infill development and re-development, which could increase the overall density of development in the watershed.

### 3.14.4 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 Foreshore Area Watershed includes the following special land use designations:

- **First Nations Reserves –** development on First Nations Reserves is governed by federal legislation (the *Indian Act* and the *First Nations Land Management Act*) and corresponding bylaws adopted by the First Nation. Local governments have no authority over land use on Indian Reserves. There is one First Nations Reserve located within the Foreshore Area, the Campbell River Indian Reserve, which totals 115.3 ha (13.5 ha of which falls within the

Foreshore Area). This Reserve is mostly undeveloped, but does have significant residential and commercial (including the Discovery Harbour Shopping Centre) development in its southern portion. Due to increasing demand for community housing, the Campbell River First Nation has plans to develop additional housing along 16th Avenue and north of Spit Road (in the adjacent Nunns Creek watershed).

**Table 3.3**
**Special Land Use Designations in the Foreshore Area Watershed**

| Land Use Designation | Description | Jurisdiction | Impact on Integrated Stormwater Management |
|---|---|---|---|
| First Nations Reserves | Federal land reserved for First Nations under the *Indian Act*. | Federal – municipality has no jurisdiction over land use on Indian Reserves | • Impact on ISMP is determined by each First Nation's land use plan – depending on scale and type of development, impact could be positive or negative. |

# 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 Foreshore 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). 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 and eventually adopting alternate subdivision design standards. The alternate standards are a way of addressing the environmental impacts of development by encouraging or allowing greater attention to development that is customized to site and land use conditions. The Phase 1 draft report on use of alternate design standards includes the use of narrower road pavements, pervious pavement, bio-swales and other low impact stormwater BMP's. The recommendations of the Foreshore Area ISMP and the alternate design standards project should be mutually compatible, with a focus long-term sustainability.

## 4.2 Provincial Level

### *4.2.1 Riparian Areas Regulation*

The Provincial Riparian Area 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. Riparian protection for these activities is under separate initiatives.

Currently in Campbell River, a Memorandum of Understanding (MOU) among the City, MWLAP, and Fisheries and Oceans Canada (DFO), deals with activities in the riparian area. Since this MOU was signed under previous provincial streamside protection regulations, RAR has not been fully incorporated into the agreement.

### *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* allows local governments to enact various bylaws and policies that can affect stormwater management. Under the *Local Government Act,* 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* 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

### *4.4.1 Harbours and Marinas*

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.

### *4.4.2 Discovery Passage*

Jurisdiction over the foreshore area is shared among the federal, provincial, and municipal governments:

- The Federal Department of Fisheries and Oceans has jurisdiction over fish habitat in both fresh-water and marine-water environments on both private and public lands.
- The Province owns the Aquatic Foreshore, which is all the land from the high water mark extending offshore within the waters between Vancouver Island and the mainland. Land and Water British Columbia, which is presently being dissolved, has been the agency administering provincial jurisdiction, and managing water leases – the new Ministry of Agriculture and Lands will assume LWBC's responsibilities once LWBC is dissolved.

- The City of Campbell River manages the Environmental Development Approvals Process and zoning; however, the City's policies must be in accordance with those established by the Provincial and Federal Governments.

## 4.5 Land Use Policy Gaps

Because the Foreshore Area drains directly into Discovery Passage, stormwater issues within the Foreshore Area are somewhat different from those within the City's other watersheds (e.g. Simms, Willow, and Nunns Creek). Relative to runoff volume or peak flows, water quality is of more concern within the Foreshore Area because flood risks are minor. While all three aspects of stormwater are essential to the effective management of stormwater, this analysis pays particular attention to water quality issues related to stormwater management.

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 Draft OCP and Zoning Bylaw to identify land use policy gaps relevant to stormwater management within the Foreshore Area.

### *4.5.1 Official Community Plan*

In general, the City's Draft OCP policies for the Foreshore Area 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 Foreshore Area falls almost entirely within the boundary, the Foreshore Area will not benefit from the URCB.

The Draft 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 (including the foreshore area), thereby supporting and promoting integrated stormwater management principles. Furthermore, the Draft OCP protects natural areas by supporting residential infill, and encouraging cluster development near Environmentally Sensitive Areas.

While the Draft 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 Foreshore Area.

### *4.5.2 Zoning Bylaw*

Like the Draft 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. Specifically, the most common zone in the Foreshore Area, the Residential One Zone, could include a maximum impervious area provision (currently this zone does not include such a requirement). Landscaping requirements could also be more specific regarding the use of pervious materials and the planting (or retention) of trees. 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 Foreshore Area Watershed.

#### *4.5.3 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 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.

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." Examples of such bylaws are Port Moody's Pesticide Use Control Bylaw No. 2575 and West Vancouver's Pesticide Use Control Bylaw No. 4377, which both prohibit the use of certain types of pesticides.

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, and the City of North Vancouver's Stream and Drainage System Protection Bylaw No. 7541.

This Page Left Blank

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

| Bylaw | Purpose | Provisions Supportive of Stormwater Management (applied within the Foreshore Area) | Identified Policy Gaps (recommended improvements) |
|---|---|---|---|
| Official Community Plan (Draft) | To direct future development in the watershed. | • Designation of residential densities discourages intense residential development<br>• 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<br>• Residential land use designation supports cluster development<br>• The residential land use designation permits some medium density development and infill development | • Draft OCP does not include measurable targets for preserving open space or limiting impervious area |
| 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<br>• Some zones include minimum requirements for usable open space<br>• Parking requirements – one off-site space for each single-family residence (low requirement decreases impervious area)<br>• Development within any streamside protection and enhancement area is prohibited– required streamside setbacks and guidelines for foreshore development | • No maximums on parking requirements<br>• Impervious area measures should extend to all zones<br>• Landscaping specifications could be more specific to support stormwater management principles<br>• Not all zones directly encourage cluster development<br>• Calculation of lot coverage should extend to impervious areas |
| 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. |

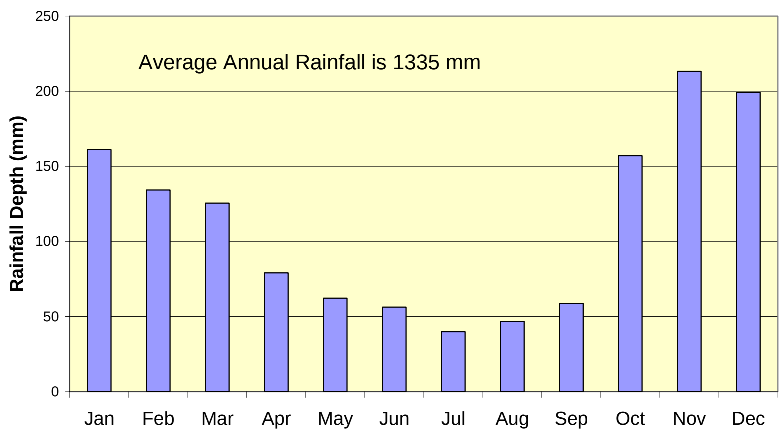
This Page Left Blank

# 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[7]. 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.

---

[7] 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**

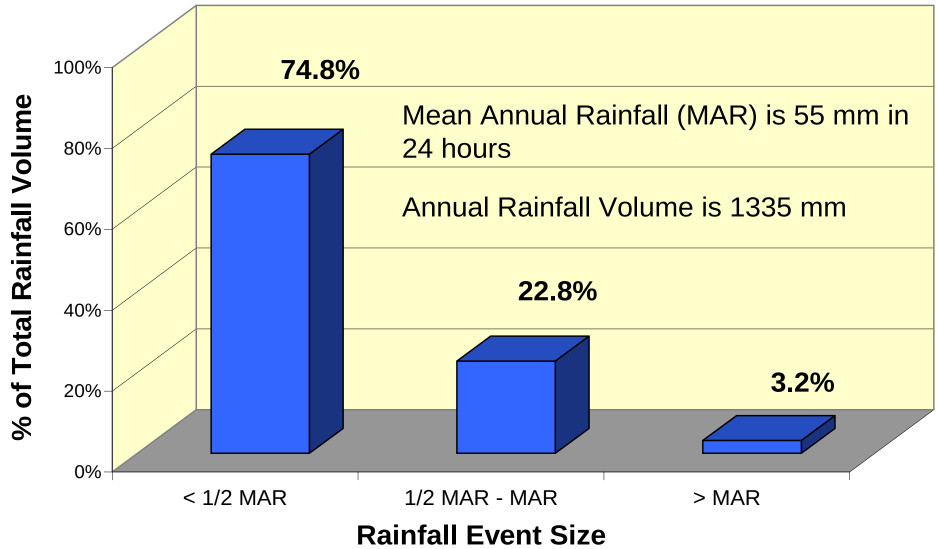



**Figure 5.3**
**Typical Annual Frequency Distribution of Rainfall**

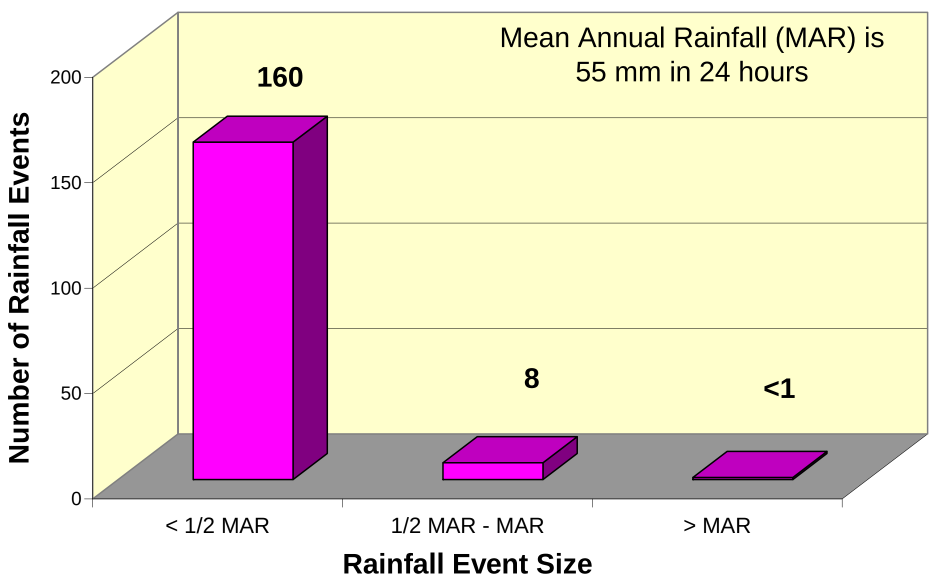


**Table 5.1**
**Design Storm Rainfall Depths**

| Recurrence (Year) | 1-Hour Rainfall Depth (mm) | 12-Hour Rainfall Depth (mm) | 24-Hour Rainfall Depth (mm) |
|---|---|---|---|
| 2 | 12 | 44 | 52 |
| 5 | 15 | 53 | 65 |
| 10 | 17 | 59 | 74 |
| 25 | 22 | 64 | 84 |
| 100 | 24 | 78 | 100 |

### 5.2 Model Development

As in previous ISMP Studies, the hydrologic and hydraulic modeling for this study was done using the XPSWMM software package. This package is able to model the multiple outfalls and backwater conditions present in the Foreshore 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 the Foreshore. 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 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

A skeletonized, or simplified model was developed for the Foreshore 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, 45 outfalls have been included in the model. A model schematic can be found in Appendix D.

Although the Foreshore study boundary extends east past Highway 19A, the model extends to the west edge of the Highway 19A right-of-way. This was done because we understand that the re-development of Highway 19A will incorporate infiltration capabilities and application of other BMP's to manage stormwater.

### 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 | Open Channel Roughness Coefficient | 0.045 |
| Impervious Manning's "n" | 0.011 | Contraction / Expansion Loss Coefficient | 0.2 |
| Pervious Manning's "n" | 0.2 | Entrance / Exit Loss Coefficient | 0.5 / 1.0 |
| Average Capillary Suction (mm) | 200 | Boundary Water Surface Condition at Discovery Passage (m) | 1.4 |
| Initial Moisture Deficit (m/m) | 0.050 | - | - |
| Saturated Hydraulic Conductivity (mm/hr) | 1.5 | - | - |

**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) | 22.2% | -21.8% | -23.2% | 23.2% | High |
| Impervious Area (%) | 8.3% | -9.0% | 8.6% | -9.8% | High |
| Catchment Width (m) | 1.8% | -2.5% | 3.1% | -4.2% | Medium |
| Catchment Slope (m/m) | 0.9% | -1.2% | 1.6% | -2.1% | Low |
| Impervious Depression Storage (mm) | -0.5% | 0.5% | 0.0% | 0.0% | Low |
| Pervious Depression Storage (mm) | -2.8% | 2.9% | -2.2% | 2.0% | Medium |
| Impervious Manning's "n" | -0.1% | 0.1% | -0.5% | 0.5% | Low |
| Pervious Manning's "n" | -1.8% | 2.2% | -2.9% | 3.5% | Low |
| Average Capillary Suction (mm) | -4.2% | 5.0% | -3.1% | 3.5% | Medium |
| Initial Moisture Deficit (m/m) | -6.0% | 7.2% | -4.5% | 4.5% | Medium |
| Saturated Hydraulic Conductivity (mm/hr) | -4.2% | 5.0% | -3.1% | 3.5% | Medium |

**Table 5.4**
**Sensitivity Analysis on Hydrologic 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 – Downtown**

| 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 |
| **Foreshore** | | | | | | | | | |
| Painter-Barclay | 59 | 11,600 | 16,200 | 197 | 275 | 0.4 | 0.6 | 7.1 | 9.5 |
| Downtown | 380 | 115,400 | 148,900 | 304 | 392 | 3.8 | 5.0 | 9.9 | 13.2 |
| Simms/Willow | 53 | 10,000 | 13,400 | 189 | 253 | 0.4 | 0.4 | 6.6 | 8.3 |
| Ocean Grove | 164 | 27,600 | 40,300 | 168 | 246 | 0.9 | 1.2 | 5.4 | 7.6 |
| **Creeks** | | | | | | | | | |
| Nunns | 762 | 197,100 | 258,200 | 259 | 339 | 3.5 | 4.7 | 4.6 | 6.2 |
| Simms | 1,650 | 277,200 | 414,400 | 168 | 251 | 5.5 | 8.2 | 3.3 | 5.0 |
| Willow | 2,869 | 248,800 | 410,800 | 87 | 143 | 3.8 | 6.0 | 1.3 | 2.1 |

Note: Duration for all storms is 24 hours.

The Foreshore catchments represent approximately 20% of the more than 6,000 hectares listed in Table 5.6. The total flow volumes reflect this relationship. The flowrate per hectare and volume per hectare values are particularly revealing in that they show the difference between the various catchments. Of note are the values for the Downtown catchment, and Nunns Creek watershed. These two catchments are both subject to higher levels of development and so exhibit higher volumetric unit discharges. Conversely, the Painter-Barclay catchment which has a relatively low level of residential development exhibits the lowest volumetric unit discharges with the exception of the Willow Creek watershed which has nearly 1,000 hectares of completely undeveloped area.

The hydrologic impacts of urban development are well illustrated in Table 5.6. For example, the high volumetric unit discharges for the Downtown catchment and for Nunns Creek watershed reveal the impact of significant tree cover losses accompanied by significant areas of impervious surfaces. Conversely, with the exception of Willow Creek, the Painter-Barclay catchment, which has a relatively low level of residential development, exhibits the lowest volumetric unit discharges. Though highly developed in its lower areas, Willow Creek watershed has nearly 1,000 hectares (>33%) of completely undeveloped mature and regenerating forest cover that contribute to a lower volumetric unit discharge.

Peak discharges are typically a function of the travel time of rainfall from the furthest edges of a watershed to the outlet. Thus, smaller watersheds (or catchments) and watersheds with very fast runoff travel times will typically show higher flowrate unit discharges than large watersheds. Faster travel times are, of course, one result of paving and building storm sewer systems to convey runoff quickly away from property. This is seen in Table 5.6, where the Foreshore Area catchments, which are generally smaller and more developed than any of the creek watersheds, have the highest peak unit discharges. Even though extensively developed, at least Nunns Creek watershed retains some ditches in the upper western portions of the watershed that provide some attenuation of peak runoff. Willow Creek, with its large watershed and extensive wetlands and forest cover, not surprisingly has the lowest peak unit discharge.

## 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, 5.8 and 5.9 list the pipes and locations that were determined to be undersized (i.e., surcharging). (See also Figure 5.4 in Appendix A.) 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 – Downtown**
**(10-year Level of Service)**

| Surcharged Pipe # | Location | Ex. Size | Length | Flooded ? | Upgrade Pipe # | Recc. Size |
|---|---|---|---|---|---|---|
| 1259 | Alder Street and 2nd Avenue | 300 | 99 | √ | 1259 | 450 |
| 1268 | Alder Street and 2nd Avenue | 300 | 71 | √ | 1268 | 450 |
| 1269 | Birch Street and 2nd Avenue | 300 | 17 | √ | 1269 | 450 |
| 1271 | Birch Street and 2nd Avenue | 300 | 141 | √ | 1271 | 450 |
| 1272 | Birch Street and 2nd Avenue | 350 | 20.6 | √ | 1272 | 450 |
| 1452 | Alder Street and 7th Avenue | 380 | 60.7 | | | |
| 1453 | Alder Street and 7th Avenue | 350 | 33.33 | | | |
| 869 | Carnegie Street | 375 | 47 | | | |
| 871 | Carnegie Street | 375 | 25.7 | | | |
| 876 | Carnegie Street | 375 | 22 | | | |
| 877 | Carnegie Street | 375 | 55.1 | | | |
| 878 | Carnegie Street | 375 | 19.7 | | | |
| 879 | Carnegie Street | 300 | 27.74 | | | |
| 880 | Carnegie Street | 300 | 16.73 | | | |
| 933 | Cormorant Road and Albotros Cr. | 250 | 72.24 | √ | 933 | 450 |
| | Cormorant Road and Albotros Cr. | | | | 932 | 450 |
| | Cormorant Road and Albotros Cr. | | | | 931 | 450 |
| | Cormorant Road and Albotros Cr. | | | | 930 | 450 |
| | Cormorant Road and Albotros Cr. | | | | 928 | 525 |
| 934 | Cormorant Road and Albotros Cr. | 350 | 111.2 | | | |
| 916 | Galerno Road and Marina Boulevard | 375 | 12.3 | | | |
| 1251 | McLean Street and 2nd Avenue | 410 | 41 | √ | 1251 | 525 |
| | Thulin Street and 2nd Avenue | | | | 1252 | 525 |
| 1256 | McLean Street and 2nd Avenue | 410 | 49 | | | |
| 1214 | McLean Street and Evergreen Street | 460 | 3.05 | | | |
| 1215 | McLean Street and Evergreen Street | 460 | 84.49 | | | |
| 1220 | McLean Street and Evergreen Street | 460 | 91.59 | √ | 1220 | 525 |
| 1204 | S. Alder Street and Evergreen Street | 350 | 97.54 | √ | 1204 | 375 |
| 1213 | S. Alder Street and Evergreen Street | 460 | 98.45 | | | |
| 833 | S. Alder Street and Frances Boulevard | 400 | 176.7 | √ | 833 | 450 |
| 834 | S. Alder Street and Frances Boulevard | 460 | 143.8 | | | |
| 820 | S. Alder Street and Marina Boulevard | 375 | 19.8 | | | |
| 824 | S. Alder Street and Marina Boulevard | 380 | 85.65 | | | |
| L1061 | S. Alder Street and Marina Boulevard | 400 | 15.52 | √ | L1061 | 450 |
| L1062 | S. Alder Street and Marina Boulevard | 400 | 9.49 | √ | L1062 | 450 |

| Surcharged Pipe # | Location | Ex. Size | Length | Flooded ? | Upgrade Pipe # | Recc. Size |
|---|---|---|---|---|---|---|
| 1157 | S. Alder Street and Pinecrest Road | 350 | 87.78 | | | |
| 935 | S. Birch Street and Albotros Cr. | 380 | 61.25 | | | |
| 961 | S. Birch Street and Albotros Cr. | 350 | 89.92 | | | |
| 1155 | S. Murphy Street and Pinecrest Road | 450 | 85.95 | | | |
| 1166 | S. Murphy Street and Pinecrest Road | 610 | 91.44 | | | |
| 1473 | St. Ann's Road and Alder Street | 610 | 44 | | | |
| 1476 | St. Ann's Road and Alder Street | 610 | 69 | | | |
| 1477 | St. Ann's Road and Alder Street | 380 | 70.71 | | | |
| 1236 | Thulin Street and 2nd Avenue | 510 | 110 | | | |
| 1252 | Thulin Street and 2nd Avenue | 410 | 47 | | | |
| 1458 | Thulin Street and 6th Avenue | 380 | 87 | | | |
| 1459 | Thulin Street and 6th Avenue | 380 | 81 | √ | 1459 | 525 |
| 1455 | Thulin Street and 7th Avenue | 380 | 110 | | | |
| 1457 | Thulin Street and 7th Avenue | 380 | 63 | | | |
| 1378 | Mcarthy Street and 3rd Avenue | 300 | 50.9 | | | |
| 1379 | Mcarthy Street and 3rd Avenue | 300 | 39 | | | |
| 1380 | Mcarthy Street and 3rd Avenue | 300 | 70.1 | | | |

**Table 5.8**
**Undersized Pipes and Locations – Simms / Willow**
**(5-year Level of Service)**

| Surcharged Pipe # | Location | Ex. Size | Length | Flooded? | Upgrade Pipe # | Recc. Size |
|---|---|---|---|---|---|---|
| 177 | Larwood Road and Highway 19A | 380 | 182.9 | | | |
| 200 | Eardly Road and Dino | 510 | 30.2 | | | |
| 201 | Eardly Road and Dino | 510 | 75.9 | | | |
| 199 | Hilchey Road and Highway 19A | 610 | 75.9 | | | |
| 264 | Hilchey Road and Highway 19A | 610 | 54.9 | | | |
| 202 | Eardly Road and Dino | 460 | 28.3 | | | |
| 666 | Nunns Road and Simms Road | 300 | 104.5 | | | |
| 667 | Nunns Road and Simms Road | 300 | 79 | | | |
| 263 | Hilchey Road and Highway 19A | 410 | 82.9 | | | |
| 1929 | Eardly Road and Dino | 360 | 45 | √ | 1929 | 450 |
| 204 | Eardly Road and Dino | 360 | 57.5 | | | |
| 196 | Dalton Road | 300 | 59.9 | | | |
| 194 | Dalton Road | 300 | 68 | | | |
| 195 | Dalton Road | 300 | 48.1 | | | |
| 193 | Dalton Road | 300 | 37.3 | | | |

**Table 5.9**
**Undersized Pipes and Locations – Ocean Grove**
**(5-year Level of Service)**

| Surcharged Pipe # | Location | Ex. Size | Length | Flooded? | Upgrade Pipe # | Recc. Size |
|---|---|---|---|---|---|---|
| 10 | Colorado Drive and Highway 19A | 450 | 63.42 | | | |
| 77 | Dahl Road | 600 | 96.9 | | | |
| 12 | Colorado Drive and Highway 19A | 450 | 36.21 | | | |
| 78 | Dahl Road | 600 | 80.3 | | | |
| 13 | Colorado Drive and Highway 19A | 450 | 66 | | | |
| 14 | Colorado Drive and Highway 19A | 450 | 93.7 | | | |

The model shows that the business district of downtown Campbell River experiences moderate (or nuisance) flooding at a significant number of locations. This is due to the high percentage of impervious surfaces and flat topography downtown and the tidal backwater from Discovery Passage. Much of this portion of storm sewer network is at or near elevation 0 m and thus nearly always subject to backwater conditions. Under these conditions flooding will always be a problem unless significant detention storage or flood routing paths can be found.

These results were confirmed by comments from City Public Works. On occasion they have had to close down streets, place sandbags, and undertake other mitigating works to protect habitable property from flooding in the storm network. Anecdotally, these incidences occur when the rainfall coincides with a high tide condition.

Preliminary analysis was undertaken with the model to attempt to resolve the downtown flooding issues. First, we attempted to optimize individual pipe sizes, but this did not yield satisfactory results. Then, to test whether significant additional pipe storage might mitigate flooding, all pipes in the downtown subcatchment were increased by 50%; this improved conditions only slightly. Only by removing the tidal backwater from these oversized pipes do conditions improve significantly. This of course is unrealistic, only suggesting that pipes may be properly sized for downstream conditions that never exist. Other options for relieving the flooding in the downtown subcatchment are discussed in Section 6.

### 5.7 Future Development Hydrology

As discussed in the land use section of this report, the Foreshore area is nearing buildout. The change in land use from existing to future will not be a significant impact to stormwater peak flows and volumes. The re-development of existing sites and infill development may change local stormwater patterns slightly, however it is expected that over the entire catchment, the change will be insignificant (see Table 5.10).

**Table 5.10**
**Aggregate Peak Flow for Each Catchment Area (Future Conditions)**

| Catchment | | Discharge Volume ($m^3$) | | 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 |
| **Foreshore** | | | | | | | | | |
| Painter-Barclay | 59 | 17,100 | 22,200 | 290 | 376 | 0.6 | 0.7 | 9.5 | 12.5 |
| Downtown | 380 | 122,300 | 156,100 | 322 | 411 | 4.0 | 5.2 | 10.6 | 13.8 |
| Simms/Willow | 53 | 12,000 | 15,400 | 226 | 290 | 0.4 | 0.5 | 7.2 | 8.7 |
| Ocean Grove | 164 | 41,400 | 54,900 | 252 | 335 | 1.3 | 1.7 | 7.6 | 10.3 |

Note: Duration for all storms is 24 hours.

### 5.8 Impacts of Management Strategies

There are a variety of management strategies available to mitigate the effects of development. However, as stated previously, peak flow and volume are not the primary concern, as was the case in previous ISMP studies. The impact of management strategies, as discussed, in a following section, will be to improve the quality of stormwater being discharged to Discovery Passage.

### 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 Foreshore 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. For this study area, Category 1 is represented by the Public Assembly Zone (PA-1) and the Greenway Zone (G-1).

- **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.) For this study area, Category 2 is represented by all of the single-family zones (some of which permit duplexes) as well as rural residential zones. Indian Reserves are also included in Category 2 because the typical use on reserve is low density residential.

- **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 polluting activities, the substantial impervious area contributes to increases in runoff pollutant loads over Categories 1 and 2. Category 3 includes all mid- to high-density residential zones as well as commercial zones permitting office and retail uses.

- **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. For the Foreshore Area, Category 4 is represented by the Commercial Six Zone, which permits waterfront marine commercial and the Industrial Two Zone, which permits marine industrial.

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.

As shown on Figure 5.5 (Appendix A), most of the Foreshore Area (54%) falls within Category 2, which is the category of land uses associated with the second lowest level of pollutants. Another 24% falls within Category 1, 17% within Category 3, and 5% within Category 4.

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 as a proxy for land use. Of course, the actual land use may vary somewhat from that defined in the Zoning Bylaw.

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 Table 5.11.

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, Table 5.11 should be viewed as an order of magnitude estimate of the potential pollutant loading from Foreshore 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 5.11, 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 Foreshore catchments. What is equally interesting are the pollutant loading rates (in kilograms per hectare), by category. Again as shown in Table 5.11, 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 Foreshore 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 5.11. 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 Table 5.11. 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.

**Table 5.11**
**Runoff Pollutants by Major Land Use Categories**

| Foreshore ISMP - Potential Pollutant Loading Estimate | | 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 |
| Category 1 - Open Spaces and Public Uses | 224.4 | 25544 | 114 | 102 | 0.5 | 562 | 2.5 | 63 | 0.3 | 67 | 0.3 | 19 | 0.1 |
| Category 2 - Low Density Residential | 497.1 | 244218 | 491 | 977 | 2.0 | 5373 | 10.8 | 606 | 1.2 | 638 | 1.3 | 186 | 0.4 |
| Category 3 - High Density Residential and Retail Commercial | 156.3 | 110500 | 707 | 442 | 2.8 | 2431 | 15.6 | 274 | 1.8 | 289 | 1.8 | 84 | 0.5 |
| Category 4 - "High Risk" Commerical/Industrial | 49.7 | 38412 | 773 | 102 | 2.1 | 1024 | 20.6 | 127 | 2.6 | 134 | 2.7 | 39 | 0.8 |
| **Total Area** | 928.2 | 418675 | 451 | 1623 | 1.7 | 9390 | 10.1 | 1070 | 1.2 | 1128 | 1.2 | 328 | 0.4 |

| Category | Zoning Designations |
|---|---|
| 1 | G-1 & PA-1 |
| 2 | R-1, R-1A, R-2, R-3, R-4, RU-1, RU-2 & Indian Reserves |
| 3 | RM-1, RM-2, RM-3, RI-1, RI-2, C-1, C-2, C-3, C-5 & C-6 |
| 4 | C-4 & I-2 |

This Page Left Blank

# 6.0 ISSUES AND CHALLENGES

## 6.1 Issues from Consultation Process

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 Foreshore Area can be named. Some of these are also issues and concerns raised by residents at the open houses and by members of the Stakeholders Working Group.

At the Open Houses, local residents voiced a variety of concerns with respect to stormwater. Key concerns were:

- Preservation of wildlife and recreational use of the beach at the end of Ocean Grove Road
- Importance of involvement of senior environmental agencies and other stakeholders
- Land development practices around the City in general and in upper Ocean Grove Catchment specifically; note was made of:
    - Loss of trees
    - Importance of maintaining "natural" drainage paths, including infiltration
    - Poor drainage routes
- Stormwater quality and impact on receiving waters; specifically noted were:
    - Oil
    - Pesticide/herbicide use
    - Slime in ditches
    - Impacts to salmon

Other specific issues were expressed as well, for example, unmanaged runoff from the highway that was flowing over local properties.

A large contingent of residents from the beach at the end of Ocean Grove were present at the first Open House expressing concern for upland stormwater practices and their impact on the beach.

Several Open House attendees voiced concerns over development impacts on salmon and salmon habitat in the Campbell River, an area outside the scope of the current ISMP and not directly affected by runoff from the Foreshore Area. Nonetheless, their sentiments concerning water quality and stormwater management are consistent wherever development occurs in Campbell River.

There were some dissenting voices at the open houses. For example, one attender felt it unfair to penalize "late comers" to the development community by requiring them to meet stringent performance targets that previous developers did not have to meet. Another attender expressed opposition to forming a stormwater utility to raise funds for stormwater controls, calling it another tax on local residents.

The Stakeholders Working Group generally voiced similar areas of concern as the Open House attendees. Specific items noted at the Working Group meetings were:

- Locations and conditions of existing outfalls to Discovery Passage
- Lack of any BMP and/or stormwater management components in the current infrastructure
- Long-term maintenance of municipal drainage infrastructure
- Long-term degradation, Zone 1, the beach and banks along the foreshore (loss of large woody debris, nearshore habitat, and beach straightening/armouring)
- Alteration of estuarine fish habitat on the nearshore due to development
- Mitigation of invasive plant species
- Vegetation retention during development
- Sediment control practices on construction sites and rate of vegetation re-establishment
- Water quality, specifically, the monitoring and implementation of any pilot programs
- Establishment of a practical and effective flow monitoring program
- Public education, outreach and support mechanisms
- Tidal influences on outfall performance
- How to address future development in each watershed (e.g. use of low impact development techniques)
- How to implement / enforce recommendations from ISMP (e.g. new / revised bylaws and municipal standards, staffing implications for City for monitoring / inspection / enforcement, funding sources, etc)
- How to implement / monitor / enforce existing regulations from pertinent authorities (DFO, Coast Guard, Federal and Provincial Governments)

### 6.2 Primary Issues and Challenges

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

a) Runoff quality
b) Establishment / maintenance of year-round baseflows in outfalls
c) Need for stormwater controls in new developments
d) Adequacy of existing drainage systems
e) Protection and maintenance of shoreline and marine riparian corridor, including intertidal habitat
f) Erosion and sediment controls during construction
g) Public education and outreach
h) Establishment of long-term environmental monitoring system

This Page Left Blank

## 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 Foreshore 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. Although none are located in the Foreshore Area, the large stormwater pond in Georgia Park development in the Willow Creek watershed is a local example. 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[8]. This type of swale has been proposed for use along the soon to be reconstructed Old Island Highway.

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. 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 Foreshore 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 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 Foreshore Area presents particular challenges to the use of some of these as well as excellent opportunities for use of others. The paragraphs that follow provide discussion of several aspects of BMP implementation unique or especially applicable to the Foreshore.

### *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 Foreshore Area have already been constructed with an urbanized cross section. Notable exceptions are the roads in the Pointer/Barclay catchment and significant stretches of the Old Island Highway. However, there are opportunities to convert an existing urbanized road to a road using alternative standards, or to incorporate an alternative road design in future developments.

As currently proposed, the Old Island Highway will be constructed with the addition of a bio-swale along its west side, in place of a traditional ditch and in order to make use of the infiltration capacity of the native soils. In addition, new roads in the Ocean Grove catchment could be designed and constructed to make use of alternative roadway designs.

---

[8] 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.

**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 |
| Rock / Soakaway Pit | X | | | | X | | | |
| Turf Reinforcement Mats | X | | | | | | | X |
| Underground Infiltration System | X | | | | X | | | |
| Underground Tank / Vault | X | | | | | | X | |
| Wet Detention Pond | | 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 significant parts of the Foreshore Area. However, due to the topography and presence of springs along the escarpment, 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. 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.

As the Ocean Grove catchment is currently under development with the Maryland Estates subdivision, and also the catchment with the most undeveloped contiguous tracts of land, alternative scenarios were run to demonstrate the applicability of roof leader disconnection and amended soils (see Section 7.2.6) for stormwater management. The results for these scenarios are shown in Table 7.2.

**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 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 (see Appendix A).

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 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/km 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.

### *7.2.4 Peak and Volume Controls*

Two unique characteristics of the Foreshore Area may strongly influence the recommended approach to controlling runoff volumes and peaks. First, the Foreshore Area is largely developed and already has an extensive storm drain system with capacity to safely convey storm flows[9]. In fact, as noted in Section 5.7, this existing system generally can also handle future increases in runoff from areas in the upper Ocean Grove Catchment without providing stormwater controls. Further, infill and redevelopment will not significantly alter the total runoff from the remainder of the Foreshore Area. From this perspective, there may be no need for new detention to manage either existing or future runoff.

Secondly, the current system discharges directly to Discovery Passage via numerous outfalls that do not, by definition, cause flooding and erosion in the receiving water as might be experienced in a natural stream receiving stormwater runoff[10]. This is so due to the sheer size of Discovery Passage compared to the outfalls as well as to the significant currents regularly coursing this tidal water body. Again, from this perspective, there may be no need for new detention to handle either existing or future runoff.

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 the Foreshore Area and thus, barring significant deviations in future land uses from the OCP, BMP's for reduction in peak runoff are not required.

Concern was raised by some in the Stakeholders Working Group that new or increased stormwater discharges could negatively impact local salinity levels in Discovery Passage. Except for any former small streams that were present along the Foreshore Area long ago, the current storm drain outfalls already concentrate runoff that formerly would have infiltrated and slowly seeped out along the entire shoreline. Some of them apparently actually convey some "base flow," likely due to "leaky" pipes that allow conveyance of groundwater from the surrounding soils. One probable result has been the creation over time of local salinity depressions along the shoreline at each outfall. According to our biophysical survey, these areas have become small habitat "refuges" for salmon and perhaps other sea life.

Given their current fisheries habitat value, it would seem important to maintain many or most of the current outfalls. Wholesale return to "natural" infiltration patterns in the uplands would likely result in the loss of the outfall-based habitat areas. Thus, one goal may be to retain current runoff peak and volume levels. A second goal may be to retain or even enhance, in some cases, the base flows issuing from the outfalls.

---

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

10 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.

### 7.2.5 Stormwater Quality

As previously discussed, urban runoff typically can carry a variety of potentially harmful pollutants. The biophysical inventory completed for this ISMP identified a number of existing storm drain outfalls that now support fish habitat of varying qualities. On the one hand, the presence of the outfall would seem to have been the catalyst for these habitat "islands." On the other hand, the stormwater could be contaminating receiving water and bottom sediments at these locations, as well as supplying contaminants to the marine environment in general. At this time, there is no specific runoff, receiving water or ambient sediment quality data that suggests there is a problem in the Foreshore Area. However, it seems prudent to confirm the findings of this study's preliminary pollutant loading analysis by determining the extent of runoff contamination at the sites 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.

### 7.2.6 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 and by providing 300 mm or more of landscaped absorbent (or "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 when under very wet 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.

---

[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.

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.

### 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 stormater 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. Absorbent landscaping that retains rainfall on site can be viewed as a negative, especially if the lawn is "soggy" in 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 the Foreshore anyway.

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 Foreshore 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 Foreshore 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 Water Quality

A stormwater strategy for the Foreshore Area will need to be consistent with the strategies recommended for previous watersheds and drainages, while recognizing two basic distinguishing characteristics of the Foreshore. These characteristics are:

- The Foreshore Area is essentially fully developed, much of the area being serviced by an extensive system of storm drains
- Storm drains in the Foreshore Area discharge directly to Discovery Passage

From a stormwater management perspective several things follow from this. First, there are essentially no freshwater stream systems to protect from high volumes of runoff. The corollary is that Discovery Passage which is a tidal water body does not require protection from flooding or stream bed and bank erosion. Thus, in general, stormwater detention to attenuate peak flows is unnecessary in the Foreshore Area. In any case, the potential increases in runoff from new (i.e., future) development within the Foreshore Area are small, further supporting that runoff detention is probably unnecessary. The one exception is the upper Ocean Grove catchment which is currently undeveloped.

Second, highly urbanized areas such as the Foreshore Area tend to generate significant volumes and concentrations of pollutants in runoff. Since there are no local streams, freshwater pollution is not generally a concern. However, there may be concern for receiving water quality and sediment contamination at and below the outlets to the numerous storm drain outfalls that line the marine shoreline. Many of these outfalls now support pockets of fish habitat along the short channels through the intertidal zone. This has occurred due to processes such as the establishment of base flows in many of the storm drains, development of scour holes and short channels below the outfalls, and growth of protective vegetation around the outfalls and their outlet channels. Thus, in general, stormwater quality issues are of greater concern in the Foreshore Area than stormwater volume and peak issues.

Third, since many of the storm drains now apparently discharge base flow that has become part of the shoreline's habitat support system, any changes in the base flows in the storm drains must be reviewed critically for impacts on these scattered habitat sites. The corollary is that stormwater practices that emphasize infiltration will need to be reviewed carefully for their potential impact on these storm drain base flows. Thus, in general, if the existing outfall-based habitat sites are valued, stormwater controls that increase base flow in the storm drains should be preferred to those that reduce it even if that means less use of diffuse infiltration in upland areas that are already developed.

Fourth, while the use of site adaptive planning and on-site stormwater controls to manage rainfall and runoff in ways that mimic the natural water balance are becoming the preferred standards for stormwater management in British Columbia, retrofitting such 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 City's downtown 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 Foreshore Area, this applies primarily to runoff quality treatment.

When developing initiatives for water quality treatment in the Foreshore, 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).

Stormwater quality treatment systems could be constructed at the end of every outfall along the shoreline. Assuming these were all underground treatment systems, the construction cost for providing this treatment would be on the order of $7.0 million (see Appendix H). A cost effective approach might be to provide treatment only at outfall locations with high pollutant loadings, such as those draining the downtown core area. The cost (construction) to provide treatment for the four outfalls serving about 90% of the downtown core and nearby areas (DT20, 25, 27 and 31) is $0.9 million. In addition, providing treatment at four locations also noted as opportunities for habitat enhancements (see Section 8.3, below) will cost approximately $0.7 million.

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[12]) 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 for the downtown core area only, compared to about $0.9 million for providing treatment at the four main downtown outfalls. However, 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.

### 8.3 Fish Habitat Enhancements

During the biophysical inventory task, a number of sites were identified as potential candidates for habitat enhancements. The selection of sites took into account factors such as:

- Presence of base flow at the outfall
- Presence of existing habitat features, e.g., pools and channels
- Presence of fish, e.g., salmonids
- Proximity to City-owned land

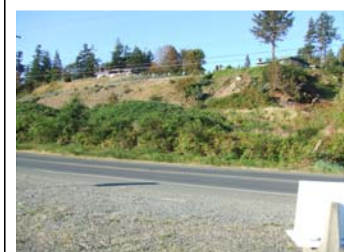
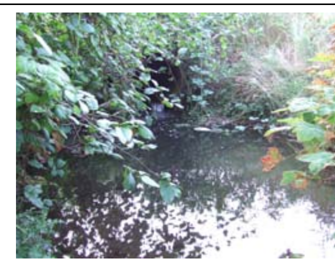
The enhancement opportunities include planting native grasses, shrubs and trees, removal of invasive vegetation, creation of rearing habitat, improving access to rearing habitat, and preservation of existing high quality habitat for fish and other wildlife. Table 8.1 provides information on these sites. The table also notes sites that may be suitable for stormwater treatment in the area between the highway and the shoreline. In some cases, side channels could be constructed in conjunction with the treatment facilities in order to provide new fish habitat.

With respect to these fish habitat enhancement opportunities, these could be done as "stand alone" projects, however the City has 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:

- Waterfront Sewer Replacement Project
- Shoreline Land Acquisition Program
- Old Island Highway Upgrade
- "End-of Pipe" stormwater quality treatment facilities resulting from ISMP recommendations

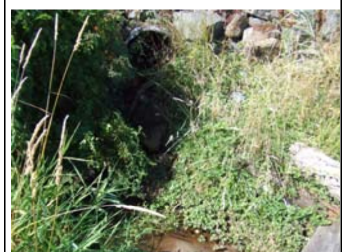
[12] A top-of-the-line high performance street cleaner costs approximately US$280,000, or about $340,000, depending on exchange rates, but not including shipping the vehicle to Campbell River.

**Table 8.1 Summary of Priority Foreshore Stormwater Treatment and Habitat Improvement Sites[13]**

| Catchment Area | Site(s) | Stormwater Treatment Opportunities | Habitat Improvement Opportunities | Photos | |
|---|---|---|---|---|---|
| Downtown | DT 01 and 08 | | Recolonization of high foreshore riprap by Native species could be accelerated by infilling riprap with gravel/sand to facilitate natural recovery of Elymus and beach pea. Sites could also benefit from fill planting of Native grass and shrub species tolerant to dry conditions. |  Upper foreshore margin at DT 08 (Rotary Beach Pk) |  Extensive riprap berm at DT 20 (Discovery Pier) |
| Downtown | DT 04 and 05 | City owned property at Rockland Road on both sides of H19. Suitable for stormwater detention pond or other treatment options west of H19. Potential to combine discharge from both outfalls located immediately adjacent to the N and S boundary of the City property. | Opportunity for development of backshore/foreshore salmonid rearing habitat in City owned property between H19 and Discovery Pass. Riparian planting could enhance habitat for bird and amphibian species. Candidate for backshore vegetation improvement. |  Seawalk and habitat improvement site at DT 04/05 |  Potential stormwater treatment site at DT 05 |
| Downtown | DT 13 | | Best foreshore fish habitat observed during survey with 32 $m^2$ (8 m x 4 m x 0.8 m deep) plunge pool leading into 17 m long channel. Presence of 50+ coho juveniles at 120 mm fork length. Fish access and utilization could be improved by partial removal of beach logs. High priority for water quality testing. Site could be used as a template for future foreshore fish habitat improvements. |  Outfall outlet pool at DT 13 |  Seaward view of outlet channel at DT 13 |

13 See Figure 8.1. in Appendix A for site locations.

| Catchment Area | Site(s) | Stormwater Treatment Opportunities | Habitat Improvement Opportunities | Photos |
|---|---|---|---|---|
| Downtown | DT 06 | Outfall site located in zone of longshore accretion due to the riprap berm immediately to the south constructed for McCallum Park boat ramp. Infilling of beach materials at outfall could be addressed by increasing the length of the outfall pipe. City owned property adjacent to the outfall could be used for SW treatment in future in necessary. | |  U/S view of DT 06 at McCallum Park<br> Potential stormwater treatment site at DT 06 |
| Downtown | DT 19 | City owned property along low profile bench ranging from 20-40 m wide beyond the toe of slope towards the foreshore. Flats are dominated by blackberry and thimble berry with a 3 m wide zone of *Elymus* along shoreline margin. Good Potential for end of pipe detention structure and further enhancement for public trails and Native revegetation of backshore habitat | Good potential for habitat improvement site downstream of stormwater treatment site. Foreshore/backshore rearing pond and channel for salmonids, planted with Native vegetation would result in a net gain of fish and wildlife habitat. Groundwater flows observed in August 2005 with anecdotal reports of groundwater seepage through the benched area. |  Backslope bench at DT 19<br> N view of foreshore at DT 19 |
| Downtown | DT 20 | | Large City owned lot adjacent to government marina (Discovery Fishing Pier). Potential for fish habitat enhancement if WQ is acceptable. Channel could be cleared of debris and terraced with additional complexing to facilitate access and improve instream habitat quality. Recolonization of high foreshore riprap by Native species could be accelerated by infilling riprap with gravel/sand to facilitate natural recovery of Elymus and beach pea. |  Downstream view of existing outfall channel with potential for habitat improvement at DT 20 |

| Catchment Area | Site(s) | Stormwater Treatment Opportunities | Habitat Improvement Opportunities | Photos | |
|---|---|---|---|---|---|
| Ocean Grove | 01, 02, 03/04 | | Backshore vegetation restoration opportunities include removal of invasive species and fill planting with Native shrub species including snowberry, thimbleberry, as well as willow, alder, maple and conifers to increase quality of foreshore for wildlife. | <br>Shoreward view of OG 03/04 | <br>N view of seawalk and backslope at OG 02 |
| Ocean Grove<br><br>Simms Willow | 06<br><br>07 | | *Groundwater flows observed throughout the catchment. At OG06 (Dahl Rd), flow obs within the 19 m long channel in upper foreshore where fish presence was not confirmed. Candidate for improvement to access and habitat quality to the existing channel. Fish presence confirmed at OG 01.*<br><br>Similar foreshore feature and habitat improvement opportunity observed at SW 07 | <br>Upstream view of outfall outlet pool at OG 06 | <br>Upstream view of log debris in outflow channel |
| Simms Willow | SW06 through SW09 | | Backshore vegetated with grass and shrubs at Hilchey Road area. Opportunity for improving shoreline vegetation in upper foreshore area through addition of Native trees | <br>Headwall and outfall at SW06 | <br>North view of backshore habitat at SW 07 |

This Page Left Blank

### 8.4 Monitoring

There are a number of reasons for performing environmental monitoring within the Foreshore 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) and in the associated outlet channels and pools (water and sediment quality)
- To determine performance of the overall stormwater management strategy once implemented

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.

This Page Left Blank

# 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 Foreshore 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 watershed which are realistic and practical to achieve, and which are adaptable should conditions change as future information on the watershed is obtained.

While there is currently pressure to develop the upper lands in Ocean Grove Catchment, the Foreshore Area will essentially remain in its current land uses and development condition.

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

- Minimize impact of new development on runoff
    - Maintain base flows to ditches
    - Maintain water quality in ditches (if present)
    - Apply sustainable stormwater management controls on new development
    - 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
- Enhance intertidal fish habitat in conjunction with other City programs and infrastructure improvements.

Table 9.1 provides a summary list of the recommendations that are discussed in the paragraphs that follow.

## 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 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)[14]
- **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

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 $\geq$ 50 microns) conveyed by runoff from all new development. This standard would be supplemented during construction by application of an approved ESC plan (see Recommendation 9.12). 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

[14] The Mean Annual Rainfall (MAR) is 55 mm in 24 hours.

permit process. For commercial and industrial development, we also recommend requiring removal of oil and grease before discharge to storm systems or the creek.

We suggest the City encourage the use of "treatment trains" whenever possible. Simply described, this means multiple BMP's constructed in series.

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.

### 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 23 pipe segments, as shown in Table 5.7 and Figure 5.4 (see Appendix A). The total estimated construction cost for these upgrades is $0.94 million (see Section 10; full details in Appendix H).

We are not recommending any storm drain upgrades within the downtown core at this time as our preliminary analysis shows that only limited improvement of nuisance flooding is gained by the replacements. Additional detailed study is required to identify and evaluate potential solutions to the flooding.

The addition of tide gates should also be considered for all storm drains in low lying areas. Our recommendation is that, when tide gates are added, that they be all-rubber construction check valves that prevent backflow and allow sealing even when obstructions become lodged in the valve. Traditional flap gates will not seal when an obstruction is present.

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.

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 Foreshore Area, as delineated in the draft OCP. Therefore no new trunk storm sewers are recommended at this 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 throughout the Foreshore Area. However, due to the large number of outfalls, the potential remains relatively diffuse along the 13 km shoreline. The greatest exception is the downtown core, where a very high impervious area is coupled with the presence of much automobile traffic and possible commercial activities that can contribute to runoff contamination. Thus we recommend construction of runoff treatment facilities for the four outfalls serving the downtown core (see Figure 8.1 in Appendix A). 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. 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 four vortex-based sediment removal systems can meet the performance target for an estimated cost of about $820,000; estimated annual O&M is about $8,000. Sizing is based on the 2-year recurrence storm event, which varies from 120 L/s to 450 L/s for the downtown 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.

Four sites associated with potential habitat improvements have also been identified as candidates for stormwater treatment as well (see Table 6.2). The cost to provide vortex-based treatment systems at these four sites is $570,000 with estimated annual O&M of $5,000. At sites where land is available and the facility can be integrated with the foreshore environment (pathways, habitat conditions, etc.), then a water quality pond and / or infiltration pond may be preferable at one of more of these sites. Costs will be similar or slightly more for such ponds.

Prior to proceeding with implementation, we recommend the City undertake a more thorough assessment of its street cleaning program, particularly within the downtown core (and similar areas lying outside within other City watersheds). The assessment should include comparing life cycle costs for street cleaning versus those for the water quality treatment facilities. 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 downtown core water quality treatment facility proceeds (rather than purchase of the high-end street cleaner), it should be accompanied by:

- An environmental monitoring program (see Section 9.5)
- Reassessment of water quality treatment requirements at other outfalls based on the monitoring program
- An enhanced program of street cleaning using existing City-owned equipment
- Program to identify specific hot spot commercial or industrial enterprises
- Spill containment procedures

### 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. This is generally unnecessary for most of the Foreshore Area (except Ocean Grove catchment) and, in any case, the flow data obtained in other parts of the City can be used to adjust model parameters in the Foreshore Area catchments as well. 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. Additional ditch level gages should be installed around the Foreshore Area as well, as a minimal cost method of assessing base flows, but only as a part of network throughout the City.

More importantly for the Foreshore Area, 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 along the shoreline. 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.

Sampling frequency and locations would be:

- First year, sample each major outfall twice
- Second and subsequent years, sample on a semi-annual basis the downtown core outfalls plus other select outfalls chosen based on the first year's sampling (anticipated to be about 15 outfalls, based on subcatchment sizes, land uses and the results of the biophysical inventory)

As this testing is likely to be expensive, an alternative would be simply to sample at the downtown core outfalls plus six others scattered throughout the catchments (10 total sites).

In preparation for design of the proposed stormwater treatment facility (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 downtown core.

The second prong of the environmental monitoring program is to establish periodic biotic inventories of several areas along the foreshore. This could be done by the City alone or in conjunction with a local organization such as the Greenways Land Trust. (The Trust currently does eel grass studies which these could supplement.) Quadrants established at two dissimilar sites, for example at the Rockland Road spring area and a storm drain outfall, would allow some assessment of the impact that stormwater discharges have on the intertidal and marine environments.

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.

### 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 locations in each catchment 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 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 downtown 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 a street cleaning in its O&M schedule, setting frequency has high as possible in the downtown core 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).

### 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 area also shown on Figure 8.1 (Appendix A).

### 9.11 Erosion and Sediment Control Practices on Construction Sites

We recommend that the City implement 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

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.

### 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.

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 Pilot Projects

In general, pilot projects are a great way to test out new stormwater concepts before they are permitted City-wide, but the City has to first be willing to test out these new concepts in the field and realize that there may be a period of trial and error involved. Monitoring of constructed works and analysis of measured data are critical to the success of any pilot project. More often than not, constructed works need to be refined or even replaced over time in order for them to be completely successful, however, once any issues are worked out, these types of projects will provide great benefits and represent a step towards mimicking the natural hydrologic and hydraulic response of the watershed.

We recommend that the City consider testing the construction and use of a parking lot retrofit with sustainable stormwater controls. For high visibility this should be undertaken in the downtown core in partnership with one or more local businesses, or perhaps even at the municipal hall itself or public parking along the shoreline. Depending in part on the site conditions, the retrofit could include the use of pervious pavement, infiltration galleries and vegetated bioswales. The site could be monitored (flow; water quality) "before" and "after" to assess the overall performance as well as to provide a basis for modifying design criteria for future parking lots. If the site were large enough (or if several parking lots were done simultaneously) different pervious pavement alternatives could be compared. Financing may be possible through the Municipal Green Infrastructure Fund.

### 9.14 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.

### 9.15 City Bylaw and Policy Revisions

As noted in Section 4.5 on Land Use Policy Gaps, the City's land use bylaws (the Draft 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 Foreshore Area:

#### *9.15.1 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.

#### *9.15.2 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
- Encouraging the use of native species of vegetation and Best Management Practices, where appropriate, to support integrated stormwater management

- 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

#### 9.15.3 Tree Protection Bylaw

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.

#### 9.15.4 Pesticide Use Bylaw

The City should consider adopting a bylaw to limit the use of pesticides and herbicides.

### 9.16 Updates to City Engineering Standards and Specifications

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

The updated standards should include a provision for deeper sumps and trapping hoods on catch basins (see Section 9.3).

### 9.17 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[15]. 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.

[15] 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.

This Page Left Blank

**Table 9.1**
**Summary of Recommendations for Foreshore Area Stormwater Management**

| Category | Recommendation | Priority Level | | |
|---|---|---|---|---|
| | | 1 | 2 | 3 |
| Municipal Infrastructure | Upgrade deficient municipal drainage infrastructure (storm drains) | | X | |
| | Construct runoff water quality treatment facilities for downtown core area (4 total) | X | | |
| | Construct runoff water quality treatment facilities at habitat enhancement sites (4 total) | | X | |
| | Upgrade existing catch basins with deeper sumps and trapping hoods | | | X |
| | Prepare operations and maintenance schedule for stormwater system, incl street cleaning | X | | |
| Environmental | 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 inventory program at 2 or more sites | X | | |
| | Initiate soils property verfication program | | X | |
| | Re-establish digital recording of continuous rainfall measurements at the airport rain gauge | | X | |
| | Enhance foreshore habitat in conjunction with other City initiatives (15 key, potential sites) | X | | |
| Pilot Projects | "Green" parking lot with pervious pavement and bioswales | X | | |
| Data Management | Obtain updated, detailed aerial contour mapping of area (supplemented by ground survey) | | X | |
| | Compile manhole rim data throughout the area | | X | |
| | Refine the current XP-SWMM model to perform extended period (continuous) simulations | | | 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 | |
| | Prepare and distribute to builders an Erosion and Sediment Control Brochure | X | | |
| | Adopt measureable targets in OCP for preserving tree cover and limiting impervious area | X | | |
| | Update zoning bylaw to include maximum parking space and impervious area limits, encourage vegetation retention and native species plants, and encourage cluster development | | 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 | Conduct a long term public eduation and outreach program | X | | |
| | Publicize stormwater pilot projects | X | | |
| | Develop a stewardship award for the development community | | X | |

This Page Left Blank

# 10.0 COST ESTIMATES

Several recommendations for the Foreshore 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 Link ID | Location | Proposed Pipe Size (mmØ) | Pipe Cost ($/m) | Length (m) | Capital Cost ($) | O & M Cost ($/yr) | Present Value of O & M Cost |
|---|---|---|---|---|---|---|---|
| 1259 | Alder Street and 2nd Avenue | 450 | 285 | 99 | $ 46,100 | $ 500 | $ 7,300 |
| 1268 | Alder Street and 2nd Avenue | 450 | 285 | 71 | $ 33,100 | $ 400 | $ 5,900 |
| 1269 | Birch Street and 2nd Avenue | 450 | 285 | 17 | $ 8,000 | $ 100 | $ 1,500 |
| 1271 | Birch Street and 2nd Avenue | 450 | 285 | 141 | $ 65,600 | $ 700 | $ 10.200 |
| 1272 | Birch Street and 2nd Avenue | 450 | 285 | 20 | $ 9,300 | $ 100 | $ 1,500 |
| 933 | Cormorant Road and Albotros Cr. | 450 | 285 | 72 | $ 33,500 | $ 400 | $ 5,900 |
| 932 | Cormorant Road and Albotros Cr. | 450 | 285 | 27 | $ 12,600 | $ 200 | $ 3,000 |
| 931 | Cormorant Road and Albotros Cr. | 450 | 285 | 59 | $ 27,500 | $ 300 | $ 4,400 |
| 930 | Cormorant Road and Albotros Cr. | 450 | 285 | 44 | $ 20,500 | $ 300 | $ 4,400 |
| 928 | Cormorant Road and Albotros Cr. | 525 | 340 | 152 | $ 79,100 | $ 800 | $ 11,700 |
| 1251 | McLean Street and 2nd Avenue | 525 | 340 | 41 | $ 21,400 | $ 300 | $ 4,400 |
| 1252 | Thulin Street and 2nd Avenue | 525 | 340 | 47 | $ 24,500 | $ 300 | $ 4,400 |
| 1220 | McLean Street and Evergreen Street | 525 | 340 | 92 | $ 47,900 | $ 500 | $ 7,300 |
| 1204 | S. Alder Street and Evergreen Street | 375 | 230 | 97 | $ 39,800 | $ 400 | $ 5,900 |
| 833 | S. Alder Street and Frances Boulevard | 450 | 285 | 177 | $ 82,400 | $ 900 | $ 13,100 |
| L1061 | S. Alder Street and Marina Boulevard | 450 | 285 | 16 | $ 7,500 | $ 100 | $ 1,500 |
| L1062 | S. Alder Street and Marina Boulevard | 450 | 285 | 9 | $ 4,200 | $ 100 | $ 1,500 |
| 1459 | Thulin Street and 6th Avenue | 525 | 340 | 81 | $ 42,200 | $ 500 | $ 7,300 |
| 1929 | Eardly Road and Dino | 450 | 285 | 45 | $ 21,000 | $ 300 | $ 4,400 |
| | | | | Total | $ 626,200 | $ 7,200 | $ 105,600 |
| | | | | +35% Contingency | $ 219,200 | $ 2,600 | $ 37,000 |
| | | | | + 15% Engineering | $ 94,000 | | |
| | | | | Total (Capital) | $ 939,400 | $ 9,800 | $ 142,600 |
| | | | | | | **Grand Total (Capital + O&M)** | **$1,082,000** |

**Notes:**
1 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)
2 Present worth based on 30-year life with 5.5% interest rate

## 10.2 Water Quality Treatment Facilities

Stormwater quality treatment facilities are recommended for the core of downtown Campbell River and for four priority habitat improvement sites. 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. Tables 10.2 and 10.3 summarize the capital and O&M costs for the facilities.

**Table 10.2**
**Stormwater Treatment Facility Costs for Downtown Core**

| Outfall(s) Name | Capital Cost ($) | O&M Cost ($/yr)[1] | Present Worth of O&M Cost ($)[2] |
|---|---|---|---|
| DT20 | $ 156,667 | $ 1,600 | $ 23,300 |
| DT25 | $ 106,667 | $ 1,100 | $ 16,000 |
| DT27 | $ 90,000 | $ 900 | $ 13,100 |
| DT31 | $ 193,333 | $ 2,000 | $ 29,100 |
| Sub-Total | $ 546,667 | $ 5,600 | $ 81,500 |
| +35% Contingency | $ 191,400 | $ 2,000 | $ 28,600 |
| +15% Engineering | $ 82,000 | | |
| Total | $ 820,067 | $ 7,600 | $ 110,100 |
| | **Grand Total (Capital + O&M)** | | **$ 940,000** |

NOTES:
1. O&M Cost based on required sediment removals and cleanings
2 Present worth based on 30 year life with 5.5% interest rate

**Table 10.3**
**Stormwater Treatment Facilities for Priority Habitat Enhancement Sites**

| Outfall(s) Name | Capital Cost ($) | O&M Cost ($/yr)[1] | Present Worth of O&M Cost ($)[2] |
|---|---|---|---|
| DT 04, 05 | $ 67,000 | $ 700 | $ 10,200 |
| DT 06 | $ 193,333 | $ 2,000 | $ 29,100 |
| DT 19 | $ 120,000 | $ 1,200 | $ 17,500 |
| Sub-Total | $ 380,333 | $ 3,900 | $ 56,800 |
| +35% Contingency | $ 133,200 | $ 1,400 | $ 19,900 |
| +15% Engineering | $ 57,100 | | |
| Total | $ 570,633 | $ 5,300 | $ 76,700 |
| | **Grand Total (Capital + O&M)** | | **$ 650,000** |

NOTES:
1. O&M Cost based on required sediment removals and cleanings
2 Present worth based on 30 year life with 5.5% interest rate

## 10.3 Topographic Update

As noted previously, topographic information in the Foreshore 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, but ground survey can provide more detail in the downtown core.

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 |

## 10.4 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 |

## 10.5 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.

This Page Left Blank

# 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 both 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 stakeholders working group 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 outfall sites
- Improving water quality at monitored outfall 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 Foreshore 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

Archipelago Marine Research Ltd. (2003). *South Campbell River Sewer Project Marine Inventory and Impact Asessment*, District of Campbell River, British Columbia.

Center for Watershed Protection. (*ca.* 2003). "The Simple Method to Calculate Urban Stormwater Loads," Center for Watershed Protection, Ellicott City, Maryland. Available from www.stormwatercenter.net. [Accessed 08 August 2003].

District of Campbell River. (2000). "Engineering Design Standards and Specifications," District of Campbell River, British Columbia.

District of Campbell River. (2003). "Environmental Action Plan, A 5-Year Plan, 2003-2007," District of Campbell River, British Columbia.

District of Campbell River. (2004). "Official Community Plan (OCP) Draft," Bylaw No. 2555, District of Campbell River, British Columbia.

Komori Wong Environmental. (2003). *Fish Habitat Assessment and Recommended Stormwater BMPs on Maxwell Property (Section 15, TP.1, Comox District, Plan 552)*, Komori Wong Environmental, Comox, British Columbia.

Lanarc Consultants, Ltd. (2005). *Draft Report for Alternate Design Standards, Phase 1*, City of Campbell River, British Columbia.

Lanarc Consultants, Ltd., Richard Drdul Community Transportation Planning, Highland Engineering and Surveying, and AMEC Americas Ltd. (2005). *South Island Highway (19A), Conceptual Design, Phase 2*, City of Campbell River, British Columbia.

McElhanney Consulting Services. (2004). *Drainage Study for the Maxwell Properties Campbell River, BC,* City of Campbell River, British Columbia.

McElhanney Consulting Services and Lanarc Consulting Ltd. (2003). *Campbell River Waterfront Sewer Replacement Project,* City of Campbell River, British Columbia.

Minton, Gary. (2002). *Stormwater Treatment: Biological, Chemical and Engineering Principles*, Resource Planning Associates, Seattle, Washington.

Minton, Gary and Roger Sutherland. (1998). "How Do We Judge the Equivalency of New Treatment BMPs?" in Stormwater Treatment Northwest, Vol. 4 No. 4.

Planning Collaborative Inc. (1983). *Campbell River Harbour and Crown Foreshore Plan*, City of Campbell River, British Coulmbia.

Sharp and Diamond Landscape Architecture. (1993). *Willow Point Revitalization Plan*, District of Campbell River, British Columbia.

Urban Systems Ltd. (2005). *Integrated Stormwater Management Plan Nunns Creek Watershed,* City of Campbell River, British Columbia.

Urban Systems Ltd. (2005). *Integrated Stormwater Management Plan Simms Creek Watershed,* City of Campbell River, British Columbia.

Urban Systems Ltd. (2005). *Integrated Stormwater Management Plan Willow Creek Watershed,* City of Campbell River, British Columbia.

Various correspondence. Department of Fisheries and Oceans, District of Campbell River. (2000).

# APPENDIX A

**OVERSIZED FIGURES**

**Figure 3.1**
**Foreshore Area Overview**

11x17

**Figure 3.2**
**Foreshore Area Topography**

11x17

**Figure 3.3**
**Hydrologically Significant Existing Land Uses**

Fig3.3

11 x 17

**Figure 3.4**
**Municipal Drainage System**

Fig 3.4 (4 figures)

11 x 17

**Figure 3.5**
**Biophysical Reconnaissance**

Fig 3.5 (4 figures)

11 x 17

**Figure 3.6**
**Potential Locations for Long-Term Stormwater Infiltration**

11 x 17

**Figure 3.7**
**Existing Land Use Zoning Designations**

11 x 17

**Figure 3.8**
**Future Land Use OCP Designations**

11 x 17

**Figure 5.4**
**Existing Municipal System Deficiencies**

Fig.5.4 (2 figures)

11 x 17

**Figure 5.5**
**Land Use and Pollution Potential**

Fig.5.5

11 x 17

**Figure 8.1**
**Priority Stormwater Treatment and Habitat Improvement Sites**

Fig. 8.1 (4 figures)

11 x 17

# APPENDIX B

## HABITAT / FISHERIES REPORT

# APPENDIX C

## HYDROGEOLOGICAL REPORT

# APPENDIX D

**HYDROLOGIC / HYDRAULIC MODELING**

**INPUT AND RESULTS**

**(Electronic Version of Output on CD-ROM only)**

**NOTES on Modeling Results**

The following items are included in this appendix:

- Model schematic showing links (pipes, culverts and ditches) and nodes (generally, manholes and culvert ends)
- Output tables for the 5-year 1-hour storm event (on CD-ROM only)
- Output tables for the 10-year 1-hour storm event (on CD-ROM only)

Three output tables are provided for each of the two storm events noted above:

- *Table E4 Conduit Connectivity* - Describes how conduits* (pipes, culverts and ditches) and junctions** (manholes, culvert ends and other connection points between conduits) 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)
- 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)

---

* Also called links
** Also called nodes

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, it was found that a portion of the sewer along 1st Avenue had been recently rebuilt but that the requisite information had not been updated in the City's GIS database as provided to the Project Team. Thus, the current version of the model uses outdated information for this particular storm drain. This does not significantly change the computed runoff rates for this system, but the current output indicates that the pipes along 1st Avenue are surcharged and causing flooding when in fact they are not.

# APPENDIX E

## STAKEHOLDERS WORKING GROUP MATERIALS

**(Electronic Version on CD-ROM only)**

# APPENDIX F

## PUBLIC OPEN HOUSE

## PRESENTATION MATERIALS AND FEEDBACK

**(Electronic Version on CD-ROM only)**

# APPENDIX G

**CAMPBELL RIVER DRAINAGE COMPLAINT SUMMARY**

**(2000 – 2004)**

**(Electronic Version on CD-ROM only)**

# APPENDIX H

**COST ESTIMATES**

# APPENDIX I

## PHOTO INVENTORY

# APPENDIX J

## SUMMARY OF EXISTING CITY OF CAMPBELL RIVER POLICIES

# APPENDIX K

## FORESHORE AREA

## INTEGRATED STORMWATER MANAGEMENT PLAN

## TERMS OF REFERENCE