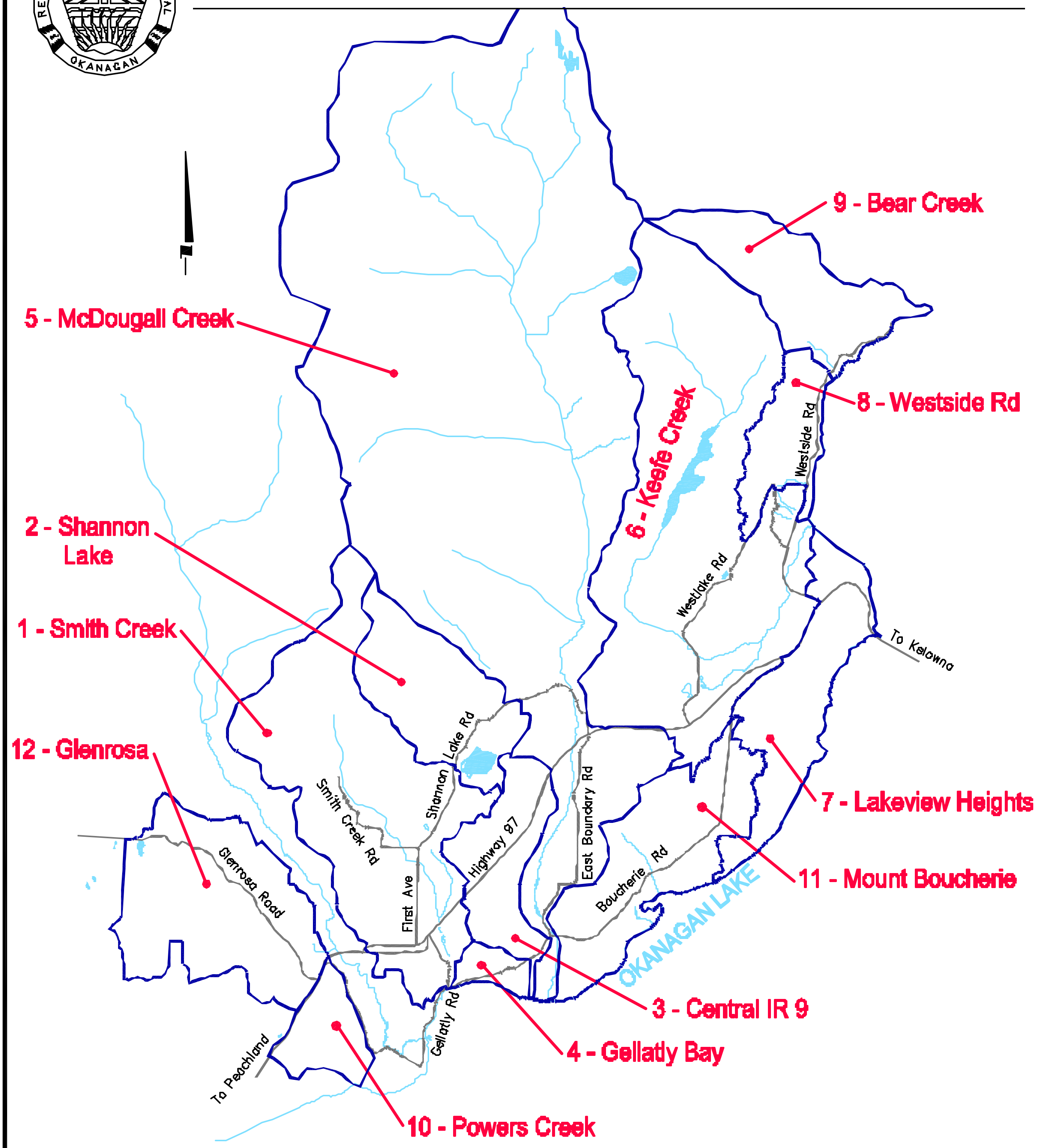
REGIONAL DISTRICT OF CENTRAL OKANAGAN



WESTSIDE
MASTER DRAINAGE PLAN

URBAN SYSTEMS

PROJ: 1117931.1
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TERMS AND ABBREVIATIONS

AES	Atmospheric Environment Service (Canada)
ALR	British Columbia Agricultural Land Commission
AMC	antecedent moisture condition (indicator of initial soil moisture)
BMP	Best Management Practice (related to stormwater quality)
cfs	cubic feet per second
CMP	corrugated metal pipe
CN	US SCS curve number (related to infiltration)
CN*	modified US SCS curve number
CSP	corrugated steel pipe
DCC	Development Cost Charge
EDR	emergency (major) drainage route
EU	equivalent unit (defined as one single family development unit)
HDPE	high-density polyethelene pipe
ha	hectare
Ia	initial abstraction (related to effective rainfall)
IDF	intensity-duration-frequency (rainfall data)
m	metres
mm	millimeter
m^3/s	cubic metres per second
MoELP	the Ministry of Environment, Lands and Parks
MoTH	the Ministry of Transportation and Highways
OTTHYMO	hydrological and hydraulic computer model
PVC	poly vinyl chloride pipe
RDCO	the Regional District of Central Okanagan
SF	single family (development unit)
Tc	time of concentration (indicates basin response time to a rainfall event)
US SCS	United States Soil Conservation Service
SWMP	Stormwater Management Plan
WFN	the Westbank First Nation
WMDP	Westside Master Drainage Plan

1. INTRODUCTION

This section provides the context for the *Westside Master Drainage Plan* (herein referred to as the WMDP). It outlines why the WMDP is necessary, how it was prepared, and how it is to be used.

1.1 Background

In 1993, the Regional District of Central Okanagan (RDCO) initiated the master drainage planning process on the Westside by commissioning the *Glenrosa Drainage Study.* This area was selected first because of severe groundwater discharge problems within the Ranch Road and Ponderosa Pines subdivisions. A geotechnical study and master drainage plan were prepared by Golder Associates Ltd. and Urban Systems Ltd. respectively. In 1995, a similar study was completed by the Urban Systems Ltd. / Golder Associates Ltd. team for the Westbank area. The current WMDP was commissioned in May, 1997 to complete the process for the remaining areas on the Westside. Urban Systems Ltd. and EBA Engineering Ltd. were also commissioned to update the previous drainage plans and integrate them with the new information into a single document.

1.2 Authorization to Prepare and Administer a Master Drainage Plan

The Municipal Act gives regional districts specific powers, which can be interpreted to mean that the RDCO has the power to prepare a Master Drainage Plan. The Municipal Act includes a range of powers; the relevant ones are as follows:

"A regional district may establish and operate the following general services:

(a) general administration. . . .
(c) services relating to the management of development . . .
(d) regional district planning services consisting of . . .

> *(ii) coordination, research and analytical services relating to the development of the regional district;"*

The *Westside Master Drainage Plan* clearly provides information and support that will direct some forms of development in the RDCO. However, it does not have the legal status of a bylaw. Indeed, the RDCO currently does not have the power to provide, require or maintain drainage works. Actions that can be taken to address this point are discussed in Section 2.1.

1.3 Purpose of This Master Drainage Plan

In general, a Master Drainage Plan provides the context within which stormwater management occurs. The WMDP is intended to:

- Delineate each watershed and corresponding drainage divisions within the study area.
- Identify the primary drainage system(s) that service each watershed.
- Establish a clear understanding of the key stormwater management issues within the study area.
- Present a standardized set of design and analysis criteria.
- Recommend general policies to maximize the effectiveness of stormwater management efforts.
- Identify both existing and potential deficiencies of the primary drainage systems.
- Develop, evaluate, and recommend proposed works to correct the identified deficiencies.
- Estimate the preliminary capital costs of the proposed works, and prepare an implementation strategy.

- Review potential cost-recovery mechanisms, evaluate their impacts on each Primary Stakeholder, and recommend an appropriate strategy.

1.4 MDP Organization

This document is organized to support the review and planning functions executed by RDCO and Ministry of Transportation and Highways (hereafter referred to as MOTH) Staff on a day-to-day basis. Since much of this activity is focused on individual re-zoning or development applications, the information is organized by geographic location. This ensures that all of the information required to conduct an efficient and effective review are available in one location.

Sections 1 to 3 present concepts and data relevant to the entire study area. This includes design criteria, MDP objectives, methodologies, and other general discussions. Section 4 focuses on issues that are better understood within the context of individual watersheds. Each watershed-based section includes a basin description, existing and future land use, soil types, groundwater conditions, major drainage, and an overview of proposed improvements. Each section also includes detailed discussions about existing and anticipated system deficiencies, potential improvement options, preliminary capital cost estimates, recommended works, and suggestions for implementation.

Section 5 summarizes the preliminary capital costs based on various criteria such as priority and benefiting stakeholders. It also presents the unit cost for each jurisdictional Stakeholder and recommends a cost recovery implementation strategy.

1.5 Acknowledgments

The majority of effort in producing the WMDP has been expended gathering good data about existing conditions and proposed developments. RDCO Staff have been extremely cooperative and helpful in responding to on-going requests for more and more information as understanding of the study area improved.

The same can be said of most of the Engineering Consultants responsible for much of the development within the study area during the last several years. MOTH Staff provided valuable input during discussions and review sessions while the Lakeview Irrigation District provided information about the operation of Rose Valley Dam. The Westbank First Nation graciously coordinated access to IR 10 to evaluate the condition of Keefe Creek.

1.6 Disclaimer

Although this document contains drawings and illustrations showing existing drainage works, they are not intended to be relied-upon as as-constructed information. Most of the data contained on these drawings have been gathered from many different sources that span several years. Often, we had no guarantee that the obtained documents were, in fact, the most up-to-date. Nor were we always certain that other systems hadn't replaced the structures shown in the documents we had. Field reconnaissance was conducted to verify major drainage routes within developed areas, but it was beyond the scope of this project to confirm each and every system within the study area.

Therefore, prior to implementing any of the works recommended in this document, field information should be confirmed in greater detail, hydraulic analyses should be updated, and appropriate designs should be prepared.

This document also contains information about soil and groundwater conditions. These data were developed / compiled on a very general basis to provide an indication of potential conditions. Final stormwater management works or decisions contingent upon groundwater and / or soil conditions should be based on site-specific data.

2. ISSUES AND POLICIES

This section presents the primary issues that are addressed by the WMDP and recommends policies that should be considered by RDCO and MOTH.

2.1 Stormwater Management Authority

2.1.1 Issue

To what extent should RDCO obtain authority under the Municipal Act to provide, require, and maintain stormwater management facilities.

2.1.2 Discussion

Existing Powers

This section briefly sets out the existing powers of RDCO. It provides a context for discussing the power (or lack of power) that RDCO has for dealing with stormwater management.

<u>Letters Patent</u>

The letters patent define the services a regional district provides, and for the RDCO the letters patent provide authority for the following services:

- Local works and services
- Contract works and services
- Planning
- Okanagan Basin Water Basin Board
- Noxious insect and mosquito control
- Garbage disposal
- Soil removal regulation
- Nuisance and unsightly premises
- Recreation complex (Arena, Curling Rink)
- Community parks
- Regional parks
- Fireworks regulation
- Weed control
- Noise control
- Economic Development Commission
- Transit
- Emergency 911
- Sewage treatment and disposal
- Crime stoppers program
- Victim assistance program
- Regional rescue service
- Fire Protection
- Dog / Animal control
- Septic tank effluent disposal

General Services

The Municipal Act also states that the RDCO may establish and operate the following general services:

- general administration
- electoral area administration
- management of development
- administration of local community commissions
- planning services
- social planning services
- grants in aid
- grants for a business promotion scheme

Local Services

In addition to the services discussed in the letters patent noted above, the Municipal Act states that a regional district may establish and operate the following local services:

- water supply, treatment, conveyance, storage and distribution
- collection removal and disposal of waste and noxious, offensive or unwholesome substances
- art galleries, museums, historic sites, theatres, and other public buildings and facilities
- street lighting
- television re-broadcasting
- cemeteries
- airports
- participation in a regional library district

Extended Services

In addition to the services discussed in the letters patent noted above, the Municipal Act states that a regional district may also establish and operate the following extended services:

- regulation of fire alarm and other security alarm systems
- building inspection
- building numbering

- emergency preparation
- heritage conservation

Some of the local or extended services noted as set out in the Municipal Act are already provided by the RDCO but fall under one of the broader categories in the Letters Patent, such as ‘local works and services’.

Obtaining Other Powers

Although the letters patent and the Municipal Act set out a wide range of powers, RDCO does not have the power to provide and maintain drainage works. Currently that power rests with MoTH. However RDCO may request that power from the Province in accordance with section 801 of the Municipal Act:

> *“801. (1) The Lieutenant Governor in Council may, by regulation,*
>
> *a) grant a power to a specified regional district or a described class of regional districts, or*
>
> *b) provide for a specified regional district or a described class of regional districts an exception or a modification of a requirement established by an enactment”*

A regional district also has some other powers that relate to drainage. In some cases, however, the extent of these powers is limited or unclear. Some of these powers include Development Cost Charges subdivision servicing, and excess or extended services.

Development Cost Charges

Section 933 (2) of the Municipal Act states that

> *“Development Cost Charges may be imposed . . . for the purpose of providing funds to assist the local government [which includes a regional district] to pay the capital costs of providing, constructing, altering or expanding . . . drainage . . . facilities”.*

However section 933 (3) states that

> *"A development cost charge is not payable if the development does not impose new capital cost burdens on the municipality, regional district or greater board".*

So if a regional district is not responsible for stormwater management, then the DCC is not payable, since the development would not place new capital cost burdens on the regional district. Therefore, if the RDCO wanted to collect Development Cost Charges for drainage, the RDCO would need to obtain some level of authority for drainage from the Province.

<u>Subdivision Servicing</u>

Section 938 (1) states that

> *"A local government may, by bylaw, regulate and require the provision of works and services in respect of the subdivision of land, and for that purpose may, by bylaw, do one or more of the following . . .*
>
> *c) require that, within a subdivision . . . a drainage collection system or a drainage disposal system be provided, located and constructed in accordance with the standards established in the bylaw"*

As a result the RDCO can establish standards for stormwater management within a subdivision. This includes Works within a subdivision or on roads abutting subdivisions up to the centreline of the road. Any other services are excess or extended services, as described below.

Currently the RDCO sets out servicing requirements in its *Subdivision and Development Servicing Bylaw.*

<u>Excess or Extended Services</u>

Section 939 of the Municipal Act gives the Regional District the power to

> *"require that the owner of land that is to be subdivided or developed provide excess or extended services".*

Excess or extended services means, amongst other things,

> *"a portion of a water, sewage or drainage system that will serve land other than the land being subdivided or developed".*

Based on these sections of the Municipal Act, a regional district can require excess or extended drainage services that serves land other than the parcel being subdivided or developed.

Background Issues

There are a number of background issues and factors that affect the provision and maintenance of stormwater management works within RDCO:

- The RDCO currently does not have the authority under the Municipal Act to address stormwater management.
- Generally MOTH focuses on construction and maintenance of drainage directly related to roads.
- MOTH currently provides the Approving Officer function.
- The RDCO has set out standards for construction of drainage works in its *Subdivision and Development Servicing Bylaw.*
- MOTH is not set up to handle the management of stormwater management for urban development occurring in pockets of rural areas.
- The authority to require off site stormwater management works is unclear, particularly if they do not fall squarely into the category of excess or extended services. In particular, an issue is how to provide for required major off-site storm stormwater management facilities such as major trunks, detention facilities, outfalls, etc.
- The liability for stormwater management problems is a concern.
- The RDCO does not have cost recovery mechanisms available, such as Development Cost Charges, since they do not have the authority to deal with stormwater management.

- The RDCO prepares stormwater management plans with the support of MOTH, in order to provide better information to guide the design and construction of stormwater management works.
- Stormwater management will become a bigger issue as development proceeds in the future.
- Retrofitting existing residential areas experiencing stormwater management problems with new works, will become a bigger issue over time.

2.1.3 Recommendation

The following sets out some suggested strategies, terms and conditions for RDCO to deal with stormwater management. Many of the points were developed and discussed at a workshop on a wide range of services, held with senior RDCO staff in November 1997. The key suggestions are set out below:

- Set and Enforce Standards - The RDCO should continue to ensure new on site drainage works are well designed and built, by setting and enforcing standards in the subdivision servicing bylaw.
- Request Authority - The RDCO should request authority from the Province to provide stormwater management services. This could be done under section 801 of the Municipal Act.
- Develop Tools to Require Off Site Drainage - The RDCO should develop tools needed to require and provide off site drainage works. These may include development agreements (if given the authority by the Province), excess or extended service requirements, and other tools.
- Develop Tools To Recover Drainage Capital Costs – RDCO should develop effective tools, such as Development Cost Charges, that will allow for the recovery of drainage costs. The cost recovery tools for various components are discussed in more detail later in this report.

- Enhance Ability To Retrofit Existing Areas - The RDCO, when it obtains the authority to address drainage, may be able to request a change in the counter-petition rules for area specific works. This would allow for more drainage retrofit projects to proceed.
- Get MOTH to Maintain Drainage Components - The RDCO should work towards obtaining an agreement from MOTH to look after the maintenance of drainage components since MOTH has the tools, resources, and contractors to better maintain drainage works.
- Obtain Responsibility for Major Components - The RDCO may wish to look after maintaining major components such as trunks, outfalls, and detention ponds. This could be a point of negotiation when discussing responsibilities with MOTH.

2.2 Jurisdictions

2.2.1 Issue

How should the RDCO approach jurisdictional differences with respect to stormwater management in the WMDP study area?

2.2.2 Discussion

The WMDP study area is subject to several jurisdictions as presented below.

- <u>The Regional District of Central Okanagan</u> is responsible for developing and administering the zoning bylaw and official community plans within its boundaries. It also has developed the *Subdivision and Development Servicing Bylaw*, which stipulates the level of services, required for each zone.
- <u>The Westbank First Nation</u> has two reserves within the study area: IR 9 and IR 10. It is responsible for administering all activities within the reserve boundaries.

- The Ministry of Transportation and Highways is currently responsible for approving subdivision applications within RDCO boundaries. It is also responsible for maintaining stormwater management facilities, including upgrades and improvements.
- The Ministry of Environment, Lands and Parks administers activities within perennial streams and reviews development applications with respect to environmental impacts. Stream activities also include the decision to enclose specified sections within a pipe.

Since major drainage routes do not usually follow political boundaries, several basins within the study area drain from RDCO jurisdiction onto WFN lands. Disrespect for development plans and activity by either party for the other party will most likely lead to stormwater management challenges. For example, if a section of a stream is enclosed in pipe on WFN land without consideration for long range development plans within the upstream RDCO jurisdiction, the proposed works will eventually become a bottleneck to system capacity. Conversely, if development occurs within RDCO jurisdiction without considering existing downstream capacity on WFN property, flooding potential is increased. In some cases, where proposed stormwater management facilities would benefit properties within both jurisdictions, the potential for cost sharing should be discussed.

2.2.3 Recommendation

As the RDCO takes over more control of stormwater management within its own jurisdiction, it must also maintain open dialogue with the Westbank First Nation. It is essential that all of the key stakeholders work together for the benefit of the entire area.

2.3 Convenience / Emergency Drainage Systems

2.3.1 Issue

Most developments are constructed with a planned convenience drainage system. Recent system failures, however, underscore the need to also plan and construct an emergency drainage system.

2.3.2 Discussion

There are two key drainage systems that must be considered in the stormwater management discussion. The first is the convenience system and the second is the emergency system. Each system plays a distinct role and differs significantly from each other as described below:

Convenience System

The convenience system (also called the “minor” system) is designed to accommodate runoff from frequent rainfall and snowmelt events. It is constructed to minimize inconveniences to both pedestrian and vehicular traffic due to surface ponding and flooding. System components usually include roof gutters, rainwater leaders, service connections, swales, street gutters, catch basins, and storm sewers. It may also include detention ponds and various facilities to enhance stormwater quality prior to discharge to receiving waters.

Emergency System

The emergency system (also called the “major” system) is intended to lessen the risk of property damage and/or loss of life due to flooding caused by less frequent rainfall events. It usually consists of natural streams, gullies, man-made streets, swales, channels, culverts, and in some instances, even large storm sewers. This system operates only when the convenience system fails, usually under extremely high runoff conditions. Since convenience systems usually fail infrequently, the emergency system must be able to function reliably after years of disuse, often at a moment’s notice.

In the past, it has often been assumed that because a convenience system has been constructed, natural drainage routes downstream of the inlets can be filled-in or constructed in. This approach puts property, and sometimes human life, in jeopardy. In the *WMDP*, primary emergency drainage routes and associated structures have been identified. It is intended that future development will respect these routes and incorporate them into their plan. Where the primary emergency drainage system within a developed area proves to be inadequate, the WMDP identifies and recommends appropriate improvements.

2.3.3 Recommendation

The emergency system must be planned for in new developments, and in some cases, upgraded in existing developments. This means, for example, that wherever a low point occurs at the entrance to the convenience system, an emergency overflow route must be identified and protected. Under these conditions, when the inlet's capacity is exceeded under high runoff conditions, or when the inlet becomes blocked by debris, there is a planned route for the excess runoff to safely reach the receiving channel or water.

> *"It must be remembered that the major system will exist in a community whether or not it has been planned or designed and whether or not development has been wisely situated with respect to it."*
>
> *URBAN DESIGN GUIDELINES, PROVINCE OF ONTARIO*

2.4 Unplanned Emergency Drainage Routes

2.4.1 Issue

What should the Stakeholders do to address the potential problems associated with the many existing emergency drainage routes which have either not been planned for, or have been neglected?

2.4.2 Discussion

Referring to Figures 4.1 to 4.12, which are located in Section 4, there are many locations within the *WMDP* area which are serviced by unplanned emergency drainage routes. Essentially, these routes are not recognized as such by the owners of the properties through which they pass. Because of this, there is a risk of property damage should runoff flow through these routes.

In most cases, these routes do not comprise the primary drainage routes for the basin. Instead, they service small areas that drain to low points which have no planned overflow route. Figure C1 in Appendix C illustrates a typical situation where runoff would flow through a residential lot should the minor system catch basin become either clogged or have its capacity exceeded. In most cases, the unplanned emergency drainage route starts at either a low point in a road, or at the end of a cul-de-sac which slopes away from the main road.

It is beyond the scope of the *WMDP* to individually address the issues associated with each of these sites. This would require:

- drainage area delineation,
- peak flow and runoff volume estimation,
- mitigative option development, and
- cost estimation.

Sites which appear to carry higher risk of damage have been included in the *Proposed Works* part of each section. This does not mean that damage at the sites not specifically addressed would be insignificant. Indeed, the affected property owner would consider any damage to be very significant! It does mean, however, that the risk of high flows and extensive damage is probably low.

It is economically unfeasible for the RDCO and/or MOTH to implement mitigative measures at each of the identified unplanned emergency route sites. In most cases, the route contains extensive landscaping, and/or major buildings. This precludes open channels and would require a piped solution. The cost of installing a piped storm sewer and restoring the landscaping at each site could be extensive.

Conversely, some sites may offer the opportunity to implement simple measures that could reduce the potential for property damage. These measures should be identified and implemented where feasible.

2.4.3 Recommendation

Develop a policy which defines the conditions under which mitigative measures should be implemented. Also develop and implement a systematic plan to address the following for each identified unplanned emergency drainage route:

- evaluate risk in terms of design flow, frequency, and potential damage;
- identify mitigative options;
- assign priorities;
- include highest-priority works in MoTH's annual maintenance budget;
- develop a method of collecting funds for this specific maintenance issue.

2.5 Piped Emergency Drainage Routes

2.5.1 Issue

Under what circumstances should piped systems be used as emergency drainage routes?

2.5.2 Discussion

When development is allowed to occur upstream of private property, prior considerations must be given to the potential for downstream damage should stormwater management facilities within the new development fail. (This also holds true for lots within sub-divisions that are downstream of low points in roads.) Therefore, it is extremely important for the emergency system to function properly while providing maximum, cost- effective protection. Excessive runoff must be safely conveyed from the development to an appropriate receiving water or major drainage route.

In most situations, surface emergency drainage routes provide the most protection because they usually have a trapezoidal cross section, and are designed with some freeboard. This provides significantly increased capacity as flow depth rises.

Open channels inherently provide a greater factor-of-safety than piped systems. There are, however, situations where use of an open channel may not be appropriate. Two of the most common are:

- routes over extremely steep slopes, and
- routes through developed areas with insufficient room for an open channel.

Some of the challenges of using a piped emergency system are as follows:

- Inlets to piped systems are often subject to clogging by sediment and / or debris. This is especially true under extreme runoff conditions.
- Once a piped system is installed, new development often occurs within the natural drainage route downstream of the inlet that would not have occurred otherwise. This can result in potentially greater downstream damage if the inlet fails than if the piped system had not been installed in the first place.

2.5.3 Recommendation

Piped emergency drainage routes should be used only when surface drainage routes are not feasible. When used, the Design Engineer must ensure that:

- inlet structures are appropriately sized and designed to minimize clogging,
- development downstream of inlets is planned to minimize potential damage should the inlets fail, and that

When surface routes are used, it is essential that:

- an easement or right-of-way is obtained in favour of the RDCO or MoTH.
- appropriate works are constructed to ensure adequate capacity, and that
- potential erosion is adequately addressed.

In all cases, an on-going inspection and maintenance plan for emergency drainage routes should be developed and implemented.

2.6 Stormwater Quality

2.6.1 Issue

What level of environmental protection does the RDCO want provided with respect to stormwater quality?

2.6.2 Discussion

The issues surrounding stormwater quality and the impact of urbanization are many and complex. The purpose of this section is to provide an overview of the issues related to stormwater quality and measures available to deal with the problems. This section has been prepared following a review of available literature and discussions with staff of the Ministry of Environment, Lands and Parks (MoELP) who have regulatory authority with respect to drainage and watercourse and pollution control issues. This section of the WMDP provides the following:

- background information about the nature of the problem,
- regulatory requirements related to stormwater quality control, and
- overview of current best management practices (BMPs) for control.

Background

It has been recognized for some time that land development and urbanization generally have a negative impact on the quality of stormwater runoff. This deterioration results from the following three principal causes:

a) Soil erosion and alteration of riparian areas during construction of urban developments such as residential subdivisions, roads, and municipal infrastructure.

b) Alteration of the hydrology of urbanized watershed, such as an increase in the peak of stormwater runoff, and a reduction of groundwater infiltration and stream base flows.

c) The wash-off of pollutants such as pesticides, herbicides, road sand and salt, among others, after construction of urban developments.

Soil erosion occurs when rain falls on areas which have been stripped of vegetation in conjunction with development. The result can be that stormwater runoff carries many times more suspended solids such as silt and sand than before construction, and this can affect fish and their habitat. The alteration of riparian areas includes the stripping of land and removal of trees and brush within the buffer area around the stream channel. Such alteration can reduce shade cover, shelter, and food sources.

Watershed hydrology is affected as a watershed is developed. Under natural, undeveloped conditions, much of the rainfall that occurs within a drainage basin infiltrates into the ground. It moves through the watershed as base flow and minimizes surface runoff. In this way, the ground acts as a reservoir, storing runoff and releasing it over a longer period of time. Following urbanization, there can be a significant increase in the amount of impervious surface which reduces infiltration and causes rain fall to runoff rapidly. The result is lower base flows, and the greater likelihood that smaller streams will dry up between rainfall events.

Finally, following development of an area, stormwater runoff will typically contain a variety of pollutants related directly to urbanization. These may include fertilizers, road sand and salt, herbicides and pesticides, bacteriological pollutants from animal waste, and heavy metals. All of these degrade stormwater quality and affect fish. It is known that most pollutants are contained in what is commonly called the "first flush." This is the initial portion of rainfall which appears as surface runoff. There is no quantifiable limit which defines the end of the first flush, but it is generally accepted that the first few millimeters of runoff contains the majority of pollutants. Therefore, by providing stormwater quality control for the most frequent storms, most of the problem is dealt with.

It has also been recognized for some time the degradation of stormwater quality, or more generally the quality of all runoff, has an impact on fish and fish habitat. Furthermore, fish and fish habitat are both considered valuable resources by the Federal and Provincial governments, and legislation is in place to protect these resources. MoELP's concerns are with respect to the protection of the fisheries resource, including both fish and their habitat, recognizing that essentially all watersheds eventually drain to fish bearing streams or water bodies.

It is worth noting that fish habitat consists of several elements. These include cover which provides protection from predators and controls water temperatures, food, substrate which provides spawning areas, water quality, water quantity, and access up and down stream channels.

Regulatory Requirements

There are essentially two regulatory issues which are to be considered in stormwater quality control:

a) The first is the impact of in-stream work, and this is regulated by MoELP under the *Water Act*. The regulations which have been established under Section 9 of the *Water Act* give MoELP the authority to control all works which are carried out in and about a watercourse which is broadly defined under the Act. The regulations control the time of year when works can be undertaken, and allow for the establishment of other specific measures to control the discharge of silt, sediment, or pollutants during construction.

b) The second regulatory authority is also granted to MoELP under *the Waste Management Act* which obliges municipalities to discharge waste under a permit system. Although stormwater discharges are currently included in the Act as a waste discharge, permits are not required at this time. However, on the basis of comments made by staff of MoELP it is expected that in the next decade, MoELP will begin to deal more strictly with stormwater discharges, and this may include the need to incorporate specific measures into developments to deal with stormwater quality degradation.

There are a variety of measures which have been developed over the past few decades and which are shown to mitigate the detrimental impacts of urban development on stormwater quality. These measures are intended to accommodate urban development and while at the same time conserve the fish resource, and are commonly referred to as BMPs.

The measures can be further categorized as structural BMPs and non-structural BMPs. Structural BMPs are defined as measures which generally require the construction of a major facility or some other physical element in the drainage system, such as a detention pond. Non-structural BMPs are non-physical measures such as land use and pollution control bylaws.

Best Management Practices

As previously noted, BMPs can be separated into two broad categories; structural and non-structural BMPs. The following section outlines BMPs which are appropriate for application in the WMDP study area. It should be noted, however, that there are several other factors which must be considered by designers and reviewers when selecting BMPs for specific sites. These include issues such as slope, contributing area, ground cover, soil type, land use, and density of development.

Guidelines for designing all of the BMPs discussed in the following section are provided in the following two documents:

- Urban Runoff Quality Control Guidelines for British Columbia, BC Environment, Municipal Waste Reduction Branch, Environmental Protection Division, June, 1992
- Land Development Guidelines for the Protection of Aquatic Habitat, Ministry of Environment, Lands and Parks, and Department of Fisheries and Oceans, September, 1993.

Structural BMPs

Structural BMPs are in-field works and methods used to enhance stormwater quality. The following examples are grouped with respect to the principle causes of runoff quality degradation.

In-Stream Work

During the course of land development projects, it is sometimes necessary to carry out construction work within a stream. Examples include utility crossings of streams, and construction of culverts and bridges. The Ministry of Environment, Lands and Parks should always be consulted prior to undertaking in-stream works. MoELP has established procedures for obtaining approvals for in-stream works, and the process can take several weeks. Therefore, early discussions with MoELP are recommended.

In general terms, in-stream works should be planned for periods that have the least impact on the fisheries resource. MoELP has defined fisheries work windows for lakes and stream throughout the province, and this can vary depending on the fish species of concern. BMPs include the use of physical barriers to separate stream flow from the work site. The primary objectives of BMPs related to in-stream work are as follows:

- Minimize duration of in-stream activities.
- Prevent the use of toxic materials such as wood preservatives, paint, hydrocarbons, and concrete leachate.
- Limit sediment generation during excavation of stream substrate.
- Maintain fish passage through structures such as culverts.

Erosion and Sediment Control

Typically, during construction, areas of the development site are stripped of vegetation and may remain that way for some time. The result can be that rainfall washes exposed soil from the site into nearby streams. It is also common for storm sewer systems servicing the completed development to discharge into natural ravines or small streams that are tributary to fish-bearing waters. In this situation, the increased flow rates and frequency of flow events can cause channel erosion. The resulting suspended solids can harm fish gills as well as smother eggs in spawning areas adjacent to the site and further downstream.

There are essentially two types of BMPs to control erosion and sediment on construction sites:

a) The first type of BMP prevents soil from being washed off the site in the first place. These BMPs include limiting the amount of exposed area, covering exposed slopes with mulch, plastic sheets, or commercially available erosion control mats, and promptly re-vegetating areas which are stripped for grading. For channels, they include armouring or use of root reinforcement systems.

b) The second type of BMP captures eroded soil after it has been washed off the site. These BMPs include the use of silt barriers such as straw bale dikes and commercially manufactured silt fence, as well as sediment control ponds. These ponds are similar to stormwater detention ponds, except that they are generally earthen pits and are designed to capture and control eroded soil washed off by relatively frequent storm event.

Stormwater Management

The objective of stormwater management measures to control stormwater quality ranges from the simple control of peak post-development flow rates to pre-development levels, to the attempt to control post-development drainage to as near existing conditions as possible. The first objective is often achieved by providing a detention pond facility at the end of the major and minor drainage systems prior to release to the receiving water body. The second objective is usually difficult to achieve, and requires the use of a variety of measures including a heavy reliance on BMPs which promote infiltration into the soil.

a) The simplest of these measures include *vegetated swales and filter strips*. These are simply grassed areas through which small quantities of surface drainage are passed to promote infiltration by slowing down the surface runoff. These measures also settle out suspended solids and associated contaminants. Vegetated swales and filter strips are most effective in residential developments for treating runoff from local impervious surfaces.

b) Other infiltration systems include *infiltration trenches and pervious pavements*. Infiltration trenches are essentially ditches which are filled with drain rock. Stormwater runoff fills the voids between the stones and then infiltrates into the soil. Pervious pavements are similar to conventional pavements, except that they contain a considerable amount of voids, and thus allow more of the rainfall to pass through rather than become runoff. These systems are prone to failure because of silting, and often require some form of pretreatment to remove suspended solids. However, their use increases groundwater and can enhance base flows in stream within the watersheds where they are used.

c) *Extended detention dry ponds and wet ponds* are also effective at removing pollutants in urban runoff. These ponds are called extended detention ponds because they are designed to detain stormwater runoff longer than is required simply to meet a water quantity control objective such as post-development peak rate control. By extending the time of detention, more time is available to allow pollutants which are suspended in the stormwater runoff to settle out of the water column. Extended detention wet ponds are more effective because they are less prone to the re-suspension of collected pollutants.

d) The effectiveness of ponds can be further enhanced through the development of *engineered wetlands*. These systems rely on plant activity as well as physical processes such as settling to remove pollutants. Engineered wetlands are sometimes difficult to construct as they are very near to natural systems, and require a constant supply of water to sustain them. In arid areas such as the Okanagan, these systems sometimes need make-up water during dry periods to sustain them.

e) There are also other physical systems which are intended to enhance stormwater quality. These include *oil-water separators and swirl concentrators*. The former captures and store hydrocarbons which are carried in the runoff, and are effective when used to treat runoff from large paved areas such as parking lots. The latter separates suspended solids from flows in underground storm sewers. Both of these measures require regular maintenance to ensure that they remain in good working condition.

Non-Structural BMPs

Non-structural BMPs do not require the construction of physical systems to control pollutants in urban runoff. They often begin with public education and participation. By making people aware of the issues of pollutants in urban stormwater runoff, and the ways in which individuals and groups can help to control stormwater quality, a number of impacts can be eliminated. For example, public education can help to reduce the incidence of people dumping waste oil or other toxic household products into catch basins and the public storm drain system.

Land use control by-laws can also be effective in reducing stormwater quality degradation. For example, by increasing density within portions of a development, larger areas can be left undisturbed. This type of development is often called clustered development. It results in the same number of units as conventional residential development, but places these units within a smaller portion of the total site.

The identification of leave strips can also reduce the impact on the fisheries resource. Leave strips are by-law regulated buffers along creek and stream channels. The buffers can be from between 15 and 30 metres wide, and are intended to protect riparian areas through the restriction of the buildable area of a site.

Other simpler, non-structural BMPs include litter control, system maintenance, and regular street sweeping.

2.6.3 Recommendation

Since the long term MoELP plan is to regulate stormwater discharge to receiving waters, the RDCO should encourage and support the use of structural BMPs where feasible. Planning and policy documents should also promote stormwater management systems that improve runoff quality. Failure to initiate these practices may result in significant future upgrade costs.

2.7 Slope Stability

2.7.1 Issue

What steps should be taken to ensure that concentrated runoff, infiltrated into the ground, does not adversely impact slope stability?

2.7.2 Discussion

Under natural, undeveloped conditions, there is a relatively stable equilibrium between groundwater flow and slope stability. Once development activity takes place, this equilibrium is altered. Rainfall that used to fall and infiltrate more or less uniformly over an entire area, is now concentrated into ditches, or into a convenience system that either discharges runoff to a channel, or infiltrates it into the ground. Under these circumstances, groundwater can mound, and on a moderate to steep slope, can potentially cause instability. Since a significant portion of the study area contains relatively steep slopes, this issue must be addressed.

Although ditches along hillside roads pose potential problems if perennial streams are diverted into them, in-ground stormwater disposal systems are of particular concern. As presented in Section 2.6 (Stormwater Management), infiltration systems are favoured by the Ministry of Environment, Lands and Parks to minimize impacts to stormwater quality. If these systems are to be considered, then it is essential that adequate invest-igation is completed to ensure slopes remain stable.

2.7.3 Recommendation

Whenever in-ground stormwater disposal systems are considered for use within a development, or whenever there is potential for significant amounts of surface water to be concentrated prior to infiltration, the issue of groundwater-induced slope instability must be adequately addressed in the required Stormwater Management Plan. (See Section 2.12.2).

2.8 Groundwater

2.8.1 Issue

What measures should the RDCO take to ensure that:

a) groundwater does not adversely impact proposed development, and that

b) conversely, proposed development does not adversely impact groundwater conditions?

2.8.2 Discussion

Although the WMDP is primarily focused on managing surface runoff, groundwater within the study area can and does have a significant impact upon development. Many sites within the study area have been identified as having a high groundwater table, and are characterized by surface discharges (springs or marshy areas). Significant works are often required to collect and divert such groundwater to appropriate drainage systems. Since groundwater tends to flow for longer durations than surface runoff, sometimes even perennially, there can often be significant downstream impacts when it is diverted into an open-channel drainage system that is normally dry.

Development can, in turn, also have a significant impact on the groundwater regime. It can alter the natural subsurface flow direction so that areas which depend upon groundwater are deprived of it. Alternatively, other areas which previously had no groundwater problems, can sometime become inundated. This is often due to mounding along ditches, detention ponds, or in-ground disposal systems.

As discussed in Section 1.1, the *WMDP* is partially based on three hydrogeological studies that provide an overview of potential groundwater problem areas. These reports also recommend typical works that should be constructed to prevent or mitigate problems within new or existing developments respectively.

2.8.3 Recommendation

If a proposed development is located, even partially, within groundwater Zone II or Zone III as defined in Section 3.5, a site-specific groundwater investigation should be required as part of the required Stormwater Management Plan for that development. This investigation should identify groundwater conditions and recommend specific measures to mitigate potential problems.

2.9 In-Ground Stormwater Disposal Systems

2.9.1 Issue

In keeping with the long range stormwater quality objectives of the Ministry of Environment, Lands and Parks, should the RDCO and the MOTH encourage (or even require) the use of in-ground stormwater disposal systems?

2.9.2 Discussion

Currently, the RDCO *Subdivision and Development Servicing Bylaw* requires developers to install curb, gutter, and storm sewers for most residential and commercial developments. This requirement, however, defeats the objectives outlined by the Ministry of Environment, Lands and Parks as discussed in Section 2.6.

The Regional District adopted the current requirements for several reasons:

- The OCP's recommended "full urban services" for these types of developments.
- Storm sewer systems were recommended in previous studies as part of the solution to groundwater problems in select areas.
- The MOTH has historically experienced maintenance problems with drywell systems.

There are also several reasons why historical problems occurred with drywells:

- Some were installed in soils that were not suited for in-ground disposal systems.
- Others were installed on hillsides that became unstable when saturated.
- Once installed, there were often no preventative measures were taken during the construction period to keep sediments out the drywells. Therefore, some units were clogged even before the subdivision was completed.

The hydrogeological studies completed for the various drainage plans indicate that some portions of the study area are suitable for in-ground stormwater disposal, and some are not. These areas are identified to facilitate implementation of the recommended policy.

2.9.3 Recommendation

Where conditions appear favourable to implement in-ground stormwater disposal systems, a site-specific hydrogeological investigation must be completed by a Professional Hydrogeologist as part of a development's Stormwater Management Plan. If suitability is confirmed, then an in-ground disposal system should be installed based on the recommendations of the hydrogeological report. The report should address projected life span and maintenance costs of the proposed system.

2.10 Deficiency Correction Philosophy

2.10.1 Issue

Should the stormwater management Stakeholders be reactive or proactive with respect to correcting existing deficiencies, especially those associated with emergency drainage routes?

2.10.2 Discussion

The *WMDP* has identified a large number of deficiencies. These have been prioritized as per the criteria outlined in Section 3.7. Based on the definition of the priorities, it is obvious that the Stakeholders should take a proactive approach in addressing Priority 1 deficiencies. The question is how proactive should the Stakeholders be toward correcting Priority 2 and 3 deficiencies?

To be proactive means that the Stakeholders initiate the implementation process necessary to complete the recommended works before design runoff conditions occur. To be reactive means that nothing is done until design conditions occur and affected property owners complain, or even worse, pursue legal action!

Many of the lower priority deficiencies carry a low risk of experiencing failure. This should not, however, be confused with a low amount of damage should failure occur. In most cases, even a small flow of rogue runoff can cause substantial damage to houses, landscaping, roads, and other expensive items.

A low risk of failure tends to create an attitude that the associated deficiency is not worth addressing until perhaps “something happens”. This is the reactive approach. Usually, however, when “something” does “happen”, those responsible for the stormwater management system end-up compensating for the damages as well as correcting the deficiency that caused the damages in the first place.

2.10.3 Recommendation

Since a reactive approach to correcting serious deficiencies is probably the more expensive approach over the long term, the Stakeholders should choose to proactively address the identified deficiencies based on the priorities assigned in the *WMDP*.

2.11 Cost Recovery

2.11.1 Issue

What method or methods should the RDCO employ to recover costs for off-site stormwater management works required by both existing and proposed development?

2.11.2 Discussion

There are four classes of costs associated with stormwater management facilities:

- on-site capital costs for new development,
- off-site capital costs generated by new development,
- retrofit capital costs , and
- maintenance costs.

On-Site Capital Costs For New Development

Works required to service development on a given property are generally installed and paid for by the Developer. The only exception may be on-site trunk facilities that must be oversized to service future, upstream development by others. Under these circumstances, the Developer is expected to pay for the base system while the oversize costs can be recovered through latecomer agreements.

Off-Site Capital Costs Generated By New Development

Works associated with the offsite capital costs sometimes also improve stormwater management within existing developments. Since it is not reasonable to expect the development community to fund all of the stormwater management costs when the benefits are shared with existing development, and since it is also unreasonable to expect one developer to fund works that will benefit other potential developments, an equitable cost recovery strategy is required. While latecomer charges are the only ones currently available to RDCO, if the power to deal with drainage is acquired from the Province, the following options are available:

- DCCs
- Local Service Area taxation
- Late comer agreements
- Development Works Agreements
- General taxation

Development Cost Charges (DCCs) are the primary method for collecting funds to pay for the portion of off-site costs that benefit new development. As mentioned earlier, the RDCO would need to acquire the authority for drainage in order to establish a drainage DCC.

Local Service Area taxation could be used in cases where land owners agree to pay for specific off-site drainage upgrades that benefit an area. Once again, the RDCO would need to acquire the authority for drainage in order to establish a local service area for drainage.

Latecomer agreements could be used to recover costs for off-site extended services. However latecomer agreements can only run for a maximum of 10 years. If the RDCO pays for part of the works, this may present an unacceptable risk that the funds would not be recovered within that time period.

Development Works Agreements could be used if the RDCO obtains the power to use these agreements. These agreements require the developer to pay for off-site capital costs required due to the development.

The RDCO does not have the same general taxation powers as a municipality. However, the RDCO may wish to request some general taxation powers in order to deal with off-site capital costs, or the maintenance of off-site works.

Retrofit Capital Costs

The RDCO is faced with retrofitting stormwater management systems in existing developed areas.

One of the key issues is the difficulty in obtaining electoral assent for retrofit work if the work is defined as a local service. A workshop with senior RDCO staff identified some approaches that may help address issues associated with retrofit projects:

- The RDCO could request the authority to do drainage works as a Local Improvement, similar to municipalities. Local Improvement initiatives proceed unless a petition against the works is supported by a majority of the owners, representing at least 50% of the combined property value. Property owners have one month in which to complete the petition process.

- When requesting drainage powers, the RDCO could ask for a modification to the requirements for obtaining the assent of the electors (under Section 801 of the Municipal Act). The minimum number of counter petition signatures required to force a vote could be increased to a higher percentage, such as 50% for example. Power to make this change must be granted through regulation by the Lieutenant Governor in Council. This higher percentage would reflect the more urban setting in RDCO to more closely follow rules currently established in municipalities.
- Another approach would be to create a package of services that would include drainage with other services. The package would cover a specific area, provide a certain range of services, and have a total maximum budget. The RDCO could collect taxes for this bundle of services, and the concept would be similar to the general taxation authority used by municipalities.
- The provincial government could contribute toward capital retrofit costs in recognition that the RDCO is taking over some of the deficiencies that currently belong to the Province.

Maintenance Costs

Maintenance costs could be addressed in the following manner:

- MOTH could maintain most works by including them in their maintenance contracts. Since they have such large contracts they should be able to realize better economies of scale than the RDCO.
- The RDCO could maintain certain works owned by them, such as major trunks and outfalls.

The costs could be recovered as part of a Electoral Area wide or Region wide bylaw. As with the capital works, the counter petition rules could be changed to increase the probability of the bylaw passing. It could also be included as a broader package. Provincial contributions may also be appropriate.

2.11.3 Recommendation

The RDCO should consider requesting additional powers from the Province that would allow it to establish Development Cost Charges, Development Works Agreements, and other tools necessary for the provision of drainage.

Development cost charges should be used as the primary method of cost recovery for the off-site capital costs generated by new development.

Development Works Agreements should be investigated as another means for requiring developers to pay for off-site capital costs generated by new development.

Retrofit costs should be recovered through local service areas, with a modification to the requirements for obtaining electoral assent. The minimum percentage of counter petition signatures should be increased to reflect the more urban setting in RDCO, and to allow local service area projects to proceed.

The RDCO should develop and implement a Region-wide bylaw to collect monies for drainage works maintenance. The RDCO should also develop a process that would allow it to fund drainage works maintenance performed by either MOTH or another contractor.

2.12 WMDP Implementation

2.12.1 Issue

How should the WMDP be implemented?

2.12.2 Discussion

It is one thing to prepare a plan, but quite another to implement it effectively. All of the Primary Stakeholders must understand the issues, “buy into” the process, and commit to fulfilling their respective roles.

The WMDP provides the framework within which stormwater management facilities are to be designed and constructed. One of the key processes to ensure this happens is to require that all development proposals be accompanied by a Stormwater Management Plan as defined by the Regional District's *Stormwater Management Plan Preparation Guidelines.* These plans essentially refine the general concepts outlined in the WMDP, and ensure that appropriate site-specific solutions are implemented when the development occurs.

2.12.3 Recommendation

The RDCO should require that a Stormwater Management Plan be prepared for each proposed development. The RDCO must also:

- Work with MOTH to correct existing deficiencies.
- Maintain and strengthen relations with the Westbank First Nations with respect to implementing mutually beneficial stormwater management facilities.
- Develop a stronger cost recovery program for off-site stormwater management works.

3. Design Criteria and Assumptions

This section presents the criteria and assumptions adopted to conduct analyses, prepare conceptual designs, and estimate capital costs for the WMDP. It also contains the standards against which existing and proposed stormwater management facilities have been evaluated to determine adequacy and feasibility.

3.1 Integration with Other RDCO Documents

To various degrees, stormwater management within the study area is addressed in three adopted RDCO policy documents;

- the Subdivision and Development Servicing Bylaw,
- the Area G Official Community Plan, and
- the Area H Official Community Plan.

The WMDP provides the framework within which the general policies outlined in the OCPs can be implemented. The *Subdivision and Development Servicing Bylaw*, however, sets many of the design and analysis criteria used within the WMDP. Since all of these documents are periodically updated, it is essential that discrepancies between them be identified and thoroughly addressed to ensure an increasingly cohesive and integrated set of policies is developed. Although no major discrepancies have been identified, RDCO Staff should note issues that arise during the rezoning and land development processes. These can then be adequately addressed.

3.2 Peak Flow Estimation Methods

3.2.1 OTTHYMO

The peak flow estimation analyses conducted for the WMDP are for general planning purposes. Schedule “C.8”, Section 2.02 of the RDCO *Subdivision and Development Servicing Bylaw*, specifies that the OTTHYMO computer model is to be used for this purpose. Because the Bylaw also forbids the use of the “SCS method”, some clarification is necessary as to why the analyses conducted for the WMDP are based on modified SCS curve numbers. (See Section 3.3.2.)

The U.S. Soil Conservation Service (SCS) has developed an imperical method for estimating peak runoff based on soil type, land use, soil condition, and soil moisture content. This method was developed using data from relatively flat agricultural areas in the U.S. Midwest. It provides a set of numbers used to estimate the peak flow, and these numbers are determined using default values which are only applicable to the original study area. OTTHYMO provides the option to use this method, but it is not applicable to the current study area. Therefore, the peak flow estimation used in this Master Drainage Plan is based on analyses using OTTHYMO’s Standard and Nash instantaneous unit hydrographs (IUHs). These routines use modified SCS curve numbers which allow the user to adjust for local conditions.

3.2.2 Regional Analysis

For the very large watersheds within the study area which maintain perennial streams, peak flows usually occur during spring freshet. This is a snowmelt-induced phenomenon, and therefore requires a more suitable peak flow estimation method than that offered by OTTHYMO. The Ministry of Environment and Parks has published a set of Regional Analysis data which allows the user to estimate design peak flows for any large basin within the subject hydrological region. Although OTTHYMO was used to estimate peak flows under design conditions for the basins within the lower reaches of the large watersheds, Regional Analysis was also used to estimate base and freshet flows. This ensures that all of the critical runoff conditions have been adequately evaluated. See Section 3.3.9 for more detail.

3.2.3 Rational Method

In a very few instances, and for small catchment areas, the Rational Method was also used to estimate peak runoff from rainfall events. This was done for specific projects where model revisions would have been an onerous task. Results were compared with OTTHYMO values generated for neighbouring or similar catchments to ensure continuity.

3.2.4 Process

Each basin was modeled as follows:

- existing land use; existing drainage; 25 year rainfall
- existing land use; existing drainage; 100 year rainfall
- future land use; existing drainage; 100 year rainfall
- future land use; proposed drainage (where applicable); 100 year rainfall

The first analysis provides the "calibration" for the models. Note that because extensive rainfall and runoff data are not available for the study area, true model calibration cannot be completed. Therefore, the models have been "tuned" to reflect anecdotal responses. Several storm events have occurred during the last 10 years that provide such anecdotal runoff data. During this period, it was noted that runoff from undeveloped, well vegetated basins did not occur. This infers that rainfall from events with at least a 10 year return period is totally intercepted and infiltrated. Considering that some of the events probably had return periods greater than 10 years,

> *it is assumed that for undeveloped basins, runoff will occur only for critical rainfall events with return periods of 25 years or greater.*

Once the models were "tuned", the second analysis established existing deficiencies. The third analysis identified potential deficiencies and provided peak flows for preliminary designs. The fourth analysis is only for select basins which would be impacted by proposed works that alter current drainage routes.

3.3 Hydrological Criteria

3.3.1 Land Use

One of the influencing factors on how a drainage basin responds to rainfall and snowmelt events is land use. In the WMDP, land use is referenced in terms of modified OCP designations. That is, Lakeview Heights and Westbank OCPs were used as the basis for describing how land could be used. Current cadastral mapping, aerial photographs, and select field reconnaissance were then applied to modify the OCP boundaries to reflect existing land use conditions.

Since the two OCP documents employed slightly different designation criteria, and since planning designations differ in purpose than hydrological designations, a modified set of land use designations was also prepared. Table B1 in Appendix B lists the designations and their associated descriptions.

Although this is not a perfect system, it provides an adequate indication of the elements that influence parameter value selection for hydrological analyses. For example, the GRASSED designation indicates that the land is in a natural state containing scrub grass and perhaps very sparse tree cover. It is also unirrigated. As discussed in Section 3.3.7, this condition governs assumed values of Ia and CN*.

3.3.2 SCS Soil Groups

Surface and subsurface soil conditions also have a significant impact on how drainage basins respond to precipitation events. Several soil types were identified in the various geotechnical reports prepared by Golder Associates Ltd. and EBA Engineering Ltd. For purposes of the *WMDP*, these soil types have been assigned to one of four soil groups as defined by the United States Soil Conservation Service. The US SCS has developed a classification system for soils based on drainage characteristics. These data, combined with land use assumptions, are used to select the SCS curve number (CN) used by OTTHYMO for hydrological analyses. (See Section 3.3.7 for more details.) Table 3.1 provides a description of each soil group's drainage characteristics.

Table 3.1	
Group A	Soils having high infiltration rates even when thoroughly wetted, consisting chiefly of sands or gravel that are deep and well to excessively drained. These soils have a high rate of water transmission.
Group B	Soils having moderated infiltration rates when thoroughly wetted, chiefly moderately deep to deep, moderately well to well drained, with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.
Group C	Soils having slow infiltration rates when thoroughly wetted, chiefly with a layer that impedes the downward movement of water, or of moderately fine to fine texture and a slow infiltration rate. These soils have a slow rate of water transmission.
Group D	Soils having very slow infiltration rates when thoroughly wetted, chiefly clay soils with high swelling potential; soils with a high permanent water table; soils with a clay pan or clay layer at or near the surface; and shallow soils over nearly impervious materials. These soils have a very slow rate of water transmission.

3.3.3 Return Periods

The convenience and emergency stormwater management systems are each designed to provide different levels of service. The convenience system minimizes the nuisance associated with frequent rainfall events while the emergency system protects life and property when the convenience system fails. As outlined in Schedule “C.8”, Section 2.01 of the RDCO *Subdivision and Development Servicing Bylaw*:

- the convenience (minor) system must be designed to convey flows with return periods of up to 10 years, and
- the emergency (major) system must be capable of accommodating runoff from events with return periods of at least 100 years.

3.3.4 IDF Curves

Atmospheric Environment Service of Canada (AES) has prepared IDF curves for three meteorological stations near the study area;

- Kelowna Airport
- Kelowna's Okanagan College
- Summerland

Comparison of the three curves indicates that the station located at Okanagan College experiences higher-intensity storms, (especially for less frequent events,) than the other two stations. Since this station is the closest to the study area, and use of the IDF curves based on its data would be more conservative, the WMDP uses the Okanagan College IDF curves and associated statistical data. These curves are included in Appendix A.

Since many of the calculations for this study are completed using computer-based tools, the AES plotting equation has been used to calculate the required intensities (rather than manually interpreting them from the actual curve). The equation is:

$$I = a\,t^{\,b}$$

Where: I = rainfall rate in mm/hour;
t = time in hours; and

Return Period (yrs)	2	5	10	25	50	100
Coefficient a	8.2	12.5	15.3	18.8	21.4	24.0
Exponent b	-0.741	-0.771	-0.783	-0.792	-0.797	-0.801

3.3.5 Storm Duration

When sizing stormwater management works, the designer must consider both peak flow and runoff volume. Usually, one or the other becomes the governing factor. For example, the governing criteria for a culvert may be peak flow if there is no available headwater storage. On the other hand, runoff volume may be the governing factor when sizing a detention pond.

Drainage basin size and characteristics also play an important role in determining the critical design conditions for any given works. For example, a small, highly urbanized drainage basin would exhibit a high peak runoff rate from a relatively short duration storm, and a low peak flow from a long duration storm. The converse would be true of a large, rural basin.

Therefore, for any given works, it is essential to determine which storm duration yields the critical design conditions. This becomes the *critical design storm* for that stormwater management facility. Table A1 in Appendix A summarizes the rainfall volume for various combinations of select storm durations and return periods. These become part of the input to the OTTHYMO modeling process.

3.3.6 Rainfall Patterns

Precipitation does not normally fall at a uniform rate during a storm; the rainfall rate (intensity) varies throughout the event. For the analyses conducted for the WMDP, several curves based on statistically analyzed data are used to simulate rainfall patterns for different storm durations. Reproduced from the City of Kelowna design manual, and located in Appendix A, these curves show the portion of total rainfall within a given portion of a storm's duration. Curves are provided for storm durations of 6 hours or less and from 6 to 24 hours. A uniform (flat) storm pattern is assumed for durations exceeding 24 hours.

3.3.7 Effective Rainfall

Not all of the rain that falls into a drainage basin becomes surface runoff. Some of it is intercepted by foliage, some is stored in surface depressions, and some is infiltrated into the ground. The effective rainfall, therefore, is the rainfall that is net of these mechanisms.

For the WMDP, modified United States Soil Conservation (SCS) curve numbers were used to calculate the effective rainfall because:

- there is insufficient detailed data about soil types and conditions within the study area to warrant the use of more sophisticated methods;
- its simplicity supports the general nature of the master drainage planning process;
- it allows adaptation to local conditions.

This method is comprised of several assumptions and sets of data. These are presented as follows.

Initial Abstraction

The initial abstraction represents the amount of rainfall that is prevented from becoming runoff due to:

- interception, and
- depression storage

Interception is the rainfall that is temporarily stored on vegetation, buildings, and other items. It is the portion of the rainfall that makes items “wet”. Vegetation has the highest capacity for storing intercepted rain, and depending on the type of vegetation, this can range from a fraction to several millimeters in depth. Depression storage is the amount of rainfall that is temporarily stored in surface depressions such as potholes and mud puddles.

Using the traditional SCS curve numbers, the initial abstraction, Ia, is calculated as:

$$Ia = 0.2S \text{ (mm)}$$

Where:

$$S = 254(100/CN - 1)$$

$$CN = \text{the SCS curve number}$$

The traditional SCS CN method, however, over-estimates the initial abstraction and under estimates the amount ultimately infiltrated into the ground. This results in higher peak runoff rates for longer, more intense rainfall events. In order to correct this, the modified SCS CN method allows the user to specify the initial abstraction directly.

The initial abstraction is essentially a function of land cover found in a drainage basin. For example, a forested area will have a significantly higher Ia than a school playground because trees provide a much larger surface area for rainfall to adhere to. Table B2 in Appendix B summarizes values of Ia which have been allocated for each type of existing and future land use within the study area.

Antecedent Moisture Conditions

SCS CN values are dependent upon what is termed *antecedent moisture conditions.* These have been classified into three categories:

AMC I Soil is dry (conditions expected of non-irrigated land under 5 average sunny days).

AMC II Soil is moist (conditions expected of irrigated land under 5 average sunny days).

AMC III Soil is near saturation (conditions expected under a combination of rainfall and low temperatures during preceding 5 days).

Historically, the most intense rainfall events within the study area occur during late spring and early summer. These are usually thunderstorms that occur after several days of warm or hot weather. It is true that rainfall often occurs during snowmelt events, or during the late fall when the ground is near saturation, however, these events usually have relatively low intensities. Therefore, for the analytical purposes of the WMDP:

AMC I is assumed for all unirrigated areas such as natural, undeveloped land, and

AMC II is assumed for all irrigated areas such as residential development (lawns) and agricultural land.

Modified SCS Curve Numbers (CN*)

Since the user is able to specify the initial abstraction directly with the Modified SCS CN method, the traditional curve numbers (CN) cannot be used. The reader is directed to the OTTHYMO manual for a detailed discussion on the conversion process. However, several assumptions, which impact this process, are outlined as follows:

1. Most CN tables are based on the assumption that the ground is partially “wet”. This condition has been defined as Antecedent Moisture Condition II, and has been adopted for the analyses for the WMDP.
2. Table B3 in Appendix B presents the Unmodified (traditional) CN values for each combination of soil group and land use.
3. Table B2 in Appendix B presents the initial abstraction (Ia) based on land cover and surface features.

4. The Time of Concentration (Tc) is estimated as outlined in Section 3.3.8, and is used to calculate the approximate rainfall volume of the critical 100 year storm (P). This is based on the observation that in general, the critical storm duration for a selected basin usually coincides with its Tc.
5. The maximum Modified CN value (CN*max) is calculated as follows:

$$CN^*max = 25400/\{[(P-Ia)^2(P^2+0.8PS)/(P-0.2S)^2-P^2]/P+Ia+254\}$$

Where:
- P = Precipitation, mm
- S = (25400/CN - 254), mm
- CN = the Traditional Curve Number based on the assumption that Ia = 0.2S
- Ia = the assumed initial abstraction

6. The Modified CN value is then assumed to be:

$$CN^* = 0.85CN^*max$$

3.3.8 Time of Concentration

The time of concentration (t_C) represents the time it takes for overland flow to reach a basin's outlet from the furthest point in the drainage basin. The value of this parameter significantly impacts the peak flow rate generated during the computer analyses. Of the many methods available to determine the time of concentration for drainage basins, the WMDP uses the following:

$$t_C = \frac{6.989(nL)^{0.6}}{I_{eff}^{0.4}\,S^{0.3}}$$

where:

- t_C= time of concentration in minutes
- n= Manning's roughness coefficient
- L= travel length, meters
- I_{eff}= effective rainfall intensity, mm/hr
- S= average surface slope, m/m

Unless there is substantial reason reduce it, the minimum value of t_C used is 10 minutes, regardless of the calculated value.

3.3.9 Snowmelt - Regional Analysis

Although computer models can be used to simulate a basin's response to snowmelt events, they are very complex and require large amounts of data for both calibration and modeling procedures. Since this level of effort is beyond the requirements of the WMDP, the Ministry of Environment's regional analysis method was used to estimate both base flows and peak snowmelt runoff.

The regional analysis method allows the user to estimate a design flow by using the subject basin's drainage area. A curve based on peak annual flows having a 100-year return period was developed to estimate the design snowmelt event. A second curve based on peak annual flows having a 1 year return period was developed to estimate the design base flows. These curves can be found in Appendix A.

Note that because the basins upon which the regional curves were produced have very large areas at higher elevations than the subject drainage basins, a reduction factor of 0.6 was used based on anecdotal flow data.

3.3.10 Base Flows

Several of the drainage channels located within the study area contain perennial flows due to ground springs and/or lakes. These flows fluctuate seasonally, and even in response to individual rainfall events.

It is possible for a very intense rainfall event to occur during the spring freshet, when stream flows are at their highest. However, the probability that the 100 year design storm will occur during the 100 year freshet peak flow is very low (1 in 10,000). Therefore, the base flows in most major drainage routes was assumed to be zero. For small, spring-fed streams, the base flows were estimated from field observations.

3.3.11 Rational Method

The Rational Method is expressed as:

$$Qpeak = k\ C\ i\ A$$

Where:

$Qpeak$ = *peak flow [m^3/s]*
k = *0.0028*
C = *runoff coefficient*
i = *rainfall intensity [mm/hr]*
A = *catchment area [ha]*

Values for *C* can be found in Table B4 in Appendix B.

3.4 Hydraulics

3.4.1 Open Channels

Hydraulic design of open channels is based on cross-sectional geometry, slope, design flow, and proposed construction materials. The Manning equation is used for hydraulic calculations under uniform flow conditions. Table A2 in Appendix A summarizes representative “n” values for open channels considered in the WMDP.

Wherever possible, open channels are designed to flow under sub-critical conditions. This is often achieved by introducing check dams which create "hydraulic steps" that affect sub-critical slopes. Where this is not feasible, it is assumed that the channel will be armored to protect against erosion.

Table A3 in Appendix A summarizes the maximum allowable velocities for channels constructed with various types of soils and erosion control techniques. For situations not represented by the values presented in this table, erosion protection measures must be designed based on site-specific data.

In general, all open channels should function with a minimum freeboard of 0.3 meters. If the channel is lined, then the lining freeboard should be a minimum of 0.2 meters.

3.4.2 Culverts

Culvert capacity is dependent upon several factors:

- entrance configuration (projecting, tapered, headwall)
- controlling condition (inlet or outlet)
- geometry (diameter, length, slope)
- material (roughness coefficient)

Since the WMDP is a general planning document, the WMDP assumes that

- ditch slopes are generally steep enough to prevent tailwater ponding,
- culverts are relatively short in length, and
- inlet control is the governing condition.

The RDCO *Subdivision and Development Servicing Bylaw* stipulates that culverts on major drainage routes should be sized to accommodate the design peak flow at a headwater to diameter ratio no greater than 1.5. This assumption has been implemented for estimating the diameter of proposed works. For practicality, however, the headwater to diameter ratio available at each particular location (to a maximum of 2.0) has been used when evaluating the capacity of existing culverts. Table A4 in Appendix A lists the inlet capacity for circular culverts under inlet control conditions. Where there is not enough depth to install a culvert of the specified diameter, two or more culverts having the combined capacity of the larger, single unit have been specified.

Regardless of calculated culvert sizes, The Bylaw stipulates the following minimum diameters:

a) 400 mm for driveways;
b) 600 for roads crossed by the emergency system.

3.4.3 Piped Systems

The hydraulic capacities of piped systems within the study area are calculated using the Manning equation. Table A2 in Appendix A summarizes the “n” values assumed for the various types of pipe materials used. The system must be sized to ensure that at 50% flow depth, the minimum velocity is 0.75 m/s. The maximum velocity allowed without scour-prevention considerations is 4.5 m/s.

3.5 Subsurface Drainage Zones

Groundwater conditions can have a significant impact on a development. Conversely, development can have a significant impact on groundwater conditions. Within the context of the WMDP, the issues of potential groundwater problems within developed areas and the potential to dispose of stormwater by discharging it to the ground are considered. These potentials appear to have an inverse relationship, and therefore a single set of subsurface drainage zone classifications has been developed. These are as follows:

Zone I Development within this zone is considered least likely to experience groundwater drainage problems because of sufficiently deep, well-drained soils and a low groundwater table. The soils within this zone are also the most suited to in-ground stormwater disposal systems.

Zone II Groundwater problems within this zone may or may not occur, depending on the specific site. This is primarily due to variable soil and groundwater conditions. This zone is also generally suited to in-ground stormwater disposal systems, but confirmation is required for each specific site.

Zone III Development within this zone has the highest probability of experiencing significant groundwater problems. Therefore, this zone is not generally suited to in-ground stormwater disposal applications.

3.6 Required Systems

Table C.2.2 of the RDCO *Subdivision and Development Servicing Bylaw* indicates the zoning for which a storm sewer system, complete with curb and gutters, is required. These specifications have been followed when estimating the increased runoff due to development. A copy of this table has been included in Appendix B for convenience purposes.

Based on the hydrogeological reports prepared for the *Glenrosa and Westbank Drainage Studies*, some developable areas may be suited for groundwater recharge system use. Therefore, such areas that by bylaw are required to use storm sewer systems, have been identified. Based on the discussion and recommendation presented in Section 2.9, the RDCO may wish to amend its bylaw or set a Board policy that will allow use of appropriate systems within these areas.

3.7 Deficiency Priorities

To facilitate the RDCO and MOTH in developing a drainage improvement program that can be phased over several years, each improvement identified in Section 4 has been assigned one of three priority levels.

The intent is to direct available funds towards those works that pose the greatest risk to both public and private property as well as to the general public. The three priority levels are defined as follows:

3.7.1 Priority 1

Improvement is necessary to prevent significant damage to both public and private property and/or danger to the public from runoff generated under existing development conditions.

3.7.2 Priority 2

Improvement is necessary to prevent:

- inconvenience or annoyance from runoff generated under existing development conditions, or
- significant damage to both public and private property and/or danger to the public from runoff generated under future development conditions.

3.7.3 Priority 3

Improvement is required to meet identified standards, but failure to meet these standards is unlikely to cause:

- significant inconvenience from runoff generated under existing development conditions, or
- significant damage to both public and private property and/or danger to the public from runoff generated under future development conditions.

Works classified as a Priority 3 may be postponed until future development occurs.

3.8 Cost Estimates

The capital cost estimates presented in this document were developed to evaluate potential cost-recovery mechanisms. They include allowances for land, easement, or ROW purchase. They also include:

- 15% for engineering,
- 25% for construction contingencies,
- 5% for RDCO administration, and
- 7% for GST.

Note that these estimates are based on very limited, general information that must be refined through preliminary and detailed design processes. Land-related costs for priority projects should be reviewed in greater detail.

Also note that in addition to capital costs, estimates for updating the MDP and for reviewing submitted stormwater management plans have been included in Section 5. A 12% RDCO administrative allowance, based on the MDP update and SWM plan review estimate, has been assumed.