City of Chilliwack

Policy and Design Criteria Manual for Surface Water Management

Prepared by

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Preface to Front-End

The Front End of the Manual summarizes key information that City staff, elected officials and land developers need in order to understand and implement the City of Chilliwack's approach to stormwater management. The front end comprises the following sections:

- **Section 1 - Context and Overview:** Provides an overview of the Manual and the City's approach to stormwater management.
- **Section 2 - Stormwater Goals and Objectives:** Defines the goals and objectives that summarize the City's drainage planning philosophy and approach.
- **Section 3 - Action Plan:** Defines the actions that are needed over the next five years to achieve the City's stormwater related objectives, and who is to take the lead role in implementing each of the actions.
- **Section 4 - Design Guidelines:** Defines the City's design criteria for drainage systems and provides guidance to city staff, land developers, and consultants regarding how to implement these design criteria at the site level.
- **Section 5 - Submission Requirements:** Defines the information that land developers must submit to the City in order to obtain development approval.

Sections 2 and 3 are written primarily for elected officials and City staff. Sections 4 and 5 are written primarily for land developers and City staff.

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Executive Summary

This Manual replaces the drainage section of the *Subdivision and Development Control Bylaw*. The Manual was developed as a case study application of *Stormwater Planning: A Guidebook for British Columbia,* a collaborative effort of an inter-governmental partnership that was initiated by local government. Through interaction with the Chilliwack community during its development, the Manual has also provided a feedback loop for the Guidebook process.

The Manual incorporates the content of the Bylaw that it has replaced, and is designed to manage both flood risk and environmental risk:

- **At the Watershed and Neighourhood Scales** – It provides the City with a comprehensive framework that will guide the development and implementation of individual Integrated Master Drainage Plans over a multi-year period.
- **At the Subdivision Scale** – It provides land developers with direction in undertaking the stormwater component of sustainable urban design.

To illustrate the scope of the Manual, core aspects of its content are highlighted as follows:

- **Manage the Complete Spectrum of Rainfall Events** – The City's approach to stormwater management is evolving, from a reactive approach that only dealt with the consequences of extreme events, to one that is proactive in managing all 170 rainfall events that occur in a year. The objective is to control runoff volume so that watersheds behave as though they have less than 10% impervious area.

  Reducing runoff volume at the source – where the rain falls - is the key to protecting property, habitat and water quality.

- **5-Year Action Plan for Integration of Stormwater Management and Land Use Planning** – In 2000, Council accepted a *Process Flowchart and Timeline* for moving forward with master drainage planning. The Manual is a milestone step in that process. It identifies and organizes the actions that will be needed over the next 5 years to achieve the City's stormwater management objectives.

  Implementation of regulatory change should proceed on a phased-in basis, with the Integrated Master Drainage Plans providing a mechanism to study, test and adapt proposed regulations to suit the range of needs and conditions in Chilliwack.

- **Submission Requirements for Land Development Projects** – To provide clarity and conciseness regarding the City's expectations and requirements for subdivision design, the Manual defines the technical information that land developers must submit to the City in order to obtain development approvals. The Manual also includes *Design Guidelines* that illustrate how to comply with performance targets for stormwater source control, detention and conveyance.

  Having a comprehensive checklist will help proponents think through the drainage details of project implementation, and will ensure consistency in the way information is presented for review and evaluation by the City.

Section 1 - Context and Overview

1.1 Purpose of the Manual

The City of Chilliwack's *Policy and Design Criteria Manual for Surface Water Management* (hereafter referred to as 'the Manual') serves two purposes:

- provide a comprehensive framework that will guide the development of individual Master Drainage Plans over a multi-year period
- provide land developers with specific direction in undertaking the stormwater component of sustainable urban design.

In order to accomplish this, the Manual:

- Defines a drainage planning philosophy
- Formulates a set of supporting policy statements
- Establishes design criteria to achieve the policies

The Manual was undertaken as a case study application of *Stormwater Planning: A Guidebook for British Columbia,* a collaborative effort of the Federal and Provincial governments that was funded under the *Georgia Basin Ecosystem Initiative*.

The Manual content has been, and continues to be, tested and refined on the basis of Chilliwack-specific case study applications.

1.2 Content of the Manual

The Manual comprises seven Parts. The scope of each part is captured in a single sentence below:

- **Front End** – Summarize key information for City staff, elected officials and land developers
- **Part A – Community Planning and Development** - Assess risks and issues that might affect the future of the watersheds
- **Part B – Inventory of Surface Water Resources** – Describe the drainage basins and sub-basins that comprise the City's land base.
- **Part C – Stormwater Management Goals, Objectives and Policies** - Integrate stormwater management with land use planning.
- **Part D – Modelling Framework for Hydrologic and Hydraulic Simulation** – Select tools for modelling peak flow conveyance.
- **Part E – Guidelines for Design of Stormwater Management Systems** - Customize "alternative development standards" to mimic the natural hydrology.
- **Part F – Stakeholder Consultation** - Document the process for building community understanding and support for the project goal.

1.3 Process for Developing the Manual Content

Development of the manual content was a collaborative effort between City staff and the consultant team. The Manual content has been developed and vetted through an inter-departmental and inter-agency process that has also included community participation. This process included:

- a series of 6 working sessions with City staff and representatives from senior government agencies.
- working sessions with the Agricultural Commission and the Development Process Advisory Committee (DPAC).
- an open public meeting.

The direction of change in the City's approach to stormwater planning has been endorsed through all of these sessions. Part F of the Manual provides documentation of the manual development process.

1.4 Stormwater Management Innovation in the City of Chilliwack

The City of Chilliwack is addressing the root cause of drainage related problems – that is, land development alters the Natural Water Balance.

When natural vegetation and soils are replaced with roads and buildings, less rainfall infiltrates into the ground, less gets taken up by vegetation, and *more becomes surface runoff.* This causes channel erosion, flooding, loss of aquatic habitat, and water quality degradation. Thus, Chilliwack's approach to stormwater management is evolving:

- **from a reactive approach** that only 'deals with the consequences' of land use change, often at great public expense.
- **to a proactive approach** that also 'eliminates the root cause of problems' by reducing the volume and rate of runoff at the source.

Managing the Complete Spectrum of Rainfall Events

Chilliwack's stormwater management approach is to manage the complete spectrum of rainfall events, from the very small to the extreme (discussed further in Part E of the Manual). Figure 1-1 on the opposite page illustrates this approach. The operative words are *retain*, *detain,* and *convey*:

- ***Retain -*** The small rainfall events, which account for the bulk of the total rainfall volume, are to be captured and infiltrated (or reused) at the source.
- ***Detain -*** The intermediate events are to be detained and released to watercourses or drainage systems at a controlled rate.
- ***Convey –*** The extreme events are to be safely conveyed to downstream watercourses without causing damage to property.

Section 4 of this Manual front-end provides specific criteria and guidelines for designing drainage systems that perform these three functions.

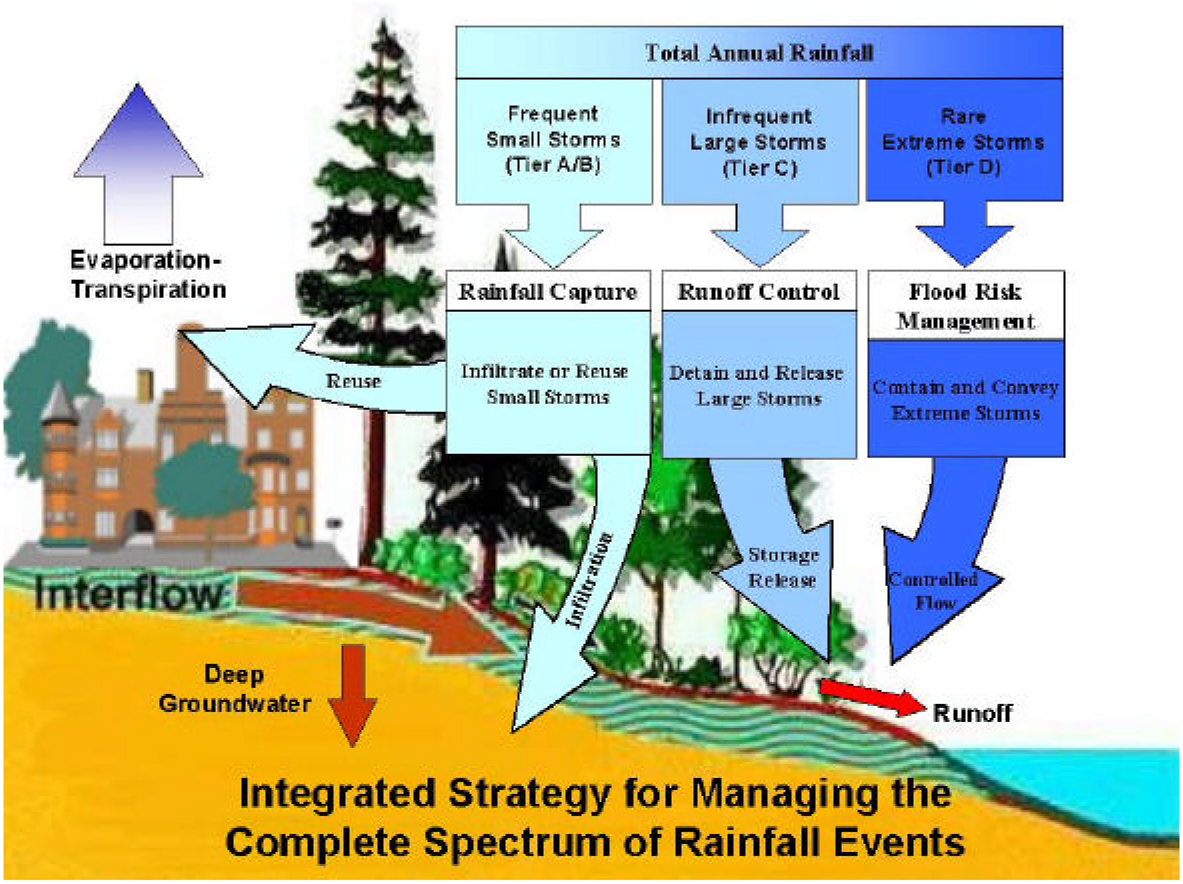


Figure 1-1

1.5 Blending Conventional and Progressive Drainage Practices

The key to avoiding aquatic habitat and water quality impacts AND protecting property, is *decreasing the volume of runoff that flows to streams*, thereby creating a situation that approximates the water balance of a naturally vegetated watershed. But conventional stormwater management practices, in many jurisdictions, have focused on managing peak flows (i.e. detention and conveyance) and neglected to mange runoff volumes (i.e. retention).

The City of Chilliwack has long been progressive in recognizing the need to manage runoff volume – for example, Chilliwack's *Subdivision and Development Control Bylaw 1995* states that all new development must restrict flows from the subdivision or development to pre-development volumes, and encourages infiltration of stormwater.

This Manual, which supercedes the *Subdivision and Development Control Bylaw*, provides further guidance regarding how to design on-site drainage systems that reduce runoff volume at the source (see Section 4). All the relevant design criteria for stormwater detention and conveyance have been incorporated from the Bylaw.

1.6 The Importance of Stormwater Source Control

Stormwater source control (e.g. infiltration facilities) is at the heart of Chilliwack's proactive approach to stormwater management. This Manual provides guidance for improving land development and stormwater management practices to incorporate source control.

The purpose of *stormwater source control* is to capture rainfall at the source (on building lots or within road right-of-ways) and return it to natural hydrologic pathways - infiltration and evapotranspiration - or reuse it at the source. Source control creates *hydraulic disconnects* between impervious surfaces and watercourses (or stormdrains), thus reducing the volume and rate of surface runoff.

The Manual defines **performance targets** and **site design criteria**, which provide City staff and developers with practical guidance for incorporating source controls into on-site drainage systems.

Local Case Study Experience

There are a number of development projects in the City of Chilliwack where source controls have been or will be applied. Practical experience and performance data from these *demonstration projects* will enable constant improvement to land development and stormwater management practices.

The primary objective of this constant improvement process is to reduce stormwater related costs while still achieving the defined goals for protecting downstream property, aquatic habitat, and receiving water quality.

The City of Chilliwack is taking a leadership role in the application of stormwater source controls, but the City is not alone. Municipalities in the Greater Vancouver Regional District, for example, are also beginning to embrace a source control philosophy as a central element of integrated stormwater management.

Effectiveness of Rainfall Capture

A report on the *Effectiveness of Stormwater Source Control* was recently prepared for the Greater Vancouver Regional District. This report provides a quantitative reference on the effectiveness of applying various categories of stormwater source controls to achieve rainfall capture objectives, including:

- **absorbent landscaping**
- **infiltration facilities (on lots and along roads)**
- **green roofs**
- **rainwater re-use.**

The GVRD report presents graphs of soil/water/vegetation inter-relationships, and develops performance curves for both runoff volume reduction and runoff rate reduction.

Application of the Water Balance Model

The information in the GVRD report is available to the City, and can complement the Manual in terms of helping City staff and developers determine:

- which source control options are worth pursuing for different land use types and soil types, and
- what can realistically be achieved through the application of source controls.

The GVRD source control evaluation project has resulted in a decision support tool named the Water Balance Model. It provides an interactive and transparent means for municipalities to evaluate the potential effectiveness of stormwater source controls in a watershed context, and to evaluate source control design options at the site level. This model is available to the City, and has been applied to establish the City's design criteria for infiltration facilities (see Section 4.3). Refer to Part E of the Manual for further information.

Section 2 - Stormwater Management Goal and Objectives

The City of Chilliwack's drainage planning philosophy is summarized below. The goal and supporting objectives have evolved through the inter-departmental and inter-agency process.

Stormwater Management Goal
(for all watersheds in Chilliwack)

Implement integrated stormwater management that maintains or restores the water balance and water quality characteristics of a healthy watershed, manages flooding and geotechnical risks to protect life and property, and improves fish habitat values over time.

Stormwater Management Objectives

1. To manage development to maintain stormwater characteristics that emulate the pre-development natural watershed.

2. To predict the cumulative stormwater impacts of development and to integrate this information with other economic, land use and sustainability objectives and policies when considering land use change.

3. To regulate watershed-specific performance targets for rainfall capture, runoff control, and flood risk management during development, and to refine these targets over time through an adaptive management program.

4. To identify, by example and pilot studies, means of meeting the performance targets by application of best management practices, and to remove barriers to use of these practices.

5. To support innovation that leads to affordable, practical stormwater solutions and to increased awareness and application of these solutions.

These goals and objectives reflect the need for flexibility to account for variability in local conditions, and emphasize the importance of *demonstration projects* to prove the effectiveness of new approaches.

Each of the above stormwater management objectives is supported by a set of policies, presented in Part C of the Manual.

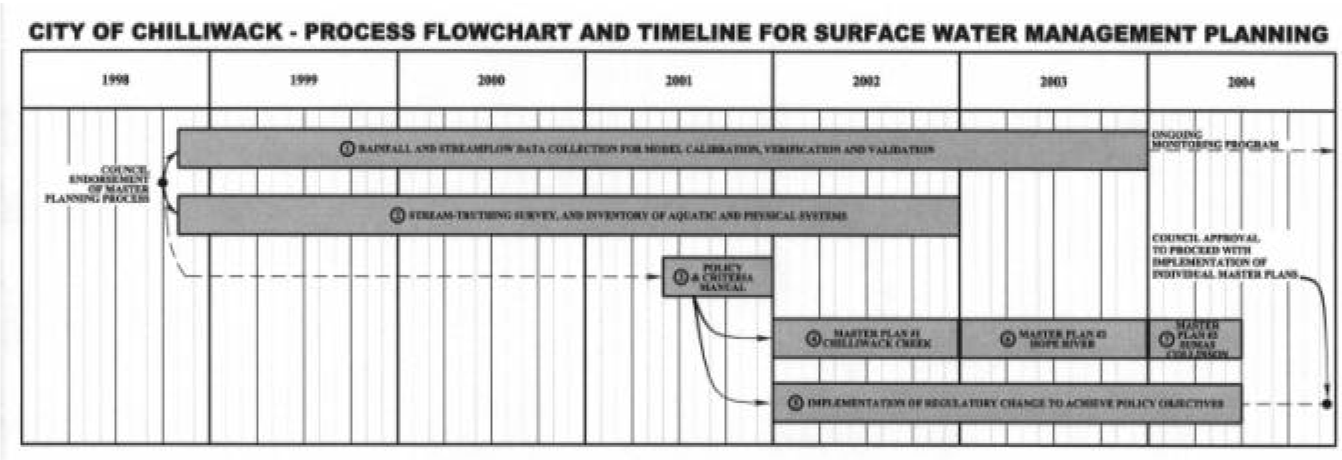
Section 3 - Action Plan

3.1 Timeline for Implementation

The actions that will be needed over the next 5 years to achieve the City's stormwater management objectives are listed in Table 3-1. Also listed are: the department to take the lead role for implementing each action, department(s) that will play supporting roles, and potential funding sources.

The Action Plan condenses the majority of the actions into the first three years (2002 to 2004). By the end of Year 2004, integrated stormwater management would be in full swing in the City of Chilliwack. The years 2005/2006 then provide a chance to review the early effectiveness of the new approaches. If necessary, early fine-tuning of bylaws and approaches could be made, in a truly adaptive management arrangement.

This general schedule conforms with the *Process Flowchart and Timeline for Surface Water Management Planning* that has been accepted by Council (shown below). Implementation of regulatory change would proceed on a phased-in basis, with the master drainage plans providing a mechanism to study, test and adapt proposed regulations to the various conditions in Chilliwack. At the end of the process, surface water regulatory certainty that is appropriate to Chilliwack should be achieved.



Year	Focus
2002	Removing Barriers
2003	Training/Public Awareness
2003	Implementing Actions
2005 / 2006	Review and Adjust Action Plan

The focus for each year of the 5-year Action Plan is summarized on the adjacent table and described on the pages following Table 3-1.

3.2 Year 2002 Focus: Removing Barriers

The Action Plan begins with Council adoption of the Manual.

Information materials – both introductory and technical – will need to be created to show how to incorporate low impact stormwater management into development. This information will be needed not just for staff, but also for the development community, Council and the public at large.

To look for ways to reduce pavement, runoff, pollution and development costs, a review of riparian policies, parking and road standards, and other existing standards that affect stormwater will need to be undertaken.

Administrative arrangements will also have to be designed for stormwater funding, approval systems, and intergovernmental cooperation towards one-window approvals.

Chilliwack Creek Master Plan

A fundamental concept behind the Year 2002 Action Plan is to use the first master drainage plan (Chilliwack Creek) as a pilot Integrated Stormwater Management Plan (ISMP). This applied planning process will test coordinated stormwater, riparian, flood protection and parks policies, and the related administrative systems.

If barriers to implementation of Low Impact Development are found in existing bylaws or procedures, they will be brought to Council to consider ways to remove the barrier.

3.3 Year 2003 Focus: Training / Public Awareness

Low Impact Development can involve many techniques that are familiar (forgotten?) and some that are new. It is very important for staff and the development community to be comfortable and knowledgeable about these techniques prior to making them requirements of development.

To address this need for ‘time and knowledge to adjust’, the Year 2003 focus is on Training and Public Awareness about the new expectation and techniques.

Leading by Example

To make learning practical and applied, developers who will voluntarily create demonstration projects on Low Impact Development should be encouraged. City public works (and senior governments too) should lead by example.

A Low Impact Awards Program could recognize and publicize leadership in getting better development underway.

Environmental Monitoring Program

There is a need to provide an Early Warning System to identify potential aquatic ecosystem degradation. To support this, Year 2003 should initiate baseline environmental monitoring for indicators of water quality and ecological performance. Collection of this baseline data would allow comparison of data collected in future years to ensure that the Surface Water Policy is working, and to allow for adjustments if necessary.

Table 3-1: 5-Year Action Plan for Stormwater Management in the City of Chilliwack

	Projects	Lead Role	Support Role	Potential Grants
Priority	**Year 2002 Focus: Removing Barriers**			
1	Adopt Policy and Design Criteria Manual	MD – Land Devel.	Engineering	
	Create Introductory and Technical Low Impact Development / BMP Information Materials – print / web / video	MD – Land Devel.	Consultants	Collaborate with Munis / Agencies
	Review and Update Riparian Policies	MD - Planning	Parks/Engineering	MWLAP, DFO
	Review and Update Road / Parking Standards	MD - Planning	Engineering	MCAWS
	Design overall Environmental Monitoring program	MD – Land Devel.	Engineering	EC
	Complete Intergovernmental Cooperation Agreement for one-window approvals	MD – Land Devel.	MD - Planning / Engineering	MWLAP, DFO, LRC
	Design Stormwater Funding and Administrative Mechanisms	MD – Land Devel.	Finance	
	Update subdivision / building bylaws to allow (but not require) Low Impact Development / BMPs and new administrative approaches.	MD – Land Devel.	Engineering	
	Complete the Chilliwack Creek Watershed Plan as a pilot ISMP to integrate stormwater, riparian, flood protection, and parks policies as well as related administrative and monitoring systems.	MD – Land Devel.	Engineering / Parks / MD - Planning / Finance	
2	**Year 2003 Focus: Training / Public Awareness**			
	Train staff / developers / builders / NGOs on Low Impact Dev. / BMPs	MD – Land Devel.	Consultants	Collaborate
	Complete Low Impact demonstration projects	Developers	City of Chilliwack	MWLAP, DFO
	Create a Low Impact awards program	MD – Land Devel.	MD - Planning	MWLAP, DFO
	Adopt Stormwater Funding and Administrative Mechanism	MD – Land Devel.	Finance	
	Design Low Impact bylaws and development permits (to include single family development) and undertake public / stakeholder review	MD – Land Devel.	MD - Planning	MCAWS
	Implement Environmental Monitoring program (baseline conditions)	MD – Land Devel.		MWLAP, DFO, EC

	Projects	Lead Role	Support Role	Potential Grants
	Complete the Hope Slough Watershed Plan as an ISMP to integrate stormwater, riparian, flood protection, and parks policies, and to customize them to that watershed.	MD – Land Devel.	Engineering / Parks / MD - Planning	
3	**Year 2004 Focus: Implementing Actions**			
	Adopt BMP requirement bylaws (including single family development)	MD – Land Devel.	MD - Planning	
	Adjust the scope of Development Permits to meet the City's riparian protection policy.	MD – Land Devel.	MD - Planning	
	Complete the Sumas/Collinson Watershed Plan as an ISMP to integrate stormwater, riparian, flood protection, and parks policies, and to customize them to the remaining watersheds.	MD – Land Devel.	Engineering / Parks / MD - Planning	
4/5	**Year 2005/2006 Focus: Review & Adjust Action Plan**			
	Review monitoring data, re-evaluate design criteria, review ISMP effectiveness, and identify gaps in data	MD – Land Devel.	Consultants	MWLAP, DFO
	Review the status / success of the Action Plan	MD – Land Devel.	Consultants	MWLAP, DFO
	Prepare an updated 5-year Action Plan	MD – Land Devel.	Consultants	MWLAP, DFO
	Refine Development Permits and other implementation tools	MD – Land Devel.	MD - Planning	MCAWS
	Refine Intergovernmental Agreement, Funding and Administration	MD – Land Devel.	Finance	MWLAP, DFO, LRC

MD = Municipal Development

Hope Sloough Master Plan

A major part of the Year 2003 Action Plan is the completion of an ISMP (integrated master drainage plan) for the Hope Slough Watershed. This second plan in a series will incorporate lessons learned from the Chilliwack Creek Plan in Year 2002.

It is also quite possible that some Low Impact approaches that may be appropriate in one part of Chilliwack may not be advisable in other areas (e.g. due to soil conditions, terrain, geotechnical or environmental issues). Therefore, the emphasis of the Hope Slough ISMP will be to look at what can be standardardized across the City, and what must be area-specific.

3.4 Year 2004 Focus: Implementing Actions

In Year 2004, existing bylaws would be revised and reviewed in a public stakeholder process to bring in the requirement for the Low Impact Development approaches where they are appropriate. This regulatory approach is necessary, eventually, to 'level the playing field' so that all builders are meeting the same standard in the marketplace. The details of these bylaws need to respect both economics of development and the public good.

Sumas/Collinson Master Plan

The final ISMP (integrated master drainage plan) will also be completed in Year 2004, for the remaining area in Chilliwack (Sumas, Collinson). This plan will incorporate lessons learned from the Chilliwack Creek and Hope Slough Plans.

3.5 Year 2005 / 2006 Focus: Review and Adjust Action Plan

In Year 2005 and 2006, the Surface Water Policy will have been implemented, and the emphasis will move to monitoring and adjustments.

It is important to create a public understanding that changes may be needed to respond to new technology, improved understanding, and senior government policy that can change very quickly. Therefore, some adjustments in local government standards and approaches are to be expected from year to year.

If good data from watercourses on both flows and water quality has been collected in previous years, there will be the opportunity to compare data from Year 2005 or 2006 to measure progress. This scientific feedback allows for either relaxing or tightening the program as needed to meet objectives – thus allowing a measure of 'cost / benefit' reality.

The five year review should extend to administrative systems as well, including the relationship with senior agencies.

An Action Plan for the second five years of the Surface Water Program would ensure effective organization into the future.

3.6 Framework for Master Drainage Planning

Master drainage planning in the City of Chilliwack will comprise 3 nested levels of plans, which become increasingly focused and more detailed.

The Integrated Master Drainage Plans (MDPs) for the City's three major watersheds (Chilliwack Creek, Hope Slough, and Sumas/Collinson) will develop solutions at the *watershed* and *sub-watershed* levels, and prioritize effort for functional planning at the *catchment* level.

The focus of each of these levels is summarized below. Table 3-2 provides further details regarding the scope of work at each of these levels.

Planning Level	Type of Plan	Focus
Watershed	Strategic Plan (Integrated MDPs)	Provide a watershed overview, focus level of effort, and prioritize sub-watersheds.
Sub-Watershed		Develop Integrated Solutions for protecting property, aquatic habitat and water quality.
Catchment	Functional Plan	Complete pre-design to work through the 'how to' details of implementing the Integrated Solutions.

Terminology

Master Drainage Plan (MDP) and *Stormwater Management Plan (SMP)* have tended to be used interchangeably in British Columbia over the past 20 to 25 years. The City of Surrey, for example, continues to use the term MDP. The term SMP became popular in the late 1970s as "management" became a catch-phrase for all infrastructure planning activities. The basic engineering approach did not materially change. Typically, an MDP was the "flows-and-pipes" risk management product resulting from a stormwater management strategy.

Integrated, ecosystem-based and watershed-based are terms that came into vogue at the end of the 1990s, and are interchangeable. This change in terminology reflects the broadening of the traditional MDP process to encompass environmental risk management. As a result, *Integrated Stormwater Management Plan (ISMP)* has gained widespread acceptance as the terminology of choice in British Columbia.

Integrated Stormwater Management recognizes the relationships between the Natural Environment and the Built Environment, and manages them as integrated components of the same watershed.

In the City of Chilliwack, "Integrated MDP" and "ISMP" are interchangeable terms.

Hierarchy of Products

Watershed drainage systems typically comprise primary, secondary, and tertiary channels and facilities.

The focus of watershed and sub-watershed planning is on primary and secondary watercourses and drainage facilities (e.g. major culvert installations).

The focus of catchment planning is on the tertiary drainage channels and facilities (e.g. minor culvert installations).

At the 'watershed and sub-watershed level', the three Integrated MDPs (i.e. ISMPs) will integrate stormwater management with land use planning to protect life, property and natural systems. This means that Integrated MDPs comprise component plans that provide specific direction for:

- Flood Risk Management - to protect life and property
- Environmental Risk Management - to protect natural systems

At the 'catchment level', the MDP recommendations will be translated into highly detailed implementation plans for drainage system improvements.

Table 3-2 Scope of Work for Master Drainage Planning

At the Watershed Level	Determine where in the watershed to concentrate investigative effort. Identify critical reaches of the main channels, including reaches where: - there are existing drainage problems (e.g. flooding, channel erosion). - there are significant aquatic resources to be protected. - land use change (either new development or re-development) is likely to cause future drainage problems or degradation of aquatic resources. Undertake hydrologic and hydraulic modelling (using MOUSE, as discussed in Part D) to generate flows at control points on the main channels, under existing conditions and future development conditions. Identify needs and establish priorities for upgrading of primary (major) drainage facilities, and enable operating rules to be developed for pump stations.
At the Sub-Watershed Level	Identify critical reaches of secondary channels, and establish priorities for upgrading of secondary drainage facilities and/or construction of new facilities. This will focus the level of effort at the catchment level. Evaluate the impact of future land use change (new development and re-development) to identify: - the potential need for future improvement of drainage facilities. - the opportunity to reduce channel erosion and restore stream health by applying source controls to future development/re-development projects. Develop coarse level soils maps to show where infiltration could be an effective in achieving runoff reduction targets.
At the Catchment Level	Refine the details relating to implementation of solutions identified at the watershed and sub-watershed levels. Complete the preliminary engineering for proposed drainage facilities. Undertake peak flow modelling using a relatively simple hydrologic/hydraulic model (OTTHYMO) to assess the impact of future development in catchments that drain into critical reaches (identified at the previous two levels). This will enable an assessment of: - the need to improve the conveyance capacity of tertiary drainage facilities and/or implement other mitigation measures (e.g. off-site detention facilities). - appropriate development cost charges to be imposed on developers.

Section 4 - Design Guidelines for Drainage Systems

4.1 Introduction

This section provides specific criteria and guidelines for designing drainage systems that meet the City of Chilliwack's performance targets for stormwater retention, detention and conveyance (see Section 4.2 below).

Design criteria from the drainage section of Chilliwack's old *Subdivision and Development Control Bylaw* are incorporated into this section. These criteria have been complemented with further guidance regarding how to implement stormwater source controls (i.e. retention).

Specific design criteria for drainage systems are presented in two separate sections:

- **Section 4.3 - Rainfall Capture and Runoff Control Criteria** – Guides developers through the process of designing the retention and detention components of drainage systems. This section includes a methodology for sizing infiltration facilities, and requirements for performance monitoring. This section consists mostly of new guidelines and criteria.
- **Section 4.4 – Peak Flow Conveyance Criteria –** Provides criteria for conveyance of peak flows within development sites, and for discharge of peak flows to existing City drainage infrastructure. These criteria are extracted from the old Development Control Bylaw, and edited for consistency with Manual.

Standard drawings are provided for some stormwater system components (see Section 4.5), however there is a need to develop standard drawings for stormwater source controls (e.g. infiltration facilities). Note that this task fits under one of the key Action Plan items for 2002 - *Create Low Impact Development / BMP Information Materials.*

4.2 Performance Targets

All new development projects in the City of Chilliwack must incorporate stormwater management systems that meet the following Performance Targets:

- **Rainfall Capture (retention) -** Capture the first 30 mm of rainfall per day and restore it to natural hydrologic pathways by promoting infiltration, evapo-transpiration or rainwater reuse.
- **Runoff Control (detention) -** Detain the next 30 mm of rainfall per day and release to drainage system or watercourses at natural interflow rate.
- **Flood Risk Management (conveyance) -** Ensure that the stormwater plan can safely convey storms greater than 60 mm (up to a 100-year rainfall).

> A stormwater system on a development site that meets the above targets would include:
>
> - Source controls (e.g. infiltration facilities) on building lots and roads that overflows to a detention facility (e.g. pond) about 6 to 8 times per year.
> - A detention facility (or facilities) that would overflow once per year, on average.
> - A stormwater conveyance system that can safely convey runoff from extreme storms to the outlet of the development site.

Figure 4-1 Methodology for Developing Performance Targets and Design Criteria for Stormwater Systems

Step #1 – The City of Chilliwack has compiled a rainfall database comprising both long-terms and short-term climate stations

Step #2 – This has enabled characterization of the rainfall distribution pattern

Tier A/B Storms	Tier C Storms	Tier D Storms
less than 50% MAR (1)	50% MAR to MAR (1)	> MAR (1)
= up to 30 mm	= 30 to 60 mm	= greater than 60 mm

Step #3 – Performance targets have been established for managing the complete spectrum of rainfall events

Rainfall Capture (runoff volume reduction)	Runoff Control (runoff rate control)	Flood Risk Management
Capture the first 30 mm of rainfall per day at the source and restore to natural hydrologic pathways (infiltration, evapo-transpiration, or reuse)	Detain the next 30 mm of rainfall and release to storm sewers or streams at natural interflow rate (2)	Ensure that the stormwater infrastructure can safely convey storms greater than 60 mm

Step #4 – Performance targets have been translated into design criteria for application at the site level

Rainfall Capture (retention facilities)	Runoff Control (detention facilities)	Flood Risk Mgmt (conveyance facilities)
❑ Capture 300 m^3 of rainfall per hectare of impervious area ❑ infiltrate at the natural percolation rate of local soils, and/or ❑ reuse within the development site	❑ Provide an additional 300 m^3 of *detention* storage per hectare of impervious area(3) ❑ release to storm sewers or streams at a rate of 1 Lps per ha(2)	❑ Provide 'escape routes' for extreme storms ❑ Ensure that these routes are both hydraulically adequate *and* physically adequate

Notes: (1) MAR is the site-specific 'mean annual rainfall' for a 24-hour duration (see Figure 4-2 on the following page).

(2) This natural interflow rate was determined based on streamflow data from undeveloped drainage catchments on the Eastern Hillsides

(3) Release rates are not subtracted from detention storage volumes. This builds in a safety factor to account for back-to-back large rainfall events. Performance monitoring on *demonstration projects* may demonstrate that the safety factor may not be needed in future projects.

Methodology

Figure 4-1 is a flowchart that summarizes the 4-step methodology for developing stormwater design criteria. This shows how performance targets relate to:

- design criteria that can be applied at the site level
- The Chilliwack-specific Mean Annual Rainfall (MAR)

Referencing the Performance Targets to the MAR provides consistency with criteria that became accepted practice in the late 1990s. Note that a rainfall event with a magnitude that is equal to 50% of the MAR corresponds to what some jurisdictions describe as the '6-month storm', a somewhat abstract concept. MAR is a more practical definition.

Mean Annual Rainfall

Figure 4-2 below shows how the MAR is determined through a statistical analysis of long-term data.

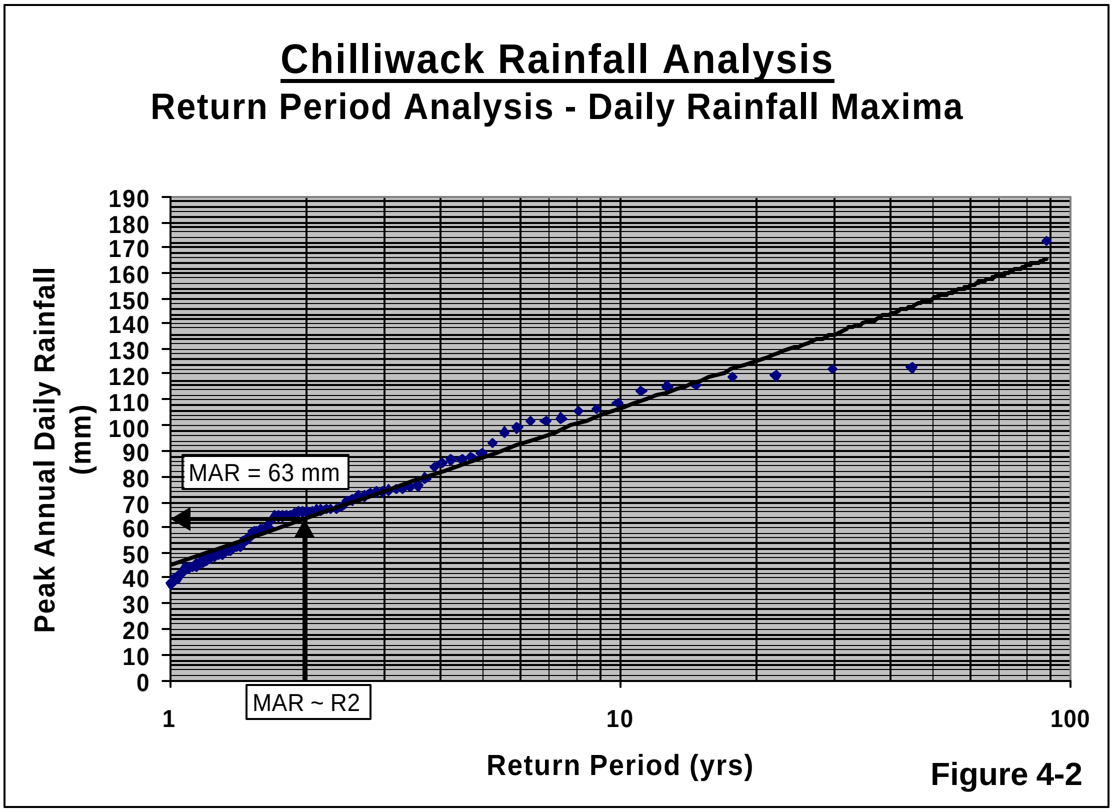


Figure 4-2

The MAR values for a 24-hr duration at the three long-term rainfall stations in the Chilliwack region are:

- Chilliwack = 63 mm (shown above)
- Agassiz = 60 mm
- Sardis = 55 mm

Therefore, *the regional MAR for Chilliwack is 60 mm* (over 24 hrs). This is the value used in Figure 4-1.

Distribution of Rainfall Over a Year

Figure 4-3a and 4-3b illustrate the average annual distribution of rainfall relative to the three tiers defined in Figure 4-1. Note that most of total rainfall is to be retained at the source, and relatively little rainfall is to be conveyed to the outlet of a development site.

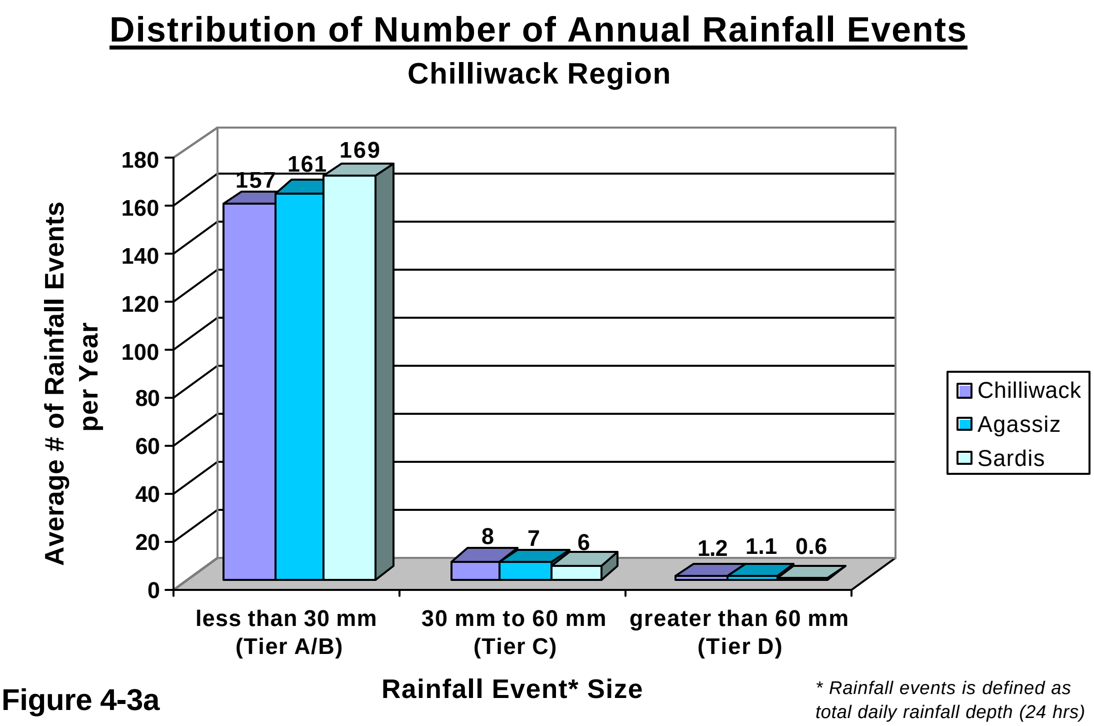


Figure 4-3a

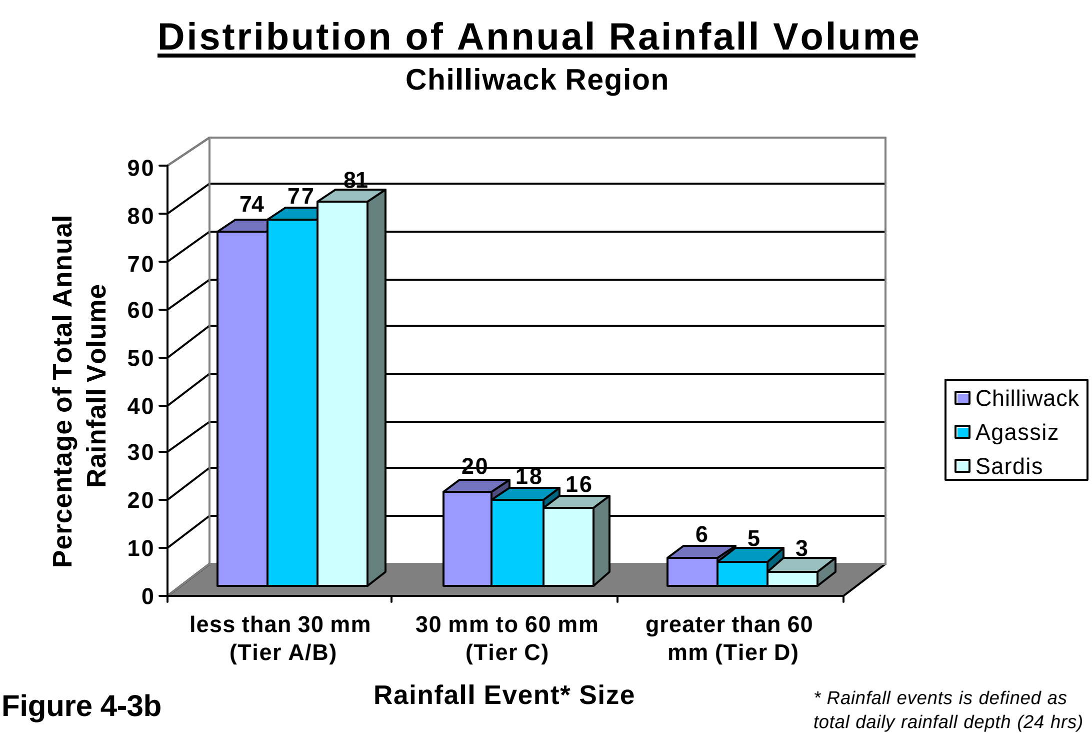


Figure 4-3b

4.3 Rainfall Capture and Runoff Control Criteria

Infiltrate and Detain

This section presents the methodology for designing infiltration and detention systems that meet the City's performance targets for rainfall capture and runoff control (see Section 4.2). This Section also specifies performance monitoring requirements.

For the step-by-step procedure that is to be followed by Developers, refer to the forms on the following pages. These include:

- **Form 1 - Development Site Summary Characteristics**
- **Form 2 – Design of Infiltration Facilities.** This form includes the following attachments:
  - **Attachment 2a - Determining Infiltration Area**
  - **Attachment 2b - Illustration of Design Parameters for Infiltration Facilities**
- **Form 3 – Design of Detention Facilities**
- **Form 4 – Performance Monitoring Requirements**.

Note that Figure 4-4 on the page opposite illustrates the relationship between infiltration area and hydraulic conductivity of soil.

Also note that Figure 4-5 on the page following illustrates the *Flowchart for Comprehensive Performance Monitoring*. One objective of performance monitoring is to provide a picture of how water moves through a drainage system, from rooftop to receiving water body.

The design of infiltration facilities (or other source controls) and detention facilities must be integrated into a comprehensive drainage plan for land development projects (see Section 5), and approved by the City.

Other Source Control Strategies

The most appropriate source control options for any given development site will depend on site-specific conditions, such as soil type, land use type, rainfall, and groundwater characteristics.

Figure 4-4 shows that the amount of space required to meet rainfall capture targets using infiltration becomes very high when the hydraulic conductivity of soils is low (less than about 5 mm/hr). Where the permeability of local soils prohibits effective infiltration, alternative source controls may be required to meet the City's performance targets. Combinations of source controls can also be applied.

Source control strategies other than infiltration facilities that can be used to meet the City's rainfall capture targets could include:

- capturing rainfall for reuse (indoor greywater uses and/or irrigation).
- applying *green roofs* to residential buildings, commercial buildings or parkades.

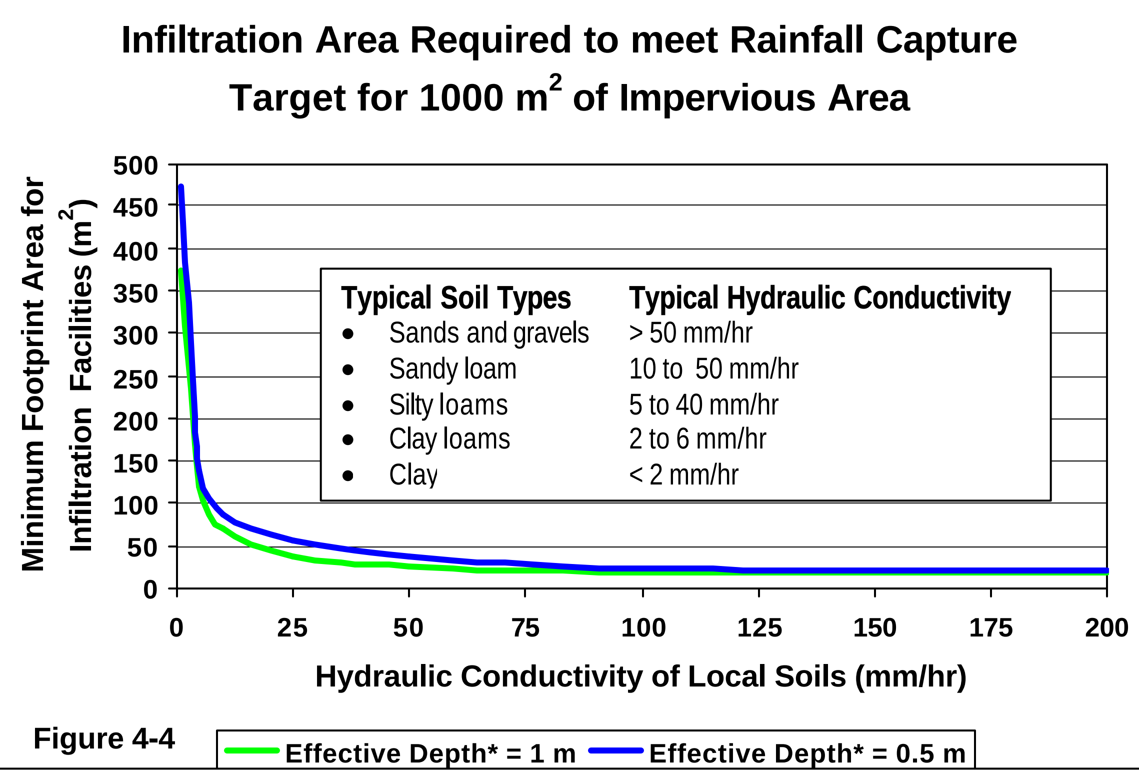


Figure 4-4

* Note: effective depth of an infiltration facility = (design depth, D) x (void space storage, VS) where,

- D = the distance from the bottom of the facility to the maximum water level/overflow level).
- VS = the ratio of the volume of water retained per unit volume of the infiltration facility.

Void space storage for different types of infiltration facilities is summarized below

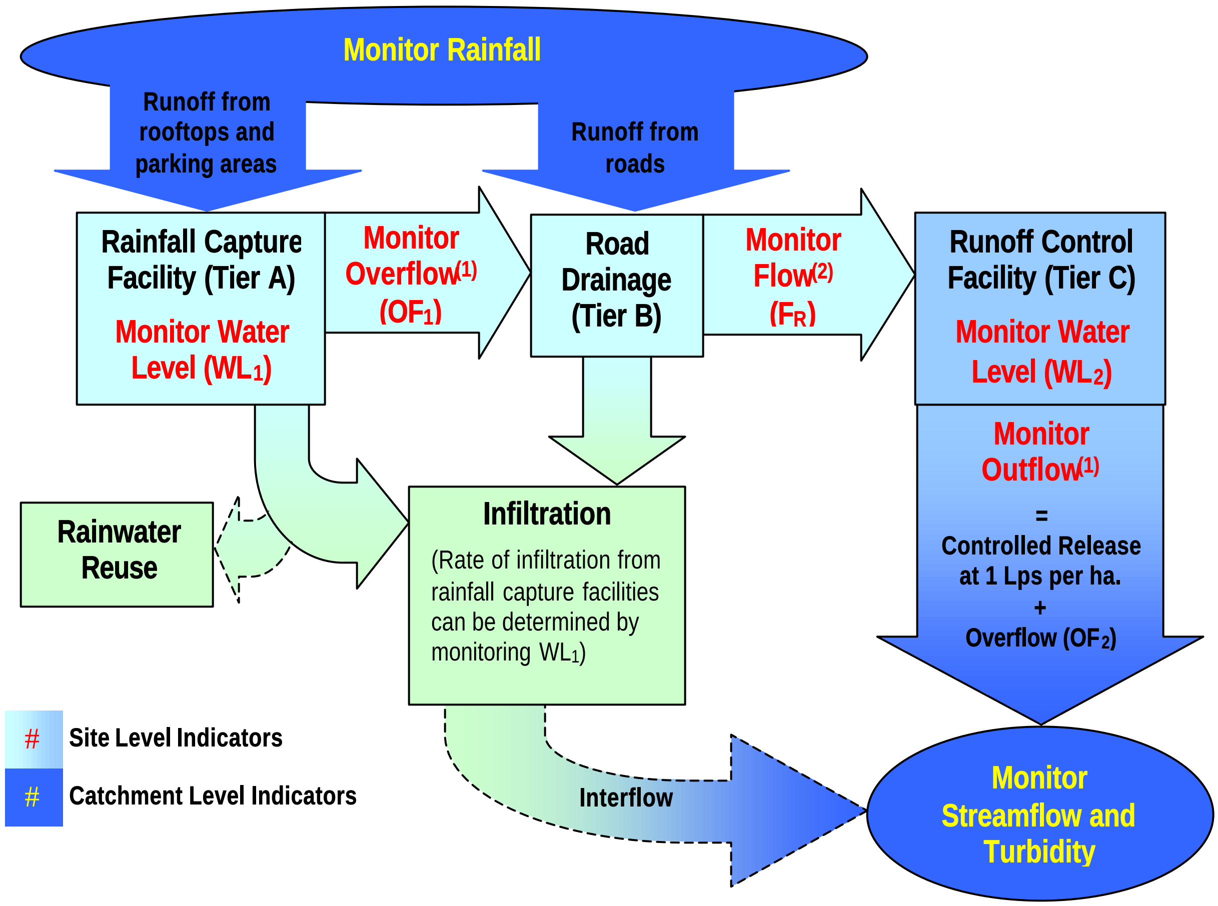
- for retention ponds, VS = 1
- for soakaways (storage in drain gravel), VS = 0.33
- for infiltrator chambers (storage in sub-surface chambers & surrounding drain gravel), VS = 0.55
- for bioretention facilities (storage in absorbent soil), VS = 0.2

A design table corresponding to Figure 4-4 is provided with the following design forms (see Table A in Attachment 2a). Developers can use this table to size any type of infiltration facility.

Soil conditions govern the feasibility and affordability of using infiltration facilities to meet rainfall capture targets. Hence, it is important to consider soil conditions at the planning level as well as the site design level. Chilliwack's Integrated MDPs will provide coarse level soils mapping to provide City staff and Developers with guidance regarding where infiltration makes sense and where other source control options need to be considered.

This soils mapping will be a planning tool. Soil investigations and percolation testing on individual development sites is still needed to design infiltration facilities.

Figure 4-5 Flowchart for Comprehensive Performance Monitoring



(1) Compound weir outlet structures will enable overflow from Rainfall Capture Facilities and outflow from Runoff Control Facilities to be correlated with water levels (WL_1 and WL_2, respectively). Overflow from Runoff Control Facilities (OF_2) can be determined by subtracting controlled release (a known parameter) from outflow.

(2) There may be more than one road drainage pathway to monitor (e.g. an overflow pipe in an infiltration trench plus an overflow catch basin connected to a storm sewer). The amount of road runoff that infiltrates can be determined by subtracting F_R from total road runoff (and accounting for OF_1).

Indicator	OF_1	OF_2	Road Drainage	Streamflow
Performance Targets	➢ **Total overflow volume** should be about 10% of total runoff volume. ➢ **The frequency of overflows** should be about 6 to 8 times per year, on average.	➢ **Total overflow volume** should be about 3% of the total runoff volume. ➢ **The frequency of overflows** should be about once per year, on average.	➢ **total flow in the road drainage system** should meet the volume and frequency targets (3) for OF_1 or OF_2	➢ **The pre-development hydrograph** should be maintained in downstream watercourses.

(3) If the design objective for roads is to provide rainfall capture, then the targets for OF_1 would apply. If the design objective is to make roads 'self-mitigating' (i.e. provide rainfall capture *and* runoff control), then the targets for OF_2 would apply. Note that storage does not need to be provided in Runoff Control Facilities for Self-Mitigating Roads.

Form 1 – Development Site Summary Characteristics

<table>
<tr>
<td>

Total development site area:

- **A_{total}** = ________ ha

Minimum hydraulic conductivity of on-site soils (from on-site percolation testing):

- **H** = ________ mm/hr

Total impervious area on development parcels (excluding green roofs, see note below):

- **$IA_{on\text{-}lot}$** = ________ ha

Total impervious area on roads (excluding pervious paving, see below):

- **IA_{road}** = ________ ha

Total impervious area on development site

- **$IA_{total} = IA_{on\text{-}lot} + IA_{road}$** = ________ha

Total pervious area on development site

- **$PA_{total} = A_{total} - IA_{total}$** = ________ha

see criteria for absorbent landscaping below

</td>
<td>

Site and Key Plan

To be included as an attachment. Refer to Section 5 for details of submission requirements

</td>
</tr>
</table>

Criteria for Absorbent Landscape

The design guidelines presented in Forms 2 and 3 are based on *impervious areas only*.

On-site pervious areas must be 'self-mitigating' (i.e. meet rainfall capture and runoff control targets). In order to achieve this:

- ❑ **Minimum depth of absorbent soil* for on-site pervious area = 300 mm**

  * must meet *BC Landscape Standard* for medium or better landscape. The range of acceptable soil textures is shown below:

Lightest Soil:	Heaviest Soil:	Typical Design Soil:
Sand 90%	Sand 55%	Sand 75%
Silt/Clay 5%	Silt/Clay 25%	Silt/Clay 15%
Organic Matter 5%	Organic Matter 20%	Organic Matter 10%

Form 2 – Design of Infiltration Facilities

Rainfall capture target: capture and infiltrate 300 m³ of rainfall per day per impervious hectare

Infiltration facilities are to be provided as follows:

- On individual development parcels to capture runoff from rooftops and parking areas (e.g. by means of on-lot soakaways)
- Within road right-of ways to capture runoff from paved roadway (e.g. by means of roadside infiltration trenches)

Sizing Infiltration Facilities (applies for both development parcels[1] and roads)

1) *Select Facility Type[2]:*

- ❑ ***Type A** – 100% void space storage (e.g. retention pond)*
- ❑ ***Type B** – 33% void space storage (e.g. soakaway pit filled with drain rock)*

2) *Select Design Depth,* **D**[(2)] *(i.e. distance from bottom of infiltration facility to the maximum water level/overflow)*

D = ______ m

2) *Determine Minimum Footprint Area,* **A**[(2)] *(i.e. bottom area) needed to meet rainfall capture target*

$\mathbf{A_{min}}$ = ____ m^2 (**from Attachment 2a, *use Table A for Type A Facilities and Table B for Type B Facilities***)
x (_____ m^2 of IA served by the facility)/1000

(1) A typical facility size may be developed for multiple lots that have similar soil characteristics and similar amounts of IA.

(2) Refer to Attachment 2a for procedure to size other facility types.

(3) Attachment 2b illustrates these design parameters.

Conveyance of Overflow from Infiltration Facilities

Overflow from infiltration facilities (On-Lot and On-Road) should be conveyed into runoff control facilities (refer to Form 3) via a stormwater drainage system, most likely within the road ROW. Road drainage may consist of:

a) a perforated pipe *at the top* of an infiltration trench
b) a catch basin connected to storm sewer pipe
c) a surface swale

Providing Additional Detention Storage in Infiltration Facilities (Optional)

Increasing the dimensions of Infiltration Facilities (whether they are on 'On-Lot' or 'On-Road') above the minimum requirement (i.e. $A > A_{min}$) reduces the storage volume that must be provided in off-lot Runoff Control Facilities (refer to Form 3).

The amount of *Detention Volume* provided by On-Lot and On-Road facilities can be calculated as follows:

- ❑ $\mathbf{V_{on\text{-}site}}$ **=** **[**Facility depth **(D)** x Footprint Area **($\mathbf{A_{actual}}$)] – [D** x $\mathbf{A_{min}}$**] =** ____ m^3

The total *Runoff Control Volume* provided by all On-Lot and On-Road facilities **(**S $\mathbf{V_{on\text{-}site}}$**)** can then be subtracted from community detention requirements (refer to Form 3)

Attachment 2a - Determining Infiltration Area

Developers are to undertake comprehensive percolation testing of their properties to characterize the hydraulic conductivity of the site. For a given depth, storage type and hydraulic conductivity, the required 'footprint area' can be selected from the tables below. The design values presented are preliminary and subject to future refinement.

Required Footprint Area (in m^2) for Infiltration Facilities (per $1000m^2$ of impervious area served by the facility)

Table A(1) - For Type A Rainfall Capture Facilities (100% Void Space Storage)

Depth of Rainfall Capture Facility(2)	Hydraulic Conductivity of On-Site Soils(3) (mm per hour)					
	1	**5**	**10**	**25**	**50**	**> 100**
0.25 m	575	175	125	75	50	30
0.5 m	475	140	90	55	40	25
1 m	375	120	70	40	30	20
1.5 m	335	110	65	35	25	15
2 m	305	100	60	30	20	15

Table B - For Type B Rainfall Capture Facilities (33% Void Space Storage)

Depth of Rainfall Capture Facility(2)	Hydraulic Conductivity of On-Site Soils(3) (mm per hour)					
	1	**5**	**10**	**25**	**50**	**> 100**
0.25 m	725	300	200	110	70	40
0.5 m	620	210	150	90	55	35
1 m	540	155	105	65	45	30
1.5 m	475	140	90	55	40	25
2 m	425	130	80	50	35	20

NOTES:

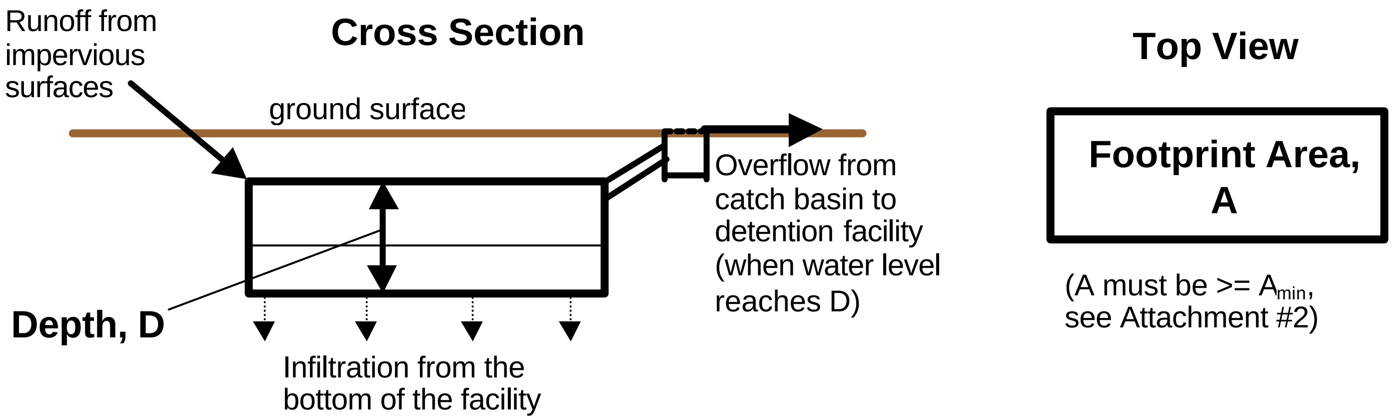
(1) For other types of facilities, calculate depth (**D**) as the *effective depth* = [actual depth] x [void space storage], and refer to Table A above. (e.g. For 1.5 m of absorbent soil depth, **D** = [1.5 m] x [0.2] = 0.3 m. For 1.5 m of absorbent soil with 0.3 m of ponding on the surface, **D** = 0.3 m + 0.3 m = 0.6 m.)

(2) Refers to the depth from the bottom of the facility to the top (the level where overflow occurs). Depths for rainfall capture facilities must be selected based on site-specific characteristics and constraints. The feasible depth may be governed by depth to the water table or to bedrock, especially for sub-surface facilities. For surface facilities feasible depth may be governed by safety or aesthetic considerations.

(3) Based on percolation tests from the development site (ideally carried out under saturated conditions, following periods of extended rainfall). Sizing of rainfall capture facilities should normally be based on the *minimum* percolation test results from a development site.

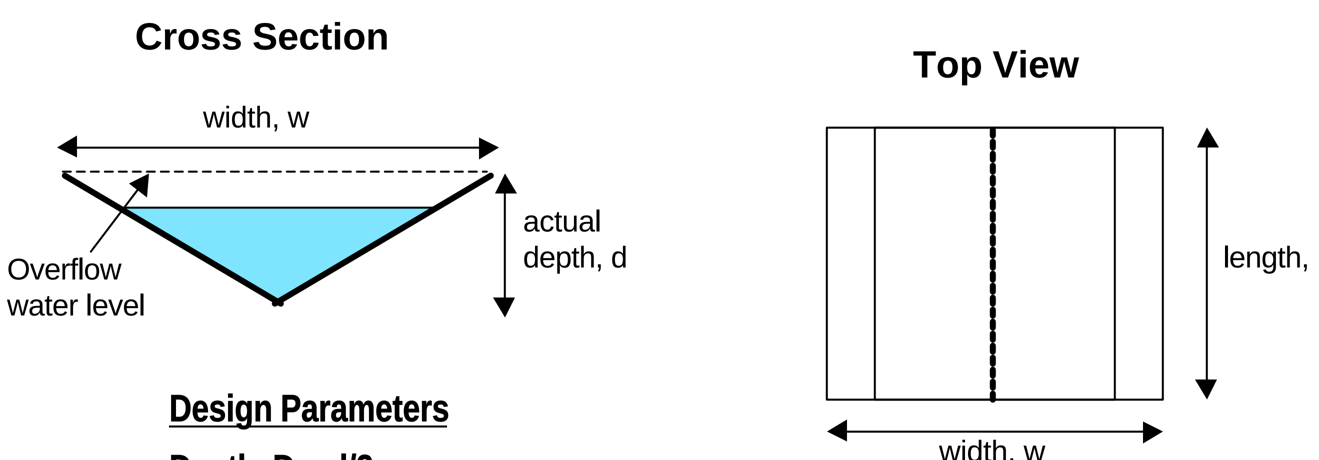
Attachment 2b - Illustration of Design Parameters for Infiltration Facilities

Example #1: Underground Soakaway Pit Filled with Drain Rock (Type B Facility)



Example #2: Infiltration Trench (non-rectangular cross section)

[The Design Parameters, D and A, are defined based on a rectangular cross-section. For non-rectangular rainfall capture facilities, these design parameters must be approximated based on the dimensions of an equivalent size rectangular facility]



Design Parameters

Depth, D = d/2

Footprint Area, A = (w) x (l)

Form 3 – Design of Detention Facilities

Runoff Control Target: Detain an additional 300 m^3 of rainfall per impervious hectare and release at 1 Lps per hectare (total site area)

Designing Community Detention Facilities

The storage volume that must be provided in community detention storage facilities (e.g. wet or dry detention ponds):

- $V_{off\text{-}site} = [IA_{total} \times 300\ m^3/ha] - [S\ V_{on\text{-}site}] =$ _____ m^3

The rate of release from detention storage:

- $R = A_{total} \times 1$ **Lps per ha =** _____ Lps

Form 4 – Performance Monitoring Requirements

Target: to provide an accurate picture of how rainfall moves through the stormwater system to enable future evaluation of system performance and optimization of design criteria

A) Monitoring within Development Sites

The City will select certain development sites as *demonstration projects,* and develop a comprehensive monitoring plan for these sites. The costs of installation and continued operation of monitoring equipment will be funded through Development Cost Charges.

The purpose of monitoring within development sites is to evaluate and refine the City's design criteria and customize criteria for different zones within Chilliwack. In order to properly evaluate the performance of a stormwater system the *water balance of the development site served by that system must be defined.* Therefore, it is important to monitor a representative sample from each component of the stormwater system, including:

- **On-Lot Rainfall Capture Facility monitoring** – Monitor water levels and overflow from at least one On-Lot rainfall capture facility.
    - for surface facilities - install a compound weir, water level sensor and data logger at the overflow point.
    - for sub-surface facilities – install a piezometer (to measure water level) and data logger
- **Road drainage monitoring** – Monitor the road drainage flow from at least one section of road. This may include more than one drainage path (e.g. perforated pipe + catch basins connected to a storm sewer)
    - install a compound weir, water level sensor, and data logger in a manhole at the downstream end of the road
- **Runoff Control Facility monitoring** – Monitor water levels and outflow from detention facilities (e.g. community detention ponds)
    - install a compound weir, water level sensor, and data logger in the outlet control manhole

B) Monitoring at the Catchment Level

The City will install streamflow and TSS monitoring stations downstream of catchments where land development is occurring to verify that development practices are adequately protecting downstream hydrology and water quality. The costs of installation and continued operation of monitoring equipment will be funded through Development Cost Charges.

Refer to Figure 4-5 for illustration of a comprehensive monitoring program.

4.4 Design Criteria for Stormwater Conveyance Systems

4.4.1 Introduction

The City requires all developments to provide drainage systems that manage the majority of rainfall events within the development site (all but one per year, on average), and safely convey runoff from extreme storms to the outlet of the site.

The result is that channel erosion and stream degradation impacts of land development are effectively mitigated on-site. But new development may trigger the need to improve the conveyance capacity of downstream drainage facilities and/or other mitigation measures (e.g. regional detention).

As discussed in Section 3.6, the City will model the impact of development on downstream peak flows, assess the need for improved conveyance/mitigation measures, and allocate Development Cost Charges accordingly.

Developers are responsible for conveying the 100-yr storm to the outlet for their site.

4.4.2 Conveyance Requirements

The City of Chilliwack's performance target for flood risk management is to ensure that runoff from extreme rainfall events, up to a 100-yr storm event, can escape to downstream watercourses without posing a threat to property or public safety. To achieve this objective, the following design conditions must be addressed:

- All rainfall capture and runoff control facilities must incorporate 'escape routes' to allow extreme storms to be routed to downstream watercourses, either as overland flow or via a storm drainage system (i.e. whether ditched or piped).

- Sites must be graded to ensure that any overland flow resulting from extreme storms is dispersed away from areas where flooding problems could otherwise result (e.g. residential properties in low areas).

- The downstream storm drainage system must meet assessment criteria for both hydraulic adequacy and physical adequacy to handle the runoff from the upstream development area (refer to discussion below).

The first two design conditions above refer to the conveyance of peak flows through on-site drainage systems, and the third refers to the routing of runoff from development sites through off-site drainage systems (i.e. existing City drainage infrastructure and watercourses).

4.4.2 Connecting to Existing City Drainage Infrastructure

Through the process of developing catchment plans, the City will assess the risk and adequacy of existing downstream drainage facilities to handle the increase in peak runoff generated by new development. Upgrading programs will then be funded through Development Costs Charges. The risk assessment will be based on:

- **Hydraulic Adequacy** – A comparison of rated capacity versus design flow (see Section 4.4.3 below)
- **Physical Adequacy –** A qualitative judgement regarding physical constraints (e.g. culvert blockage) that could adversely impact hydraulic adequacy (see Section 4.4.4).

Physical adequacy is typically the governing flood risk management criterion. Drainage system failure is most often the result of the sediment or debris transported from upstream development areas.

All developments or works which will cause drainage discharge into existing City drainage systems and/or natural watercourses must ensure that no silt, gravel or debris enters those systems (see also Section 4.5.3**).**

Over the next 3 years Master Drainage Plans will be developed for all watersheds in the City of Chilliwack (see Section 3 - Action Plan). These plans will review all drainage systems in the City with respect to peak flow conveyance and the effects of development within the drainage catchment areas. The Plans will determine peak flow estimates for existing and future conditions, at critical points of the City's drainage system (including watercourses).

Developments that occur in advance of the Master Plans will be required to provide an assessment of the impact on downstream drainage systems. Developers may be required to share in the cost of upgrading downstream City drainage infrastructure, and/or provide additional detention (i.e. above the requirements described in Section 4.2) in order that no impact to the downstream drainage systems will result from the new development.

4.4.3 Hydraulic Criteria for Stormwater Conveyance Systems

In order to ensure the hydraulic adequacy of stormwater conveyance systems, each system shall consist of the following components:

- **The Minor System** shall consist of pipes, swales, and/or ditches, which convey overflows from on-site rainfall capture and runoff control facilities (see section 4.2) resulting from storms up to a 10-year return frequency. Driveway culverts that form part of the minor system shall be designed to a 10-year return frequency with the design headwater not to exceed the top of the culvert.

- **The Major System** shall consist of overland flow paths, roadways and watercourses which convey peak flows resulting from storms up to a 100-year return frequency. Major flood path routing is required wherever surface overland flows in excess of 0.05 m^3/s are anticipated. Roadway crossings shall be designed to accommodate the 100-year return frequency. Surcharging at the inlet for the 100-year flow is acceptable provided the headwater profile does not intersect habitable property.

Conveyance System Design Methods

The Rational Formula can be used to generate conservative peak flow estimates for the design of conveyance systems within development sites that are less than 10 hectares. Use of the Rational Formula is described on the following pages.

The OTTHYMO computer model shall be used to generate peak flow estimates for the design conveyance systems within development sites that are greater than 10 hectares.

To determine design flows by computer modelling, the peak flow rate resulting from 10-year and/or 100-year storms with durations of 1, 2, 6, 12 and 24 hours shall be determined. The maximum peak flow rate shall govern the design of minor and major systems. This task will be performed by Developers to evaluate conveyance systems within development sites, and by the City to evaluate off-site conveyance systems.

As part of the catchment planning process, the City will generate peak flow estimates for drainage facilities downstream of development sites.

The Developer shall provide the City with all calculations pertinent to the design of the proposed conveyance system at the time design drawings are submitted (see Section 5). All designs shall determine and include post-development upstream flows based on the highest land use as per the OCP for the upstream lands.

Use of the Rational Formula

The Rational Formula to use for design on site conveyance systems is, **Q = RAIN**, where:

- Q = Flow in m^3/s
- R = Runoff coefficient
- A = Drainage area in ha
- I = Rainfall Intensity in mm/hr
- N = 0.00278

Runoff Coefficients

The following runoff coefficient (R values) shall be used in the calculation for the Rational Formula:

Type of Area	Coefficient Low	High	Standard
Low density housing	0.45	0.55	0.50
Medium density housing	0.55	0.65	0.60
High density housing	0.60	0.80	0.70
Commercial, Industrial	0.80	1.00	0.85
Institutional	0.70	1.00	0.80
Park or golf course	0.15	0.25	0.20
Churches or schools	0.60	0.85	0.75

Type of Area	Coefficient		
	Low	High	Standard
Grassland	0.15	0.30	0.20
Cultivated	0.30	0.50	0.40
Woodland	0.10	0.40	0.25
Roofs or pavements	0.90	1.00	0.95

Low values are applicable to areas with high soil permeability and gentle slopes (5% or less).

High values are applicable to areas with low soil permeability and steeper slopes (greater than 5%).

Standard values are for general application. The Designer/Consultant should verify the coefficient applicable for the area involved. A soils report may be required to verify the coefficient/s to be used.

The City shall be the final authority on the coefficient to be utilized.

Drainage Areas

The entire tributary drainage area for the conveyance system under design shall be determined based on the natural contours of the land. While contour maps provided through the Engineering Department can be expected to be reasonably indicative of the actual condition, designers are cautioned not to interpret them to be exact and correct.

It is the Designer's responsibility to ensure that they obtain true and accurate elevations for the development site.

Rainfall Intensities

Rainfall intensities can be determined from the Rainfall Intensity/Duration/Frequency (IDF) curves shown on Standard Drawings DD-12 and DD-13 (see Section 4.5). DD-12 shall be used for areas south of the Trans Canada Highway, and DD-13 shall be used for areas north of the Highway.

The following parameters are needed to obtain intensity values from the IDF curves:

- **Time of Concentration (Duration)** – The time of concentration shall be calculate using the formula, $\mathbf{T_c = [Ct*L*n]/[12*S^{0.5}]}$, where:
  - T_c = Time of concentration in minutes
  - C_t = Concentration coefficient depending on the type of flow
    = 0.5 for natural watercourses or ditches
    = 1.4 for overland flow
    = 0.5 for storm sewer flow
  - L = Length of watercourse, conduit or overland flow in metres, along the drainage path from the furthest point in the basin to the outlet (maximum length = 300 m)

- n = Channel friction factor

  = 0.050 Natural Channels
  = 0.030 Excavated ditches
  = 0.016 Overland flow on smooth paving
  = 0.400 Overland flow on natural areas
  = 0.013 Concrete pipe
  = 0.011 PVC

- s = Basin slope in metre / metre

  Actual flow velocities in storm sewers shall be used. A composite value for T_C shall be calculated in cases where the type of flow along the longest path varies or the slope changes.

- **Rainfall Return Period (Frequency)** - As discussed previously, the 10 year return for design Minor Systems - and the 100 year return period shall be used for Major Systems.

Calculating Flow Capacities

Manning's formula shall be used to calculate flow capacities for storm sewers and open channels, $\mathbf{Q = [A*R^{0.667}*S^{0.5}]/n}$, where:

- Q = Design flow in m^3/s
- A = Cross sectional area of pipe or channel, in m^2
- R = Hydraulic radius (area divided by wetted perimeter)
- S = Slope of hydraulic grade line in m / m
- n = Roughness coefficient

  = 0.024 for corrugated steel pipe
  = 0.020 for gravel lined channels
  = 0.013 for concrete or asphalt lined channels
  = 0.050 for natural streams and grassed channels
  = 0.013 for concrete
  = 0.011 for P.V.C.

To calculate the flow capacity for culverts, the Designer is advised to use the inlet control and outlet control methods referred to in:

- Handbook of Steel Drainage and Highway Construction Products, by American Iron and Steel Institute.
- Handbook of Concrete Culvert Pipe Hydraulics, by Portland Cement Association.

These methods can be used to estimate the hydraulic adequacy of culverts, however, it is the physical adequacy (i.e. vulnerability to blockage) that generally governs the performance of culverts (see Section 4.4.4).

4.4.4 Physical Adequacy of Stormwater Conveyance Systems

Assessment of physical adequacy is a key input for any flood risk analysis. Drainage problems often occur in small tributaries where stream crossings, such as culvert installations, are vulnerable to blockage (i.e. physically inadequate). Flooding may be a common occurrence at tributary stream crossings even though conventional hydraulic analysis indicates that the conveyance capacity (i.e. hydraulic adequacy) is adequate.

All watercourse crossings (including culverts) shall conform with the following guidelines:

1	Maintain line and grade of creek channel
2	Maintain the waterway opening by "bridging" the creek channel
3	Construct inlet structure to provide direct entry and accelerated velocity
4	Ensure that it can pass trash, small debris and bedload material
5	Install debris interceptor upstream to provide protection from large debris
6	Provide scour protection to prevent undermining of the outlet structure
7	Incorporate provision for an overflow route in the event of a worst-case scenario
8	Provide equipment access for ease of maintenance (debris removal)
9	Consider environmental issues, such as fish passage

4.4.5 Site and Lot Grading

Developments in the City of Chilliwack shall incorporate proper site and lot grading techniques. The following criteria shall be used:

- Each lot should be graded to drain to a municipal drainage system, or natural watercourse, independent of adjacent lots where possible. Minimum lot grades to be 1.0 percent and are to be shown draining away from building areas.
- Areas around buildings (or proposed building sites) shall be graded away from the (proposed) foundations to prevent flooding.
- Lots lower than adjacent roadways should be avoided, where possible, or acceptable stormwater management techniques must be incorporated to direct drainage to an existing or proposed drainage system.

Minimum Building Elevations (M.B.E.)

The M.B.E. means the top of slab (crawl space, basement or slab on grade). The M.B.E. shall be set by a Professional Engineer as part of an approved Comprehensive Drainage Plan (see Section 5), or by the Municipal Engineer where no storm water management plan exists.

The purpose of setting a M.B.E. is to ensure that the means of draining a building is provided in accordance with the B.C. Building Code. M.B.E.'s set by a Professional Engineer as part of an approved Comprehensive Drainage Plan may not be revised without referral to the City.

A gravity connection to the municipal storm drainage system may be made only where the habitable portion of a dwelling is above the Major System hydraulic grade line.

4.5 Stormwater System Design Details

4.5.1 Rainfall Capture and Runoff Control Design Details

Infiltration Facilities

The design of infiltration facilities must be supported by site-specific soils report, including percolation tests (see Section 5). Based on site-specific soils information, infiltration facilities shall be sized according to the methodology presented in Section 4.2. The final design of infiltration facilities requires certification from a Professional Engineer.

All infiltration facilities shall be designed with overflow pathways (can be pipes, channels, or overland flow) that connect to the conveyance system (discussed in Section 4.5.2).

All pipes leading into infiltration facilities (e.g. roof leaders) shall be fitted with debris catchers and cleanouts, to minimize the movement of sediment and debris into the facilities.

Infiltration facility sites shall be protected during construction from either compaction or sedimentation, by pre-identification and fencing or other means. Inadvertent compaction shall be removed by ripping or scarifying the site prior to installation of infiltration facilities. Piezometers shall be installed for post-construction groundwater monitoring these facilities.

Adequate sediment and erosion control during construction is essential to prevent clogging of infiltration facilities and their underlying soils (see Section 4.5.3).

The following types of infiltration facilities can be used to meet the City's rainfall capture (and runoff control) targets:

- **Retention Ponds (Dry Ponds) –** Unlined ponds that retain runoff and allow it to infiltrate through the pond bottom.
- **Bioretention Areas** - Shallow landscaped basins that retain runoff in a thick layer of absorbent soil and on the surface (shallow ponding). The low points of should be planted with plants that tolerate flooding – higher areas should be planted with streamside or upland species.
- **Soakaway Trenches or Pits –** Trenches or pits filled with drain gravel. Absorbent landscaping can be installed over the surface, and with proper engineering, pavement (with light vehicle traffic) may be allowed on the surface (e.g. a soakaway under a driveway).
- **Infiltrator Chambers** - Inverted plastic half pipes can be installed in infiltration trenches to increase retention storage capacity and improve infiltration performance.
- **French Drains –** Runoff exfiltrates from a perforated pipe into an infiltration trench and then into the surrounding soil. Refer to Standard Drawing DD-8.
- **Soakaway Wells** – Runoff exfiltrates from screened wells into the surrounding soil. Refer to Standard Drawings DD-10 and DD-11.
- **Infiltration Swales** - Consists of a surface swale (i.e. Conveyance Swale as described in Section 4.5.2) on top of a gravel filled infiltration trench.

Standard detail drawings for these facility types will be created (or updated) as part of the City's 5-year Action Plan.

Other Source Controls

Other source controls (rainwater reuse or green roofs) may be applied, without or in combination with infiltration facilities, provided it can be shown that the City's rainfall capture criteria are met.

The design of a rainwater reuse system must be supported by a detailed water use and rainfall collection report. Low flow release to ensure adequate stream baseflow may be required in some cases. Designers shall consult with City staff.

The design of green roofs must be supported by a drainage plan for the building envelope. Standard drawings will also be created for Green Roofs will be created as part of the City's 5-year Action Plan.

The final design of all source control facilities requires certification from a Professional Engineer.

Detention Facilities

Detention facilities shall be provided on development sites where the City's runoff control targets are not met through source control. Detention facilities shall be sized according to the methodology presented in Section 4.2.

Designers shall obtain approval of all proposals for detention systems from the Engineering Department prior to detailed design.

Detention facilities shall be designed with bottom drainage to ensure the facility is dry when not in use, except where slope stability concerns require ponds to be lined.

4.5.2 Conveyance System Design Details

Conveyance systems may consist of ditches, swales and/or storm sewer pipes. Runoff may be collected into the conveyance system via overflow connections from rainfall capture facilities (e.g infiltration facilities) and/or overland flow pathways.

Swales

Conveyance swales shall be a maximum 150 mm deep and shall conform to Standard Drawing DD-9. All swales are to be lined with turf on a minimum 300 mm layer of absorbent soil. Swales that drain adjacent lots shall be located on a 3.0 m easements. Swales for Major Flood Path routing shall be designed to accommodate the anticipated flows and the easement established accordingly. Swales shall have a minimum 1.0% grade.

Swales can be designed as combined infiltration and conveyance facilities (i.e. infiltration swales).

Ditches

Ditches adjacent to roadways shall conform to the following criteria:

- maximum depth = 1.0 m
- minimum grade = 0.5 %
- maximum velocity* = 1.0 m/s (*Unlined ditch)

Where soil conditions are suitable or where erosion protection is provided, higher velocities may be permitted. If grades are excessive, erosion control structures or ditch enclosure may be required.

The minimum right-of-way width for a ditch shall be 6.0 m where the ditch crosses private property. The ditch shall be offset in the right-of-way to permit a 4.0m wide access for maintenance vehicles. Additional right-of-way may be required.

Where a new ditch is proposed to be located adjacent to an existing property line or where a new property line is proposed to located adjacent to an existing ditch, no portion of the ditch cross-section shall lie closer than 0.5m to that property line.

Storm Sewer Location/Corridors

On roads with storm sewers, the utility shall be located within the road right-of-way as noted in the applicable Standard Drawing Typical Cross-section for that road.

When the utility is required to cross private land(s), refer to the City's Design Standards for Water Systems for minimum right-of-way width standards.

Where there are manholes, oil and silt interceptor facilities, or other appurtenances which require maintenance are located within the right-of-way, the Developer may be required to provide for and construct an access from a Municipal road to enable access by maintenance vehicles. The maintenance access shall be constructed in such a manner and to a paved standard that is adequate to support the maintenance vehicles for which the access is intended. The Developer shall ensure that the maintenance access will not present a nuisance to adjoining properties, and that hardened impervious surfaces are kept to a minimum.

Utility Separation

The minimum separation between storm sewers and watermains shall be 3.0 m horizontally (center line to center line) and 0.5 m vertically (from the water pipe invert to the top of the storm sewer).In situations where the minimum separations cannot be attained, protection of the watermain may be considered subject to the acceptance of such proposals by the Ministry of Health and the City. Where storm and sanitary are installed in a common trench, the clearance between pipes shall be minimum 1.0 m invert-to-invert.

Minimum Pipe Sizes

The minimum size of storm sewer pipes shall be 250 mm diameter, except where a terminal section is within a short cul-de-sac. In this case the size may be reduced to 200 mm diameter where there are no catch basin connections. Catch basin leads shall be a minimum 150 mm diameter for single lead and 200mm for double.

Service connections shall be a minimum 100 mm diameter (residential) and 150 mm diameter (industrial/commercial), and in addition shall be sized and designed to satisfy runoff requirements for the ultimate development of the property being served.

Driveway culverts shall be sized and designed to accept the design flows of the upstream tributary area and in no case shall be less than 300 mm in diameter.

Minimum Depth of Cover

The minimum depth of cover shall be 1.0 m for storm sewer pipes and culverts up to 600 mm under roads, and 0.3 m for culverts under driveways, subject to the correct pipe loading criteria. For pipe sizes larger than 600 mm, an engineering design for cover will be required. Where minimum cover is not attainable, a design for concrete encasement should be discussed with the City.

The elevation of storm sewers at the upstream tributary points must be of sufficient depth to service all of the tributary lands.

Storm Service Connections

For development sites that are served by storm sewer conveyance systems, storm service connections shall:

- be installed to all lands fronting the storm sewers, so that the lands may be provided with a 'gravity-flow' connection for overflow from rainfall capture facilities to enter the storm sewer system.
- have a diameter of a minimum 100 mm for residential and 150mm for industrial/commercial.
- have a slope of not less than 2.0%. At the property line, the minimum depth shall be 1.0 m and the maximum depth shall be 1.2 m.
- be installed at the lower (downstream) portion of the lot for larger lots or parcels of land. In urban developments connections shall be as noted on Standard Drawing DC-1 and DC-2.
- establish the Minimum Building Elevation (M.B.E.) at not less than 0.6 m above the storm service connection invert at the front property line of the lot/s adjacent.
- connect all existing storm service connections to the proposed storm sewer, when the design proposes to infill an existing ditch.

Minimum/Maximum Velocity

The minimum velocity for pipes flowing full, or half full, shall be 0.75 m/s.

There is no maximum velocity, however, where grades exceed 15%, scour protection may be required and anchor blocks will be required.

Where drainage discharge enters a natural watercourse, the Ministry of Water, Land and Air Protection generally requires adequate erosion protection and maximum velocities under 1.0 m/s.

Curvilinear Sewers

Curvilinear sewers are not recommended. Where no other acceptable alternative exists and the Municipal Engineer has granted approval, the minimum radius should not be less than 60 m and the maximum joint deflection should be one half the pipe manufacturer's recommended maximum pipe deflection.

Manholes

Storm drain manholes require a 600 mm deep sump unless approved otherwise by the Municipal Engineer.

Manholes are required at:

- all changes in grade
- every intersecting sewer
- all changes in pipe size
- all changes in direction
- every 150 m

Hydraulic Losses in Manholes

The following criteria shall be used:

- Generally the crown of the downstream pipe shall not be higher than the crown of the upstream pipe.
- Minimum drop in invert levels across manholes:
  - straight run - no drop required
  - deflections up to 45º - 20 mm drop
  - deflection 45º to 90º - 30 mm drop
- Outside drop connections shall be provided wherever the drop exceeds 0.6 metres.

Temporary Clean-outs

Temporary clean-outs may be provided at terminal sections of a storm sewer provided that all the following criteria can be met:

- future extension of the main is proposed or anticipated.
- the length of sewer to the downstream manhole does not exceed 45.0m.
- the depth of the pipe does not exceed 2.0 m at the terminal point.

Note that clean-outs shall <u>not</u> be considered permanent structures, and that mid-block clean-outs are not permitted.

Catch Basins

On roads with storm sewers, catch basins shall be provided at regular intervals along roadways, at intersections, and at low points.

Catch basin spacing shall be designed to drain a maximum area of 500 m^2 on road grades up to 5%. On steeper grades, side entry catch basin grates are to be installed.

Catch basin leads shall be a minimum of 150 mm in diameter for single C.B.'s and 200 mm for double C.B.'s. Where possible, C.B. leads should be taken into manholes.

Inlet and Outlet Structures

The Standard Drawings for inlet and outlet structures shall be used in the design of these facilities.

Outlets shall be designed with adequate rip rap protection and/or an accepted energy dissipating structure to control erosion.

A safety grillage shall be required at the outlets of all storm sewers over 600 mm in diameter and which exceed 30 m in length. Trash racks at the inlets shall be required on all storm sewers which utilize safety grillages.

4.5.3 Standard Detail Drawings

The following drawings have been brought forward from the *Subdivision and Development Control Bylaw,* and are inserted after Section 5:

- DD-1 Manhole Frame and Cover
- DD-2 Inspection Chamber for 100mm Storm Sewer Connection
- DD-3 Storm Sewer Cleanout (Temporary)
- DD-4 Storm Sewer Service Connection
- DD-5 Outlet Structure
- DD-6 Storm Manhole, with Soak-Pit
- DD-7 Driveway Culvert with Bulkheads
- DD-8 French Drain
- DD-9 Swale
- DD-10 Soak-Away Well – 0.5cfs
- DD-11 Soak-Away Well – 1.0 cfs
- DD-12 Sardis-Vedder (south of TCH) Rainfall Duration-Intensity Curve
- DD-13 Sardis-Vedder (north of TCH) Rainfall Duration-Intensity Curve
- DD-14 Trash Rack – Type A
- DD-15 Trash Rack – Type B
- DD-16 Drainage Dry Well
- DD-17 Flow Control Manhole

Over time, the standard drawings listed above will be replaced, modified or replaced as needed to achieve stormwater management objectives. As noted previously, under the 5-Year Action Plan the City will be creating standards that provide direction for meeting rainfall capture targets and Low Impact Development objectives. It is anticipated that some of these drawings may result from experience gained with the first Demonstration Projects.

4.6 Sediment and Erosion Control

All construction sites shall employ the following sediment and erosion control strategies:

- **Source Erosion Control -** Maintain vegetation and preventing soil from being displaced until necessary.
- **Erosive Runoff Control** - Reduce the erosive energy of runoff and use non-erodable surfaces for conveyance of runoff.
- **Sediment Control -** Trap runoff and reduce velocity to allow sediment to settle.

Prior to construction, a *Sediment and Erosion Control Plan* shall be submitted to the City. The Plan must incorporate Best Management Practices. All construction work must be undertaken and completed in such a manner as to:

- Prevent the release of silt, raw concrete and concrete leachate, and other deleterious substances into any ditch, storm sewer, watercourse or ravine.
- Prevent silt, raw concrete and concrete leachate, and other deleterious substances from entering any infiltration facilities (or areas proposed for infiltration).

Proposed sediment control structures must be maintained and be functional throughout the development process. Changes in the design and the structure will be required if the proposed structure is found not to be adequate.

Construction and excavation wastes, overburden, soil, or other substances deleterious to aquatic life shall be disposed of or placed in such a manner as to prevent their entry into any watercourse, ravine, storm sewer system, or restrictive covenant area.

The location of all sediment control devices shall be placed as close as possible to the area they are required to protect, at the downstream ends of all development, and before entrance into the existing drainage system.

All stockpiles located within 3.0 metres of a public road and/or drainage system shall have the perimeter silt fenced and the pile covered.

The proposed location of sediment control ponds shall be situated to provide ready access for cleaning and maintenance, and shall be sited and designed to prevent property damage in the event of structural failure.

Soil Removal and Deposit

All locations within the development site on which spoil material is to be placed must be identified by the Design Engineer. Any off-site property or location to which material is to be trucked is to be identified and is to receive prior approval by the City as a designated "deposit" site under a permit issued in accordance with the *City of Chilliwack Soil Removal and Deposit Bylaw.*

Proposed truck haul routes not located wholly within designated City "truck routes" are subject to application to and approval by the City. Proposed routes are to be shown on a plan, and the means by which the haul route will be kept clean and free of dust and soils is to be identified.

4.7 Water Quality Protection

4.7.1 Scope

New storm drainage systems which are located on land that is zoned CD, industrial, multi-family or commercial according to the Zoning Bylaw, shall not be connected to a storm sewer or infiltration system connection unless equipped with an oil and grit interceptor. The oil and grit interceptor shall:

- meet the technical specifications set out in the City's Standard Drawing;
- be suitable for the sampling and inspection of the stormwater which is discharged from the storm drainage system to the storm sewer connection; and
- be suitable for the interception, retention, and removal of deleterious substances in that discharge.

4.7.2 Compliance with Notice to Install

A property owner that is served with written notice from the City advising that an oil and grit interceptor is required on an existing or new storm drainage system located on that owner's property shall install an oil and grit interceptor on that storm drainage system.

- within one year of the notice being served for an existing storm drainage system; or
- prior to connection to the storm sewer connection in the case of a new storm drainage system; or
- as ordered by the City.

4.7.3 Responsibility for Installation and Maintenance

An owner of a parcel of land, or person on behalf of the owner, who installs an oil and grit interceptor shall install the oil and grit interceptor on the storm drainage system at or near the property line within the bounds of the owner's parcel of land. All costs associated with the installation and maintenance thereof shall be the responsibility of the owner.

4.7.4 Maintenance Requirements

- All oil and grit interceptors shall be cleaned by a waste contractor holding a valid City's business licence as frequently as necessary to ensure that deleterious substances in the discharge from the storm drainage system are intercepted and retained for removal;

- The owner of the property on which an oil and grit interceptor has been installed shall maintain records of the cleaning for inspection by the Director and shall forward, to the Director, by May 1 of each year, a copy of the record of inspections for the previous 12 months;

- Such records are to be maintained on the premises on which the oil and grit interceptor is located and are to be retained for not less than six years;

- The City may order the owner of an oil and grit interceptor to undertake more frequent cleaning if there is evidence that inadequate or lack of cleaning of the oil and grit interceptor has impaired its ability to intercept, and retain for removal, the deleterious substances in the discharge from the storm drainage system.

4.7.5 Exceptions

The City may waive the requirements of this section where the property owner has submitted a report from a Professional Engineer certifying that the intended use of the property including any construction or remodelling work, will not introduce deleterious substances to the storm sewer system.

Section 5 - Comprehensive Drainage Plan for Land Development Projects: Submission Requirements

5.1 Objective

The objective of a Comprehensive Drainage Plan is to propose specific drainage control systems that will prevent potential adverse impacts to the site's natural hydrologic system and to existing and planned offsite drainage systems and resources.

Some of the impacts that the Comprehensive Drainage Plan would be expected to address include the following:

- Increase in flow rates and volumes that could result in flooding along the natural and constructed drainage system, or that would aggravate existing flooding problems, either on-site or downstream.
- Increase of flow rates and volumes, both on and offsite that could destabilize the existing geomorphic balance of natural drainage systems. Examples would include an increase in the rate of frequency of stream bank erosion resulting in bank or slope failures along stream corridors, destruction of habitat, downstream sedimentation reducing channel capacity, and smothering of spawning beds.
- Alteration of natural topography and or native vegetation that could result in unstable soil conditions in slopes or embankments, and increases in water temperature.
- Alteration of natural hydrologic features or provision of site improvements that could reduce the functional ability of the catchment to preserve water quality and quantity and/or instream and other aquatic habitat values.
- Alteration of groundwater interflow that could adversely change downstream base flows and/or impair existing water rights.

5.2 Scope

The proposed drainage plan, impact analysis and mitigation measures shall be supported by detailed technical analysis and reports as part of the Comprehensive Drainage Plan.

In addition to engineering plans, comprehensive drainage plans shall include appropriate geotechnical and hydrogeologic investigations, water quality and aquatic habitat analysis, and hydrologic/hydraulic computer modeling as may be required by the City to resolve concerns that may be identified during the project review process.

All drainage plans shall provide a comprehensive analysis of existing and proposed surface and subsurface water quality and quantity conditions for both internal (onsite) and external (offsite) systems.

5.3 Technical Elements

Minimum technical information is to include the following:

- Provide a general plan of the proposed drainage collection, infiltration, and flow control systems based upon accurate field topographic mapping and geologic data, along with appropriate cross sections and details necessary to fully and properly identify drainage systems elements.
- Compile all assumptions, input parameters, and output data from hydrologic and hydraulic computer models in an appendix.
- Provide hydrologic performance data for all infiltration facilities and other stormwater source controls (reduction in volume and rate of runoff through infiltration, evapo-transpiration and/or rainwater reuse). This data shall be used to generate runoff hydrographs.
- Provide hydraulic performance data (storage, discharge) for all elements of the hydrologic system, whether existing or proposed, including lakes, ponds and wetlands. This data shall be used to route inflow hydrographs to produce outflow hydrographs.
- Provide flow data for all existing and proposed conveyance facilities, including streams, swales, pipes and ditches, which will support the proposed rainfall capture and runoff control system.
- Complete a floodplain analysis identifying the extent of flooding for the existing and proposed conditions, and other backwater analyses required to determine existing and proposed conveyance capacity.
- Complete a soils analysis that establish the hydraulic conductivity of soils within the development site. Soils reports must include the results from percolation tests performed at the location and depth of proposed infiltration facilities (ideally performed under saturated soil conditions).
- Complete a hydrogeologic analysis identifying groundwater flow patterns for the existing and proposed conditions, with particular focus on stream base flows and the effect of proposed infiltration facilities.
- Complete an erosion analysis of onsite and downstream open drainage systems, identifying flows, velocities, areas of the existing and future deposition and channel erosion, and characterization of sediment.
- Complete a geotechnical analysis of the site and proposed improvements which specifically addresses soils and slope stability for proposed lakes or ponds, road alignments, channel and ravine conditions, building setbacks from steep slopes, vegetative preservations and controls, existing and proposed drainage facilities, and downstream system stability.
- Complete an ecological analysis of the physical and biological features of the streams, lakes, wetland and swales.

- Describe the method and conceptual design for maintaining existing water balance of the development site, and existing flow regimes in any swales or watercourses that may be altered by the development.
- Describe the method, conceptual design, and location of water quality compensating facilities that may be necessary to replace naturally occurring "biofiltration" functions of site vegetation.
- Develop construction phasing plan that will ensure stormwater control, sediment and erosion control, and protection of proposed infiltration sites during development of individual sub-catchments.

5.4 Mapping

Mapping for the Comprehensive Drainage Plan must be of adequate scale and detail for accurate definition and location of all system elements, both onsite and offsite, and must provide support for hydrologic and hydraulic model characterization. In general the following are required.

- Delineate sub-catchments of appropriate size/land use for computer model characterization and hydraulic analysis of all tributary flows.
- Identify location and size of all existing and proposed hydrologic features and facilities in the sub-catchments. This includes infiltration facilities, lakes, ponds, wetlands, swales, streams, pipes and culverts.
- Provide overall plan/profile and cross sections of conveyance systems and identify the floodplain and floodway, and the frequency of flooding for existing and developed conditions.
- Identify areas of in-stream erosion, sedimentation and unstable slopes.
- Identify site soils for use in sizing of infiltration facilities, hydrologic modeling, and preliminary analysis for controlling erosion during construction.
- Identify upstream and downstream habitat conditions, including spawning, rearing and transport areas, pools, riffles, other instream habitat features, and species observed.
- Identify general required setbacks, clearing limits and native growth protection easements in areas of steep slopes and drainage features.

5.4.1 Specific Mapping Requirements

A) Identification Plan

1. Name and address of applicant
2. Name, address and phone number of all consultants
3. Scale – use a scale that clearly identifies all drainage features – 1:500 for general layout, 1:100 for details
4. Legal and civic description
5. Dimensions of all property line – north arrow
6. Site and Key Plan

B) Building Plan

1. Footprints of building structures
2. Location of parking and driveways (existing and proposed)
3. All impervious surfaces
4. Existing and proposed septic system including systems components
5. Utility structures.
6. Existing and proposed wells, reservoirs, etc.

C) Topography

1. Permanent benchmark tied with geodetic elevation.
2. Ground elevations where activity is likely to happen
3. Contours of land at 1 metre interval.
4. Show top of slope and toe of slope where applicable.
5. Show erosion and landslide areas, as identified by geotechnical engineer.

D) Sensitive Areas and Natural Drainage Features

The following need to be identified and established:

1. All streams, wetlands, lakes, closed depressions, groundwater recharge / discharge locations, and any other water features.
2. Location of all steep slopes, landslide hazard areas, buffer zones, and building setback lines.
3. Location of all existing and proposed drainage easements.
4. Location of all existing and proposed ditches, swales, pipes, culverts, etc. with dimensions and co-ordinates.
5. Location of all habitat sensitive areas as identified by a professional biologist.
6. All setbacks from watercourses, lakes, pools and wetlands, as per Provincial and Federal guidelines and regulations.

E) Proposed Stormwater System

The following information must be identified:

1. Type and location of rainfall capture facilities (e.g. infiltration facilities) that will serve impervious surfaces, including inflow and overflow pathways (overland flow, channels and pipes). Plans should show design criteria for rainfall capture facilities (from Section 4.2).
2. Type and location of all detention facilities, including inflow and overflow pathways (overland flow, channels and pipes). Plans should show design criteria for detention facilities (from Section 4.2).

3. Type and location of development site outlet(s), and characteristics of receiving water bodies or drainage infrastructure.
4. Type and location of all flow conveyance pathways between rainfall capture facilities, detention facilities, and development site outlets, including overland flow pathways, channels (ditches, swales, watercourses), and pipes.
5. Setback distances between stormwater system components and property lines, structures, streams and wetland.
6. Type and location of proposed sediment and erosion control facilities.
7. Delineation of proposed clearing limits.
8. Delineation of protected infiltration areas (areas to be fenced off during contruction).
9. Type and location of any significant off-site drainage features, and expected effect on natural watercourses downstream of development site outlets.

5.5 Core Requirements for the Protection of Life and Property

1. **Flow Control -** Contain and convey the peak runoff resulting from the 100-year rainstorm (for the critical duration, see Section 4.4.3). Route the runoff to the boundary of the development area via some combination of overland flow paths, roadways, drainage channels, natural watercourses, and pipes.

2. **Design Flows -** For relatively uniform urban areas less than 10 hectares in area the rational method may be sufficient for estimating peak runoff flows. For non-uniform land use and for areas larger than 10 hectares, computer generated rainfall-runoff simulation using OTTHYMO is required (for consistency with the City's modelling).

3. **Flooding –** Ensure the hydraulic adequacy of off-site drainage facilities to receive and pass the increased 100-yr peak flow resulting from the development project. Determine whether and how the downstream facilities need to be upgraded. The City will perform this assessment as part of functional plans for catchments (as discussed in Section 3.6). Where these functional plans have not been completed the Developer will be required to pay for off-site flood risk analysis (to be completed by the City).

4. **Erosion -** Assess whether downstream drainage installations are vulnerable to blockage due to debris and/or bedload movement. Identify overflow routes should a blockage occur, and assess the acceptability of those overflow routes. The City will perform this assessment as part of functional plans for catchments, or in advance of the plans (as stated above).

5.6 Core Requirements for the Protection of Environment and Water Rights

1. **Catchment -** Preserve natural systems or provide simulation of natural systems in balance with impervious development.

2. **Stream Flow Protection -** Maintain base flow and preserve natural features in watercourses through practices of infiltration, storage and diversion.

3. **Erosion -** Control stream flow velocities and provide beneficial stream protection for the complete range of frequent (less than 2 years) to infrequent storm events (2 years to 100 years).

4. **Rainfall Capture -** Capture the first 30 mm of rainfall per day on building lots and roads right-of ways, and restore it to natural hydrologic pathways (infiltration, evapo-transpiration and / or rainwater reuse).

5. **Runoff Control -** Detain the next 30 mm of rainfall per day (either in rainfall capture facilities, separate community detention facilities, or a combination), and release to drainage system or watercourses at natural interflow rate.

6. **Storage/Infiltration Volume –** The network of rainfall capture and runoff control facilities must be designed to infiltrate and store a total of 600 m^3 of rainfall per impervious hectare. Refer to Section 4.2 for design methodology to meet this criterion.

7. **Release Rate and Baseflow –** Mimic a natural forested condition. Support baseflow by releasing captured rainfall to the interflow zone at the natural infiltration rate of surrounding soils. Size detention facility outlet controls to release flow at a rate of 1 litre per second (Lps) per impervious hectare.

8. **Water Quality –** Provide biofiltration for the first 30 mm of rainfall per day as it moves through the interflow zone.

9. **Monitoring –** For development sites designated by the City as *Demonstration Projects*, incorporate monitoring equipment into the stormwater system design, in accordance with the City's comprehensive monitoring plan for the site (the costs of installation and continued operation of monitoring equipment will be funded through Development Cost Charges). For all development sites, design detention pond outlet structures such that they can be equipped with water level and flow monitoring equipment.

5.7 Off-Site Analysis

The City will assess the impact of development on downstream watercourses and drainage infrastructure as part of functional plans at a catchment level.

The intent of the off-site analysis is to identify and evaluate potential off-site drainage problems that may be created or aggravated by proposed development projects, and to determine measures for appropriate mitigation of those impacts. The analysis is to encompass erosion, sedimentation, habitat and flooding (see Sections 5.5. and 5.6).

The intent is to ensure the minimum level of control needed to protect downstream habitat, properties and resources from increases in peak, duration and volume of runoff generated by new development.

The intent is also to prevent the transport of sediment to streams, wetlands, lakes, drainage systems, and adjacent properties. Erosion on construction sites can result in excessive sediment transport to adjacent properties and to surface waters. Sediment transport is a concern because it can result in major adverse impacts, such as flooding due to obstructed drainage installations, smothering of salmonid spawning beds, and creation of algae blooms in wetlands.

In terms of downstream water quality, the City's objective is to require an efficient, cost effective level of water quality treatment tailored to the sensitivities and resource protection needs of the downstream receiving water to which the development site drains, and to protect the receiving ground water system where infiltration facilities are applied.

It is expected that the City's design criteria for stormwater systems will result in effective on-site mitigation of channel erosion, stream degradation and water quality impacts, but that new development may trigger the need to improve the peak flow conveyance capacity of downstream drainage facilities.

5.8 Declaration Confirming Acceptability

A narrative description of the proposed project must be included, with existing conditions, proposed plans and recommendations, signed by a qualified professional, with specialized knowledge in the field of stormwater management. The description should acknowledge that the appropriate requirements relating to hydrology, water quality, geology, groundwater, soils, habitat and forestry have been addressed.

5.9 Submissions to Environmental Agencies

Proponents will forward all proposals for land development adjacent to watercourses directly to the Federal and Provincial environmental agencies.