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March 23, 2006

Mr. Mark Wellman, P.Eng.
Senior Engineer
Regional Utility Planning, Policy and Planning Department
Greater Vancouver Regional District
4330 Kingsway
Burnaby, BC V5H 4G8

Dear Mr. Wellman:

RE: TEMPLATE FOR INTEGRATED STORMWATER MANAGEMENT PLANNING 2005
Submission of Draft Report
Our File 251.073

We are pleased to provide 30 copies of the draft report entitled *Template for Integrated Stormwater Management Planning 2005*. The document is an update on the original May 2002 Working Draft Report but has been substantially revised to reflect the changes requested by the *Stormwater Inter-Governmental Liaison Group* (SILG) through an all-day workshop and six follow-up SILG meetings. The major changes to the document can be summarized as follows:

- **Revision of Minimum Effort Clauses:** Revisions to the "minimum effort" clauses to allow for more flexibility in reducing the scope of ISMPs based on implemented citywide stormwater bylaws and riparian/ streamside protection regulations;

- **Revision of DFO Sign-off Process:** The adoption of a two letter process that streamlines the approval process, and provides flexibility depending on the plans ability to meet the no-net-loss objective;

- **Introduction of the *Watershed Health Tracking System*:** A re-calibration of the original *Watershed Classification System* to better reflect local conditions using the B-IBI results to date;

- **Impact of Adopting the Riparian Area Regulation (RAR) or Streamside Protection Regulation (SPR) in the Riparian Forest Integrity (RFI) index**: The RAR and SPR are regulations and the RFI is a measurement system. However, each uses a different method of calculating the health of the riparian forest. Since ISMPs use RFI to calculate the health of the riparian forest, the impact of adopting either the SPR or RAR has been explained.

- **New Method to Calculate Effective Impervious Area:** The 2002 template utilized the *probability of exceedence* method to calculate EIA. This updated template proposes three additional methods.

- **Integration of the Provincial Guidebook Stormwater Criteria with the DFO Stormwater Criteria:** A recommended blend of the two criteria has been made. Adoption of the 6-month storm over 50% of the Mean Annual Rainfall has been proposed. The 6-month, 24-hour storm is defined as 72% of the 2-year, 24-hour storm.

Supporting information is found in the Appendices. In closing, we trust that this meets your needs, and look forward to receiving comments back from SILG on the revised Draft Report.

Yours truly,

KERR WOOD LEIDAL ASSOCIATES LTD.

Chris Johnston, P.Eng.
Project Manager

/cj
Encl.

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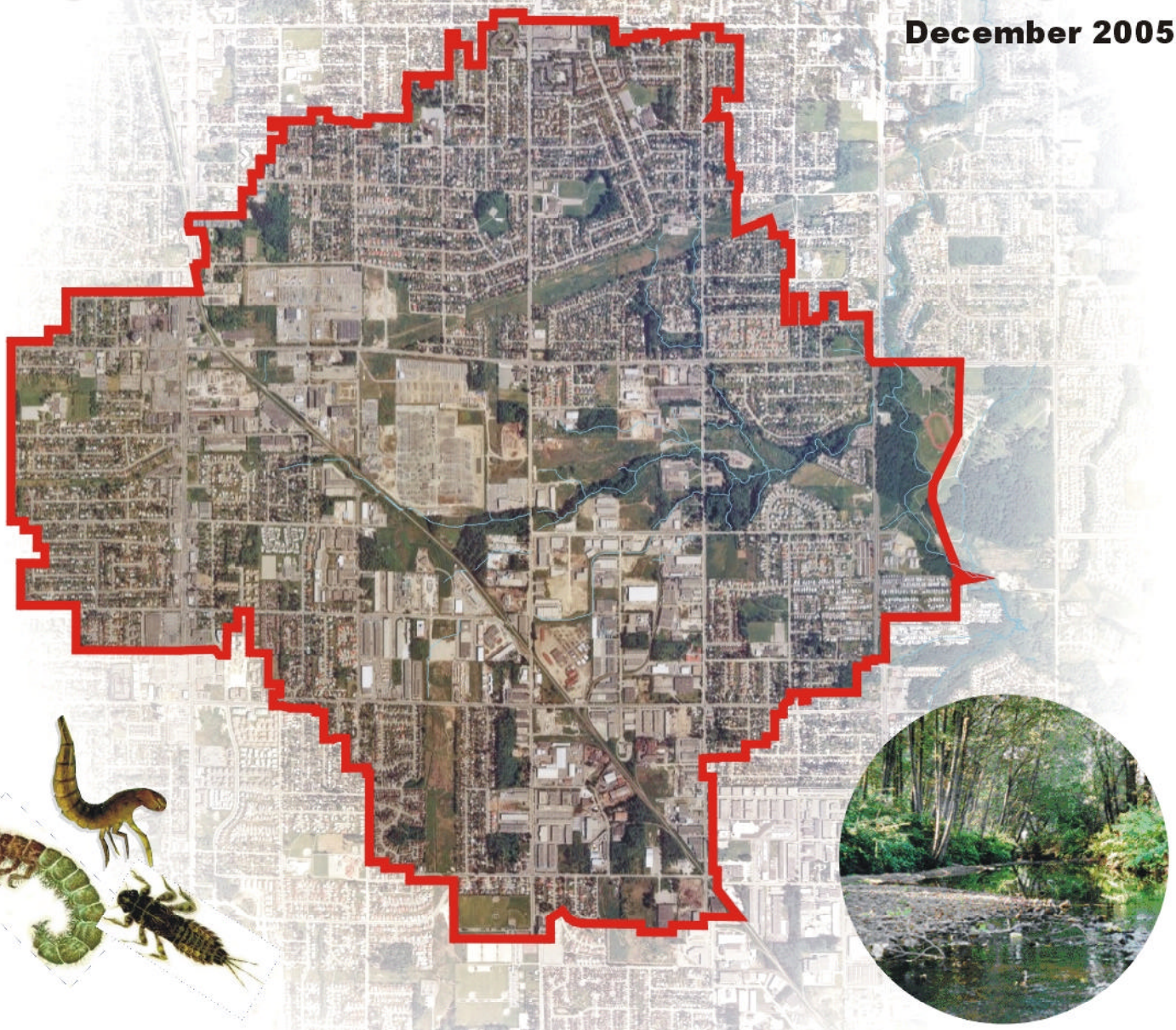
Greater Vancouver Regional District

Template for Integrated Stormwater Management Planning 2005

December 2005



Terms of Reference Template

Draft Report

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CONTENTS

ISMP TEMPLATE CLAUSES

Clauses are inserted after Section 6

FIGURES

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Executive Summary

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EXECUTIVE SUMMARY

< to be completed after the Draft has been reviewed by SILG >

Section 1

Introduction

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1. INTRODUCTION

1.1 BACKGROUND

The Greater Vancouver Regional District's (GVRD) population of 2 million people will double in the next 70 years, leading to considerable land-development pressure, and straining the environment. Unless current land-use, development, and stormwater management practices are reformed, region-wide watershed degradation will accelerate. Therefore, under the GVRD's Liquid Waste Management Plan, its member municipalities have committed to undertake integrated stormwater management planning (ISMP) on a watershed scale for every urban watershed in the region by 2014.

The types of surfaces in a watershed, and how they connect to watercourses are the single largest parameter contributing to the health of a watershed. These surfaces determine the hydrology of a watershed. Stormwater management and land use planning, and the resultant hydrology that binds them are the two biggest contributing disciplines to determining the watershed health outcome. The purpose of integrated stormwater management planning is to marry these two disciplines in the form of a plan that facilitates development while protecting the environment.

1.2 DEVELOPMENT OF AN ISMP TEMPLATE FOR THE REGION

The Greater Vancouver Regional District retained Kerr Wood Leidal Associates Ltd. (KWL) in August 2000 to develop a Terms of Reference (TOR) template for Integrated Stormwater Management Planning (ISMP) at a watershed scale. The GVRD spearheaded this initiative under the Liquid Waste Management Plan (LWMP) to facilitate the implementation of ISMP in its member municipalities. A working draft report was adopted by the Stormwater Task Group[1] (SWTG) in May 2002.

In October 2004, the GVRD commissioned KWL to review the working draft report and develop a process to obtain feedback from member municipalities on its application. The purpose of this document is present the updated Template reflecting the necessary changes. The Terms of Reference for the original May 2002 Template is included as Appendix A.

1.3 2005 ISMP REVIEW PROCESS

The process to review the 2002 Template featured a workshop with follow-up sessions to resolve raised issues. The initial workshop was held on December 2, 2004. Case studies of ISMPs that had been completed (or close to completed) were reviewed in the morning,

[1] The *Stormwater Task Group* was a predecessor to the current *Stormwater Inter-Governmental Liaison Group* (SILG)

and issues associated with the 2002 Template identified. A brainstorming session in the afternoon generated ideas for solutions to some of the more pressing issues. The intent of the workshop was to facilitate a review highlighting what worked well and what did not within the 2002 Template, and to obtain suggestions regarding updating and improving the Template.

The workshop was facilitated by Chris Johnston of KWL. Presentations were made on ISMPs case studies for the following watersheds and by the following presenters:

- Hyde Creek ISMP – Dana Soong and John van der Eerden;
- McDonald/Lawson Creek ISMP – Ray Fung;
- Yorkson Creek Watershed Plan –Steven Lan and Scott Newman;
- Wexford and Walley Creeks ISMPs – Crystal Campbell; and
- Still Creek – Lambert Chu.

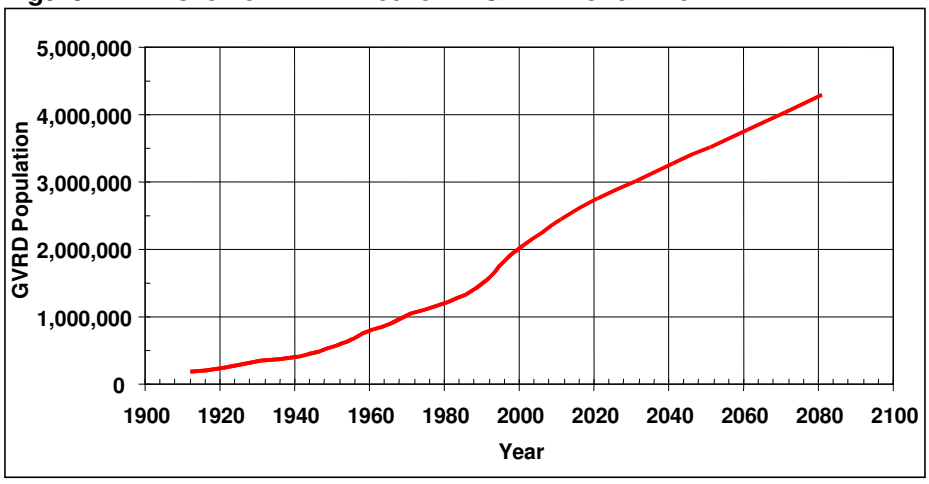
The Workshop generated 31 issues that required resolution. The issues ranged from the clarification of analysis processes to completely changing the direction of several aspects of the Template's approach. Following the workshop, a series of six sessions were held with the *Stormwater Inter-Governmental Liaison Group* (SILG) to resolve each of the issues prior to updating the ISMP Template document.

As mentioned previously, a document entitled *ISMP Terms of Reference Template Review, Workshop Summary*, *September 15, 2005* was prepared summarizing the results of the workshop with resolutions to the 31 issues raised. Relevant sections of the September 15, 2005 report are included as Appendix B.

1.4 THE RATIONAL FOR AN ISMP TEMPLATE

The GVRD's population is 2 million, and is estimated to double in the next 70 years. The following graph shows the GVRD's historical and projected population from 1900 to 2100.

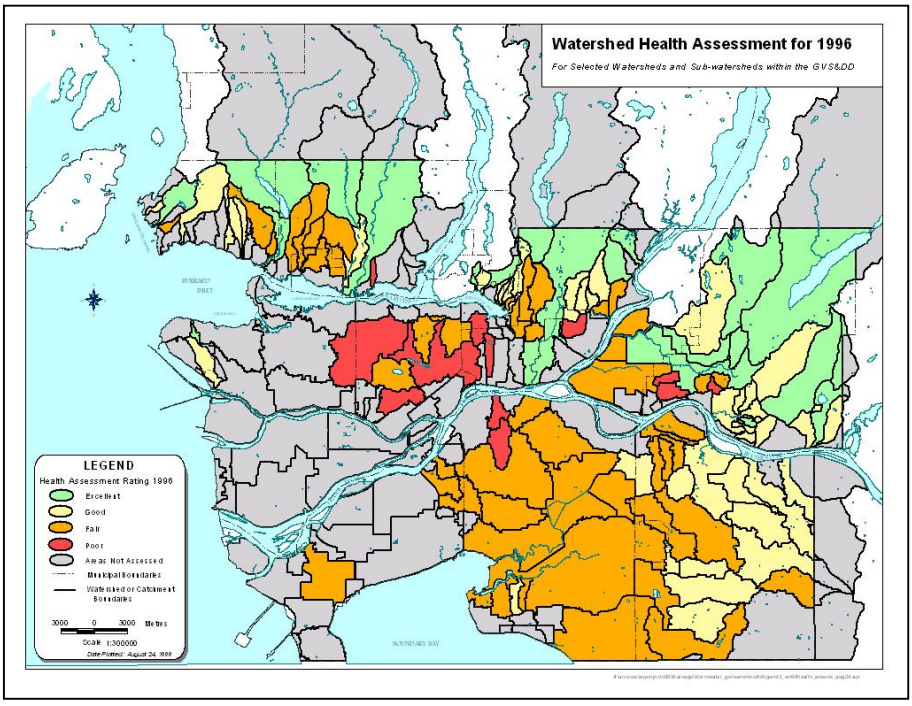
Figure 1-1: HISTORICAL AND PROJECTED GVRD POPULATION



The additional population will place a considerable strain on the environment. As part of the LWMP, the GVRD's original Stormwater Task Group (SWTG) commissioned a study to estimate the current health of the region's watersheds, and forecast their health for the year 2036. The health evaluation method was based on considerable research and is the subject of a document titled *Proposed Watershed Classification System for Stormwater Management in the GVRD*[1].

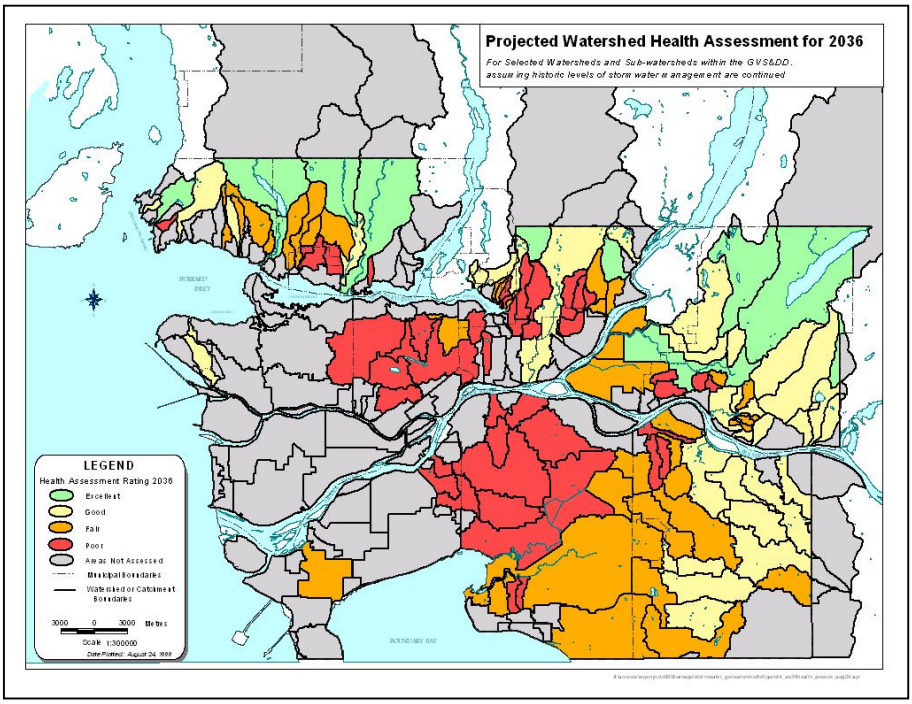
Using this methodology, the GVRD classified all watersheds, and produced the following two figures, which are taken from the *Assessment of Current and Future GVS&DD Area Watershed and Catchment Conditions* report. The figures clearly show the predicted watershed degradation in the region, if current stormwater management and land use planning practices do not change.

Figure 1-2: GVRD WATERSHED ASSESSMENT FOR 1996



[1] *Proposed Watershed Classification System for Stormwater Management in the GVRD,* GVRD, May 1999.

Figure 1-3: GVRD Watershed Assessment for 2036



The analysis used population projections for polygons throughout the GVRD to develop population densities. Population densities were then linked to an impervious area relationship to determine the projected percentage of impervious surfaces. Finally, since there is a well established relationship between impervious surfaces and watershed health as measured by biological indices, a prediction was made of future watershed health.

Comparing Figure 1-2 and Figure 1-3, one sees the degradation that increased unmitigated development and redevelopment can cause.

The purpose of this study is to develop an ISMP process that allows for development but at the same time protects the environment from further decline. For the process to be successful, land use planning must be integrated with stormwater management, and a method of "trading" developed. This has provided the impetus for developing the ISMP Template.

LWMP POLICY AND COMMITMENT

The GVRD member municipalities have committed to undertake ISMP. The planning approach will integrate watershed, catchment, master drainage plans, and stormwater plans with relevant municipal planning processes such as Official Community or Neighbourhood Concept Plans, Recreation and Parks Master Plans, and Strategic Transportation Plans into one document to address stormwater management impacts on community values. These values include recreation, agriculture, fisheries, greenways,

heritage, archaeology, safety, transportation, economics, property values, flood protection, affordability, and the environment.

ISMPs will be developed and reviewed for all watersheds on a 12-year cycle beginning from the LWMP approval date of April 2002.

1.5 TARGET AUDIENCE

The ISMP Template is designed to facilitate ISMPs for GVRD's member municipalities under the commitments made in the region's LWMP. Its target audience is local government's internal and external engineering, planning, and environmental professionals tasked with developing stormwater management plans within the GVRD. However, the template can also be applied in other major urban areas within the province where prescriptive practices such as city-wide stormwater criteria are not practical or affordable (e.g. the City of Nanaimo used the ISMP process on their Wexford/Walley Creeks and City of Abbotsford used it on Marshall Creek).

1.6 FORMAT OF REPORT

This report is divided into the following eight sections:

1. **Introduction:** Rational for developing the Template and the history of its review process;
2. **Recommended ISMP Process:** Summary of the proposed process and key attributes.
3. **ISMP Template Clauses:** Presentation of the Template details (accompanied by the "ISMP Clause Sheets" that are included after Section 6).
4. **Recommended Watershed Health Tracking System:** Details on how to calculate watershed health, effective impervious area, and how to use the Watershed Health Tracking System.
5. **Proposed ISMP Sign-Off Strategy:** Details on the two different senior government approval methods, and on-going performance monitoring recommendations.
6. **Conclusions and Recommendations:** Conclusions reached during the review process, and recommendations for future work.
7. **Template Clauses:** Thirty-five "clauses" listing the tasks that should be completed to carry out a successful ISMP.
8. **Supporting Appendices:** Seven supporting appendices helping the reader to better understand the extensive consultative process that was undertaken to prepare this document.

The length of the written text has been limited to 50 pages. Following the text, there are 35 clauses that make up the bulk of the Template. The clauses can assist a municipality

with developing a terms of reference for a specific watershed. The clauses have been included at the end of Section 6.

1.7 ACKNOWLEDGEMENTS

The following individuals contributed to the original development of ISMP Template in 2001, either as members or regular participants of the *Stormwater Task Group (SWTG)*[2].

Stormwater Task Group Members:

Igor Zahynacz	Past Chair, City of Port Coquitlam	Steven Lan	Township of Langley
John Irving	District of Maple Ridge	Steve McTaggart	City of Vancouver
Tony Barber	Chair, City of North Vancouver	Chris Jenkins	MWLAP, Victoria
Bill Jones	City of Richmond	Jian Guo	MWLAP, Surrey
Hugh Fraser	Corporation of Delta	Vince Busto	Dept. of Fisheries
Vince Lalonde	City of Surrey	Laura Maclean	Environment Canada
Mike Iviney	City of Coquitlam	Ted Van der Gulik	MAF, Abbotsford
Greg Scott	City of White Rock	Bob Gunn	Independent–BCIT
Doug Wylie	District of West Vancouver	Ed von Euw	GVRD-P&P
Eric Mazzi	UBC-Utilities		

Other Participants:

Melody Farrell	Dept. of Fisheries	Lisa Walls	Environment Canada
Megan Sterling	Dept. Fisheries	Elana Paller	City of Richmond
Erin Stoddard	MWLAP, Surrey	Eric Emery	City of Surrey
Robert Hicks	GVRD–P&P	Chris Johnston	KWL Associates
Sarah dal Santo	City of Coquitlam	Crystal Campbell	KWL Associates
Catherine Berris	Catherine Berris Assoc	Joe Simmler	Entranco
Bill Sims	City of Nanaimo	Peter Law	MWLAP
Al Magnan	Dept. of Fisheries		

The following people contributed to this Template update, and helped resolve the identified 31 issues.

December 2, 2004 Workshop Attendees

Municipalities			
Dipak Dattani	City of Burnaby	Tamsin Guppy	District of North Vancouver
Robyn Wark	City of Burnaby	Marcel Bernier	District of North Vancouver
Lambert Chu	City of Burnaby	Ariel Estrada	District of North Vancouver
Dave Palidwor	City of Coquitlam	Richard Boase	District of North Vancouver
Sarah Dal Santo	City of Coquitlam	Elena Paller	City of Richmond
Randy Chang	City of Coquitlam	Chessy Langford	District of Squamish

[2] The Stormwater Task Group was the predecessor to the current Stormwater Inter-Governmental Liaison Group (SILG). SILG was formed in 2002 after the LWMP was approved by the Province.

Dana Soong	City of Coquitlam	Carrie Baron	City of Surrey
Steve Lan	Township of Langley	David Hislop	City of Surrey
Andrew Wood	District of Maple Ridge	Neil McCreedy	City of Vancouver
John McMahon	City of New Westminster	Ray Fung	District of West Vancouver
Tony Barber	City of North Vancouver	Alexis Paderewski	UBC Utilities
Paula Huber	District of North Vancouver		
Environmental Agencies			
Mike Engelsjord	Department of Fisheries	Mike Younie	WLAP
Corino Salomi	Department of Fisheries		
Greater Vancouver Regional District			
Kim Parmentier	GVRD	Ed von Euw	GVRD
Andrew Lewis	GVRD	Mark Wellman	GVRD
Consultants			
John van der Eerden	Associated Engineering	Chris Johnston	KWL
Mike MacLatchy	Associated Engineering	Crystal Campbell	KWL
Scott Newman	Earthtech		

Section 2

Recommended ISMP Process

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2. RECOMMENDED ISMP PROCESS

2.1 INTRODUCTION

Historically, stormwater management planning began as part of the land use planning process. Its primary function was to support economic development by identifying the infrastructure needed to support the conversion of forested lands to developed cities and towns. It was not originally intended to assess or mitigate the impacts of development on the environment.

Stormwater management planning today has expanded significantly to become a holistic approach to also include the preservation and utilization of resources within a watershed. It is intended to balance the land use needs of society with the natural values and functions of the watershed; in essence, to integrate and preserve resource values into the land use planning process.

DEVELOPMENT OF AN ISMP TEMPLATE

Modern day *integrated* stormwater management planning typically involves the following components:

- A vision for the watershed to manage growth;
- A dynamic public goal setting process that establishes watershed priorities;
- Land use planning with a myriad of policies and goals;
- A technical flood management plan for the protection of private and public property;
- An inventory and protection/restoration plan for the environment;
- Mitigation of the impacts of development on hydrology and water quality;
- Public and municipal staff education and involvement;
- Community, business, developer, land owner, and elected official support; and.
- A long-term commitment for successful implementation.

The above components were derived based on survey that reviewed watershed planning in other jurisdictions throughout North America. It was then modified with local input from GVRD municipalities and senior environmental agencies. Appendix C summarizes the background information on how the GVRD's ISMP process was originally developed in 2000 through 2002. Appendix C also lists the specific issues facing GVRD municipalities.

2.2 BACKGROUND ON MEASURING WATERSHED HEALTH

The driving force behind the development of this template is the concern that unless stormwater management practices are changed, with the large population growth

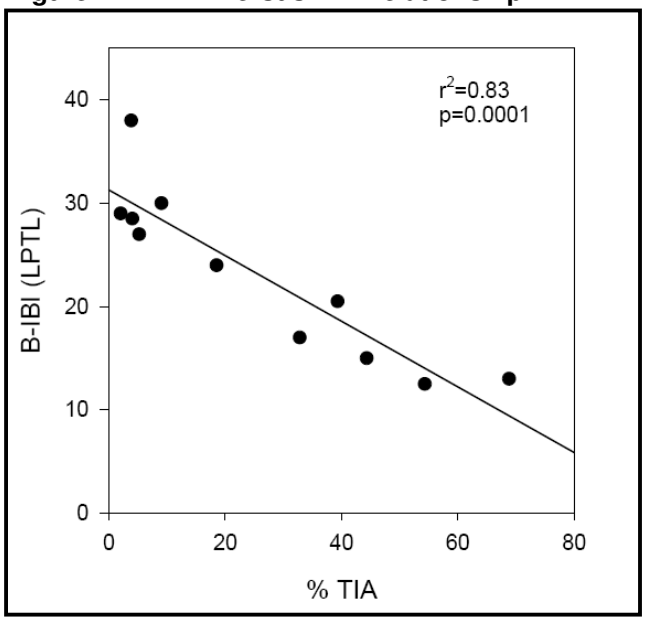
expected throughout the region, watershed health will decline leading to a decline in fish habitat and population.

BENTHIC MACROINVERTEBRATES THE MOST APPROPRIATE BIOLOGICAL INDICATOR

Recent scientific literature recommends the incorporation of biological indicators to assess and monitor stream or watershed health in the management of watersheds. In the Pacific Northwest, where fish species diversity is low, the structure and diversity of the benthic macroinvertebrate community is considered the most appropriate biological measure of stream health. Benthic macroinvertebrates are diverse and abundant in streambed substrates, sensitive to human disturbance associated with patterns of land use (e.g., changes to hydrology and channel stability, water quality, water temperature, etc.), and are relatively easy to sample and identify.

Figure 2-1 shows the strong relationship between increasing total impervious area (TIA) and decreasing biological index of benthic integrity (B-IBI). The graph was derived as part of the *Assessment of the Use of B-IBI in Greater Vancouver* report that was completed by KWL and Rain Coast Applied Ecology in December 2004.

Figure 2-1: B-IBI versus TIA Relationship



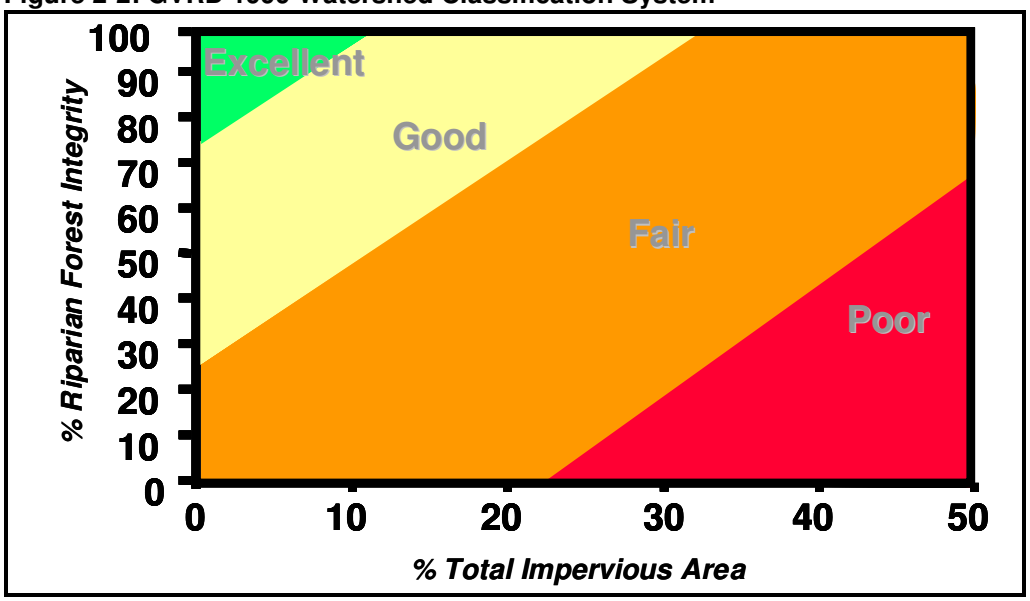
TIA: Total Impervious Area
B-IBI (LPTL): biological index of benthic integrity (lowest practical taxonomic limit)

If more innovative stormwater practices are employed such as source controls that disconnect impervious surfaces from creek systems, the effective impervious area (EIA) of the watershed would not increase as dramatically, potentially leading to smaller decrease in B-IBI, and hence, watershed health.

Integrating TIA with a measure of the strength of the riparian forest produces the following graph as shown in Figure 2-2. This graph is known as the GVRD's Watershed Classification System, and was developed as part of the *Proposed Watershed*

Classification System for Stormwater Management in the GVS&DD Area, GVRD, May 1999.
(http://www.gvrd.bc.ca/sewerage/stormwater_reports_1997_2002/classrpt/rpt.pdf)

Figure 2-2: GVRD 1999 Watershed Classification System



This measurement system was used to derive the watershed health predictions thoughout the GVRD. The system illustrates the influence of riparian forest integrity (RFI) and TIA on watershed health; watershed health declines if RFI is allowed to decrease and TIA is allowed to increase.

ABANDONING THE "HEALTH CLASSIFICATIONS"

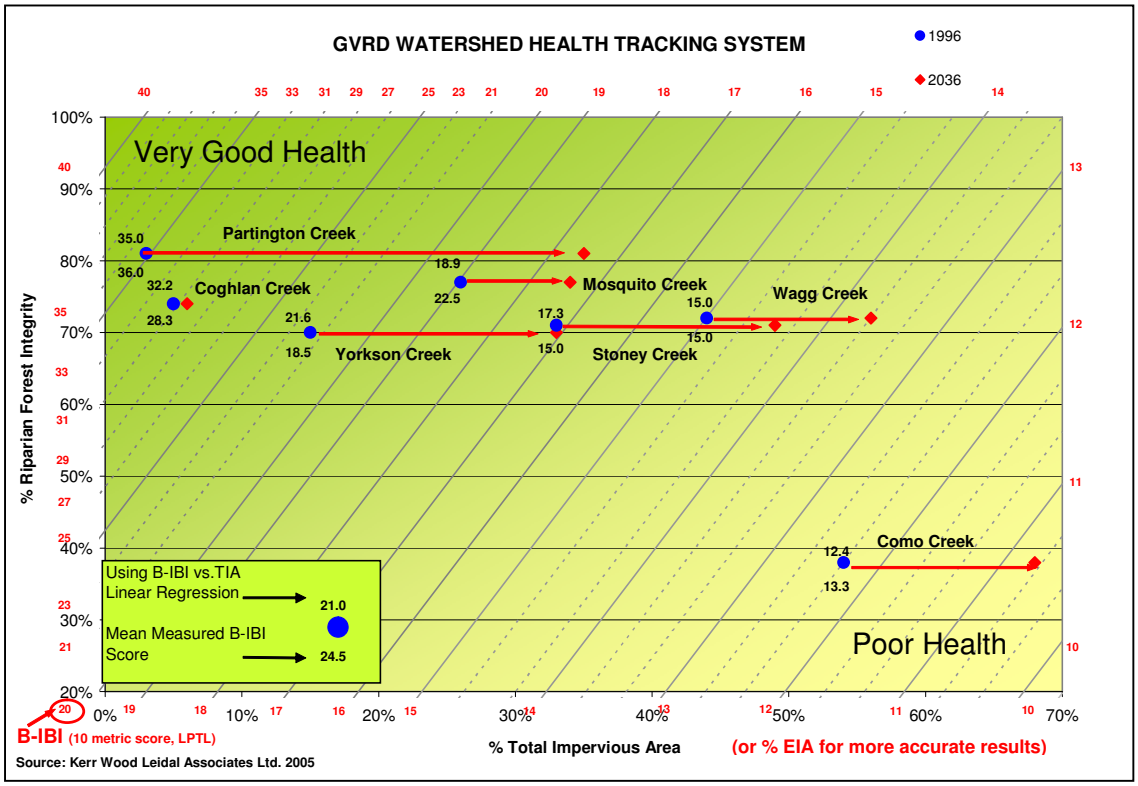
The designations of "excellent", "good", "fair", and "poor" were developed as a possible classification system to help prioritize watershed improvements and protection. These classifications have resulted in significant controversy, and as a result have been discontinued. Senior environmental agencies argued that the *Fisheries Act* makes no distinction between fish habitat in "Excellent" or "Fair" watersheds, all fish habitat should be protected. Work in other regions of North America has also found that watershed health declines incrementally with increasing urbanization rather than at defined thresholds of urban land use. Further, work completed by Environment Canada with the use of their Reference Condition Approach (RCA), has successfully shown that the absolute classifications shown in Figure 2-2 can not be consistently reproduced. However, the relative movement of developing watersheds towards the bottom right was never questioned.

PROPOSED *WATERSHED HEALTH TRACKING SYSTEM*

Ignoring the classifications, the graphing system still serves as an excellent predictive tool to measure the health of a watershed given future land use changes, riparian corridor decisions, and stormwater management plan recommendations. Futhermore, if TIA is replaced by Effective Impervious Area (EIA), the system would be useful in predicting the impact of disconnected impervious surfaces and the use of source controls. For example, if EIA and RFI can be maintained through the implementation of source controls and streamside regulations, the health of a watershed is also likely to be maintained.

A new Watershed Health Tracking System was created, shown on Figure 2-3, by removing the classification designations, exchanging TIA for EIA on the x-axis, and adding the underlying B-IBI scores that helped develop the original system. Figure 2-3 shows the estimated watershed health of seven GVRD watersheds, and how they are predicted to worsen over time unless stormwater management measures are implemented. The figure also shows how a biological measurement system can be used to compare predicted B-IBI scores with actual measured scores obtained in the field sampling.

Figure 2-3: Proposed *Watershed Health Tracking System* – Perennial Creeks



The above graph shows how the health of a permanently flowing creek system can be predicted, and how the system can be verified using a relatively simple field and laboratory analysis. The graph also shows how the health of a watershed can be

predicted for future land uses assuming no stormwater management measures are implemented and the riparian corridor is not allowed to decline.

For ephemeral and soft-bottom creeks, a similar system could be developed either based on the B-IBI system or Environment Canada's RCA method.

The details and use of this system, how riparian forest integrity (RFI) and effective impervious area (EIA) are calculated, and how the system can be integrated with stormwater computer models is discussed in Section 4.

2.3 ISMP REGIONAL OBJECTIVE

One of the landmark decisions of the 2000-2002 work was that the SWTG agreed to a common and consistent regional ISMP objective to strive to maintain watershed health.

Regional ISMP Objective

Strive to maintain existing watershed health and achieve no-net-loss on a watershed basis.

The SWTG agreed that watershed health as measured by a system similar to the Watershed Classification System should be maintained. The ISMP process is the impetus of change to the way stormwater management is undertaken in the region to avoid degradation from occurring on a watershed scale.

It was understood that with significant development pressures in the region watershed plans may result in a loss in aquatic habitat in some areas of the watershed and gains in other areas. Authorizations will still be required for these losses, but it is hoped that as a result of the ISMP process, losses and gains will be managed in an organized, defensible manner, such that the overall watershed health will not decline.

It was agreed that the watershed health must be maintained throughout the development of a watershed on an annual basis and not just over the long term. This means that some compensation measures must be implemented before major components of new developments occur. This concept is explained further in Section 4.

The 2005 review process re-confirmed the original regional objective, but noted that it may be difficult to achieve a no-net-loss in watershed health in large greenfield watersheds where major development is underway. Further, it was acknowledged that if the objective is not maintained, environmental approval for any proposed works in and about fish habitat may not be approved. This may introduce uncertainty to the development schedule. Therefore, it becomes significantly important to understand the objectives of an ISMP at the start of the project such that there are no surprises in the approval process.

WHAT MAKES THE GVRD ISMP PROCESS DIFFERENT?

The proposed ISMP process strives to preserve watershed health as a whole by allowing tradeoffs so that environmental losses in one area are offset by gains in other areas, thereby meeting the regulatory guiding principle of no-net-loss. The final strategy will represent the best solution towards achieving this objective in consultation with stakeholders and the public, and then approved by council.

THE IMPACT OF WATERSHED SIZE

To meet the no-net-loss guiding principle on a watershed basis, the subject watershed must be large enough to allow for tradeoffs within the basin. Sensitive habitat areas will be protected. However, a loss may occur on some reaches where development is intensive, and low impact development (LIDs) and other best management practices (BMPs) strategies are difficult to implement. Compensation in other areas of the basin can offset losses and result in an overall no-net-loss of the watershed as a whole. This may be difficult to accomplish in watersheds less than 500 ha in size. It would also be very expensive to apply the ISMP process to watersheds greater than 1,500 ha. Therefore, the ISMP process is ideally applied to watersheds of 500 to 750 ha.

DEFENSIBLE, QUANTIFIABLE AND SCIENTIFIC METHODOLOGIES

The environmental analysis within the ISMP process must be quantitatively based and defensible to enable appropriate watershed decisions to be made. To achieve no-net-loss of watercourse health on a watershed scale through tradeoffs between land development and the environment, alternatives must be evaluated and justified with measurable watershed health benefits rather than with qualitative statements.

To facilitate a defensible methodology to measure watershed heath over time, the environmental Watershed Health Tracking System tool, presented in Section 2.2, was developed to measure current and predicted watershed health. This tool can be used to predict changes to watershed health. Section 4 provides details how this tool can be administered.

2.4 THE ISMP TEMPLATE AND PROCESS

Figure 2-4 outlines the overall three phases of the ISMP process.

- **Phase 1: ISMP Watershed Screening Process** – goal is to classify and prioritize all watersheds based on flood risks and environmental degradation and development pressure.

- **Phase 2: ISMP Process** – goal is to clearly identify goals/objectives and problems, to develop an appropriate planning process, and to undertake an ISMP and achieve consensus.

- **Phase 3**: **Functional/Feasibility Plans** – goal is to provide further analysis of the proposed works prior to detailed design.

OBJECTIVES OF STAKEHOLDER OUTREACH AND INVOLVEMENT

The extent and objectives of stakeholder outreach and involvement is also summarized in Figure 2-4 by coloured arrows. Stormwater management and watershed planning are prime examples of issues and programs for which citizens, developers, land owners and environmentalists have strong, and often differing, views.

Agencies, interested groups, and citizens will have direct input into the ISMP process and, therefore, all interests will be represented and included. In this way, the community clearly outlines what it values and is willing to pay for. The primary objectives of stakeholder involvement are to identify key issues, gather background information, seek buy-in to the process, review the results of the technical analyses, select preferred alternatives, and endorse and adopt the ISMP.

The stakeholder consensus-building process must begin at the project's initiation and continue throughout its duration. Stakeholders must commit to the study and decision-making process and be prepared to endorse the resulting integrated stormwater management plan and final product. If the process is done correctly, ISMP plans will remain on track with only a minor amount of changes required during the final review and approval phase.

The minimum requirement of an ISMP is to develop a strategy to facilitate land development without degrading watershed health. There are a myriad of strategies that can be implemented to achieve this objective, and some will be more acceptable to stakeholders than others. Furthermore, the outreach program may determine that simply meeting the minimum requirement is not good enough for a particular watershed, or that other community values and terrestrial habitat are just as important. For these reasons, and because each watershed is unique, a stakeholder outreach program was incorporated into the ISMP process.

TECHNICAL COMPONENTS OF ISMP

Figure 2-5 outlines the technical components that form the ISMP process. The figure is the supporting technical flow chart to Figure 2-4. Three disciplines are shown: engineering, planning, and environmental. The flowchart shows schematically linear links between the components although in reality the links are more complex.

The technical process involves seven steps:

- identifying the problem and developing a framework to approach it;
- collecting meaningful, reliable data;
- completing technical analyses;

- assessing and evaluating mitigative alternatives;
- completing management analyses;
- developing a plan and strategy; and
- follow-up/evaluation.

Each step is applied to the engineering, planning, and environmental disciplines. Each of the 34 boxes outlined on Figure 2-5 represents a separate component of ISMP and, therefore, a separate clause in the template. A description of each clause is included in following Section 6. Municipalities can select which clauses are applicable to the subject watershed and the level of effort required. A 'minimum' and 'maximum' effort category has been developed to assist in scaling the level of effort to a watershed. It should be noted that the minimum effort is exactly that: the absolute minimum effort required should a particular clause apply. This allows municipalities to develop a tailored scope of work within an available budget, while addressing the unique social, spatial, physical, and biological features of its watersheds.

2.5 STAKEHOLDER COMMITMENT, PARTICIPATION, AND ENDORSEMENT

STAKEHOLDER TIERS

ISMP is managed and administered by the Municipality's Management Team, consisting of key municipal departments such as engineering, planning, development services, and environmental planning.

Three potential stakeholders groups are:

- Inter-agency Group (municipal departments, regulatory agencies, etc);
- Advisory Group (representatives from streamkeepers, environmental groups, landowners, development community, agricultural community, etc.); and
- General public.

To achieve stormwater management and environmental protection, all interested parties must work together. Figure 2-4 outlines effective stakeholder involvement in the study process. This may vary depending on the issues of the watershed.

MUNICIPAL MANAGEMENT TEAM

The Municipal Management Team must be involved in every step of the planning process from setting the initial project goals to evaluating and selecting the recommended level of protection/control. The municipality will have direct involvement at special briefings/status report meetings and at key decision-making meetings. Internal support is critical to the successful adoption, funding and implementation of the recommended plan.

Any major internal concerns about the project or planning process must be quickly and effectively addressed during the plan's development.

INTER-AGENCY GROUP

The Inter-agency Group will be especially helpful during the initial scoping and formation of the ISMP process. It will participate in determining many of the technical guidelines and products expected from the project. It should be briefed periodically as to status, results and direction of the project. A meeting or workshop should be scheduled to discuss and evaluate mitigative alternatives. These activities will increase the likelihood that the group will support the final plan. They may also help municipal staff convince local landowners and/or developers of the need for and merits of the proposed plan. The Inter-agency Group should include representatives from regulatory agencies and committees. These could include DFO, MOE, FREMP, and BIEAP.

ADVISORY GROUP

Organized citizens groups/committees should have opportunities to become directly involved in the planning process. In many cases, these will be the groups that keep the momentum flowing on a finalized plan. They are also the groups that have intimate historical knowledge of the watershed, and can assist the inventory process. Using an Advisory Group is an excellent way to reach and involve interested groups in the planning and decision making processes. The group's input is critical because its role is to assist municipal staff and consultants in listing the goals and evaluating the benefits of the various levels of protection alternatives. It provides a conduit for community opinion, especially at decision-making times. The group is an effective medium for informing and educating the community, and showing Council the group's direct involvement and support of the proposed recommended stormwater management plan.

The group should include stream stewardship and environmental committees, tax payers associations, significant land owners and developers, and environmental committees appointed by council.

GENERAL PUBLIC

Normally, the general public takes less of an interest and involvement in the planning process than other stakeholders. Its role, however, is not to be underestimated. It is important that the public be kept informed and be brought into the planning process at the appropriate times. Usually, the public is involved at the later stages of the planning process when the alternatives are under review and evaluation.

2.6 RESPONSIBILITY OF STAKEHOLDERS

The primary objectives of stakeholder involvement are to:

- identify key issues and desired watershed goals, provide background information, and seek buy-in to the study process;

- review the results of the technical analyses and costs, re-assess the watershed goals and objectives (i.e. no-net-loss or net gain, and other sustainability objectives), and select preferred alternatives; and

- obtain endorsement and adoption of the ISMP.

Agencies and interested groups will have direct input into the study process, and, therefore, all interests will be represented and included. In this way, the watershed community clearly outlines what it values and is willing to pay for.

Stakeholders are invited to commit to the study and decision-making process, and be prepared to endorse the integrated stormwater management plan and final product. Refer to Section 5 ISMP Sign-off Strategy.

2.7 INTEGRATION WITH PROVINCIAL STORMWATER GUIDEBOOK

The Ministry of Water, Land, and Air Protection and Environment Canada have a joint document titled *Stormwater Planning: A Guidebook for British Columbia.* The Guidebook is a three-part document intended for senior managers, municipal professionals, land developers and the consulting community; it provides a background to understanding stormwater management, a description of site-level land development guidelines, and planning to action guidelines. The Guidebook can be obtained from http://www.env.gov.bc.ca/epd/epdpa/mpp/stormwater/stormwater.html

The Guidebook outlines five guiding principles for integrated stormwater management as follows:

Guiding Principle #1 – Agree that stormwater is a resource
Guiding Principle #2 – Design for the complete spectrum of rainfall events
Guiding Principle #3 – Act on a priority basis in at-risk drainage catchments
Guiding Principle #4 – Plan at three scales – watershed, neighbourhood & site
Guiding Principle #5 – Test solutions and reduce costs by adaptive management

The Guidebook helps municipalities with the development the stormwater section of their LWMPs. It provides tools for understanding and reducing EIA, as well as, educating non-professional audiences. It can also be referenced for site level land development guidelines. Conversely, the ISMP Template will be applied to watersheds within the GVRD area where aggressive development is taking place and prescriptive practices may not be practical or affordable. The ISMP Template provides an process based on tradeoffs and balances within a watershed to achieve a no-net-loss principle. Therefore, outside of the GVRD, the Template should be considered a supporting document to the guidebook

with application in watersheds where more unique, watershed-based solutions are required.

2.8 INTEGRATION WITH ENVIRONMENT CANADA'S RCA METHOD

The proposed Watershed Health Tracking System is based on a multimetric biocriteria. More specifically, the system is based on the Benthic Index of Biotic Integrity (B-IBI), developed by Karr (1996-1999). It is a statistical rating system used to measure benthic communities and is gaining wide-spread acceptance in the Pacific Northwest. Alternatively, Environment Canada has developed a multivariate biocriteria referred to as the Reference Condition Approach (RCA) method. The system is also gaining acceptance as a possible national tool for measuring water quality and stream health.

There seems to be two camps forming that support one or the other method. The B-IBI supporters appreciate the simple scoring system of the B-IBI method, and the considerable stormwater research being undertaken in the U.S. linking the system to urban development impacts. There is also reluctance about supporting a complex national system that may one day be discontinued, or under-funded. Supporters of the RCA method promote the fact that it is a Canadian system that is more consistent among different regions of the country, and that it is better at classifying stressed and unstressed watersheds. Both camps agree that it seems silly to spend resources on maintaining two systems within the GVRD.

Bailey *et al*. (2004) claim the differences actually reflect deeper divisions in perceptions of philosophical approaches to bioassessments. McElligott (2006) in his report to the CCME titled *Developing Biocriteria as a water quality assessment tool in Canada: Scoping Assessment* recommends that the two systems be combined whereby the RCA method provides the option of calculating additional metrics from the baseline data sets.

Whatever the outcome of this debate, the current Watershed Health Tracking System proposed in this Template uses the B-IBI multimetric system as it correlates highly with urban development making it an excellent tool in stormwater management planning. Without it, it would be difficult to judge impacts of land use changes and benefits of source control measures, or BMPs over the long term.

However, since the current Watershed Health Tracking System is only calibrated to permanently flowing creeks, help is needed to build comparable systems for ephemeral and soft-bottom creek system. Perhaps if the recommendations of McElligott's report are accepted, and metrics are calculated from the base RCA datasets, relationships between the two systems can be made, and the missing information completed.

Phase 1:
Watershed Screening Process

To classify and prioritize all watersheds within the municipality on the basis of flood risk and environmental degradation

Delineate Watersheds and Sub-Watersheds
- GIS

Screening Process
- Degree of development
- Watershed classification

Assign Priority
- Risk

Phase 2:
ISMP Process

To undertake an ISMP and achieve consensus

To clearly identify problems/goals/objectives and develop an appropriate planning process

Indentify Problem and How to Approach it

Assemble Resource Team
- Consultants
- Agencies
- City Staff
- Interested Groups (e.g. Public)

Planning Process Framework
- Objectives
- Issues
- Public Input
- Regulatory Agency Involvement
- Commitment to Study Process

Scope for ISMP

A

Initiate Stakeholder Outreach and Involvement Processes

Collect Meaningful Reliable Data, Undertake Technical Analysis

Watershed Characterization
- Data Collection
- Inventory
- Mapping

Environmental Assessment
- Hydrogeology
- Land Use Planning
- Modelling / Engineering
- Flow Monitoring
- Environmental Health
- Wetlands / Riparian
- Recreational / Amenities
- Capital Facilities Plan

Management Analysis

City's Stormwater Program
- Capital Improvement Programs
- O/M

Assess Mitigative Alternatives

ISMP Alternative Analysis
- Benefits/Costs
- Evaluation Criteria
- Service Levels

B

Draft Stormwater Management Plan/Strategy and Report

Recommendations to other Municipal Master Plans

Implementation Plan
- By-Laws/Authority
- Funding/Costs
- Staff/Equipment
- Design Standards
- Land Use
- LIDs/BMPs

Develop Strategy and Plan

Plan/Strategy Review and Adoption
- Council Buy-in and Adoption of Plan
- Regulatory Agency Endorsement/ Sign-off

C

Phase 3:
Follow-Up / Functional Feasibility Plans / Servicing Plans

To provide a more detailed analysis of proposed works prior to pre-design and detailed design

Develop Functional Feasibility / Servicing Plans
- Objectives
- Issues
- Public Input
- Performance Monitoring
- Adaptive Management

REFER TO FIGURE 2 FOR MORE DETAILS

Stakeholder Outreach and Involvement Processes

Objectives of Milestone Meetings:

A. To identify key issues and desired watershed goals, obtain background information and seek buy-in to the study process.

B. To present the results of the technical analyses, reassess watershed goals (minimum no net loss or net gain, and other sustainability objectives), and select preferred alternatives.

C. To finalize and obtain endorsement of the ISMP.

Legend

Municipality's ISMP Management Team
(Administers Process)

Inter-Agency Group
(City Departments, Regulatory Agencies)

Advisory Group
(Representatives from Development Community, Landowners, Tax Payers, Stream Keepers, Environmental Groups, Agricultural Community, etc.)

General Public

251-073 \ Report-Final-Draft \ Drawings \ Fig1.CDR

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Integrated Stormwater Management Planning Process

Figure 2-4

Engineering | Planning | Environmental

Identify the Problem and how to Approach it

Establish Framework
1
- To clearly identify the goals and objectives of ISMP: to maintain watershed health and achieve a no-net-loss objective with future development. To clearly obtain an understanding of the watershed issues, establish regulatory requirements and develop an appropriate study approach and scope.

Mapping / Information Gathering
2
- To obtain review and evaluate all current and historical information/mapping/reports/plans on the watershed. Meet with streamkeepers, environmental groups and others to gather relevant information.
- → It is preferable to receive/assemble the mapping data into GIS format.

Collect Meaningful Reliable Data

HYDROMETRIC DATA COLLECTION
- To monitor rainfall, streamflow, and/or stormwater flow to determine an accurate understanding of watershed response to rainfall. Requires a minimum of 6 months of flowdata (12 months optimum).
- → Data required to determine baseflows, and to calibrate/verify the hydrological model (Tool 1).

3

DRAINAGE SYSTEM INVENTORY
- To gather information on watercourse characteristics, erosion concerns, drainage facilities and flow paths.
- To identify opportunities and constraints for flood management measures.

4

HYDROGEOLOGY / GEOTECHNICAL ASSESSMENT
- To identify sub-surface flow regimes, soil types, infiltration opportunities, ravine instability and determine the sub-surface catchment area and baseflow potential.

5

LAND USE INFORMATION
- To identify existing land use and review land use plans and policies.
- To identify land use planning constraints and opportunities.
- Input into hydrological model (Tool 1) and ecological health model (Tool 3).

6

RESOURCE LANDS
- To identify existing practices with respect to drainage and riparian area protection on resource lands including agriculture, forestry and mining.

7

RECREATIONAL / AMENITIES
- To identify opportunities for recreational trails, creek daylighting, riparian corridor relocation or enhancement, wetlands or other stormwater related amenities.
- To determine the potential for integration with Parks and Recreation Plans.
- To identify existing and potential ecological and recreational greenways.

8

BIOPHYSICAL INVENTORY
- To identify existing stream, floodplain, riparian and wetland resources.
- To identify potential opportunities for enhancement.

9

RIPARIAN CORRIDOR ASSESSMENT
- To determine the extent and quality of the existing and potential riparian corridor.

10

WILDLIFE ASSESSMENT
- To identify and protect important habitat and biological elements.

11

BENTHIC COMMUNITY SAMPLING
- To measure the aquatic health of the creek system using B-IBI.
- To establish a baseline for comparison of future years.
- To provide a calibration mechanism for the ecological health tool (Tool 3).

12

WATER QUALITY SAMPLING
- Obtain dry-weather baseflow samples at all major storm sewer outlets.
- To determine if the watershed is representative of "typical" watersheds with the similar total impervious area.
- Wet-weather monitoring only required when industrial, commercial, and institutional areas occupy more than 10 % of the watershed.

13

Baseplan Mapping (GIS Database)
14
- To geographically depict all information for quick and easy access, understanding, interpretation and analysis.

Existing Stormwater Program Review
15
- To define the Municipality's existing practices and needs related to stormwater policies such as bylaws and enforcements, design standards, operation and maintenance practices, public education, equipment, and staff training

Undertake Technical Analysis

Hydrological Analysis

TOOL 1
16
- To simulate the watershed's hydrologic response to existing and planned land use conditions.
- To determine peak flow estimates for major, infrequent events (Q5-10, Q100, 2&5 day ARDSA).
- → Use to quantify flooding problems and size drainage structures.
- To determine potential impacts of existing and planned land use with respect to effective impervious areas and riparian protection or restoration.
- To determine "effective" impervious area based on calibrating the model against the flow monitoring data collected.
- To determine peak flows and volumes for minor frequent events (<<Q2). Perform statistical analysis on model results and develop flow-duration-exceedance curves to assess impacts to the environment and LID/BMP alternatives.

CHANNEL EROSION
- To identify sections of creek channel that are or will be susceptible to erosion from <<Q2 to Q100.

18

AGRICULTURAL ASSESSMENT
- To assess lowland flooding depths and durations.

19

NATURAL HAZARD ASSESSMENT
- To identify and recommend mitigative measures for natural hazard areas (i.e. debris flows, etc.)

20

TOOL 2

HYDRAULIC ANALYSIS
17
- To assess flooding impacts.
- To determine the conveyance capabilities of channels, drainage ditches and structures and size upgrades if required.
- To hydraulically assess storm sewer systems.
- To determine structural deficiences.

LAND USE ANALYSIS
- To explore alternative development options including development and open space locations, and development densities. Project future levels of impervious cover, changes in riparian quality and quantity.
- To identify potential new greenway corridors including stormwater related amenities and trails

21

RECREATION AND PUBLIC ACCESS ANALYSIS
- To determine the potential for walkways and access points along stream corridors as a public amenity and for public education, with consideration for potential impacts to riparian areas.

22

ENVIRONMENTAL PARAMETERS
- To determine the total impervious area and riparian forest integrity for existing and future development scenarios from information collected in Steps 2 to 14.

23

TOOL 3

ECOLOGICAL HEALTH ANALYSIS
- To quantify the ecological health of the watercourse using the Watershed Health Tracking System.
- To quantify the ecological impacts of changing land use, densities, riparian corridors , development standards and/or implementing BMPs.

24

Assess Mitigative Alternatives

FLOOD/EROSION MANAGEMENT ALTERNATIVES
- To identify and evaluate structural measures to mitigate against flooding.
- To provide cost estimates.

25

LAND USE ALTERNATIVES
- To prepare alternative development scenarios that address land use location and densities, riparian corridor location and setbacks, ESAs, other stormwater amenities and public trails.
- To investigate low impact development standards potentially applicable to various land use designations and the associated reductions to the effective impervious areas.

26

STORMWATER MANAGEMENT ALTERNATIVES
- To identify feasible low impact development standards and best management practices.

27

WATER QUALITY ALTERNATIVES
- To develop potential options for managing and/or improving water quality.

28

Evaluate Alternatives
29
- Evaluate alternatives for flood/erosion management, land use, stormwater management, and water quality management in an integrated way with consideration for health and safety, environmental impacts, costs, and public acceptance.

Management Analysis

Stormwater Program
30
- To perform management analysis and develop a stormwater program, including,
  - *Bylaw changes/new bylaws, new/revised design standards* - To set standards and guidelines for City-wide implementation.
  - *O & M programs* - To develop scheduled and appropriate O & M practices to ensure optimum conveyance and environmental protection.
  - *Public education (staff/public)* - To educate staff, general public, developers, businesses, landowners, environmental groups, etc. of ISMP issues and practices.

Develop Strategy and Plan

Integrated Stormwater Management Plan
31
- To develop an ISMP plan that maintains, restores and enhances the watershed for both hydrotechnical and environmental components.

Implementation Strategy
32
- To develop a strategy and timeline to ensure the proposed works in the ISMP are implemented.
- To identify and evaluate various financial alternatives to fund and implement ISMP.

Integrate with Other Municipal Master Plans
33
- Use ISMP findings to recommend modifications or changes to other Municipal Master Plans (OCPs, NCPs, Recreation and Park Plans, Strategic Transportation Plans, etc.) in order to meet desired watershed impervious cover targets, riparian condition targets and maintain watershed health.

Follow-Up

Adaptive Management
34
- To monitor the performance of the implemented works and assess if they are meeting the original ISMP goals.
- To reassess and redirect efforts accordingly, to learn and adapt on an ongoing process.

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26 Refers to ISMP Clause Number after Section 6

Figure 2-5

Section 3

ISMP Template Clauses

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3. ISMP TEMPLATE CLAUSES

3.1 INTRODUCTION

Table 3-1 introduces the 35 Template "Clauses" that are proposed. The clauses are included after Section 6 of this report (prior to the Appendices).

Each clause has been broken down into the following headings:

- Objectives
- Significance
- Tasks: Minimum and Maximum effort
- Minimum Deliverables

The minimum effort tasks outline the minimum effort required to be part of an ISMP. The maximum effort tasks reflect potential tasks that are likely required to fully understand the watershed and make informed decisions.

The scope of each ISMP will vary significantly between watersheds with some watersheds incorporating all clauses while others require significantly less. It's important that municipalities recognize that many of the clauses can be undertaken prior to an ISMP being initiated. Some of the data collection clauses, such as flow monitoring, can take over a year to complete; it is advisable that many of the data collection and inventory clauses be undertaken on a citywide basis outside of the actual ISMP process. This allows the project schedule to be condensed and helps to keep stakeholders focussed. There will also be cost savings with some of the clauses approached on a citywide basis.

Table 3-1: Summary of ISMP Clauses

Clause	Category	Objective
Clause 1	Establish Framework	▪ To clearly identify the goals and objectives of ISMP, obtain an understanding of the issues, and develop an appropriate study approach and scope..
Clause 2	Mapping/Info. Gathering	▪ To obtain, review and evaluate all current and historical information/mapping/reports/ plans on the watershed.
Clause 3	Hydrometric Data and EIA Calculation	▪ To collect precipitation and streamflow data. ▪ To calculate existing EIA
Clause 4	Drainage System Inventory	▪ To establish a solid understanding of the watershed's physical characteristics
Clause 5	Hydrogeology /Geotechnical Assessment	▪ To identify sub-surface flow regimes, soil types, infiltration opportunities, ravine instability and to determine the sub-surface catchment area and baseflow potential.
Clause 6	Land Use Information	▪ To identify existing and future land use, and review land use plans and policies. ▪ To identify land use planning constraints and opportunities.
Clause 7	Agricultural Lands	▪ To identify agricultural lands and establish a level of flood protection and drainage requirements. (ARDSA or other standards)

Clause	Category	Objective
Clause 8	Recreational /Amenities	▪ To identify opportunities for existing and potential recreational trails, creek daylighting, riparian corridor relocation/enhancement, wetlands or other stormwater related amenities.
Clause 9	Aquatic Species and Habitat Inventory	▪ To identify aquatic species abundance and diversity and important habitat of the watershed, and opportunities for environmental enhancement.
Clause 10	Riparian Corridor Assessment	▪ To determine the extent and quality of existing and potential riparian corridors.
Clause 11	Terrestrial Species and Habitat Assessment	▪ To identify and protect important habitat and biological elements including existing wetlands.
Clause 12	Benthic Community Sampling	▪ To measure the aquatic health of the creek system.
Clause 13	Water and Sediment Quality Analysis	▪ To determine if the watershed is representative of "typical" watersheds with similar total impervious area.
Clause 14	Baseplan Mapping (GIS DataBase)	▪ To geographically depict all information for quick and easy access, understanding, interpretation and analysis.
Clause 15	Existing Stormwater Program Review	▪ To define the municipality's existing practices and needs related to stormwater policies such as bylaws and enforcements, design standards, operation and maintenance practices, public education, equipment, and staff training.
Clause 16	Hydrological Analysis	▪ To develop a useful tool to simulate the watershed's hydrologic response, determine effective impervious area, estimate design flows and volumes, determine the impact of development and assess mitigative alternatives, and to size recommended facilities.
Clause 17	Hydraulic Analysis	▪ To determine the conveyance capabilities of the existing and future drainage system (channels, drainage ditches, and structures) and size upgrades, if required.
Clause 18	Channel Erosion	▪ To identify sections of the watercourse channel that are or will be susceptible to erosion from <<Q2 to Q100. ▪ To identify mitigation measures for existing and future development conditions.
Clause 19	Agricultural Assessment	▪ To assess and mitigate agricultural flooding and poor drainage.
Clause 20	Natural Hazard Assessment	▪ To identify and recommend mitigative measures for natural hazard areas (i.e. debris flows, etc.).
Clause 21	Land Use Sensitivity Analysis	▪ To explore the impacts of modified development densities and location options.
Clause 22	Recreation and Public Access Analysis	▪ To assess walkways, greenways and access points along stream corridors as a public amenity and for public education.
Clause 23	Environmental Parameters	▪ To determine the total impervious area and riparian forest integrity for existing and future development scenarios as proposed.
Clause 24	Ecological Health Analysis	▪ To quantify the ecological impacts of changing land use densities, riparian corridors, development standards and/or implementing LIDs/BMPs.
Clause 25	Flood/Erosion Management Alternatives	▪ To investigate improvements and structural alternatives to alleviate flooding and erosion problems. ▪ To investigate environmental mitigation/enhancement, if required
Clause 26	Land Use Alternatives	▪ To prepare alternative development scenarios as a result of the land use sensitivity analysis that was performed in Clause 21 that address land use location and densities, riparian corridor locations and setbacks, ESAs, public trails and other stormwater amenities. ▪ To investigate low impact development standards potentially applicable to various land use designations and the associated reduction to the effective impervious areas.

Clause	Category	Objective
Clause 27	Stormwater Management Alternatives	▪ To investigate stormwater management alternatives to minimize the impacts of land development. ▪ Incorporate the LID strategies developed in Clause 26
Clause 28	Water Quality Alternatives	▪ To identify measures to mitigate point and non-point source water quality problems.
Clause 29	Evaluate Alternatives	▪ To evaluate alternatives for flood/erosion management, land use, land development standards, stormwater management, and water quality management in an integrated way with consideration for health and safety, environmental impacts, costs, and public acceptance.
Clause 30	Stormwater Program	▪ To develop a Stormwater Program that includes recommended practices, by-laws, standards, etc.
Clause 31	Integrated Stormwater Management Plan	▪ To address the impact of stormwater management on relevant community values. These values include recreation, agriculture, fisheries, greenways, heritage, archaeology, safety, transportation, economics, property values, flood protection, affordability, the environment, and related issues.
Clause 32	Implementation Strategy	▪ To develop a strategy and timeline for the proposed works. ▪ To identify and evaluate various financial alternatives to fund and implement ISMP.
Clause 33	Integrate with Municipal Plans	▪ To make recommendations to be considered in OCPs, NCPs, Recreations and Park Plans, Strategic Transportation Plans, etc
Clause 34	Adaptive Management	▪ To monitor watershed health using performance indictors (B-IBI scores, effective impervious area (EIA), and riparian forest integrity). To adapt the ISMP implementation strategy if needed to achieve no-net-loss of watershed health.
Clause 35	Report	▪ To document the study process and findings

3.2 MINIMUM AND MAXIMUM EFFORTS

The 2002 Template provided "minimum efforts" for tasks where if watersheds met minimum criteria, a detailed review was not required. However, the criteria chosen was vague due to disagreements between SWTG members, and the differences between minimum efforts and maximum efforts were only slight. The result yielded an expensive ISMP process for some watersheds where land use changes are relatively small. Thus, this was updated.

NEW MINIMUM EFFORT

The following requirements must be met to use the effort tasks in the Template clauses:

- Adoption of a bylaw that meets the stormwater criteria presented in Section 3.3 for new development and re-development;

- Adoption of either the *Streamside Protection Regulation* or the *Riparian Areas Regulation;* and,

- Adoption of a sedimentation and erosion control bylaw, and point and non-point source water quality control bylaw.

Adopting the minimum effort tasks will likely not occur in watersheds where greenfield development and densification is happening at a rapid pace as it is unlikely the stormwater criteria can be universally met by all land uses.

3.3 DEVELOPMENT OF CITY-WIDE STORMWATER DISCHARGE CRITERIA

Besides municipal drainage criteria, there are two other criteria that frequently get adopted related to stormwater management in B.C.:

- provincial 2002 *Stormwater Guidebook*, or
- DFO's 2001 *Urban Stormwater Guidelines and Best Management Practices for the Protection of Fish and Fish Habitat*.

Both criteria stipulate volumetric reduction. The DFO criteria outline a more stringent 6-month storm (i.e. 72% of the 2-year storm) whereas the Guidebook refers to a mean annual rainfall amount which is roughly 50% of the 2-year storm. Since the DFO criteria commonly is dependent upon approvals for instream works, it is recommended that the more stringent 6-month storm be used to facilitate a timely approval by federal agencies.

Table 3-2 summarizes the recommended criteria for use in citywide drainage bylaws should a municipality elect to implement such a bylaw. By adopting the criteria in Table 3-2, municipalities are able to use several of the "minimum effort" tasks in the template clauses. For example, if a citywide drainage bylaw was implemented and applied to all surfaces in new development and increased surfaces in re-development, there would be little need to develop an environmental model as the EIA would be maintained.

It should be noted that Table 3-2 can also be used to define what surfaces should be counted in a manual EIA calculation or not. If rain falling on a surface can be mitigated such that it meets the criteria in Table 3-2, the surface no longer is considered in the TIA calculation.

3.4 DEVELOPMENT OF WATERSHED SPECIFIC CRITERIA

The ISMP process involves comprehensive data collection and technical analyses to develop an understanding of the subject watershed and its issues. The stakeholder process ensures that community values are clearly identified, and that the study is being guided in the proper direction. It would be tremendous if every municipality could adopt the criteria listed in Table 3-2, but that is unrealistic. Many land uses, and development conditions simply can not meet that criteria. Therefore, it is likely that watershed-specific criteria relating to a variety of land uses within the watershed will be developed during an ISMP. ISMPs will be guided by no-net-loss objective and tradeoffs between land development and environment protection will be balanced.

the criteria listed in Table 3-2, but that is unrealistic. Many land uses, and development conditions simply can not meet that criteria. Therefore, it is likely that watershed-specific criteria relating to a variety of land uses within the watershed will be developed during an ISMP. ISMPs will be guided by no-net-loss objective and tradeoffs between land development and environment protection will be balanced.

Table 3-2: Summary of Stormwater Discharge Criteria

Component	Target Rainfall Amount	Criteria/Guidelines
Typical Municipal Criteria		
Flood Protection	5 or 10-year storm	▪ Minor drainage system – 5- or 10-year return period design event
	100-year storm	▪ Major drainage system - 100-year return period design event
Provincial Stormwater Guidebook		
Volumetric Reduction	0 to 50% MAR[1] (Tier A/B rainfall events)	▪ Capture 90% of the rainfall in a typical year and either infiltrate or evaporate it at the source (runoff volume reduction and water quality control).
Runoff Control for Large Storms	50 to 100% MAR[1] (Tier C storms)	▪ Store runoff from infrequent large storms, and release at a rate that approximates the natural forested condition to decrease the erosive impact. (runoff rate reduction). On-site disposal features to retain 50% of the Mean Annual Rainfall (MAR) volume[1]
Flood Risk Management for the Extreme Storms	Greater than MAR[1] up to 100-year return period (Tier D storms)	▪ Ensure that the drainage system is able to convey the extreme storm events with only minimal damage to public and private property. (peak flow conveyance)
Fisheries and Oceans Canada (DFO)[2]		
Water Quality	Treat 90% of annual rainfall[3]	▪ Provide treatment for 90% of rainfall events falling on impervious areas where source controls are not achievable.
Volumetric Reduction	6-month[4]	▪ Infiltrate, evaporate, transpirate, or re-use all rainfall up to the 6-month storm - Only applicable to fish bearing creeks
Rate Control – Erosion	6-month[4], 2-year and 5-year events	▪ Control post-development flows to pre-development levels for 6-month, 2-year and 5-year events.

Note: Shaded cells highlight governing criteria

[1] MAR is Mean Annual Rain Event (e.g. a two-year storm event).
[2] Fisheries and Oceans Canada, 2001.
[3] It is generally assumed that by treating the 6-month storm, 90% of all rainfall events will also be treated
[4] Calculated by multiplying the 2-year, 24-hour rainfall amount on the IDF curve by 72%

The ISMP process provides an opportunity for municipalities to develop their own solutions and criteria for a specific watershed, provided they follow the approved ISMP template process, and meet the no-net-loss guiding principle.

3.5 ISMP VERSUS MDP

Many Lower Mainland watersheds already have Master Drainage Plans (MDPs) in place. These plans typically focus on resolving existing drainage issues and flooding risks, and some may have plans to mitigate the impacts of future development and re-development (although the criteria may be outdated). ISMPs also focus on these aspects, but add a strong environmental component to the plan. In most cases, ISMPs will be complementary to MDPs, as the ISMP environmental component tends to be mitigate the impacts of smaller storm events whereas the MDPs mitigate the more extreme flooding events. It is possible that some MDP programs and capital plans could be modified as a result of an ISMP. However, it is unlikely that any major capital works to accommodate the 100-year flow would be affected.

3.6 PLAN DEVELOPMENT

Plan development should consider the following key steps in order of priority:

1. Try to implement citywide stormwater criteria that meet Table 3-2. Failing that, break the watershed up into areas of similar land use, slope, and soil conditions. Apply the criteria where possible.

2. Develop innovative low impact development (LID) standards for new development/redevelopment. Focus on source controls.

3. Develop best management practices (BMPs) to supplement above, to achieve no-net-loss.

4. Explore density trading schemes and zoning changes to reduce development and/or mitigative costs to achieve no-net-loss. If possible, revisit Step No.1.

5. Identify changes to the Official Community Plan (OCP) to further explore different land use schemes. OCPs are typically updated approximately every 5 years. It will take some time for revisions to be reflected in the planning documents.

6. Identify compensation opportunities within the watershed to offset any net losses and to achieve no-net-loss on a watershed basis.

Every reasonable effort should be made to meet the no-net-loss guiding principle, and preferably the 'net gain' objective while allowing development to proceed.

The importance of conducting land use planning together with stormwater management planning to protect environmental values is highlighted. Better, more integrated solutions can be found, such as considerations of development densities and their locations within a watershed, improved development standards, and low-impact development practices. ISMPs should include recommendations for other municipal master plans (OCPs, Neighbourhood Community Plans (NCPs), Parks and Recreations Plans, etc.).

Section 4

Recommended Watershed Health Tracking System

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4. RECOMMENDED *WATERSHED HEALTH TRACKING SYSTEM*

4.1 INTRODUCTION

This section provides a review the Watershed Classification System, explains the linkages to the ISMP template, recommends modifications, and shows how the new *Watershed Health Tracking System* can be calibrated using biological indices. Methods to calculate EIA using stream flow records and computer models is also discussed.

4.2 NEED FOR A WATERSHED HEALTH MEASUREMENT TOOL

Stormwater engineers and planners face numerous challenges in mitigating the impacts of development and re-development in watersheds. The three most significant technical challenges are:

1. **Determination of impacts of land-use decisions:** Over the years, many criteria have been developed to try to help engineers/planners mitigate the impact of land use changes on receiving watercourses. These criteria have included methods such as limiting post-development flows to a percentage of pre-development flows using single-event design storms. It was believed that application of these criteria could mitigate the impacts of land uses changes. It is now known that this is not the case. The application of these criteria has resulted in the pre-development hydrology being exceeded, particularly in flow duration and volumes.

2. **Comparison and evaluation of various land use strategies, low impact development (LID) measure, source controls, and regional best management practices (BMPs):** ISMPs must provide comparable alternatives that can be evaluated on an apples-apples basis. A change in land use combined with a particular LID standard and a well thought out source control has to be quantifiable and comparable.

3. **Meeting the DFO Policy Objective of "no-net-loss of productive capacity of habitat":** With the working objective of no-net-loss of watershed health and productive habitat, solutions must be evaluated using a measurable system to determine the effectiveness in meeting the objective at the watershed scale. Also, the system must allow the plan to be tracked over time comparing it to its objective.

Linking the above three challenges with a measure of biological integrity in a watershed yields a more quantifiable, measurable plan. Tracking land use changes, BMPs, source controls, and LID measures and linking it to a biological indices will make ISMPs more quantitatively-based and defensible.

Section 2 recommended the use of a *modified* Watershed Classification System, now referred to as the *Watershed Health Tracking System,* as an analysis and decision making tool. The term "classification" has been removed from the new system.

4.3 MEASURING BENTHIC MACROINVERTEBRATE COMMUNITIES

During the past decade, environmental protection has become integral to stormwater management planning. It is now widely accepted that conventional drainage and stormwater management practices were ineffective in protecting aquatic habitat. Numerous problems have been realized, ranging from the way cities are built to the type of constructed stormwater facilities to the stormwater criteria selected. Even today, many BMPs, LID measures, and source control methods are unproven, as the science behind the new technology evolves.

A measure, independent of the technology, methods, and criteria, is needed to determine whether the proposed works/scheme are achieving their objectives. The measure should also be reproducible in order to be defensible.

INTRODUCTION OF BENTHIC INDEX OF BIOTIC INTEGRITY (B-IBI)

It is generally accepted that such a measure should be biologically based. Many believe that the underlying macro-invertebrate communities, or streambed insects, that occupy all watercourses should be that measure. Their presence is independent of fish barriers and blockages, commercial and sport fishing quotas, and ocean survival rates. The Benthic Index of Biotic Integrity (B-IBI), developed by Karr (1996-1999), is a multimetric rating system that can be used to measure benthic communities. The 10-metric index version of the system reflects Pacific Northwest conditions and has proven to be surprisingly reproducible across most creek systems. There are also the 5-metric and %EPT (ephemeroptera (mayflies)) systems that are less expensive and can be correlated to the 10 metric system. However, these systems should be used to show trends, and should not replace the 10-metric score. More information on the index and how to use it can be found at http://www.cbr.washington.edu/salmonweb/ and within the report entitled *Environmental Effects of Stormwater Discharges on Small Streams - Habitat and Benthic Assessment, April 2000* available from the GVRD. http://www.gvrd.bc.ca/sewerage/stormwater_reports_1997_2002/impact_smstreams/sml_streams_rpts.pdf

The index ranges from a score from 10 indicating "poor" watershed health to 50 indicating "excellent" health. Wild salmon are expected in watersheds with high scores while fewer fish species and lower salmon densities are expected in watersheds with scores below 25. The GVRD have also developed a measurement protocol. The document can be found under http://www.gvrd.bc.ca/sewerage/pdf/bib_guide.pdf. The next step is to integrate this index into a predictive planning tool.

4.4 PROPOSED WATERSHED HEALTH TRACKING SYSTEM

IDENTIFYING LIMITING FACTORS IN STREAMS

Research shows that four primary factors affect the ecological values in urban streams. They are, in order of importance:

- changes in hydrology;
- disturbance to the riparian corridor;
- disturbances to fish habitat; and
- deterioration in water quality.

Although we do not have a complete understanding of the physical processes that link factors to environmental health, overwhelming empirical evidence strongly suggests that addressing the above four factors is a critical first step in watershed development planning.

THE ORIGINAL "GVRD WATERSHED CLASSIFICATION SYSTEM"

The GVRD, under its LWMP mandate to manage stormwater for environment protection, has developed a draft *Watershed Classification System for Stormwater Management* that categorizes the ecological health of urban watercourses.
http://www.gvrd.bc.ca/sewerage/stormwater_reports_1997_2002/classrpt/rpt.pdf

The system essentially condenses the four ecological factors (changes in hydrology, disturbance to the riparian corridor, disturbances to fish habitat, and deterioration in water quality) into two measurable watershed level indicators, Total Impervious Area (TIA) and Riparian Forest Integrity (RFI), as follows:

Primary Factor	Measurable Watershed Indicator
Changes in Hydrology	% Impervious Area
Disturbance to the Riparian corridor	% Riparian Forest Integrity
Disturbance to fish habitat	% Impervious Area and % Riparian Forest Integrity
Water quality	% Impervious Area

IMPORTANCE OF IMPERVIOUSNESS (INDICATOR #1)

Research shows a strong relationship between the amount of impervious area and a stream's health:

Stream Health Relative to Impervious Area

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

Increases in impervious areas associated with development causes increased frequency of runoff events which causes wear and tear on urban watercourses. This accelerates natural rates of erosion, washes out fish habitat, and adversely affects water quality. Urban watersheds in the Pacific Northwest eco-region may be unable to sustain abundant self-supporting populations of cold water fish once the TIA exceeds 30%.

TIA can be calculated by several methods including: air photos, GIS based pixel analysis routines, and land use with assumed percent impervious ratios. The air photo method is typically used for existing development, and the land use method for future development scenarios.

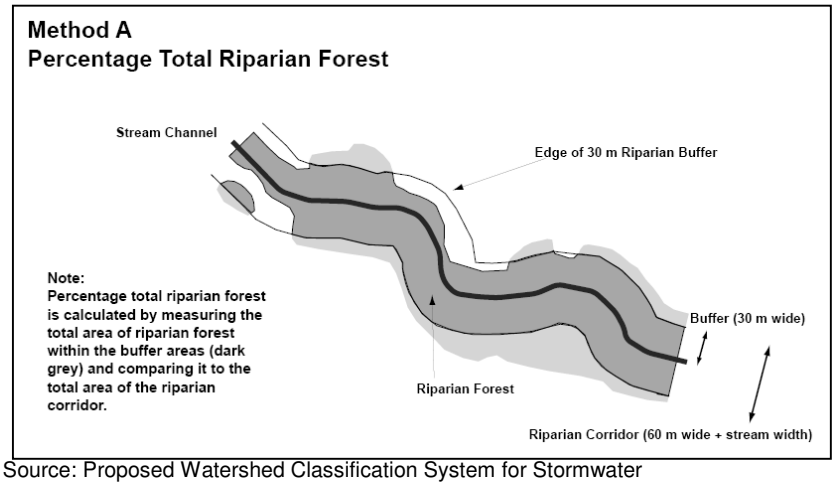
IMPORTANCE OF RIPARIAN FOREST INTEGRITY (INDICATOR #2)

Riparian (streamside) forest provides large organic debris for fish habitat, bank stabilization to reduce erosion, shading to moderate water temperature, and food for aquatic life.

This indicator measures the integrity of a 30-metre setback on both sides of a watercourse over its entire length. For example, if a watercourse is in pristine condition, the percentage of Riparian Forest Integrity will be 100 %. If a watercourse has lost half of its pre-development length due to creek enclosure projects and the riparian setback in the lower reaches has been reduced to 15 metres, the percentage of Riparian Forest Integrity will be closer to 25 %, depending on the quality of the remaining 15 metre setback.

The following figure shows an example of how the riparian forest integrity was calculated in the GVRD Watershed Classification Study.

Figure 4-1: Measuring Riparian Forest Integrity (RFI)

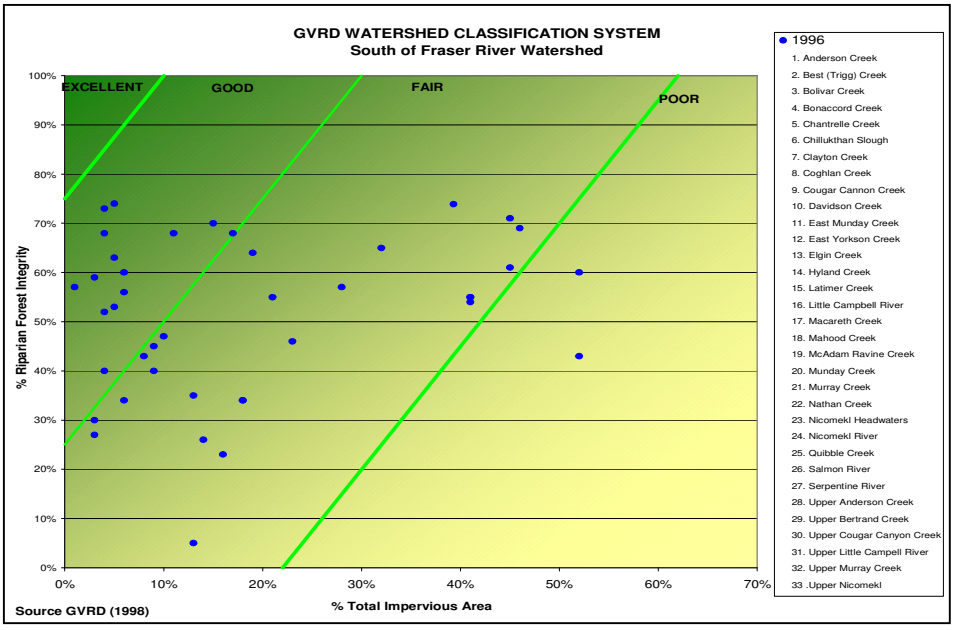


Source: Proposed Watershed Classification System for Stormwater Management in the GVS&DD Area, GVRD, May 1999.

LINKING IMPERVIOUS AREA WITH RIPARIAN FOREST INTEGRITY TO CREATE THE WATERSHED HEALTH TRACKING SYSTEM

The GVRD has combined the two indicators graphically and plotted the results of several test sub-watersheds and watersheds. Figure 4-2 ranks sub-watersheds/watersheds into four classifications of ecological health: poor, fair, good and excellent. This classification system can be used to provide a picture of a watershed's current fish-support and environmental status. The reader is referred to the report *Assessment of Current and Future GVS&DD Watershed and Catchment Conditions*, GVRD, August 1999 for the ranking of all watersheds in the GVRD.
http://www.gvrd.bc.ca/sewerage/stormwater_reports_1997_2002/assessment/main_rpt/assessment_watersheds_catchments.pdf

Figure 4-2: Original GVRD Watershed Classification System



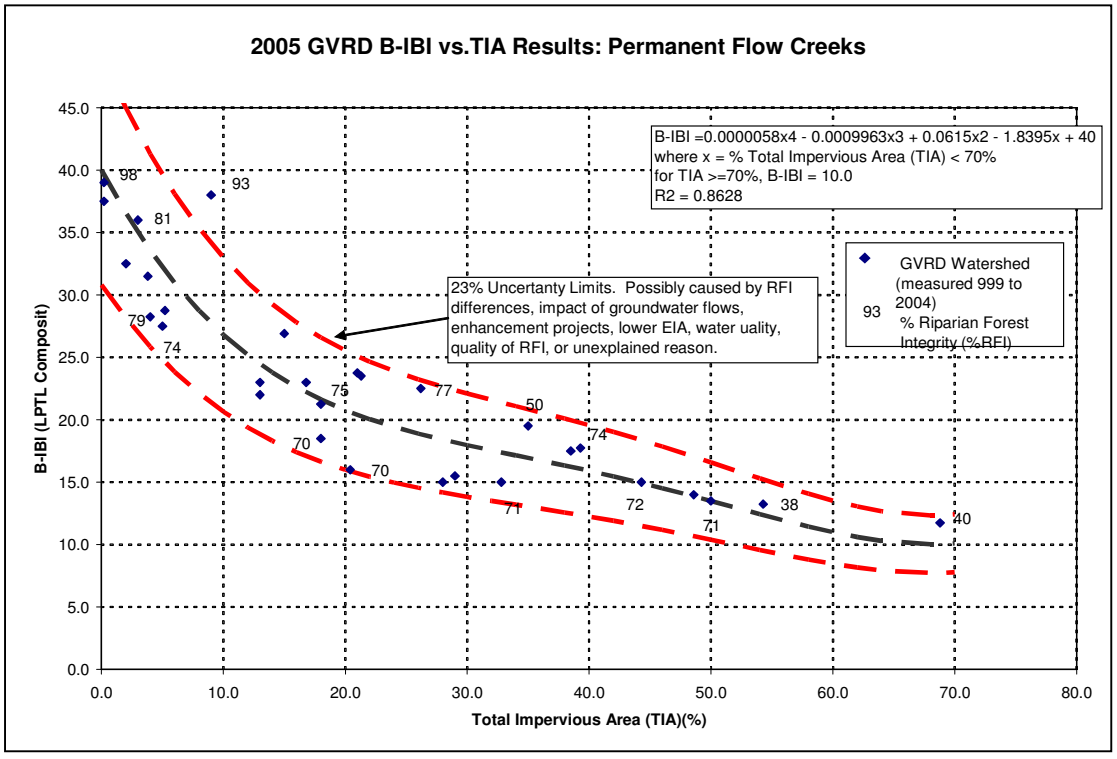
REMOVING THE CLASSIFICATION CATEGORIES AND CREATING THE WATERSHED HEALTH TRACKING SYSTEM

The creek classifications of poor, good and excellent on the Watershed Classification System have been controversial, and therefore were recommended for removal. The graph still functions well as a predictive tool to track relative changes within the subject watershed. The modified system was renamed the Watershed Health Tracking System.

CALIBRATING THE WATERSHED HEALTH TRACKING SYSTEM WITH B-IBI SCORES (INDICATOR #3)

B-IBI scores can be superimposed on the Watershed Health Tracking System. The system should be calibrated for the GVRD region using all of the B-IBI scores on local creek systems measured to date. Figure 4-3 shows an initial local relationship between B-IBI and TIA. An equation has been developed to predict the B-IBI score based on the TIA.

Figure 4-3: Calibrating Watershed Classification System with Predicted and Measured B-IBI Scores



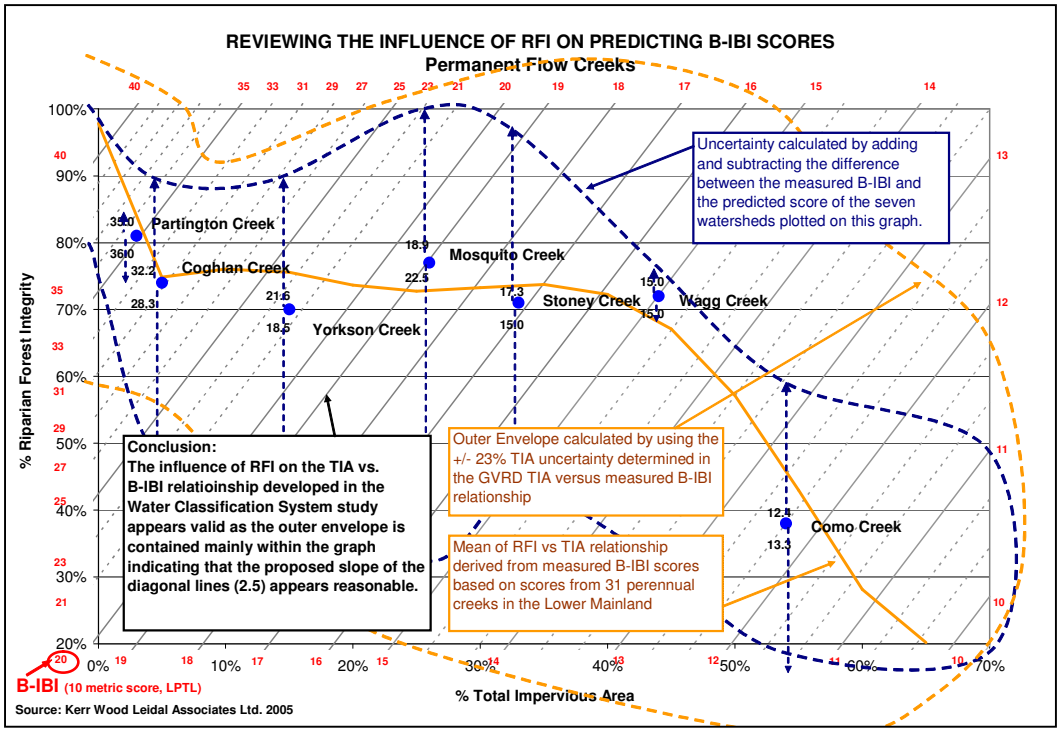
EIA can be substituted into the equation to produce more accurate results, but for most lower mainland creeks at this time, EIA is close to TIA. In the future, when more watersheds have disconnected surfaces, this will not be the case, and EIA will be lower than TIA.

CONFIRMING THE INFLUENCE OF RFI ON B-IBI PREDICTIONS (CONFIRMING THE SLOPE OF THE DIAGONAL LINES)

The original work on the Watershed Classification System included an estimated of the impact of RFI on the TIA versus B-IBI relationship (i.e. the slope of the diagonal classification lines). The work was done by Stadman (1996), and latter confirmed by Karr. The theory is that a majority of the variability between measured and predicted B-IBI scores (as shown in Figure 4-3) is due to the influence of riparian forest integrity. For example, the RFI of a watershed with a TIA of 35% may not be the same in a neighbouring watershed with the same TIA. The difference in B-IBI score between these two watersheds could be due to the difference in RFI. This is not entirely true as other factors such as baseflows, and disconnected impervious surfaces may also be playing a role, but is likely that RFI is the most significant factor.

To see how the relationship holds up, Figure 4-4 plots the 23% uncertainty in the TIA versus B-IBI relationship (the orange dashed lines) against the mean TIA versus RFI relationship (solid orange line). The uncertainty between the measured and predicted scores for seven lower mainland watersheds was also included (blue dashed lines).

Figure 4-4: Influence of RFI on Predicting B-IBI Scores for Permanently Flowing Creeks



Since the dashed orange line is roughly contained within the plotting area, it can be concluded that the slope of the lines seems reasonable. Of interest, if the band was narrower and closer to the solid orange line, it would indicate that perhaps the slope was too flat.

B-IBI SCORE OF 40 UPPER BOUND OF WATERSHED HEALTH TRACKING SYSTEM FOR GVRD REGION

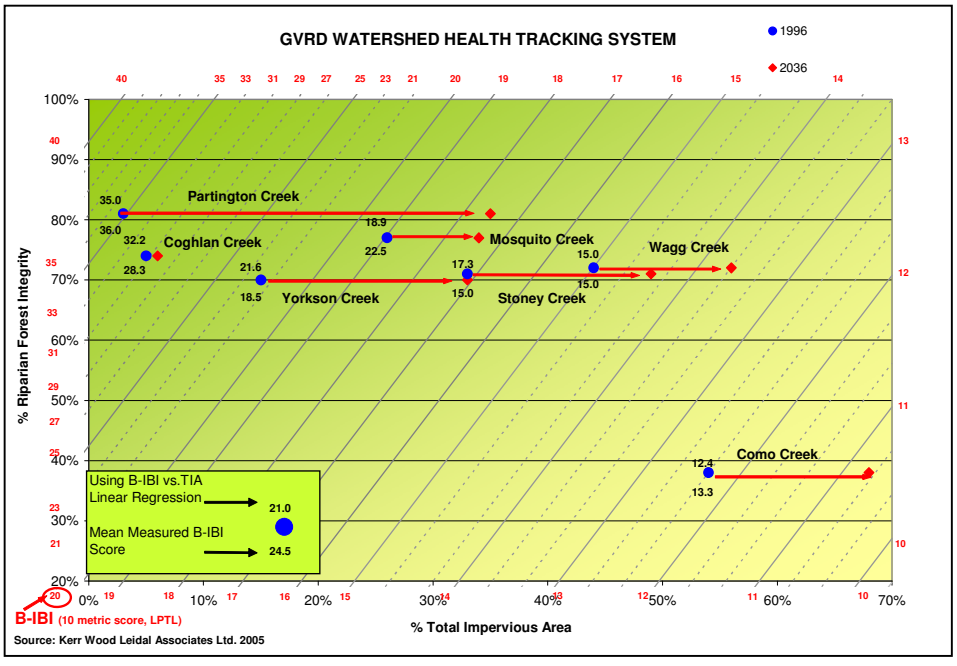
Since considerable funds have been expended measuring the B-IBI scores for 31 creek systems in the GVRD over multiple years, it is now possible to use the relationship developed in Figure 4-3 to calibrate the Watershed Health Tracking System to local conditions. The highest B-IBI score ever recorded in the data set was 39. In fact there are several scores in the 36 to 39 range. These scores were obtained on "pristine" watersheds with nearly 100% RFI and less than 1% TIA. The sites have produced very similar results from year to year. However, the maximum score for pristine sites is 50 on the B-IBI 10 metric system. It is theorized that to achieve a score greater than 40, the watershed would be an old growth forest. Since there are no forests of that stature in the Lower Mainland, it is proposed that the highest B-IBI plotting position be 40 for a GVRD "pristine" watershed. Otherwise, the system will be predicting a higher score than possible for lower mainland creeks.

This does not affect how the score is calculated or measured, it only highlights the upper bound of the Watershed Health Tracking System. A score of 26 is still comparable to a score of 26 in King County.

PROPOSED WATERSHED HEALTH TRACKING SYSTEM

Figure 4-5 shows the plotting position of seven randomly selected watersheds out of the 31 watershed database. The watershed health is plotted for 1996 and then forecasted for 2036 (assuming conventional drainage practices are employed (i.e. unmitigated) and the riparian corridor remains the same as today).

Figure 4-5: Watershed Health Tracking System: Permanently flowing Creeks



The numeric value above each 1996 plotting position indicates the predicted B-IBI score, while the value below is the actual measured B-IBI score for the watershed. Generally speaking, the predicted score is close to the measured score, and within the error range of the samples collected. In the case of Coghlan Creek, the predicted score is greater than the measured score by a larger margin and could be a result of the influence of the agricultural practices on the watershed health.

Since the objective of an ISMP is to not allow the plotting position and B-IBI score to decrease (i.e. no-net-loss), the next step is to convert the TIA axis to Effective Impervious Area (EIA).

Appendix F includes a blank copy of the above graph. The graph can be used to plot EIA against RFI and accurately predict the B-IBI score based on the 10 metric LPTL system for any watershed with permanent flow in the Lower Mainland. If the measured score is higher than that predicted, it is possible that the watershed is performing better than expected. If the measured score is lower than predicted, it is possible that local factors are influencing the creek system, and should be investigated.

EPHEMERAL AND SOFT-BOTTOM STREAMS

The above system has been developed for permanently flowing streams (creeks that flow all-year long) at this time. A similar system could be developed for ephemeral and soft-bottom streams should a sufficient database of information be available.

4.5 CALCULATING EXISTING EFFECTIVE IMPERVIOUS AREA (EIA)

EIA is a surprisingly controversial concept. Some believe that it does not exist, and others believe that because it is difficult to measure, it should not be used. The EIA concept is based on the premise that if impervious surfaces are hydraulically disconnected from a watercourse through the use of source controls, EIA will be less than the TIA. If EIA is less than TIA the health of the watershed (and its B-IBI score) should be higher.

Little research has been completed on how far EIA can be moved away from TIA. There may be limiting factors for each level of TIA. An example of this is water quality. Although water quality impacts from non-point sources are not significant for TIAs less than 30%, they become more significant above 30%. As a result, if a particular source control technique is predicted to lower EIA by 10 %, the actual measured B-IBI may not increase substantially unless the water quality impacts are also addressed. It is likely however, that many of the source controls that are reducing EIA are also improving water quality. Notwithstanding this uncertainty, the concept of EIA and its use on the Watershed Health Tracking System provides an opportunity to predict what could be done in watersheds to raise B-IBI scores.

CALCULATING EIA

There are several methods available to calculate EIA. Jones et al. in 2002[3] summarized three of the most popular methods, and proposed a fourth. The first two methods comprise empirical equations that calculate EIA based on TIA under various land uses, and infiltration practices. The third method was based on computer models. The fourth method, a new method, was based on analyzing a minimum of a year of stream flow records.

Calibrated computer models

EIA can be determined by calibrating a physically based computer model such as the US EPA Stormwater Management Model (SWMM). Provided the groundwater parameters have been selected appropriately, the model can accurately calibrate for the percent impervious of a basin. The most recent versions of SWMM can also separate between disconnected and connected impervious surfaces. This method requires extended flow monitoring data to calibrate and validate the EIA values, preferably for a number of events with the full spectrum of expected antecedent conditions for the region.

The Annual Hydrograph Method

The Annual Hydrograph Method is the simplest method available that can be applied to an annual streamflow record. The method was developed by Jones et al., in 2002. The method determines existing EIA based on the following relationships:

Rainfall volume = Cumulative Measured Flows + Losses (Depression Storage, Evaporation, Transpiration, and Groundwater) (Eq1)

Flow Volume from EIA = Cumulative Measured Flows – Cumulative Flows from Interflow and Shallow Groundwater (Eq2)

Cumulative Flows from Interflow and Shallow Groundwater = Σ Rising Limb Flows + Σ Falling Limb flows

Where: Rising Limb Flows = 1+0.65% of the previous hour's volume assuming the measured flow is greater than interflow plus groundwater (Eq3)

Falling limb flows = Measured flows after the rain event has past and measured flow drops to rising limb flow.

[3] T. Jones, C. Johnston, and C. Kipkie, 2002. Using Annual Hydrographs to Determine Effective Impervious Area. Practical Modeling of Urban Water Systems Monograph 11, Proceedings of the 2202 Conference on Stormwater and Urban Water Systems, CHI, Guelph, ON. P291.

Equation (Eq1) states that on a volume basis, rainfall must equal runoff plus any losses. This equation can be used to calculate the losses from a system due to depression storage, evaporation, transpiration, and infiltration to deep groundwater. Equation (Eq2) isolates the portion of the Cumulative Measured Flows in Equation (Eq1) that comes from EIA by subtracting interflow and shallow groundwater from the measured flows. Equation (Eq3) shows the procedure to calculate cumulative flows from interflow and groundwater.

Rainfall and flow data are plotted as cumulative volumes for the period of record available. EIA is calculated by dividing the flow volume by EIA by the total rainfall volume.

It is preferable to analyze one wet and one dry year to obtain an average EIA. Annual data sets that contain major storm events can over-estimate EIA. The annual hydrograph method depends on the availability of a continuous record of both rainfall and streamflow data (minimum one year). The method should only be used on smaller watersheds where the rainfall is recorded within the watershed boundaries by one or more gauges to reduce the impact of spatial variability. Alternatively, rain gauge data could be corrected with Doppler radar information. This would allow the method to be used for larger watersheds.

WAGG CREEK EXAMPLE

The XP-SWMM computer model was calibrated with 14 months of flow monitoring data. The model estimated the Wagg/Mission watershed in the City of North Vancouver to have an EIA of 44.6%. The TIA of the basin was calculated to be 51% using air photo interpretation. The EIA using the Annual Hydrograph method was calculated to be 46%. 44% if the major storm in October 2003 is excluded from the data set.

Since the calibrated computer model yields the most accurate results, and the annual hydrograph method calculates a number similar to the computer model, it appears that the hydrograph method is capable of calculating existing EIA levels from stream flow data.

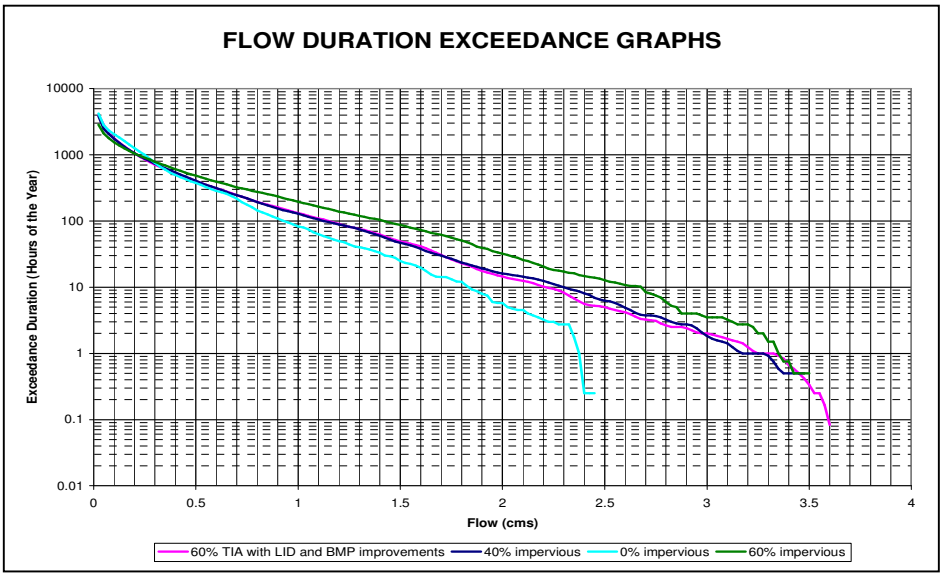
4.6 PREDICTING FUTURE EFFECTIVE IMPERVIOUS AREA

Predicting EIA based on future land use is more difficult than calculating existing EIA levels, particularly if stormwater source controls are proposed for the watershed. The following methods are recommended for use:

1. **Continuous Simulation Modelling using Annual Hydrograph Method:** Build a continuous simulation model and run the future development scenario with recommended source controls for a minimum of one year. If one year is chosen, the year should represent a typical year of rainfall. Take the results and apply the Annual Hydrograph Method described in the previous section to determine the EIA.

2. **Continuous Simulation Modelling using Exceedance Duration Curves**: Build a continuous simulation model and run the future development scenario with recommended source controls for a minimum of one year. If one year is chosen, the year should represent a typical year of rainfall. Take the results and plot them using exceedance duration curves. Run the model under various impervious levels to assist in determining the appropriate EIA (see Figure 4-6).

Figure 4-6: Example of Flow Duration Exceedance Curves



The above figure illustrates how this particular stormwater management strategy involving both BMPs and LID techniques reduces the EIA from 60 % to 40 %since it closely matches the 40 %TIA relationship. This type of analysis must be done with continuous simulation models. Single event models using design storms cannot be used for the environmental components of a plan.

3. **Water Balance Modelling using Volumetric Output:** Build a model of the watershed using the *Water Balance Model* (WBM) complete with the proposed source controls for each land use, and soil type. To determine EIA, use the output volume results and divide the sum of the runoff plus drain flow volume by the total rainfall volume.

About the Water Balance Model: The Water Balance Model is a web-enable model developed by a BC-based Inter-Governmental Partnership as an extension of *Stormwater Planning: A Guidebook for British Columbia*. The Water Balance Model enables users to compare scenarios for rainwater runoff volume reduction in order to achieve a light 'hydrologic footprint'. The tool is developed by a consortium of local, regional, provincial and federal agencies. For more information go to: http://www.waterbalance.ca/waterbalance/home/wbnIndex.asp.

The selection of one of the above EIA prediction methods will be dependent on what tools are required to address unique watershed issues. For example, if erosion is a concern, the most appropriate method is the Continuous Simulation Modelling method using Exceedance Duration Curves. This will allow the stormwater professional sufficient analysis tools to compare the spectrum of velocities with the threshold velocity of the creek substrate. On the other hand, if a previously completed MDP addressed all flooding and erosion issues, such that only watershed health was requiring attention, the Water Balance Model could be used to predict future EIAs. Once an EIA is predicted for each ISMP alternative, the Watershed Health Tracking System would have sufficient parameters to calculate health.

4.7 AVAILABLE HYDROLOGIC/HYDRAULIC COMPUTER MODELS – 2001

The purpose of this section is to review the available hydrologic models as they relate to the requirement outlined in this template. Appendix D includes a summary and comparison of available hydrologic and hydraulic stormwater and drainage models as researched in 2001. Eight commonly used models were evaluated. To comply with the ISMP template requirements, the computer model used should be capable of the following tasks:

- separate impervious/pervious area calculations;
- impervious surfaces not directly connected to conveyance system;
- continuous simulation with infiltration and groundwater regeneration;
- good statistical output summaries; and
- facility routing functions.

In 2001, there was not one single product capable of solving all stormwater management problems. In 2005, however, most models have been upgraded, and some are now capable at modelling disconnected impervious surfaces (i.e. SWMM). AS always, the modeller's experience and knowledge is critical in all modelling/simulation projects.

The products that stand out as better choices for ISMP modelling are:

- SWMM
- QUALHYMO
- HSPF
- MOUSE

For a good overall planning and design tool, SWMM or MOUSE would be the best choice. They are well established, versatile, modelling products capable of analyzing hydrologic, hydraulic and water quality issues. They are physically based models with excellent infiltration and groundwater regeneration functions for continuous simulation. QUALHYMO may be good in some applications, but it is a lumped parameter model, and it has simplistic hydraulic capabilities. HSPF is best applied to rural watersheds and,

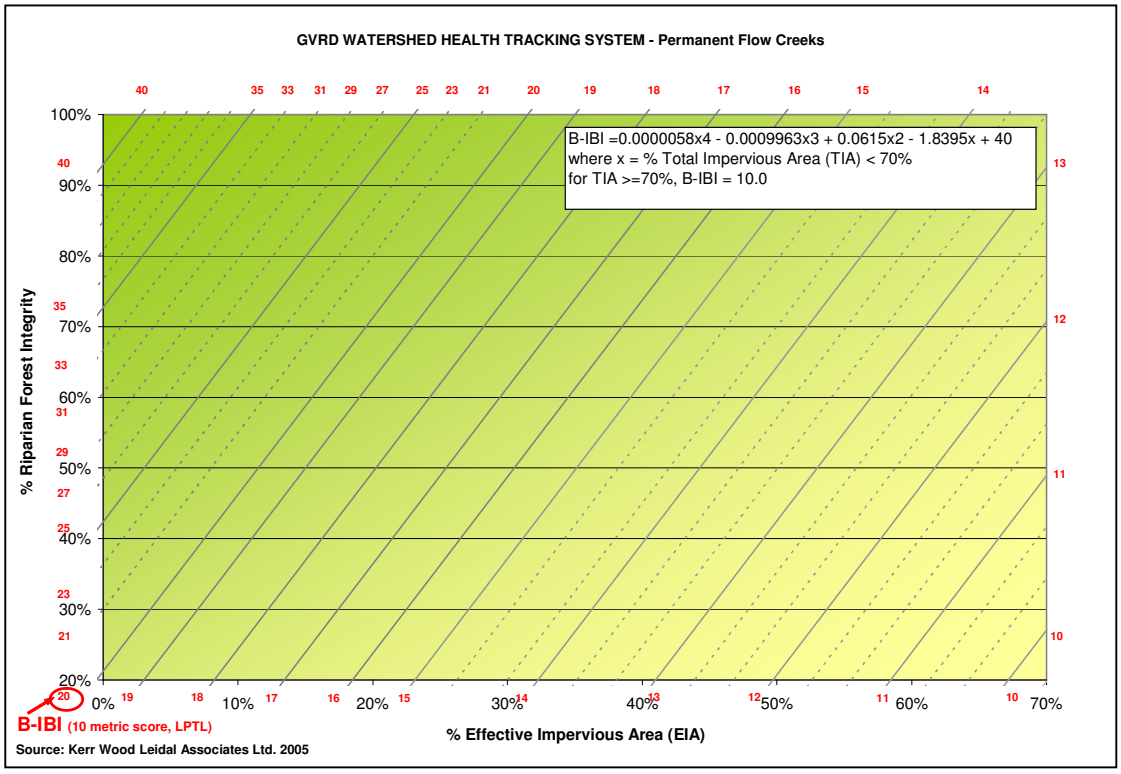
therefore, has limited application in the GVRD area. SWMM interfaces such as PC-SWMM are inexpensive and thus may be the preferred modelling choice, depending on the application. XP-SWMM and MOUSE are considerably more expensive programs to purchase, but will reduce the labour cost in the modelling effort.

4.8 SUMMARY: MEETING THE NO-NET-LOSS PRINCIPLE

Section 4 has outlined a procedure linking B-IBI scores to a health tracking system to conventional stormwater models. Equipped with these new tools, the stomwater professional should be able to predict the consequences of various land use planning decisions. Further, if ISMPs can now show these linkages, approval processes with senior agencies can be made more transparent and less cumbersome. Any losses in one area of the watershed must be offset by a gain in another, and the transaction can be tracked with these new tools. The Watershed Health Tracking System can now address this problem.

Figure 4-8 shows a blank copy of the Health Tracking System. A larger copy that can be used in future ISMPs is included as Appendix F.

Figure 4-7: GVRD Watershed Health Tracking System – Permanent Flow Creeks



Section 5

ISMP Sign-off Strategy and Adaptive Management Program

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5. SIGN-OFF STRATEGY & ADAPTIVE MANAGEMENT PROGRAM

5.1 WHY IS SIGN-OFF REQUIRED?

The main goal of the Integrated Stormwater Management Plan (ISMP) is to protect the watershed in a holistic manner. Integral to the development of the ISMP is a comprehensive review, approval and implementation plan of the strategies required to protect a watershed. An initial sign-off from the environmental agencies of the ISMP will serve as the cornerstone to a comprehensive and efficient implementation.

Since an ISMP implies trade-offs between different strategies to achieve the most effective solution, achieving agreement between the environmental agencies and local governments ensures not only acceptance but understanding of the ISMP's objectives. Each ISMP will be a unique reflection of local values and issues. The development process will, however, be common to all ISMPs. Strategies will be proposed to protect the watershed. These strategies are at the core of the sign-off process. They can be as varied as by-law adoptions or capital works, such as constructed wetlands.

The plan will only be as good as its implementation. Since municipalities will be committed to undertaking these plans within 12 years, it is imperative that a degree of certainty be introduced at implementation. The ISMP sign-off will also ensure that the agencies' goals are maintained during the long-term implementation phase.

5.2 WHAT KIND OF SIGN-OFF CAN BE EXPECTED?

The 2002 Template proposed a Memorandum of Understanding (MOU) be developed for each ISMP. ISMPs since 2002 have found that obtaining a MOU has not been practicle. In fact, not one ISMP undertaken in the lower mainland has obtained a MOU with DFO.

After a review by SILG and the senior agencies in 2005, the Template will now propose the following two track method of approval:

1. **"Letter of Endorsement".** Receiving this letter provides the municipality with certainty that the stormwater management plan could be used in support of future *Fisheries Act and Canadian Environmental Assessment Act processes*. To obtain this letter, the watershed plan must demonstrate that a no net loss in watershed health and no net loss in productive capacity of fish habitat has been obtained.

2. **"Letter of Support".** Receiving this letter indicates that strong measures to lessen the harmful impacts of development have been taken, and DFO is supportive of those measures. However, the basin is likely to still suffer a loss in overall watershed health. DFO reserves the right to re-open certain stormwater strategies within the basin at a later should an authorization or CEA process be required.

Although permits and reviews will still be required to implement many of the strategies, depending on the letter obtained, the process will be simplified. If permits and reviews are not required in a particular watershed, and the stakeholder process establishes that EIA can increase (i.e. watershed health can decline), it is possible that a "letter of support" is all that is required.

On the other hand, if new outfalls and creek crossing are required, it is advisable that a "letter of endorsement" be obtained to provide certainty for future works.

It is hoped that this new approach will provide more certainty in future decisions affecting a watershed with respect to the involvement of senior approving agencies.

5.3 SIGN-OFF STRATEGY

Since all ISMPs will follow the GVRD template, the technical data and analysis will be consistent, but the strategies and recommendations of each ISMP reflect local environmental, community and regulatory issues. For this reason, the ISMP project managers must know at the outset how the agencies will collaborate in the ISMP process. Will they have an active or passive role? Agencies not directly collaborating in the ISMP process (passive involvement) will have difficulty in understanding the range and rationale of the trade-offs made during the development process to achieve the watershed goals. Therefore, agreement in principle on the ISMP planning process and its future implementation should be obtained at the outset.

Once the ISMP is complete, a letter of endorsement or a letter of support will be obtained. If the agencies and the local government cannot agree on certain strategies, they could contact the GVRD's Stormwater Interagency Liaison Group for advice and direction.

Because ISMP's implementation will take many years, successful outcomes hinge on building trust between the agencies and municipalities. Since it is impossible for local governments to guarantee funding or implementation of all the strategies at the outset, a monitoring system is required to ensure that the watershed health and productive capacity of fish habitat does not decline. Within any calendar year, one or more of the ISMP's strategies may be constructed on the condition that the cumulative impacts to the productive capacity of fish habitat within the watershed result in an overall net gain by the end of that year. (That is, the ISMP must meet DFO's guiding principle of achieving no net loss in the productive capacity of fish habitat, in accordance with DFO's national "Policy for the Management of Fish Habitat".) Net gains accrued in any one year may be carried forward to offset net losses resulting from other strategies specifically referred to in the ISMP. Conversely some strategies will require no further review and can be implemented immediately.

To implement strategies that require permits, preliminary and detail designs will have to be prepared. The agencies will be involved at this stage in their more traditional review and permit process. The permit process should be easier for all since the justification for the individual projects will already have been completed under the ISMP. The review process can then be focussed on the details of the design. In other words, time will be spent on the "how" to implement a strategy rather than on the "why" it is needed.

5.4 ADAPTIVE MANAGEMENT AND ON-GOING MONITORING

As part of the LWMP commitment, municipalities are required to re-visit an ISMP every 12-years. To ensure that the plan is unfolding as was intended, an Adaptive Management Plan should be developed as part of the ISMP (see Clause 34).

Adaptive management is a leading-edge component of stormwater management planning. Preserving a watershed is a difficult task. It requires a comprehensive planning process and the ability to reassess and redirect efforts as required over time. It is important to monitor the performance of the implemented works and programs to see whether they are effectively meeting the watershed goals. The data must be interpreted carefully, and if the results are less than satisfactory, the program must be reassessed and efforts realigned. This process of program reassessment and redirection is critical, especially in light of the rapidly evolving stormwater management technology.

Once strategies have been implemented, two levels of monitoring are required. Individual strategies may have permit-related monitoring that is site-specific. The watershed as a whole needs to be monitored to verify that the ISMP's goals are being achieved and that the watershed is healthy. As a minimum, benthic macroinvertebrates, imperviousness, and riparian area can be used to monitor the watershed as whole. Through the use of B-IBI scores and the Watershed Health Tracking System, watershed health can be evaluated as declining, being maintained, or improving. The results of this monitoring will be critical in reassessing the ISMP.

The frequency of benthic sampling will depend on the amount of activity (development/redevelopment/implementation of proposed works/etc) within the watershed. If there are significant changes and development occurring each year, benthics should be sampled bi-annually. Reduced frequency of sampling (i.e. 6 years) applies when there is no activity in the watershed. In any event, it is not dependent on the health of the watershed but rather the degree of activity (i.e. a healthy watershed will not have reduced frequency of sampling).

Other parameters that should be collected and reported are summarized as follows:

Table 5-1: Recommended Monitoring and Reporting Parameters

Watershed Area:	Road Density (km/ha):
% Undeveloped and forested	Population Density:
% Rural Land Use	Baseline Conductivity:
% Urban Development	Baseline BOD, COD
% Forest Cover	Baseline dissolved oxygen saturation
% TIA	Baseline Fecal coliform bacteria,
% EIA	Baseline Total coliform bacteria,
RFI:	Baseline Copper, manganese, zinc, aluminium, iron, and lead.
B-IBI:	Baseline ammonia nitrogen

Depending on the degree of development, the above parameters could also be reported on a 2-year or 6-year cycle.

5.5 POSSIBLE REGION-WIDE STORMWATER REPORTING SYSTEM

The GVRD must report biannually to the Province on the progress of their LWMP implementation. It is suggested that this could provide an opportunity for the member municipalities to organize their performance measures and report back to the GVRD. Some of these measures could be reported back to the Province, and others could be made available to the public on the GVRD's web site. The purpose of this reporting would be to document how the region is doing in meeting its LWMP commitments and ISMP objectives. Since ISMP objectives will vary from watershed to watershed, it will be important to also list what the target are.

The Maryland Department of Natural Resources has set up an excellent example of this type of reporting system for tracking the implementation of the *Chesapeake Bay 2000 Agreement*. The information provides the foundation for assessing Maryland's commitment to improve habitat, water quality, and the overall health of the Chesapeake Bay. The tracking system, performance measures, and strategy targets can be found at http://dnrweb.dnr.state.md.us/watersheds/surf/bmp/

Implementation of this type of system to the degree of the Maryland system may not be feasible in the Lower Mainland. However, even if the only a few parameters were tracked, the benefit would be significant to decision makers in the region.

The GVRD already tracks a considerable number of annual performance indicators for wastewater discharges within the region. However, since stormwater is largely a

municipal responsibility, stormwater tracking plays only a minor role in the annual reports. (see http://www.gvrd.bc.ca/sustainability/pdfs/LiquidWaste.pdf). Existing reporting systems such as these could be expanded to include municipal stormwater programs for the region.

Section 6

Conclusions and Recommendations

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CONSULTING ENGINEERS

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

Based on the foregoing, the following conclusions are made:

1. The GVRD's population is 2 million, and growing rapidly. Over the next 70 years, the population is estimated to double. Using a well established relationship between impervious surfaces and watershed health, it is predicted that many of the Lower Mainland watershed will degrade significantly unless traditional stormwater management practices are abandoned and new practices developed.

2. The proposed ***Watershed Health Tracking System*** shows how the health of a permanently flowing creek system can be predicted, and verified using a relatively simple field and laboratory analysis. The system can also show how the health of a watershed can be predicted for future land uses.

3. The major breakthough in the development of this tool, was the ability to calculate EIA using flow monitoring and computer models. Once this is reliably performed, the health tracking graph can be used to predict changes to watershed health.

4. A revision to the "minimum effort" clauses allow municipalities that have implemented City-wide stormwater bylaws, and riparian/ streamside protection regulations more flexibility in reducing the scope of ISMPs.

5. A *letter of Endorsement* or *Letter of Support* will in many cases streamline the approval process, and could provide more flexibility in implementing an ISMP providing stormwater managers strive to achieve the no-net-loss objective.

6. The new *Watershed Health Tracking System* was calibrated using considerable B-IBI measurements to better reflect local conditions.

7. The Annual Hydrograph Method was chosen to calculate existing EIA values from stream flow data.

8. A recommended blend of the Provincial Guidebook Stormwater Criteria with the DFO Stormwater Criteria has been made. Adoption of the 6-month storm over 50% of the Mean Annual Rainfall has been proposed. The 6-month, 24-hour storm has been defined as 72% of the 2-year, 24-hour storm.

6.2 RECOMMENDATIONS

Based on the above conclusions, the following recommendations are made:

1. For ephemeral and soft-bottom creeks, a similar system could be developed either based on the B-IBI system or Environment Canada's RCA method.

2. Since the current Health Tracking System is only calibrated to permanently flowing creeks, help is needed to build comparable systems for ephemeral and soft-bottom creek system. It is recommended that metrics are calculated from the base RCA datasets, and a relationship between the B-IBI system and the RCA system be developed.

6.3 REPORT SUBMISSION

Prepared by:

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ISMP Technical Clauses

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CONTENTS

Refer to ISMP Flowchart Figure 2.

CLAUSE 1 – ESTABLISH FRAMEWORK

OBJECTIVES

- To clearly identify the goals and objectives of ISMP, obtain an understanding of the issues, and develop an appropriate study approach and scope.
- To establish which Template clauses are applicable and determine the level of effort required
- To clearly establish regulatory requirements (i.e. to determine which DFO approval letter is required)

SIGNIFICANCE

- This clause sets the framework for the study and ensures that the ISMP is developed in the proper context.
- This clause interfaces with all other clauses and provides guidance and direction for the study process. It will be revisited throughout the study process as more information and the results of the technical analyses become available. This is particularly relevant to the stormwater criteria, which will be developed through the study process.
- It is extremely important that an ISMP establish early in the process, the need for future senior government approvals. For example, in a developing basin where future stream crossings, outfalls, and riparian setbacks are to be established, environmental agencies may require certain stormwater criteria be met as a condition for approval. It is important that these conditions be identified early in the process.

TASKS

1.1 MINIMUM EFFORT

- Establish watershed goals and objectives.
- Review existing city-wide bylaws to confirm where minimum efforts outline in template clauses may apply.
- Summarize the issues that need to be addressed in the ISMP
- Develop stakeholder involvement objectives and processes. Discuss representatives for stakeholder/public process.
- Review the project scope, expectations of study, budget and schedule.

1.2 MAXIMUM EFFORT

- Establish watershed goals and objectives. A common and consistent goal is to maintain existing watershed health. Strive to achieve a fisheries no-net-loss in each watershed.
- Frame the problem clearly, based on discussions with the municipality and the background review.
- Summarize the issues that need to be addressed in the ISMP.
- Define the regulatory environment to determine what future senior government approvals are required.

- Confirm appropriate stormwater and drainage criteria.
- Develop stakeholder involvement objectives and processes. Discuss representatives for stakeholder/public process.
- Review the project scope, expectations of study, budget and schedule.
- Develop framework.

MINIMUM DELIVERABLES

- Work program.
- Framework to guide the study.

CLAUSE 2 – MAPPING/INFORMATION GATHERING

OBJECTIVES

- To obtain, review and evaluate all current and historical information/mapping/reports/ plans on the watershed.

SIGNIFICANCE

- Information gathering is crucial; obtaining and using existing information efficiently can potentially save large amounts of time and money.
- The extent and quality of the background information dictates the level of effort required in Clauses 3 to 16.

TASKS

2.1 MINIMUM EFFORT

- Collect and use existing information and reports, especially existing MDPs.

2.2 MAXIMUM EFFORT

- Obtain and review background information, relevant reports, as-builts drawings, historical logs pertaining to flooding and erosion, soils and hydrogeology information, environmental reports, data and, surveys, and land use planning information, OCP, etc. Recent MDPs may have significant inventory work, existing computer models, and extreme event analysis already completed.
- Meet with municipality, streamkeepers, environmental groups and others to gather relevant information.
- Review and consider other municipal master plans (OCPs, NCPs, Recreations and Park Plans, Strategic Transportation Plans, etc.).
- Document relevant information including physical watershed characteristics and drainage structures, design flows, environmental values and issues, and hydrogeology information.
- Review existing and future land use.
- Identify municipal-owned lands within the watershed.
- Identify historical problems, concerns and issues related to the watershed.
- Obtain digital files of creek systems, cadastral, contour mapping, air photos, zoning, and OCP layers, if available. It is preferable to receive/assemble the mapping data in GIS format.

MINIMUM DELIVERABLES

- Summary of existing information and digital files.

CLAUSE 3 – HYDROMETRIC DATA AND EXISTING EIA CALCULATION

OBJECTIVES

- To collect precipitation and streamflow data. (Note: depending on the continuous water quality monitoring parameters selected in Clause 13, the hydrometric station may need to be outfitted with additional sensors such as water temperature and conductivity)
- To measure at least two significant rainfall events in the winter during saturated soil conditions, two in the spring/summer during dry soil conditions, and determine summer baseflow conditions.
- To collect sufficient information to determine the effective impervious area (EIA) of the basin (note: most EIA calculation methods require a minimum of 12 months of flow data)

SIGNIFICANCE

- Hydrometric data specific to the watershed is needed to establish an accurate understanding of a watershed's response to rainfall. The measurements will be used to quantify watershed baseflows, calibrate the continuous hydrologic model, and determine the current effective impervious area (EIA) of the watershed.
- This task does not necessarily need to be conducted at the same time as the ISMP study. Rather, it is preferable if the task is completed prior to an ISMP as to avoid delaying the schedule.

TASKS

3.1 MINIMUM EFFORT

- It is recommended that the minimum effort comprises installing one station in the lower reaches of the watershed following the work items in the maximum effort describe below.

3.2 MAXIMUM EFFORT

- Identify existing and potential streamflow monitoring sites. One station should be installed in the lower reaches of the watershed to capture the response of the entire watershed. Additional monitoring stations should be added if the watershed is larger than 750 ha, or if the land use varies significantly throughout the basin. Also, if the surficial soils are highly permeable in some reaches of the watershed, it is highly recommended that those reaches be monitored separately.
- Install streamflow monitoring station(s) and rainfall station if it has been determined that the historical data is not applicable.
- Collect hydrometric data. It is recommended that 12 months of flow data be collected for station that captures the entire watershed as most EIA calculation methods require 12 months of flow data (multiple stations recording for 12 months may be required for watersheds larger than 750 ha). A minimum of 4

to 6 months of flow data is recommended for the supplemental stations to obtain sufficient wet and dry weather periods for proper hydrologic model calibration.
- Conduct station maintenance and ensure quality of data.
- Compile and graph data.
- Calculate EIA using the collected stream flow data using the procedure outlined in the Template text.

MINIMUM DELIVERABLES

- Plan of hydrometric stations.
- Graphical plot showing streamflow and rainfall data.
- Minimum baseflow in summer measured in L/s/ha
- Minimum baseflow in winter measured in L/s/ha
- Existing effective impervious area (EIA) of the basin in %.
- Measured annual volumes of rainfall over the watershed area, stream flow, estimated interflow/groundwater, and surface runoff. These annual amounts can later be compared to the predicted amounts from the selected computer model (including the Water Balance Model).

CLAUSE 4 – DRAINAGE SYSTEM INVENTORY

OBJECTIVES

- To establish a solid understanding of the watershed's physical characteristics, and to identify opportunities and constraints for flood and stormwater management measures.
- It is preferable that a GIS layer of the drainage system is compiled and should include a contiguous network showing all pipes, ditches, culverts, canals, watercourses, creeks, and rivers.

SIGNIFICANCE

- The drainage system must be clearly defined in detail to properly assess its conveyance capacities, problems, and potential solutions. All watercourses and drainage paths must be identified. This provides the backbone to every component of the study and the ISMP itself. Data obtained is used directly in Clauses 16 to 28.
- The drainage system inventory clause can be undertaken prior to an ISMP as it is likely to cause potential delays. Further, cost savings may be realized if the inventory is collected and tabulated by a variety of forces including city staff and outside consultants.

TASKS

4.1 MINIMUM EFFORT

- Utilize the inventory work completed by a previous Master Drainage Plan.
- Walk creek systems to identify existing erosion sites (including a rating of low, moderate or severe).
- Identify the physical condition of drainage infrastructure since the last assessment.
- Identify barriers to fish passage.

4.2 MAXIMUM EFFORT

- Undertake inventory of watershed characteristics and drainage facilities:
  - typical channel cross section dimensions, bedload sizes and characteristics, bank confinement and stability, and approximate slopes;
  - existing erosion sites (including a rating of low, moderate or severe);
  - diversion structures, related works, and hydraulic performance;
  - dykes, flood boxes, pump stations, and water control stations;
  - culvert sizes, types, physical condition, fish passage capabilities;
  - bridge opening dimensions; and
  - detention facilities and any other hydraulic structures including size, shape, depth-storage relationship, and outlet conditions.
- Photograph key watershed features.
- Define minor and major flow routes.
- Identify opportunities and constraints for mitigation measures.

- Obtain survey information, if required.

MINIMUM DELIVERABLES

- Plan of watershed characteristics and drainage layer (preferably in GIS form)

CLAUSE 5 – HYDROGEOLOGY/GEOTECHNICAL ASSESSMENT

OBJECTIVES

- To identify sub-surface flow regimes, soil types, infiltration opportunities, and to determine the sub-surface catchment area and baseflow potential.
- To evaluate the groundwater flow regime as it relates to stream baseflows.
- To identify ravine instabilities, and areas throughout the watershed designated as geotechnically significant.
- To identify areas in the watershed where infiltration should be minimized or prohibited.

SIGNIFICANCE

- The presence and quantity of baseflows are critical to aquatic life. Recharge areas should be identified for infiltration type source controls and BMPs.
- Unstable ravine areas will be used to establish stream bank restoration priorities.
- Watersheds with geotechnically significant areas must produce a drawing where source controls promoting infiltration are prohibited.
- In many cases, it is preferable that this clause be undertaken prior to the ISMP, and from a city-wide basis. However, some specific details may still need to be refined upon incorporation in to the ISMP.

TASKS

5.1 MINIMUM EFFORT

- Utilize existing information and reports if available, otherwise move to Maximum effort work items.

5.2 MAXIMUM EFFORT

Hydrogeology

- Compile hydrogeology related data, and undertake field program.
- Review streamflow monitoring results.
- Identify groundwater discharge areas. Estimate seasonal groundwater and baseflow rates. Develop a conceptual water balance between groundwater and creek flows.
- Assess baseflow changes due to past development and predict changes which may result from pending development.
- Evaluate the effect that utility trenches and any existing surface drainage measures may have on the groundwater flow regime.
- Evaluate measures to mitigate the impact of service trenches etc. on the groundwater flow regime (e.g. seepage cutoffs along service trenches).
- Identify groundwater infiltration enhancement areas, if appropriate.
- Evaluate the success of source controls and BMPs that could be implemented to increase infiltration, and augment baseflows, if appropriate.

- Estimate infiltration rates throughout the area.
- Map hydrogeology character and potential opportunities within study area.

Geotechnical

- Compile soil related data. Undertake field program, if required.
- Identify slope stability problems within riparian areas and develop possible solutions.
- Determine the applicability of infiltration works close to geotechnical hazards
- Establish areas where infiltration source controls and BMPs should be prohibited.
- Identify geotechnical constraints for proposed works.

MINIMUM DELIVERABLES

- Maps of hydrogeologic and geotechnical characteristics, including infiltration areas.
- Maps showing the surficial soils of the basin including the predicted infiltration rates.
- Summer and winter baseflow estimates in L/s per hectare for existing and future land uses
- Maps showing where infiltration source controls should be prohibited

CLAUSE 6 – LAND USE INFORMATION

OBJECTIVES

- To identify existing and future land use, and review land use plans and policies.
- To identify land use planning constraints and opportunities.

SIGNIFICANCE

- Impervious area is the single most important parameter that has an impact on stormwater. Since impervious area varies by land use, it is important to establish the degree of impervious surface for each land use under existing and future development scenarios. The ISMP will later match a specific source control to each surface in all land uses.
- It is hoped that all future community plans, bylaws, and development standards will incorporate the findings of an ISMP. As a result, recommendations should be made to facilitate this process.

TASKS

6.1 MINIMUM EFFORT

- Utilize existing information and reports
- Ensure that existing bylaws can be applied to existing and future land uses.

6.2 MAXIMUM EFFORT

- Obtain recent land use inventory and review existing land use (air photos).
- Review future land use based on the OCP and Neighbourhood Plans.
- Review land use plans and policies.
- In agricultural areas, review cropping patterns and note changes. Review/utilize Resource Inventory Committee Land Use Standards.
- Identify land use planning constraints and opportunities in relation to watershed management.

MINIMUM DELIVERABLES

- Map showing existing and future land use and related opportunities complete with populations densities, floor space ratios, estimated impervious surfaces, and building construction methods.

CLAUSE 7 – AGRICULTURAL LANDS

OBJECTIVES

- To identify agricultural lands and establish a level of flood protection and drainage requirements. (ARDSA or other standards. The federal/provincial ARDSA program of the 1980s established agricultural drainage standards that are used for most of B.C. Standards are available from BC Ministry of Agriculture, Food and Fisheries).

SIGNIFICANCE

- Agricultural lands can differ from urbanized lands in the level of flood protection provided, and therefore, can result in a modified hydrologic and hydraulic analysis. This analysis is outlined in Clause 19 – Agricultural Assessment.

TASKS

7.1 MINIMUM EFFORT

- Utilize existing ALR drainage criteria and level of protection that has previously been accepted by landowners and farmers.

7.2 MAXIMUM EFFORT

- Identify agricultural and/or Agricultural Land Reserve (ALR) lands within the watershed.
- Review/utilize Agriculture Land Use Coding.
- Identify and summarize drainage, flood and erosion related issues.
- Discuss water management issues with landowners, municipality, and Ministry of Agriculture, Food and Fisheries.
- Determine the appropriate drainage criteria and level of protection required (ARSDS or other).
- Ensure that agricultural drainage system and structures are obtained in the Drainage System Inventory (Clause 4), otherwise this information must be collected.

MINIMUM DELIVERABLES

- Map showing agricultural land use.
- Documentation of Agricultural Land's Drainage Criteria and accepted Level of Protection

CLAUSE 8 – RECREATIONAL/AMENITIES

OBJECTIVES

- To identify opportunities for existing and potential recreational trails, creek daylighting, riparian corridor relocation/enhancement, wetlands or other stormwater related amenities.

SIGNIFICANCE

- Streams in communities can have significant public recreational and amenity values.
- Some water features are for recreational purposes and/or amenities only, and are not functional stormwater management facilities.

TASKS

8.1 MINIMUM EFFORT

- Incorporate recommendations of previous plans that identify proposed greenway corridors, pedestrian and bike routes/paths, recreational ponds/lakes, parks and open spaces, and trail systems.
- Ensure that the objectives of each of the above amenities are clearly defined.

8.2 MAXIMUM EFFORT

- Review background information, particularly the municipality's Parks and Recreations Plans.
- Meet with municipal parks department.
- Undertake field reconnaissance.
- Determine existing park and recreational resources
- Identify potential public walkway and greenway corridors along streams.
- Identify suitable sites for future recreational/amenity facility.
- Determine the functional objective of each amenity (i.e. areas where humans will come in contact with stormwater will require an additional criteria to be met)

MINIMUM DELIVERABLES

- Map of recreational features and amenities, and related opportunities.

CLAUSE 9 – AQUATIC SPECIES AND HABITAT INVENTORY

OBJECTIVES

- To identify aquatic species abundance and diversity and important habitat of the watershed, and opportunities for environmental enhancement.

SIGNIFICANCE

- A biophysical inventory is required to identify the resources that require protection and identify areas for restoration and/or enhancement. The development of the stormwater management alternatives and the ISMP are centered around protecting and enhancing these areas and resources.

TASKS

9.1 MINIMUM EFFORT

- Utilize existing information, environmental and/or MDP reports provided the tasks outlined below have been addressed.
- Sample a few selected reference sites within the watershed rigorously for fish populations, channel and riparian conditions using the Urban Salmon Habitat Protection (USHP) or similar methodology. This could be a repeatable protocol for fish and habitat assessment to be used for maximum effort watershed performance monitoring.

9.2 MAXIMUM EFFORT

- Obtain and review background information, summarize relevant items.
- Identify and map fish distribution in the watershed (anadromous fish, resident fish, non-fish bearing reaches).
- Identify and map obstructions and barriers to fish passage.
- Characterize and map fish habitat including existing and potential spawning, rearing adult residence, and migration areas. Comment on pool/riffle ratios, channel gradient, and substrate. Rate as low, medium and high value.
- Rate the habitat sensitivity subjectively. Discuss rating with environmental agencies.
- Summarize values to be protected.
- Identify enhancement, restoration, and compensation opportunities and sites that may be required to obtain a fisheries no-net-loss.
- Refer to inventory standards: MOELP's Terms of Reference for a Watercourse Bio-Inventory and Sensitive Habitat Inventory & Mapping (SHIM).
- Sample a few selected reference sites within the watershed rigourously for fish populations, channel and riparian conditions using the Urban Salmon Habitat Protection (USHP) or similar methodology. This could be a repeatable

protocol for fish and habitat assessment to be used for maximum effort watershed performance monitoring.

MINIMUM DELIVERABLES

- Maps showing spawning/rearing areas and associated ratings, fish presence and species stream gradients, aquatic habitat ratings, and fish barriers.
- Summary of selected reference sites using the Urban Salmon Habitat Protection (USHP) or similar methodology.

CLAUSE 10 – RIPARIAN CORRIDOR ASSESSMENT

OBJECTIVES

- To determine the extent and quality of existing and potential riparian corridors.

SIGNIFICANCE

- Riparian corridor and impervious area are the two most significant factors effecting watershed health. The corridor provides shading, habitat, and food. A thorough assessment of the corridor is required for Clause 24 Ecological Health Analysis. The Riparian Area Regulation or the Streamside Protection Regulation should be considered in identifying proposed riparian setbacks.
- To provide a baseline inventory of the riparian area and quality for monitoring future change. This indicator will be used in the *Watershed Health Tracking System*.

TASKS

10.1 MINIMUM EFFORT

- Undertake a desktop evaluation to determine the riparian forest integrity (RFI) of existing and future development conditions.
- Adopt either the Riparian Area Regulation (RAR) or Streamside Protection Regulation (SPR) for future setbacks. (Note: adoption of the RAR will show a decline in the RFI if the setbacks are allowed to decrease below 30m)
- Determine methods to increase the RFI in existing areas where the setback is less than 30m.

10.2 MAXIMUM EFFORT

- Obtain and review background information, summarize relevant items.
- Evaluate extent and quality riparian corridor using the methods outlined in the GVRD's *Proposed Watershed Classification System for Stormwater Management in the GVS&DD area, May 1999*.
- Evaluate corridor for both existing and potential riparian areas
- Classify and map vegetation through field investigations.
- Identify trail systems, utility corridors, historical maintenance practices, and other features/operations that will impact on the quality of the riparian forest integrity.
- Identify areas to be protected, and specify setbacks.
- Identify potential areas for riparian corridor restoration.
- Evaluate riparian protection on privately owned agricultural lands using the MAFF Watercourse Classification System and the Riparian Self Audit Handbooks for Beef, Dairy and Horticultural Producers.

MINIMUM DELIVERABLES

- Map of existing and potential riparian corridor delineation and quality complete with setback distances for all watercourses and wetlands.

- Summarize RFI for existing and future development conditions.

CLAUSE 11 – TERRESTRIAL SPECIES AND HABITAT ASSESSMENT

OBJECTIVES

- To incorporate the findings of previous studies identifying important non-riparian habitat and other biological elements.
- To determine and protect the role of the riparian forest and aquatic habitat with non-riparian habitat and species.

SIGNIFICANCE

- This clause incorporates the results of other studies that identify terrestrial species and their habitat for protection and/or enhancement.
- This clause should be considered in the development of the stormwater management alternatives and the ISMP.

TASKS

11.1 MINIMUM AND MAXIMUM EFFORT

- Utilize existing information.
- Summarize known terrestrial species, abundance and distribution.
- Summarize values to be protected.
- Determine and protect the role of the riparian forest and aquatic habitat with non-riparian habitat and species
- Consult with local streamkeepers/environmental stewardship groups to confirm that all known information has been obtained.

MINIMUM DELIVERABLES

- Map of terrestrial species presence and quality of habitat.
- Drawing showing areas to be protected.

CLAUSE 12 – BENTHIC COMMUNITY SAMPLING

OBJECTIVES

- To measure the aquatic health of the creek system.
- To establish a baseline for comparison of future years.

SIGNIFICANCE

- To assess the benthic macroinvertebrate community is to characterized the existing stream health and establish baseline inventory of the diversity and abundance of invertebrates for monitoring future change. This indicator can be used to calibrate the Watershed Classification System.

TASKS

12.1 MINIMUM EFFORT

- Identify one sampling location near the watershed outlet.
- Obtain benthic samples in accordance with the GVRD *Benthic Macroinvertebrate B-IBI Guide*, EVS Consultants, August 2003. http://www.gvrd.bc.ca/sewerage/pdf/bib_guide.pdf
- Develop B-IBI score based on the10-metric, LPTL system.

12.2 MAXIMUM EFFORT

- Undertake the above mentioned minimum effort at multiple watershed locations, for significant reaches and/or tributaries in the creek.
- Sample upstream and downstream of major stormwater outfall locations.
- Obtain benthic samples in accordance with the GVRD *Benthic Macroinvertebrate B-IBI Guide*, EVS Consultants, August 2003. http://www.gvrd.bc.ca/sewerage/pdf/bib_guide.pdf
- Develop B-IBI scores based on the10-metric, LPTL system.

MINIMUM DELIVERABLES

- Map showing exact location of benthic sampling site(s), and B-IBI score(s).
- Matrix showing B-IBI calculations.
- Documentation of physical and chemical conditions of stream and overbank areas in accordance with B-IBI Guide.

CLAUSE 13 – WATER AND SEDIMENT QUALITY ANALYSIS

OBJECTIVES

- To determine if the watershed is representative of "typical" watersheds with similar impervious areas and land uses.
- To recommend future water quality assessment programs should water quality results exceed recommended guidelines, or fall outside what is considered "typical" for that watershed.

SIGNIFICANCE

- The template has adopted the approach that water quality and sediment quality for urban areas are well documented therefore, wet-weather water quality sampling is not recommended for areas that are predominately residential land uses. Selective baseflow and sediment sampling is recommended as an indicator of **unique** water quality problems. General problems associated with non-point source pollution are to be covered in Clause 30 Stormwater Program.
- However, should this clause identify problems that fall outside what is considered typical for a similar watershed, more detailed sampling including wet-weather sampling should be undertaken.

TASKS

13.1 MINIMUM EFFORT

- Conduct field measurements during dry-weather baseflow conditions at all major storm sewer outlets and creek reaches for temperature, conductivity, and dissolved oxygen saturation and pH.
- Conduct dry-weather sampling on baseflows at a downstream location generally considered the point-of-exit. The parameters selected for sampling should include the parameters listed in the BC *Approved and Working Guidelines for the protection of Freshwater Aquatic Life* and total suspended solids, ammonia nitrogen, hardness, and fecal and total coliform bacteria. http://www.env.gov.bc.ca/wat/wq/BCguidelines/approv_wq_guide/approved.html

13.2 MAXIMUM EFFORT

- Obtain dry-weather samples at all major storm sewer outlets and creek reaches during dry-weather baseflow conditions for temperature, total suspended solids, ammonia nitrogen, hardness, conductivity, dissolved oxygen, fecal coliform bacteria, total coliform bacteria, copper, manganese, aluminum, zinc, iron, lead, total extractable hydrocarbons, and biological and chemical oxygen supply. Baseflow samples indicate what the aquatic community experiences

most of the time, and will identify the problems with cross connections from sanitary sewers and other anomalies such as groundwater quality problems.

- Conduct dry-weather sampling on baseflows at a downstream location generally considered the point-of-exit. The parameters selected for sampling should include the parameters listed in the BC *Approved and Working Guidelines for the protection of Freshwater Aquatic Life* and fecal and total coliform bacteria. http://www.env.gov.bc.ca/wat/wq/BCguidelines/approv_wq_guide/approved.html
- Undertake wet-weather monitoring only when industrial areas occupy an area greater than 15% of the watershed or when the dry weather sampling program identifies a water quality problem that is not consistent with the upstream land use. Additional sampling may be required to find the source and extent of the problem.
- For areas where the above sampling exceeds the BC *Approved and Working Guidelines for the protection of Freshwater Aquatic Life*, conduct sediment sampling to determine the nature and history of the contaminants.
- For areas where the creek water will be used for recreational use, irrigation of non-agricultural land, irrigation of agricultural land, aquifer recharge, or drinking water, additional parameters and sampling methods are required and should be included in the sampling program if applicable.

MINIMUM DELIVERABLES

- Map of water quality sampling locations.
- Tables showing the water quality sampling results and comparison to applicable guidelines.

CLAUSE 14 – BASEPLAN MAPPING (GIS DATABASE)

OBJECTIVES

- To geographically depict all information for quick and easy access, understanding, interpretation and analysis.

SIGNIFICANCE

- Maps are an efficient and effective means to convey watershed information. They can be readily and easily interpreted for the technical analyses. They will be used in client and stakeholder meetings and included in the ISMP report.

TASKS

14.1 MINIMUM EFFORT

- Utilize existing maps.
- Develop simplistic digital maps summarizing available information.

14.2 MAXIMUM EFFORT

- Obtain and develop digital base mapping for watershed.
- Create maps showing results of data collection. Important maps may include, but are not limited to:
  - Watershed boundary delineation
  - Hydrometric stations
  - Drainage system inventory
  - Hydrogeologic and geotechnical characterizations
  - Existing and future land uses
  - Watercourse classification in agricultural areas
  - Recreational amenities
  - Biophysical inventories
  - Riparian corridor delineation and ratings
  - Wildlife locations
  - Benthic and water quality sampling sites
- Create a GIS database for watershed features.

MINIMUM DELIVERABLES

- Base plan.
- Maps.
- Digital information.

CLAUSE 15 – EXISTING STORMWATER PROGRAM REVIEW

OBJECTIVES

- To define the municipality's existing practices and needs related to stormwater policies such as bylaws and enforcements, design standards, operation and maintenance practices, public education, equipment, and staff training.

SIGNIFICANCE

- It is important to summarize the municipality's existing stormwater program. A management analysis of this information will be conducted in Clause 29 – Stormwater Program.

TASKS

15.1 MINIMUM AND MAXIMUM EFFORT

- Define municipality's existing practices.
- Review existing practices that are related to or have an impact on stormwater such as:
  - design standards;
  - by-laws and enforcement
  - operation and maintenance practices;
  - stormwater policies related to land use planning;
  - mapping environmentally sensitive areas (ESAs) including hazard areas;
  - public education;
  - management of capital improvement program (CIP); and
  - equipment, and staff training.
- Document the existing practices as the Existing Stormwater Program.

MINIMUM DELIVERABLES

- Summarize the existing municipal stormwater program including tabulating all stormwater applicable bylaws and riparian area protection bylaws that have been developed.

CLAUSE 16 – HYDROLOGICAL ANALYSIS

OBJECTIVES

- To develop a useful tool to simulate the watershed's hydrologic response, determine effective impervious area, estimate design flows and volumes, determine the impact of development and assess mitigative alternatives, and to size recommended facilities.

SIGNIFICANCE

- Design flows and volumes from this analysis are used in the hydraulic analysis to evaluate flooding and size upgrades. Results of the environmental component modelling quantify the land development impacts, and the benefits of proposed land use and stormwater management mitigative alternatives. Results are used in the evaluation of the alternatives.

TASKS

16.1 MINIMUM EFFORT

- Utilize existing hydrologic data and analysis from previous studies.
- Ensure that design flows have been determined for all major conveyance pipes, drainage canals, watercourses, and facilities. Update existing computer models if required.
- For the minimum effort to be used, a City-wide stormwater bylaw is required. The bylaw must specify a drainage criteria that meets the criteria laid out in Table 3-2. If this criteria has been met, no environmental modeling is required.
- Unlike the maximum effort, if the design flows are known for the minor and major facilities, a hydrological model is not required for the minimum effort as the bylaw will ensure that the watershed health will be maintained.

EXCEPTIONS FOR MINIMUM EFFORT:

- If the stakeholder process yields a recommendation to increase the health of the watershed, the maximum effort should be followed as the criteria may have to be updated.
- The maximum effort may also have to followed for watersheds with lowland agricultural areas if a capital program has not already been developed for protection of farmland.
- If the drainage inventory yields significant erosion concerns, a hydrologic model will be required, and the maximum effort should be followed.

16.2 MAXIMUM EFFORT

- Delineate subcatchment areas. Build hydrologic model for existing land use conditions. Calibrate and verify model. Build future condition model.

Hydrotechnical

- Develop single event design storms. In agricultural areas, use the ARDSA design storm criteria. Develop design peak flows and volume estimates to assess conveyance capabilities of the storm sewers, watercourses, major flow paths, and drainage structures.

Environmental

- Obtain digital, historical rainfall record from nearby climate station.
- Using one of the EIA prediction methods outlined in Section 4, undertake a simulation to determine effective impervious area (EIA) under existing and future land uses.
- Compare the predicted EIA under existing land uses with the calculated EIA derived from the stream flow records.
- Determine impacts of development, and size BMPs.
- Use the model to ensure that the predicted EIA of the preferred ISMP alternative meets the target set out in the watershed health analysis.

MINIMUM DELIVERABLES

- Schematic and digital files of model.
- Summary of hydrologic results including a summary of all design rainfall events used, estimated peak flows and volumes at strategic locations, graphs of calibration and verification events.
- Calibration results comparing the selected model with stream flow results. If the *Water Balance Model* is used, the annual volumes for runoff and infiltration should be compared to the measured and calculated volumes determined by the stream flow gauging. If a hydrograph based model is used, calibration graphs showing the results of at least six months of the continuous simulation run overlain by stream flow data should be shown. (assuming maximum effort is chosen)
- Predicted EIA for each alternative.

CLAUSE 17 – HYDRAULIC ANALYSIS

OBJECTIVES

- To assess flooding.
- To determine the conveyance capabilities of the existing and future drainage system (channels, drainage ditches, and structures) and size upgrades, if required.
- To hydraulically assess storm sewer systems.
- To determine structural deficiencies.

SIGNIFICANCE

- Utilizing the hydrologic results, the hydraulic analysis quantifies the flooding problems, and size drainage upgrades and facilities.

TASKS

17.1 MINIMUM EFFORT

- Utilize existing information, analysis, models, and reports.
- Update above, if required.
- For the minimum effort to be used, a City-wide stormwater bylaw is required. The bylaw must specify a drainage criteria that meets the criteria laid out in Table 3-2. If this criteria has been met and the minimum effort was followed in the hydrologic analysis clause (Clause 16), no new hydraulic modeling is required. The existing models should be sufficient if complete.

17.2 MAXIMUM EFFORT

- Identify minor and major flow routes.
- Evaluate drainage system conveyance capacity.
- Assess adequacy of minor and major drainage systems and structures.
- Assess channel conveyance and capacity.
- Assess flooding problems.
- Identify flood plain areas.
- Evaluate the effectiveness of existing detention facilities, if applicable.
- Evaluate existing pump stations and floodboxes, if required.
- Determine the need for drainage upgrades and improvements.
- Assess existing dykes, if required.
- Assess the need for and develop concept plan for future dykes, if required.
- Determine boundary conditions (i.e. receiving water levels, tidal influences, etc), if required.
- Determine size and effectiveness of mitigative alternatives developed in Clause 25, if required.

MINIMUM DELIVERABLES

- Drawings showing the existing minor and major flow paths, problem areas, and capacity deficiencies.
- Summary of hydraulic analysis.

CLAUSE 18 – CHANNEL EROSION

OBJECTIVES

- To identify sections of the watercourse channel that are or will be susceptible to erosion from flows <<Q2 to Q100.
- To identify mitigation measures for existing and future development conditions.

SIGNIFICANCE

- Existing and potential erosion are to be addressed. Mitigative solutions become part of the ISMP.

TASKS

18.1 MINIMUM EFFORT

- If no significant erosion sites and issues were identified in Clause 4 (Drainage Inventory), a City-wide sotrmwater bylaw is in place meeting the criteria specified in the Template text, and a previous capacity-deficiency already exists for the creek systems, no further analysis is required.

18.2 MAXIMUM EFFORT

- Summarize flow velocities at key locations using the results of the flow-duration-exceedance graphs developed in the hydrologic analysis.
- Determine channel velocity threshold limits and erosion susceptibility for existing and future conditions.
- Compare the expected range of velocities to the thresholds.
- Summarize areas that require bank protection works or propose upstream measures that will improve the velocity regime.
- Assess the suitability of bioengineering techniques.
- Prioritize the proposed works.

MINIMUM DELIVERABLES

- Erosion susceptibility results.
- Figure of erosion susceptibility and required erosion control measures.

CLAUSE 19 – AGRICULTURAL ASSESSMENT

OBJECTIVES

- To assess and mitigate agricultural flooding and poor drainage.

SIGNIFICANCE

- Information taken from the drainage inventory and the hydrologic analysis are used in the agricultural assessment. The existing and future conditions are quantified and drainage improvements are sized. Mitigative alternatives are developed and evaluated in Clause 25.

TASKS

19.1 MINIMUM EFFORT

- Document extent of flooding and duration for all lowlands for both minor and major storm events.
- Document any channel maintenance works completed or needed.
- Monitor drainage infrastructure such as dykes, control gates, culverts and pumping stations.

19.2 MAXIMUM EFFORT

- Obtain recent channel survey information, if required.
- Conduct an agricultural land use survey to determine crops, buildings and other infrastructure. Identify existing and future land uses.
- Build hydraulic model to undertake the analysis. Develop area-elevation curves for flood spill areas. Assess flooding depths and durations, and existing level of service. Identify areas where ARDSA criteria will be met and where a lower level of protection will be provided.
- Identify impacts of both existing and future land use conditions.
- Evaluate drainage system conveyance capacity, existing pump stations, floodboxes, and flood spill areas. Determine the need for drainage upgrades and improvements to obtain the desired level of service.
- Develop a channel maintenance plan, and work program that has approval from agencies (Use MAFF Watercourse Classification System as a reference).
- Identify irrigation requirements.
- Assess dykes. Assess the need for and develop concept plan for future dykes.
- Determine boundary conditions (i.e. receiving water levels, tidal, etc).

MINIMUM DELIVERABLES

- Summary of agricultural assessment.
- Plans of existing and future flood cell levels and durations.

CLAUSE 20 – NATURAL HAZARD ASSESSMENT

OBJECTIVES

- To identify and recommend mitigative measures for natural hazard areas (i.e. debris flows, etc.).
- Identify potential impacts of natural hazards on the drainage collections system.
- Identify areas were the stormwater plan may cause geotechnical hazards.

SIGNIFICANCE

- A natural hazard assessment is required on watersheds with steep mountain terrain and watersheds with geotechnically significant areas. Assessment of significant hazards should be investigated in a separate study.

TASKS

20.1 MINIMUM EFFORT

- Conduct desktop analysis.
- Determine if further study is warranted.

20.2 MAXIMUM EFFORT

- Assess creek hazards, (i.e. creek fans, active creek processes, including floods, debris flows, debris floods and debris slides).
- Conduct field investigations.
- Map any creek hazard areas.
- Undertake risk analysis, and rate the hazards.
- Recommend debris extractions, stabilization, mitigation measures and additional study, if required.

MINIMUM DELIVERABLES

Map showing natural hazard areas.
Summary of natural hazard assessment.

CLAUSE 21 – LAND USE SENSITIVITY ANALYSIS

OBJECTIVES

- To explore the impacts of modified development densities and location options.
- To make recommendations on land use (if required) that may eventually be incorporated into the GVRD's Livable Regional Plan and/or a municipality's OCP/NCP planning process during the next update.

SIGNIFICANCE

- To examine alternative land use scenarios and densities as a significant part in the development of the ISMP.
- Scenarios and densities will be modelled to demonstrate hydrologic impacts; and input into *Watershed Health Tracking System* to quantify ecological health impacts and benefits.

TASKS

21.1 MINIMUM EFFORT

- Undertake simplistic version of below, if applicable.

21.2 MAXIMUM EFFORT

- Discuss among project team and stakeholders, especially municipality planning department, the elements of land use planning that can be integrated into the ISMP.
- Identify land uses and densities that pose significant difficulty with the application of LIDs and investigate alternatives.
- Review the location of high impervious areas where LID strategies are difficult to implement, and explore alternatives.
- Identify potential changes to land use plans, and guidelines for future development processes that can be incorporated into future revisions of community planning documents.
- Identify sensitive areas and strive for their protection.
- Investigate setbacks, recreational, and greenway opportunities.

MINIMUM DELIVERABLES

- Summary of analysis.

CLAUSE 22 – RECREATION AND PUBLIC ACCESS ANALYSIS

OBJECTIVES

- To assess walkways, greenways and access points along stream corridors as a public amenity and for public education.
- To integrate with Parks and Recreation Plans.

SIGNIFICANCE

- Assessment of feasible recreational alternatives is required to determine the optimal community feature.

TASKS

22.1 MINIMUM EFFORT

- Utilize existing analyses and reports.
- Integrate proposed plans that have already been developed with riparian corridor improvements.

22.2 MAXIMUM EFFORT

- Identify facility/daylighting alternatives.
- Investigate conveyance capacities and soil erodibility.
- Assess suitability regarding park setting.
- Assess baseflow, and augmentation options, if required.
- Explore existing drainage system modifications and/or connections to the drainage system.
- Model proposed facility/daylighting configuration to determine impacts on drainage system.
- Investigate landscaping options.
- Determine access points along watercourses.
- Calculate cost estimates.
- Obtain stakeholder and public input.
- Locate walkways and trails an acceptable distance from stream to preserve riparian integrity.
- Evaluate alternatives.
- Recommend proposed facility/daylighting plan.
- Explore public education opportunities.

MINIMUM DELIVERABLES

- Recreational/amenity plan.

CLAUSE 23 – ENVIRONMENTAL PARAMETERS

OBJECTIVES

- To determine the effective impervious area and riparian forest integrity for existing and future development scenarios as proposed.
- To plot the parameters on the GVRD Watershed Health Tracking System to show the potential impact of unmitigated future development.

SIGNIFICANCE

- The environmental parameters are input into the Watershed Health Tracking System, that is used to quantify the ecological health of the watershed the existing and future, unmitigated development scenarios.

TASKS

23.1 MINIMUM AND MAXIMUM EFFORT

- Undertake desktop exercise.
- Develop the *Watershed Health Tracking System* parameters: percent effective impervious area (EIA) of the watershed (Clause 3 and 16) and percent riparian forest integrity (Clause 10).

MINIMUM DELIVERABLES

- Environmental Parameters plotted on Watershed Health Tracking System showing existing and future land uses.

CLAUSE 24 – ECOLOGICAL HEALTH ANALYSIS

OBJECTIVES

- To quantify the ecological health of the watercourse at key locations.
- To quantify the ecological impacts of changing land use densities, riparian corridors, development standards and/or implementing source controls, LID measures, and regional BMPs.

SIGNIFICANCE

- The ecological health analysis is a critical decision making tool because it quantitatively assesses the ecological health of a watershed for existing and future conditions, and the benefits of mitigative alternatives. The results of this analysis are used to evaluate the proposed alternatives in Clauses 26 and 27, and determine which watershed goals are capable of being met. This tool will also be used in Clause 34 Adaptive Management to monitor watershed health over time as the ISMP is implemented.
- It is proposed that the Watershed Health Tracking System be used as the tool to perform the analysis.

TASKS

24.1 MINIMUM EFFORT

- Undertake the tasks summarized below for one site only (at mouth of watershed).

24.2 MAXIMUM EFFORT

- Input the percent effective impervious area and percent riparian forest integrity parameters into Watershed Health Tracking System.
- Estimate theoretical B-IBI score using the above tracking system.
- Compare the predicted and measured B-IBI scores. Should the measured score plot lower than the predicted score, develop potential programs to raise the score.
- Plot point on the graph for both existing and future conditions using the results from Clause 16 and Clause 23.
- Summarize the ecological impacts of future development.
- Evaluate the effectiveness of existing facilities, if applicable.
- Evaluate the benefits and effectiveness of proposed land use scenarios/LID standards/BMPs developed in Clauses 26, 27.
- Determine if the fisheries no-net-loss is achieved with the proposed land use and stormwater management alternatives.

MINIMUM DELIVERABLES

- Watershed Health Tracking System graphs for existing and future conditions, and alternatives.

CLAUSE 25 – FLOOD/EROSION MANAGEMENT ALTERNATIVES

OBJECTIVES

- To investigate improvements and structural alternatives to alleviate flooding and erosion problems.
- To investigate environmental mitigation/enhancement, if required.

SIGNIFICANCE

- The flood/erosion management alternatives address drainage/creek system deficiencies discovered in the hydrotechnical assessment. It outlines drainage/creek improvements in the form of structural measures.

TASKS

25.1 MINIMUM EFFORT

- Utilize existing information, analysis, reports.

25.2 MAXIMUM EFFORT

- List mitigative options.
- Narrow list to feasible options with regard to site specific opportunities and constraints.
- Develop flood/erosion management alternatives.
- Refer to the 1992 *Land Development Guidelines* for recommending culvert upgrades that include fish passage.
- Identify land requirements and right-of-way/property acquisition issues for alternatives, if required.
- Determine need and options for mitigation/enhancement works.
- Summarize operation and maintenance requirements for alternatives.
- Provide cost estimates.
- Liaise with environmental agencies and interested groups.
- Develop new floodplain building bylaw requirements.

MINIMUM DELIVERABLES

- Flood/erosion management alternatives.

CLAUSE 26 – LAND USE ALTERNATIVES

OBJECTIVES

- To prepare alternative development scenarios as a result of the land use sensitivity analysis that was performed in Clause 21 that address land use location and densities, riparian corridor locations and setbacks, ESAs, public trails and other stormwater amenities.
- To investigate low impact development standards potentially applicable to various land use designations and the associated reduction to the effective impervious areas.

SIGNIFICANCE

- Land use alternatives have a significant impact on the hydrology for both frequently occurring and extreme events. These alternatives combined with BMP alternatives (Clause 27) are key to achieving a fisheries no-net-loss.

TASKS

26.1 MINIMUM EFFORT

- Not required if a city-wide bylaw specifying drainage criteria consistent with Table 3-2 is in place (it is assumed that the future land uses are able to meet the bylaw).
- It is also assumed that the development standards have been sufficiently modified to meet the criteria. If this has not been done, the maximum effort should be followed to develop the standards.

26.2 MAXIMUM EFFORT

- Identify development/redevelopment alternatives to enhance the watershed.
- Develop innovative development (low impact development (LID)) standards for development/redevelopment for each land use in the watershed.
- Project future levels of impervious cover, changes in riparian quality and quantity for the alternatives.
- Prepare sketches of typical plans and cross-sections of appropriate options.
- Explore density trading schemes and zoning changes to strive to achieve a fisheries no-net-loss and keep development costs reasonable.
- Identify changes to the OCP that may be possible during the next OCP update.
- Outline guidelines and design criteria for future watershed development/redevelopment (OCP, Neighbourhood Plans, etc.)
- Identify opportunities for environmental protection (ESAs, riparian, wetlands, etc.) in relation to potential land uses. Implement *Streamside Protection Regulation* where possible.
- Integrate land use planning into the ISMP. Identify stormwater options that could be incorporated into planning documents and the planning process.

MINIMUM DELIVERABLES

- Land development/redevelopment alternatives.
- Stormwater related guidelines and design criteria for future development/redevelopment.

CLAUSE 27 – STORMWATER MANAGEMENT ALTERNATIVES

OBJECTIVES

- To investigate stormwater management alternatives to minimize the impacts of land development.
- Incorporate the LID strategies developed in Clause 26

SIGNIFICANCE

- The stormwater management alternatives, in addition to land use alternatives, strive to achieve the watershed goal of a fisheries no not loss. Selected alternatives will form the ISMP.

TASKS

27.1 MINIMUM EFFORT

- Undertake simplistic version of tasks below if alternatives have been developed.

27.2 MAXIMUM EFFORT

- List mitigative options. Refer to GVRD's *Best Management Practices Guide for Stormwater Management, October 1998.*
- Using the LID strategies developed in Clause 26 as a starting point, identify additional BMPs with regard to site specific opportunities and constraints that can meet the watershed objectives.
- Develop stormwater management alternatives that supplement the land development/redevelopment alternatives and development standards. Strive to achieve a fisheries no-not-loss. (This may not be achievable in some cases i.e. greenfield development.)
- Identify land requirements and right-of-way/property acquisition issues for alternatives, if required.
- Determine need and options for mitigation/enhancement works.
- Summarize operation and maintenance requirements for alternatives.
- Provide cost estimates.
- Develop a watershed specific design criteria.

MINIMUM DELIVERABLES

- Stormwater management alternatives.
- Watershed specific design criteria.

CLAUSE 28 – WATER QUALITY ALTERNATIVES

OBJECTIVES

- To identify measures to mitigate point and non-point source water quality problems on impervious surfaces.

SIGNIFICANCE

- For new impervious surfaces within a watershed, it is likely that the surfaces will be treated with a volumetric reduction measure to mitigate its hydrological impact. These measures will also likely treat the rainfall to a sufficient level. However, new surfaces will also be added even if their harmful hydrological impacts are traded elsewhere in the watershed. For these new surfaces, treatment is required, and the water criteria listed in Table 3-2 should be followed.
- Treatment for existing impervious surfaces may also be required if the stakeholder process identified the need to improve existing conditions or if the water quality monitoring program yielded results that do not meet the receiving water quality objectives.

TASKS

28.1 MINIMUM EFFORT

- Not required as a city-wide stormwater bylaw consistent with the criteria in Table 3-2 already exists. Therefore, all new surfaces already meet the water quality criteria .

28.2 MAXIMUM EFFORT

- List mitigative options to treat all new impervious surfaces (and potentially existing surfaces).
- Identify feasible options with regard to site specific opportunities and constraints.
- Develop water quality alternatives.
- Size facilities to retain the 6-month, 24-hour runoff event (see Table 3-2).
- Identify land requirements and right-of-way/property acquisition issues for alternatives, if required.
- Determine need and options for mitigation/enhancement works.
- Summarize operation and maintenance requirements for alternatives.
- Provide cost estimates.
- Liaise with municipality and interested groups.

MINIMUM DELIVERABLES

- Water quality management alternatives.

CLAUSE 29 – EVALUATE ALTERNATIVES

OBJECTIVES

- To evaluate alternatives for flood/erosion management, land use, land development standards, stormwater management, and water quality management in an integrated way with consideration for health and safety, environmental impacts, costs, and public acceptance.

SIGNIFICANCE

- To make informed decisions in selecting the preferred ISMP alternative(s).
- To provide an integrated evaluation process including all alternatives: flood/erosion, land use scenarios and development standards, best management practices, and water quality options.

TASKS

29.1 MINIMUM AND MAXIMUM EFFORTS

- Develop evaluation matrix rating each alternative.
- Evaluate the benefits and effectiveness of the combined alternatives: flood/erosion management, land use, stormwater management, and water quality.
- Evaluation criteria may include but not be limited to the following: effectiveness in meeting watershed objective of no-net-loss of ecological health, effectiveness in flood/erosion control, land acquisitions, costs, ease of implementation, ease of operation and maintenance, and stakeholder and public acceptance.
- Rank alternatives, and select preferred.

MINIMUM DELIVERABLES

- Evaluation matrix, and selection of preferred alternative(s).
- Include EIA, RFI, and predicted B-IBI score for each alternative

CLAUSE 30 – STORMWATER PROGRAM

OBJECTIVES

- To develop a Stormwater Program that includes recommended practices, by-laws, standards, etc.

SIGNIFICANCE

- This is the non-structural component of stormwater management that can be applied municipality-wide. The clause will involve a substantial work effort for the first few watershed plans while the core program is being established. Eventually this component will only involve the identification and implementation of watershed specific practices.
- This includes policies related to stormwater management, drainage, environment, and land use planning, drainage and land development design standards, by-laws, maintenance programs, public education/involvement, and source control programs.

TASKS

30.1 MINIMUM EFFORT

- Perform management analysis on the existing program.
- Suggest future needs.
- Select management practices and policies best suited to the municipality. Discuss with municipality.
- Develop a policy framework for dealing with stormwater management, creeks and drainage issues, i.e. bylaws, committees, BMP guide, OCP, and other regulatory tools. Refer to GVRD's *Options for Local Government Use of By-laws, Permits, and other Regulations as Source Controls for Stormwater Management, 1997.*
- Develop a recommended stormwater program.

30.2 MAXIMUM EFFORT

- Same as above. Recommend bylaws changes and new bylaws. Develop new/revised design standards.
- Develop scheduled and appropriate O & M practices to ensure optimum conveyance and environmental protection.
- Educate staff, general public, developers, businesses, landowners, environmental groups, etc. of ISMP issues and practices.
- Suggest stormwater related policies that can be integrated into other municipal plans, projects and initiatives (Parks/Recreation Plans, Transportation Plans, etc.) where relevant.

MINIMUM DELIVERABLES

- Recommended Stormwater Program.

CLAUSE 31 – INTEGRATED STORMWATER MANAGEMENT PLAN

OBJECTIVES

- To develop an ISMP plan that strives to achieve a fisheries no-net-loss.
- To address the impact of stormwater management on relevant community values. These values include recreation, agriculture, fisheries, greenways, heritage, archaeology, safety, transportation, economics, property values, flood protection, affordability, the environment, and related issues.

SIGNIFICANCE

- This is the focal point of the ISMP Process

TASKS

31.1 MINIMUM EFFORT

- Undertake simplistic version of tasks below by building on existing Master Drainage Plans that are already in place..

31.2 MAXIMUM EFFORT

- Select preferred alternatives based on alternative evaluation and stakeholder input.
- Develop concept plan for hydrotechnical improvements.
- Develop concept plan for environmental protection.
- Develop concept plan for LID standards.
- Summarize development standards.
- Summarize operation and maintenance requirements for existing and proposed infrastructure.
- Summarize land and right-of-way requirements.
- Prepare cost estimates.
- Recommend modifications to other municipal master plans to ensure ecological health is maintained or enhanced.

MINIMUM DELIVERABLES

- Draft Integrated Stormwater Management Plan.
- Cost estimates.

CLAUSE 32 – IMPLEMENTATION STRATEGY

OBJECTIVES

- To develop a strategy and timeline for the proposed works.
- To identify and evaluate various financial alternatives to fund and implement ISMP.
- To evaluate the implementation timing of the proposed works and strategies and ensure that the health of the watershed will be maintained as stated by the ISMP watershed health objectives. (see Appendix G for a sample)

SIGNIFICANCE

- The implementation strategy ensures the proposed works in the ISMP are constructed.

TASKS

32.1 MINIMUM EFFORT

- Establish implementation priorities.
- Integrate with timing of other works such as development, road upgrading, etc.
- Recommend a capital works program.

32.2 MAXIMUM EFFORT

- Establish implementation priorities.
- Integrate with timing of other works such as development, road upgrading, etc.
- Recommend a capital works program for the immediate and long range (50-years) horizons.
- Tabulate the timing of capital works and stormwater strategies in a table and track the theoretical impact to watershed health. (see Appendix G for an example)

MINIMUM DELIVERABLES

- Implementation Strategy.

CLAUSE 33 – INTEGRATE WITH OTHER MUNICIPAL MASTER PLANS

OBJECTIVES

- To make recommendations to be considered in OCPs, NCPs, Recreations and Park Plans, Strategic Transportation Plans, etc.

SIGNIFICANCE

- Other municipal master plans as mentioned above can have a significant impact on stormwater. To be successful, stormwater management planning cannot be done in isolation; it must work with the other municipal plans and provide recommendations to them.

TASKS

33.1 MINIMUM EFFORT

- Same as below.

33.2 MAXIMUM EFFORT

- Conclude study with solid recommendations that can be incorporated into other municipal master plans.
- Ensure municipal departments are involved throughout study process, and receive a copy of the report.
- Recommend modifications to other municipal master plans and/or zoning to ensure that desired watershed impervious area, riparian conditions targets are met to maintain watershed ecological health.

MINIMUM DELIVERABLES

- Recommendations in ISMP Report.

CLAUSE 34 – ADAPTIVE MANAGEMENT

OBJECTIVES

- To establish and monitor watershed health and state using performance indictors (B-IBI scores, effective impervious area (EIA), and riparian forest integrity as a minimum).
- To adapt the ISMP implementation strategy if needed to achieve no-net-loss of watershed health.

SIGNIFICANCE

- Adaptive management recognizes the limitations of the current stormwater science and technology. It measures successes and failures of the ISMP recommended works, policies, strategies, and design criteria over time. It is a mechanism that allows the plan to be revisited and redirected if the watershed goals established in Clause 1 are not being met.
- The Template stipulates that ISMP strives to achieve no-net loss of ecological health for the overall watershed. The minimum performance target of no-net loss can be correlated with the well documented B-IBI scoring system. Through adaptive management, if the score of the watershed decreases, the health of the watershed is not being maintained, and future recommendations must be brought forward.

TASKS

34.1 MINIMUM EFFORT

- Develop a schedule for measuring B-IBI scores and analyzing EIA and riparian forest integrity. The schedule will depend on the pace of development/re-development and other changes within the watershed.
- Select performance indicators that best reflect the characteristics of the watershed and the changes that are to occur.
- Select a monitoring schedule.

34.2 MAXIMUM EFFORT

- Develop a monitoring program to assess the plan's effectiveness over time.
- Select performance measures to monitor the watershed health including: benthic monitoring (B-IBI scores), effective impervious area and riparian forest integrity.
- Consider the addition of additional performance indicators such as flow and rainfall monitoring, stream temperature, conductivity, dissolved oxygen, dry weather sampling, and aquatic habitat condition (i.e. select a few reference sites within the watershed and note channel and riparian conditions using the Urban Salmon Habitat Protection (USHP) or similar methodology)
- Develop strategy to assess if watershed goals are being achieved. If B-IBI scores and riparian forest integrity decrease and EIA increase, the watershed

health is not being maintained. Immediate action is required to improve the health and results of performance indicators:

- Earlier implementation of proposed environmental protection works (an example would be to implement longer term programs/strategies earlier – see Appendix G)
- Re-examination of technology recommended. Investigation of alternate solutions. Redirect efforts accordingly.

MINIMUM DELIVERABLES

Monitoring report summarizing B-IBI scores, EIA, and riparian forest integrity results, and recommendations regarding maintaining watershed health and performance monitoring parameters to measure at set intervals.

CLAUSE 35 – REPORT

OBJECTIVES

- To document the study process and findings.

TASKS

35.1 MINIMUM AND MAXIMUM EFFORTS

- Prepare draft report.
- Review with municipality.
- Obtain either "Letter of Support" or "Letter of Endorsement" from senior agencies
- Prepare final report.
- Provide digital copies.

MINIMUM DELIVERABLES

- Draft and final reports.
- "Letter of Support" or "Letter of Endorsement"

Appendix A

Terms of Reference

KERR WOOD LEIDAL
associates limited
CONSULTING ENGINEERS

Greater Vancouver Regional District
4330 Kingsway, Burnaby, British Columbia, Canada V5H 4G8

Telephone (604) 432-6375
Fax (604) 436-6970

July 14, 2000 File No. BU26

Attention: Mr. Chris Johnston
Kerr Wood Liedal Associates Ltd.,
139 West 16th Street
North Vancouver, BC
V7M 1T3

Dear Sirs:

RE: REQUEST FOR PROPOSAL—TERMS OF REFERENCE TEMPLATE FOR INTEGRATED STORMWATER MANAGEMENT PLANNING AT A WATERSHED SCALE

The Greater Vancouver Regional District (GVRD), herein referred to as the Corporation, is inviting proposals for the development of a terms of reference template for integrated stormwater management planning at a watershed scale. This letter provides background and outlines the scope of work.

Objectives

A template terms of reference for "integrated stormwater management planning at a watershed scale" (ISMP) is anticipated to:

- assist in the development of ISMPs by the Corporation and its member municipalities;
- assist in plan content standardisation; and
- provide clarification with regard to senior regulatory agencies' expectations.

Background

Under the *Liquid Waste Management Plan* (LWMP), the Corporation and its members municipalities commit to undertaking integrated stormwater management planning at the watershed scale. To facilitate implementation of the LWMP, the Stormwater Management Technical Advisory Task Group (SWTG) has requested the development of a terms of reference template for ISMP for use by member municipalities.

LWMP Policy and Commitment, P25: Integrated Planning Approach, is as follows:

> *"The member municipalities, in consultation with the District where appropriate, will undertake a proactive integrated planning approach to municipal stormwater management, in areas serviced by separated stormwater systems, thereby improving the efficiencies and effectiveness of regulatory approvals. This integrated planning approach will integrate watershed, catchment, master drainage plans, and stormwater plans into relevant municipal planning processes such as Official Community or Neighbourhood Concept plans, Recreation and Parks Master plans, Strategic Transportation plans, etc., in order to address the impacts of stormwater management on relevant community values. These values include recreation, agriculture, fisheries, greenways, heritage, archaeology, safety, transportation, economics, property values, flood protection, affordability, the environment, and related issues.*
>
> *Stormwater management planning would strive to be consistent with the stormwater management guiding principles as referenced in Table 13-1 of the* Liquid Waste Management Plan Discussion Document. *One of the guiding principles is to strive to plan at a watershed scale even in non-urban (greater than 80% of watershed area is Green Zone as defined in the 1996* Livable Region Strategic Plan*) watersheds where municipalities may have limited infrastructure."*

The following items have been identified as important components that might define an ISMP:

A comprehensive stormwater management plan at a watershed scale will balance factors such as:

- *by-laws, enforcement and education initiatives;*
- *non-structural, operations and maintenance, and structural stormwater best management practices;*
- *initiative cost, benefit and risk;*
- *flood control and the threat to life and property (agricultural, rural, and urban);*
- *preservation and enhancement of floodplain function;*
- *protection and enhancement of water quality and habitat features of aquatic ecosystems;*
- *preservation of key hydrologic and hydro-geologic watershed functions;*
- *protection and enhancement of agricultural, ecological, cultural, recreational, and visual amenities of watercourse corridors;*
- *integration with municipal master (transportation, parks, land-use,* et cetera*) and neighbourhood plans and their objectives;*
- *land use planning and decision processes; and*
- *provision of drainage programs and related stormwater management activities such as street cleaning, catch basin cleaning, and ditch maintenance.*

Recent ISMPs (*e.g.*, Stoney Creek, Brunette River Basin, *et cetera*) may be considered examples, with the terms of reference template for ISMP addressing the requirements needed to achieve the level of complexity and planning similar to these examples.

Scope of Work

The scope of work consists of the following:

- develop a draft template terms of reference for "integrated stormwater management planning on a watershed scale" along with a supporting briefing information;
- conduct a one day workshop for the Corporation and the SWTG to confirm definition and to assist in the development of a template terms of reference for "integrated stormwater management planning on a watershed scale" *(the Corporation shall provide a venue in/or near its Corporate headquarters for this workshop)*;
- revise the draft template terms of reference for "integrated stormwater management planning on a watershed scale" based upon commentary provided by the Corporation and SWTG members;
- provide copies of all draft and final briefing materials and the template terms of reference for "integrated stormwater management planning on a watershed scale" to the Corporation two weeks prior to workshops and/or reviews; and
- include a separate cost to conduct another one day workshop that is tentative and in addition to the above scope of work. This workshop will be for the Corporation, SWTG, and others as invited by the Corporation, to refine the template terms of reference for "integrated stormwater management planning on a watershed scale" developed at the previous workshop. Revision to the draft template terms of reference will address workshop commentary from the Corporation and SWTG members. *(The Corporation shall provide a venue in/or near its Corporate headquarters for this workshop. At its sole discretion, the Corporation may decide to delete the second workshop from the scope of work).*

Issues that are expected to be addressed by this work include:

- level detail of hydrologic analyses for ISMPs;

- practicalities and schedule of data collection for planning and post-plan monitoring and implementation;
- levels of ISMP integration with other plans, the community and municipal needs;
- satisfying with regulatory requirements in ISMPs; and
- levels of effort for ISMPs (*e.g.*, high level strategic *versus* detailed tactical);
- identifying objectives; and
- order of magnitude costs and schedules for completing ISMPs.

Deliverables

The successful proponent shall plan to conduct a one-day workshops for the Corporation and others to develop a terms of reference template for "integrated stormwater management planning on a watershed scale"—the successful proponent may also conduct a second, tentative workshop. The successful proponent shall develop and provide workshop participants with the materials required for the workshops.

The successful proponent shall use the findings of the workshops to develop the terms of reference template for "integrated stormwater management planning on a watershed scale", and shall provide the Corporation with three copies of the draft report, and thirty copies of the final report plus copying masters in both electronic and printed formats for the final report. Electronic word processing documents shall be in MS Word format and Adobe Acrobat PDF. The final report shall be signed by the successful proponent's project manager/reviewer. The successful proponent shall assign final report copyright to the Corporation

Schedule and Budget

The total fee budget for this project is up to $25,000.00, including GST; the second, tentative workshop may be in addition to this cost. The draft report is due no later than twelve weeks following the day of awarding of the contract. However, the successful proponent shall accept that there may be some schedule delays in co-ordinating workshop venues and participants. In such instances, the report deadline shall be extended accordingly.

Proposal Submission Requirements

The Corporation invites your firm to submit a proposal to a **maximum** of **six pages** that shows an understanding of the problem, and outlines the proposed methodology and schedule to complete the scope as outlined above. The submission should also include proposed personnel, experience, duties and hourly rates. The total estimated costs for the project—with time and budget required for each workshop and meeting with the Corporation and others shall clearly shown in the proposal. Cost of the second, tentative workshop shall be shown separately.

The proposals will be evaluated on the following criteria:

- Methodology and work plan in completing the scope of work;
- Experience of proposed personnel and proponent in integrated stormwater management, watershed management planning, urban planning, and multi-stakeholder decision making processes;
- Roles of proposed personnel; and
- Total budget and budget distribution.

The lowest cost proposal, nor any proposal, may not necessarily be accepted.

Please submit your proposal to the undersigned by 10:30 a.m., July 31, 2000. If you require additional information or have any questions please contact Robert Hicks at 451-6165.

Yours truly

Robert Hicks, P.Eng.

Senior Project Engineer,
Regional Utility Planning, Policy and Planning Department

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Appendix B

Summary of 2005 Review Process and December 2, 2004 Workshop

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Greater Vancouver Regional District

ISMP TOR Template Review Workshop Summary

September 2005

KWL File No. 251.073

KERR WOOD LEIDAL
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TABLES AND FIGURES

APPENDICES

Section 1

Workshop Overview

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1. ISMP REVIEW PROCESS

1.1 BACKGROUND

As part of the ISMP Terms of Reference Template Review, a workshop was held on December 2, 2004. Case studies of ISMPs that have been completed (or close to completion) were reviewed, and issues associated with the 2001 Template were identified. A brainstorming session generated ideas for solutions to some of the more pressing issues. The intent of the workshop was to facilitate a review of what worked well and what did not, and to obtain suggestions regarding updating and improving the Template.

The workshop was facilitated by Chris Johnston of KWL.

Presentations were made on ISMPs Case Studies for the following watersheds and by the following presenters:

- Hyde Creek ISMP – Dana Soong and John van der Eerden;
- McDonald/Lawson Creek ISMP – Ray Fung;
- Yorkson Creek Watershed Plan –Steven Lan and Scott Newman;
- Wexford and Walley Creeks ISMPs – Crystal Campbell; and
- Still Creek – Lambert Chu.

The Workshop generated 31 issues that require resolution. The issues ranged from the clarification of analysis processes to completely changing the direction of several aspects of the Template's approach. Following the workshop, a series of six sessions were held to resolve each of the issues prior to updating the ISMP Template document.

The purpose of this document is to summarize the review process, identify the issues that require resolution, and document the recommendations made by SILG in the sessions following the December 2 Workshop.

The next step will be to revise the clauses in the ISMP Template to reflect the recommendations made.

1.2 WORKSHOP ATTENDANCE

Name		Organization
Municipalities		
1.	Dipak Dattani	City of Burnaby
2.	Robyn Wark	City of Burnaby
3.	Lambert Chu	City of Burnaby

4.	Dave Palidwor	City of Coquitlam
5.	Sarah Dal Santo	City of Coquitlam
6.	Randy Chang	City of Coquitlam
7.	Dana Soong	City of Coquitlam
8.	Steve Lan	Township of Langley
9.	Andrew Wood	District of Maple Ridge
10.	John McMahon	City of New Westminster
11.	Tony Barber	City of North Vancouver
12.	Paula Huber	District of North Vancouver
13.	Tamsin Guppy	District of North Vancouver
14.	Marcel Bernier	District of North Vancouver
15.	Ariel Estrada	District of North Vancouver
16.	Richard Boase	District of North Vancouver
17.	Elena Paller	City of Richmond
18.	Chessy Langford	District of Squamish
19	Carrie Baron	City of Surrey
20.	David Hislop	City of Surrey
21.	Neil McCreedy	City of Vancouver
22.	Ray Fung	District of West Vancouver
23.	Alexis Paderewski	UBC Utilities
Environmental Agencies		
24.	Mike Engelsjord	Department of Fisheries
25.	Corino Salomi	Department of Fisheries
26.	Mike Younie	WLAP
GVRD		
27.	Kim Parmentier	Greater Vancouver Regional District
28.	Andrew Lewis	Greater Vancouver Regional District
29.	Ed von Euw	Greater Vancouver Regional District
30.	Mark Wellman	Greater Vancouver Regional District
Consultants		
31.	John van der Eerden	Associated Engineering
32.	Mike MacLatchy	Associated Engineering
33.	Scott Newman	Earthtech
34.	Chris Johnston	KWL
35.	Crystal Campbell	KWL

Section 2

Summary of ISMP Case Studies

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2. SUMMARY OF ISMP CASE STUDIES

This section summarizes key points from the ISMP case studies presentations.

2.1 YORKSON CREEK WATERSHED PLAN

- New RAR regulations are not recognized or addressed in the ISMP Template.
- Traffic and fire departments do not want to change road cross-section.

2.2 MCDONALD/LAWSON CREEKS ISMP

- Study length with consecutive approach is too long. Staff changes occurred, and momentum and continuity with stakeholders were lost. Suggestion: Break ISMP into components: flow monitoring, benthic sampling, hydrogeology, and drainage inventory that could be completed outside of the main study. Someone would have to think through the study requirements ahead of time.

- Agency sign-off is still outstanding. MOU may be too ambitious.

- ISMP flexibility: Can we customize the Template, or are we expected to follow minimums? Does every single component have to be completed for every watershed? Can we extrapolate results, i.e. water quality data?

- Riparian setbacks: Riparian forest integrity (RFI) is different than SPR regulations. RAR? Municipal bylaws?

- Validity of B-IBI as indicator: Consistent approach is required. How much weight should be placed on B-IBI?

- Stormwater program: Is it achievable? Integrated municipal approach is difficult; theoretically it's achievable, but the reality is problematic. Co-ordinating the OCP with ISMP is very difficult. Who pays? Fairness? Existing/new development? Change is a challenge.

- Project funding: DCCs, SWM utility, drainage levy, consider cost/benefit very carefully.

- Intensive data requirements: Good GIS helps, especially if addressed ahead of study.

- Do ISMPs result in better decisions? Long process, data intensive, expensive. Difficult to implement institutional change. Best bang for the buck?

2.3 STILL CREEK ISMP – HEALTHY STREAMS OR PIPE DREAMS?

WHAT WORKED WELL?

- Planning and technical process frameworks (2 figures) useful.
- Integration of drainage, environmental and social (recreational) values – although not easy.
- Technical and planning guidelines: Template gives idea and foundation of where to go.

CONSISTENT APPROACH TO ISMP ISSUES IDENTIFIED

- Hard to balance environmental objectives with land development.
- Watershed screening: difficult to look at all watersheds municipality-wide.
- Demand management – driven by growth.
- Watershed vision: With multiple visions, decision by committee is not the answer. Get overall vision that we can refer back to and resolve issues.
- Effective Impervious Area (EIA) – definition and measurement? EIA complexity, watershed too large, how to do?
- Multiple account evaluation for flood benefit, environmental benefit, and recreational benefit. The huge matrix table was overwhelming. How many benefits are accounted for in each option?
- Ranking methodology, decision criteria: How to narrow down options? High, medium, low ranking? Are criteria included to guide?
- Science based data: Relationship among B-IBI, watershed health, and development.
- Balancing competing priorities and values: Some options benefit flooding, but have a negative environmental impact. Trade-offs?
- Financial ramifications: Implementing the plan is very expensive.

LESSONS LEARNED

- Spend time on a meaningful vision statement and objectives.
- Time and resource commitments are high: We started 2 years ago, but are not finished the draft report. It is probably a 3-year program.

- Public and stakeholder workshops effectiveness: They are not well attended – 50 out of 100,000 people.

- Need better decision making criteria!

- Need better methodology in option evaluation.

- Quantitative results are not always attainable.

POSSIBLE IMPROVEMENTS

- Develop methods to filter data and structure decision making process.
- Strengthen integrated methodology of option evaluation for hydrology, hydraulics, water quality, riparian corridor, upland, recreation, cost benefits, public education.
- Determine which components are fundamental and essential to the process and which are optional.
- Strengthen recreational (connecting people) component.
- Provide simpler flow chart for quick reference. Especially for public consumption.
- Continue science-based research, relationship between B-IBI and riparian, imperviousness, etc.

2.4 HYDE CREEK IWMP

WHAT WORKED WELL?

- Very good balance and flexibility.
- 3-teir rainfall – including mean annual rainfall (MAR).
- Flow diversions: Important component as long as it is not diverted out of watershed.
- Stakeholder consultation worked well; consensus achieved.

STUMBLING BLOCKS

- Baseline data: Lack of flow monitoring data throws the schedule.

- Add recommendations to Template re: data collection.

- RFI: Does this apply to all streams, or just certain classes of channels? Add to template.

- SPR versus RFI – looking for clarification.

- Development density versus total impervious area (TIA): Higher density development makes 50% MAR capture difficult, but we want to encourage higher density.

- LID performance is unknown, and difficult to advocate, especially long term.

LESSONS LEARNED

- LID maintenance is problematic for the municipality. Incentives for homeowner maintenance is a good idea.
- ISMP does not include the ability to change municipal standards (e.g. road cross-sections).
- Include all relevant municipal departments in the ISMP planning process.
- 2-year detention criterion, may need to be higher to protect existing infrastructure and when crossing municipality boundaries.
- Template is not a stand-alone TOR.
- What will motivate developers and property owners to install /maintain LID? Building permits? Financial incentives?
- Who will decide if the monitoring results need follow-up? How can this be enforced?
- Watershed Screening Process had limited benefit. WCS was too onerous. Section 2.3 should be used as a guideline only.
- No-net-loss is hard to achieve. Instead, use words like “strive to maintain”.
- Riparian setbacks: Detailed assessment at subdivision and building permit level required.
- WCS is not of much value.
- Sign-off: Which agencies? Why? Legislative authority? What if we do not get it?
- Terrestrial Species and Habitat Assessment: Is it needed in ISMP?
- Benthic: We agree with 10-metric system. Scores can be used for comparison. Need more guidance on how to do this.

2.5 WEXFORD/WALLEY CREEKS ISMPS

WHAT WORKED WELL?

- Quantifying impacts of environmental mitigation works using Watershed Classification System (WCS) and EIA, RFI parameters.

- Achieved no-net-loss in WCS.

- Using Implementation Table. It provides clear direction for municipality. It should have added details such as predicted B-IBI impact, implementation timing, who responsible for implementation; and why works are needed (e.g. environmental or flood mitigation.

- RFI was calculated using GIS.

STUMBLING BLOCKS

- Municipality having difficulty implement changes to include source controls.
- Flow Duration Exceedance Curve was not funded. Easier methodology required.
- Discrepancies in measured and predicted B-IBI.
- Approval Process include Letter of Support instead of a MOU.

LESSONS LEARNED

- City preferred not to fund Flow Duration Exceedance Curves methodology. Spreadsheet was used to calculate EIA for various land uses, soils, slopes to determine volume reduction targets.

- Measured B-IBI scores were lower than predicted scores probably due to riparian quality (sanitary sewer alignment parallel to the creek, straightening of the channel and no in-stream complexing). Addressing these problems would result in instant benefit to RFI - Ecological Health.

- Uncomfortable relying on B-IBI scores alone as a watershed health indicator. Also used effective impervious area; riparian forest integrity; and predicted B-IBI.

Section 3

Summary of Key Issues

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3. SUMMARY OF KEY ISSUES

3.1 INTRODUCTION

This section summarizes key issues developed during the Workshop related to the 2001 working draft Template. The main issues were discussed during the Workshop Break-out Brainstorming Sessions and are summarized in Section 4. All other issues were addressed over a series of six SILG meetings.

3.2 IDENTIFICATION OF KEY ISSUES REQUIRING RESOLUTION

OVERALL ISMP PROCESS

1. What is the value of an ISMP? Are better decisions being made?

2. The Template addresses greenfield developments, add alterations for redevelopments.

3. Role of the Stakeholders: Is there a better way to obtain feedback? The process for community engagement is too vague.

4. What if municipalities do not meet the ISMP commitment within 12 years for all watersheds?

TECHNICAL ISSUES

5. GVRD's Watershed Classification System: Is there a better way of linking stormwater to watershed health?

6. Filter data and structure the decision-making process. Create a Supplement Template.

7. Performance Indicators: Are additional indicators required (i.e. flooding, recreation, others)? What should be the reporting frequency?

8. Emerging Practices: How do we deal with uncertainty? How do we implement LIDs? There is a need for further science and research on LID/BMP performance. Who should be conducting research? How can municipalities reduce their liabilities?

9. Water Balance Model and Exceedance Duration Curves.

10. EIA is too complex to calculate for large watersheds.

INTEGRATION WITH OTHER DISCIPLINES

11. Strengthen recreation component.

12. Changes to existing municipal processes and approaches are difficult. What is the linkage between municipal standards and ISMP? Contradictory? Encouragement toward updating standards?

13. What is the linkage to Overall Sustainability? High density encouraged?

14. Summary of constraints/opportunities from all disciplines. Integration between disciplines.

15. What is the timing of ISMPs with other municipal plans (e.g. Neighbourhood Plans)?

ENVIRONMENTAL ISSUES AND AGENCY SIGN-OFF

16. Cost: Are there ways to reduce ISMP costs? The ISMP process is too long and sometimes the flow data is not available. Can the "minimum effort" requirements be reduced?

17. ISMP Agency Signoff Process: Is it too formal? Is there a better way?

18. Riparian Corridor: Should it be assessed in ISMP? How do we link it to RAR or SPR? What if Qualified Environmental Professional RAR assessments are in conflict with ISMP recommendations?

19. Water Quality Treatment?

20. What happens if implementing an approved ISMP results in a decline in watershed health? How will this be determined? What will be done?

21. Water quality monitoring: What should be minimum baseline?

WITH APPROVAL FROM SILG, RELATIVELY SIMPLE ADDITIONS/MODIFICATIONS

22. Add Hierarchy of Trading.

23. Watershed screening process using WCS: Add focus on growth demands.

24. B-IBI: More clarification on sampling and science is needed, along with a consistent approach.

25. Relate recommendations to implementation: Add a sample Implementation Table?

26. Simplify the ISMP Process flowcharts.

27. Should we call it an IWMP instead of an ISMP? Is there too much emphasis on stormwater?

28. Terrestrial Species and Habitat: Should it be removed from ISMPs?

ADDITIONAL ISSUES (RAISED AFTER WORKSHOP)

29. Determine areas were stormwater source controls should not be used.

30. Strengthen Groundwater Clause 5 to promote aquifer recharge for potable water use.

31. Suggest recommending a preferred stormwater control criteria.

Section 4

Break-out Group Brainstorming Sessions

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4. BREAK-OUT GROUP BRAINSTORMING SESSIONS

4.1 INTRODUCTION

Four stations were established within the meeting room. Each station had a facilitator, and a primary and secondary issue to be discussed. Facilitators included Ed von Euw, Andrew Lewis, Mark Wellman, and Tony Barber. Workshop participants were divided into four groups, and circulated throughout the stations so everyone had a chance to brainstorm solutions for each issue. The primary and secondary issues, together with the ideas generated are summarized in this section.

4.2 PRIMARY ISSUES

MUNICIPAL PROCESSES

What are some ways to better implement ISMP recommendations, capital projects and strategies into existing municipal processes?

- Pilot studies as demonstration projects – to get political buy-in
- Council Adoption
- Need clearly laid out plan – with list of required facilities
- Need different criteria for different sizes of developments
- Include in Neighbourhood Area Plans – BMPs, setbacks
- Integrate Land Acquisition Strategy with ISMP (e.g., detention ponds)
- ISMP template should influence design guidelines and municipal bylaws
- Develop a LID manual or bylaw
- Need to involve front-line staff (e.g., inspectors)
- Water balance model is a useful support tool
- Involve all stakeholders (inter-department, disciplines, public agencies)
- Piggybacking on other projects
- Develop broad over-reaching policy/guidelines prior to completing ISMPs
- Incorporate ISMP philosophy in OCPs, bylaws, and design guidelines
- ISMPs must provide direction to OCP
- Revisions to OCP must incorporate ISMP
- Eventually, OCP should be undertaken in tandem with ISMP
- Need champions within staff to motivate change
- Municipal indemnification to address liability and risk (from the provincial and federal governments)
- Procedural guidebooks for implementing BMPs, etc.
- Develop a co-ordinated, information-sharing BMP database
- Obtain funding from federal and provincial government, utilities, and DCCs
- Educate the public about the value of LID and stormwater management

- Shift expenditures from planning to implementation and monitoring
- ISMP recommendations should be simplified and/or prioritized. "ISMP Light" for some watersheds.

RIPARIAN CORRIDOR

Should analysis of the riparian corridor be included in the Template? If so, how should it be linked to other regulations (i.e. RAR, SPR), or should it?

- Just adopt SPR
- Base it on existing conditions of what is there
- Science tells us 30 m
- What if RARs professional contradicts ISMP recommendations?
- Could adopt SPR 30 m setback to avoid confusion
- Actual setback is the greater of flood level and natural hazard
- Setback used for ISMP analysis will depend on requirement/standard per municipal and existing land use.
- Could define riparian corridor and other sensitive areas as "development permit area"' for much greater environmental scrutiny.
- RFI analysis should be based on existing conditions, then recalculate based on future.
- Very useful for ISMP to define riparian setback – more certainty.
- RFI could be based on setback as a function of land use, percentage build-out, etc. today.
- Could define area of interests for future to (avoid sterilizing lots) plan for green infrastructure.
- Need consistent methodology for RFI calculation, particularly the initial conditions
- ISMP is opportunity to be bold
- Watershed classification (RFI) analysis should be based on SPR; actual setback will be based on local requirements of conditions
- What if the QEP recommendation is in conflict with ISMP?
- RFI: Classification should be based on science, i.e., 30 m

TEMPLATE FLEXIBILITY AND COST

Are there ways to reduce the cost of ISMPs and still achieve the same objectives? Is there a way to shorten the process?

- Process is very important, and not just what comes out of it. The process is as important as the product. Stakeholder education and contribution. Outreach benefits.
- Each watershed is different. Staff changes. A process is always needed.
- Each ISMP process seems to be different. Each one starts from scratch.
- One ISMP for municipality with recommendations for each watershed.
- Combine watersheds with similar characteristics.
- Can we extrapolate across watersheds?
- What data is already there? What quality is it?
- Dedicated regional data collection system – shared costs.

- Cost savings by doing component across the municipality, i.e., benthics, not just for one watershed.
- Enact bylaws and guidelines to make it easier. Time and/or cost reduction.
- Will a city bylaw that follows regular guidelines "eliminate" the need for an ISMP or reduce the scope (i.e. DFO draft guidelines for SW Management)? May not achieve full benefit. Each ISMP is specific.
- Co-ordinate "planning" between departments, i.e., OCP/NCP incorporates ISMP, ISMP incorporates OCP/NCP
- Need more communication among groups.
- Education on RFI versus TIA.
- Drainage utility to facilitate funding
- District-wide cost sharing between municipalities.
- Where possible (i.e. greenfield), have developers contribute money to ISMP costs.
- Green MMCD is helping to alleviate design costs.

WATER QUALITY

Other than source control BMPs that control quantity and have a positive water quality impact, the treatment of stormwater quality has not been adequately addressed in the Template. How should the treatment of water quality be dealt with in the Template especially in basins with combined sewer separation programs?

- Not just B-IBI
- Should also analyze range of chemistry/microbiology and physical indicators
- Measure performance of BMPs, investigative/research studies, not forever
- Cross connection concerns
- In-stream water quality and effluent discharge
- Measure performance of BMPs
- Did NOT get into water quality treatment, should be included in the plan.
- DFO would like to see water quality treatment from impervious surface. DFO and MWALP had a problem with LWMP. Do something when you see trend of decreasing but not until then.

4.3 SECONDARY ISSUES

ISMP VALUE

Are ISMPs resulting in better decisions?

- Yes!
- Getting results (e.g., reduced flooding, fewer calls, flow monitoring showing positive results)
- Leads to better overall understanding of issues in watershed
- Provides support for political aspects

- Should do a business-case analysis. Show value of spending money.
- Should benefits of ISMP → helps to prepare a business case (i.e., budget preparation)
- Clearly identifies stakeholders issues, e.g. farmer's needs and environmentalists positions/concerns

MEASURING WATERSHED HEALTH

The Template uses the WCS to assist in watershed health trading. Is there a better way, or is more clarification required?

- Graphs deal with TIA not EIA
- Being used, but lacking on procedure for EIA
- Need a way to incorporate EIA into 'future scenarios'
- What about aquifer-fed streams that are not dependent on TIA? Is it adequate? Is it useful?
- RFI needs more rigorous approach and better definition
- Ultimately, the health of a stream is shown by B-IBI. A classification system is just a planning tool.
- Water Balance Model could be used to quantify intra-watershed trades
- Need to incorporate water quality BMPs

BETTER DECISION MAKING PROCESSES

How should we filter data and structure the decision making process? Are there existing processes that the Template can refer to? Are there other processes outside of stormwater that can be referenced? Guidebook? Brunette Basin?

- Setup a priority list.
- Identify constraints/opportunities early on, rule out options that aren't feasible. Need better ways – pointing to alternatives.
- Identify constraints to eliminate.
- Re-development sets priorities and higher risks.
- ISMP points to generalized strategies rather than specifics.
- Use other ISMPs as templates/examples (they have already gone through it). Need list/database of other ISMPs.
- Difficult to streamline because every watershed is unique and staff have different approaches.
- Agreement in plan to achieve no-net-loss through habitat trading – spread over years potentially
- Incorporate existing data from various departments. Can other departments be gathering data ahead of time in conjunction with other functions, i.e., blueways (recreational corridors), greenways, groundwater, soils
- Workshops to rank all relevant departments involved and pull out top "easy picks".
- Do not get a wish list from every stakeholder.
- Matrix System
- Hans Schrier has developed a process Multiple Account Analysis.

PERFORMANCE INDICATORS

What indicators should be added? What criteria should they be measured on (i.e. flooding risk, water quality, recreation, environment?)?

- Want to increase shopping list!

Key - Flooding:

- claims
- complaints/rainfall
- O&M reports
- stream flows – variability/rainfall
- bank width/depth
- rainfall

Key – Erosion:

- stream flows – variability/rainfall
- bank width/depth
- rainfall
- repair requests
- culvert/channel cleaning
- turbidity monitoring
- bedload accumulation
- bedload embedment (particles size)
- changes in geomorphology

Low Priority – Recreation:

- access points for water and pathways
- number of closures
- length of trails – greenway
- blueways (water-based)

Key – Watershed/Ecosystem Health:

- sediment chemistry/microbiology
- EIA
- habitat index
- natural areas
- water (bacteriology, chemistry, drinking, agricultural use?)
- total forest cover
- B-IBI
- RCA (EC-cabin)
- fish access/habitat
- stream flows

*Avoid external effects on indicators.

Section 5

Summary of Resolutions

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5. SUMMARY OF RESOLUTIONS

5.1 INTRODUCTION

The purpose of this section is to provide a context and background for each of 31 issues, then document the resolution that was adopted by SILG at each of the follow-up sessions.

5.2 SUMMARY OF FOLLOW-UP SILG SESSIONS

An additional six sessions were conducted to address the ISMP Template issues identified in the original brainstorming session on December 2, 2004. The meeting dates were as follows:

- December 9, 2004,
- January 27, 2005,
- March 10, 2005,
- April 28, 2005,
- June 2, 2005, and,
- April 15, 2005 (Environmental Sub-Committee).

The resolution status dates for each of the identified ISMP Template issues has been summarized in Table 5-1.

An Environmental Sub-Committee was struck to provide guidance on four of the regulatory-based issues. The committee then provided a recommendation to SILG for adoption.

The April 15, 2005 meeting addressed the following issues:

#16: ISMP Cost
#17: ISMP Sign-off Process
#19: Water Quality Treatment; and,
#31 SWM Criteria

5.3 PRESENTATION OF COMMENTS AND RESOLUTIONS

Table 5-2 shows the form that was used to help SILG resolve each issue. The form is broken down into the following four headings:

- Issue Description,
- Background,

- Suggested Course of Action (recommended by KWL),
- Comments by SILG (during the session), and
- Resolution (obtained).

The ISMP Template resolution forms and session documents for each meeting are provided in Appendix A. It was decided that six issues were relatively straight-forward to address or were adequately resolved during the workshop breakout sessions, and would be discussed in the update of the template text (Issues #1, 7, 13, 14, 15, and 22 see Table 5-1)

Issue #18: Riparian Corridor, has not been resolved at this time as SILG feels that the two senior regulatory agencies do not agree with each other. This makes it difficult to determine a path forward. It is hope that by the time the Template is updated, resolution of this item will be accomplished.

5.4 CONCLUDING COMMENTS

Generally speaking, the ISMP Template was largely left intact. The Template still features a process to trade stormwater criteria throughout a watershed to maintain watershed health. There are a number of significant changes to several of the analytical methods that were proposed in 2001 including the method of calculating EIA.

However, the two most major changes is in the approval process with the senior agencies and the minimum and maximum efforts required in the ISMP process.

REVISED APPROVAL PROCESS

The Template will now propose the following two track method of approval:

1. **"Letter of Endorsement".** Receiving this letter provides the municipality with certainty that the stormwater management plan could be used in support of future *Fisheries Act and Canadian Environmental Assessment Act processes*. To obtain this letter, the watershed plan must demonstrate that a no net loss in watershed health and no net loss in productive capacity of fish habitat has been obtained.

2. **"Letter of Support".** Receiving this letter indicates that strong measures to lessen the harmful impacts of development have been taken, and DFO is supportive of those measures. However, the basin is likely to still suffer a loss in overall watershed health. DFO reserves the right to re-open certain stormwater strategies within the basin at a later should an authorization or CEA process be required.

It is hoped that this new approach will provide more certainty in future decisions affecting a watershed with respect to the involvement of senior approving agencies.

REVISED MINIMUM AND MAXIMUM EFFORTS

The 2001 Template attempted to provide "minimum efforts" for tasks where it was felt that a watershed met certain criteria and a detailed review was not required. However, the criteria chosen was vague, and the differences between minimum efforts and maximum efforts were only slight. The result has yielded an expensive ISMP process for some watersheds where land use changes are small. The proposed new system clearly defines the requirements necessary to use the "minimum effort" tasks. The requirements revolve around a municipality adopting various city-wide or watershed-wide bylaws, practices, and criteria that ensure key watershed health issues are addressed. Adopting the minimum effort tasks will likely not occur in watersheds were greenfield development and densification is happening at a rapid pace.

TABLE 5-2

EXAMPLE OF ISMP TEMPLATE ISSUE RESOLUTION FORM

ISSUE:
BACKGROUND:
SUGGESTED COURSE OF ACTION:
COMMENTS BY SILG:
RESOLUTION:

Table 5-1: ISMP Template Issues

	Issue	Resolution Mechanism	Status
Overall ISMP Process	1. What is the value of an ISMP? Are better decisions being made? (1)	Workshop break-out session	No further discussion required.
	2. The Template addresses greenfield developments, add alterations for redevelopments.	SILG Meeting	Discussed at March 10, 2005 SILG meeting
	3. Role of Stakeholders: Better way to obtain feedback?	SILG Meeting	Discussed at Apr 28, 2005 SILG Meeting
	4. What if municipalities do not meet the ISMP commitment within 12 years for all watersheds?	SILG Meeting	General Discussion at June 2, 2005 SILG Meeting
Technical Issues	5. GVRD's Watershed Classification System: Is there a better way of linking SW to watershed health? (1)	Workshop break-out session, Sub-committee	Discussed at June 2, 2005 SILG Meeting
	6. Filter data and structure the decision-making process. Create a Supplement Template. (1)	Workshop break-out session	Discussed at June 2, 2005 SILG Meeting
	7. Performance Indicators: Are additional indicators required? What should be the reporting frequency? (1)	Workshop break-out session	No further discussion required.
	8. Emerging Practices: How do we deal with uncertainty, implementation, municipal liabilities, research?	Sub-Committee	Discussed at June 2, 2005 SILG Meeting
	9. Water Balance Model and Exceedance Duration Curves.	SILG Meeting	Discussed at Dec. 9, 2004 SILG meeting.
	10. EIA is too complex to calculate for large watersheds.	SILG Meeting	Discussed at Jan. 27, 2005 SILG meeting.
Integration with Other Disciplines	11. Strengthen recreation component.	SILG Meeting	Discussed at March 10, 2005 SILG meeting
	12. Changes to existing municipal processes. Linkages with municipal standards. (1)	Workshop break-out session	No further discussion required.
	13. What is the linkage to Overall Sustainability? High density encouraged?	SILG Meeting	Will be addressed in revised Template text
	14. Summary of constraints/opportunities from all disciplines. Integration between disciplines.	SILG Meeting	Will be addressed in revised Template text
	15. What is the timing of ISMPs with other municipal plans (e.g. Neighbourhood Plans)?	SILG Meeting	Will be addressed in revised Template text
Environmental Issues	16. Cost: Are there ways to reduce ISMP costs? Can “minimum effort” requirements be reduced? (1)	Workshop break-out session, Environmental sub-committee	Discussed at Apr 15, 2005 Envir.Sub-Com. Presented at Apr 28, 2005 SILG meeting
	17. ISMP Agency Signoff Process: Is it too formal? Is there a better way?	Environmental sub-committee	Discussed at Apr 15, 2005 Envir.Sub-Com. Presented at Apr 28, 2005 SILG meeting
	18. Riparian Corridor: Should it be assessed in ISMP? How do we link it to RAR or SPR? (1)	Workshop break-out session, Environmental sub-committee	**Still pending**
	19. Water Quality Treatment? (1)	Workshop break-out session, Environmental sub-committee	Discussed at Apr 15, 2005 Envir.Sub-Com. Presented at Apr 28, 2005 SILG meeting
	20. How will decline in watershed health be determined? What will be done?	SILG Meeting	General Discussion at June 2, 2005 SILG Meeting
	21. Water quality monitoring. Minimum baseline requirements?	SILG Meeting	Discussed at Apr 28, 2005 SILG Meeting
With Approval, Relatively Simple Modifications	22. Add Hierarchy of Trading.	SILG Meeting	Will be addressed in revised Template text
	23. Watershed screening process using WCS: Add focus on growth demands.	SILG Meeting	Discussed at June 2, 2005 SILG Meeting
	24. B-IBI: More clarification on sampling and science is needed, along with a consistent approach.	SILG Meeting	Discussed at Jan. 27, 2005 SILG meeting.
	25. Relate recommendations to implementation: Add a sample Implementation Table?	SILG Meeting	Discussed at Dec. 9, 2004 SILG meeting.
	26. Simplify the ISMP Process flowcharts.	SILG Meeting	General Discussion at June 2, 2005 SILG Meeting
	27. Should we call it an IWMP instead of an ISMP? Is there too much emphasis on stormwater?	SILG Meeting	Discussed at March 10, 2005 SILG meeting
	28. Terrestrial Species and Habitat: Should it be removed from ISMPs?	SILG Meeting	Discussed at June 2, 2005 SILG Meeting
Additional Issues (2)	29. Determine areas were stormwater source controls should not be used	SILG Meeting	Discussed at Jan. 27, 2005 SILG meeting.
	30. Strengthen Groundwater Clause 5 to promote aquifer recharge for potable water	SILG Meeting	Discussed at March 10, 2005 SILG meeting
	31. Suggest recommending a preferred stormwater control criteria	SILG Meeting	Discussed at Apr 15, 2005 Envir.Sub-Com. Presented at Apr 28, 2005 SILG meeting

Notes:

(1) Indicates that preliminary comments were made during workshop breakout session

(2) Issue was added after ISMP Workshop (i.e. from Questionnaire or other correspondence)

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Appendix B1

Session Notes

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ISMP TEMPLATE ISSUE RESOLUTION

ISSUE:

2. The Template addresses greenfield developments, add alterations for redevelopments

BACKGROUND:

This issue relates to two types of fully developed watersheds:

1. watersheds with creeks and existing fish populations, and
2. highly impervious watersheds with or without creek systems but little or no aquatic species in the watershed (i.e. includes direct pipe discharges to receiving waters).

Watershed health can be measured for category 1 under the existing ISMP Template process provided the issues pertaining to B-IBI measurement in seasonal creeks and soft bottom creeks are addressed (see Issue 24). Therefore, no additional alterations are recommended.

It is difficult to measure watershed health for catchments in category 2 as there may not be a creek system. For these highly developed catchments, other indicators may be more relevant for measuring ISMP success and baseline conditions. For example, recreational amenities and water quality may be more valid indicators of success. The current ISMP template does not include a set of indicators for these items. However, recreational indicators are now proposed under Issue 11.

SUGGESTED COURSE OF ACTION:

It is recommended that for highly develop watersheds with little or no downstream creek systems or with watercourses of poor biological heath, additional indicators should be provided to help guide the decision making process. Indicators could include measuring recreational amenities and discharge water quality.

COMMENTS BY SILG:

- agree, other indicators should be provided.
- It was also recommended that additional research was needed on doft-bottom creeks and ditches as the B-IBI sampling protocol may not be possible in these areas.

RESOLUTION:

It was agreed that additional indicators will be provided for watersheds without creek systems. Combined Sewered areas are exempt from the ISMP Template process (see Issue #19)

March 10, 2005

ISMP TEMPLATE ISSUE RESOLUTION

ISSUE:

Issue #3: Role of Stakeholders: Is there a better way at obtaining feedback?

BACKGROUND:

This issue can be broken down several ways: 1. The stakeholder process itself … is it useful? 2. The proposed stakeholder program in the Template … can it be improved upon? 3. The makeup of a typical ISMP stakeholder group … is it more of an educational and information gathering exercise or can it actually provide City councils a recommended course of action?

SUGGESTED COURSE OF ACTION:

In theory, stakeholder processes sound like a good idea. In practice, it's difficult to move a stakeholder process beyond the educational and information gathering stage. Perhaps this will change once more ISMPs are completed within a municipality. Stakeholder processes can be expensive, particularly if the ISMP spans more than a year. However, the role of the stakeholder process is still very much needed. When community decisions need to be made such as the target future health of a watershed, how much effort should be spent on protection/enhancement, and what methods should be used, City councils will need a voice from the community to aid in the decision making process.

It is recommended that the current system be retained in the template, but additional pointers be provided to better help the process achieve its end objectives.

COMMENTS BY SILG:

- Ensure that there is a balanced stakeholder group invited to attend.
- With respect to agencies: how do we get their feedback? Is there a better way?
- How do we increase involvement? Eg. First Nations

RESOLUTION:

A balanced stakeholder process is required, efforts to obtain comments from all agencies should be made.

April 28, 2005

ISMP TEMPLATE ISSUE RESOLUTION

ISSUE:

Issue #5: GVRD's Watershed Classification System: Is there a better way of linking stormwater to watershed health?

BACKGROUND:

This was the subject of a breakout session during the December 2, 2004 ISMP Workshop. The general consensus of the breakout session can be summarized as follows:

- The linking of impervious area, riparian corridor, and the benthic invertebrate community in the creek is supported as the primary indicators of watershed health.
- However, there is confusion over the use of total impervious area (TIA) versus effective impervious area (EIA) and the method to calculate it.
- There is also confusion over the term "Watershed Classification System". It implies that streams will be classified and that some form of priority will be assigned. Also, the classification of "excellent", "good", "fair", and "poor" remains controversial to many.

Although classifying streams was the original intent of the system, it has grown far beyond that now. Using B-IBI has been shown as the preferred indicator of measuring the performance of emerging stormwater practices. For example, the B-IBI system was used successfully in the late 1990's to prove that the construction of detention ponds alone, were not improving watershed health and sustainable salmon populations.

SUGGESTED COURSE OF ACTION:

It is recommended that the existing method of linking riparian corridor, EIA, and B-IBI be maintained to measure watershed health, but additional detail be provided to assist with the calculations. It is also recommended that the system be expanded to include soft-bottom creeks and seasonal creeks. Issue #9 (discussed at the December 9, 2004 SIG meeting) recommended that the water balance model be used as the preferred tool to calculate future EIAs. Additional write up will be provided in the updated template to help document the calculation of riparian forest integrity (RFI) and EIA.

COMMENTS BY SILG:

- This is a sub-set of a big study.

CABIN vs B-IBI , disappointed that CABIN is not used. Discussion re: CABIN vs. B-IBI ensued

RESOLUTION:

Existing method of linking riparian corridor, EIA, and B-IBI will be maintained to measure watershed health, but additional detail will be provided to assist with the calculations. The "Excellent", "Good", "Fair", "Poor" categories will be dropped as it was felt that they were misleading.

June 2, 2005

ISMP TEMPLATE ISSUE RESOLUTION

ISSUE:

Issue #6: Filter data and structure the decision-making process. Create a Supplement Template.

BACKGROUND:

ISMPs can result in a multitude of strategies that seem to be inter-related and often linked to loosely defined environmental objectives. For this reason, the decision making process can be difficult, and stakeholder are often over-whelmed by the number of options.

SUGGESTED COURSE OF ACTION:

During the December 2, 2004 ISMP Template Workshop it was suggested that a Multiple Account Analysis process be integrated with the ISMP Template to better facilitate the decision making process. It is recommended that the SILG committee review the handout provided and comment on the integration of this process into the Template.

COMMENTS BY SILG:

- Lots of people have done lots of work on it. Should not be in the document.

RESOLUTION:

A Supplement Template will be created.

June 2, 2005

ISMP TEMPLATE ISSUE RESOLUTION

ISSUE:

Issue #8: Emerging Practices: How do we deal with uncertainty, implementation, municipal liabilities, research?

BACKGROUND:

Most source controls are relatively new practices. As such, their long-term performance is not sufficiently documented at this time. However, it is recognized the short and medium term data exists on many source controls and it is reasonable to move forward with their implementation as their long-term performance can be extrapolated or at least assumed. It is also recognized that if the region waits until the data exists from other jurisdictions throughout world, significant harm will be made to the watersheds.

For those source controls that do not fit into the above category, a different approach is warranted as there will be inherent risks to their adoption. Further, it may be difficult for senior agencies to endorse an ISMP unless some documentation of on-going performance is provided.

SUGGESTED COURSE OF ACTION:

For emerging practices, it is recommended that the following approach be adopted:

- Proper identification of which source controls have been successfully used elsewhere versus which are emerging practices.
- For each emerging practice, a separate monitoring program should be outlined complete with performance objectives, methods, and timelines.
- If the emerging practice involves significant risk on behalf of the municipality, a pilot program should be suggested. An alternate plan should be documented as a backup should the pilot program fail.

By implementing the above, senior agencies should be able to support the use of emerging practices in ISMPs in a timely fashion. An example of an emerging technology is the use of stormwater diversions for environmental purposes. If these diversions are recommended in an ISMP, a more intensive monitoring program would be required by the senior agencies to prove that the technology is achieving its environmental objectives. Further, it should be documented that proven source controls could not be employed in a cost-effective manner.

COMMENTS BY SILG:

- Write the back up system into this emerging technology.
- If this doesn't work then read WLAP article on innovative technology.

RESOLUTION:

Agree with the suggested course of action. Consult the WLAP article on innovative technology.

June 2, 2005

ISMP TEMPLATE ISSUE RESOLUTION

ISSUE:

Issue 9. Water Balance Model and Exceedance Duration Curves.

BACKGROUND:

The May 2002 ISMP Template recommended that an exceedance-duration approach be used to determine effective impervious area (EIA). This approach compares the duration of flows for the current development scenario with those of a natural forested area to determine the EIA. A continuous simulation model is used to develop the flows. This method allows both source controls AND regional BMPs such as diversions to be assessed.

SUGGESTED COURSE OF ACTION:

It has been suggested by many that an additional method be included and explained in the template to simplify the determination of EIA.

Future Development – EIA Determination

It is recommended that the *Water Balance Model* be used to estimate the EIAs of a watershed under future development scenarios. The Exceedance-Duration Curve method is still preferable to assess regional BMPs such as diversions, but where the recommended future strategy includes only source control BMPs, the *Water Balance Model* will significantly simplify the analysis.

Existing Development Scenario – EIA Determination

It is recommended that the procedure to determine the existing EIA of a watershed based on the streamflow records should be fully explained in the Template document.

COMMENTS BY SILG:

-agree, the water balance model should be integrated in to the ISMP Template and should be proposed as the key method at estimating EIA.

-However, other methods should also be suggested

RESOLUTION:

The proposed course of action was adopted with the above comments noted.

December 9, 2005

ISMP TEMPLATE ISSUE RESOLUTION

ISSUE:

10. EIA too complex to calculate for large watersheds

BACKGROUND:

The Still Creek ISMP commented that Effective Impervious Area (EIA) was too complex to calculate for large watersheds. This is correct. Research has shown that just like the use of the B-IBI system, it is difficult to measure and interpret EIA in watersheds greater than 1500 Ha. Large watersheds have significant attenuation effects making it difficult to use flow-monitoring (and modeling) results to establish EIA levels.

However, the determination of EIA is critical to stormwater management planning. As more source control measures are implemented throughout the Lower Mainland, the intent is to lower (or maintain) EIA by disconnecting impervious surfaces from the receiving waters. If EIA is not measured over time, it will be difficult to measure the success of the plan.

SUGGESTED COURSE OF ACTION:

The ISMP Template suggests an optimum basin size of 500 to 750 ha. If ISMPs are undertaken on larger watersheds, it is recommended that the EIA be calculated at the sub-watershed level then aggregated to develop an overall level. Text will be added to help explain the EIA calculation process.

COMMENTS BY SILG:

- Given that an optimum basin size has been suggested, it is important to ensure that the approach for EIA determination is targeted appropriately to the watershed area. The approach should take into account natural buffering by the watershed.

RESOLUTION:

A minimum of two methods will be proposed to calculate EIA (see issue 9 from Dec 2). EIA will continue to be used as the measure of actual impervious area in a basin and should be determined for each watershed and then predicted over time.

January 27, 2005

ISMP TEMPLATE ISSUE RESOLUTION

ISSUE:

11. Strengthen recreation component

BACKGROUND:

The Still Creek ISMP recommended that the Clause 8: Recreational/Amenities be strengthened to provide help in making decisions. In highly developed watersheds, recreation is more likely to be the major driving force behind stream corridor decisions than the biological health of the watershed. Stream corridor decisions based on greenway planning, parkland linkages, pedestrian walkways, alternative transportation planning, etc. and their linkage with floodway routing projects will likely dominate the decision matrices. However, currently, the ISMP template is more focused on indicators relating to watershed health rather than the above indicators.

SUGGESTED COURSE OF ACTION:

It is suggested that additional decision making tools be added but the underlying watershed health indicators remain the same.

COMMENTS BY SILG:

- Agree, the recreational component should be strengthened

RESOLUTION:

The recreational component should be strengthened.

March 10, 2005

ISMP TEMPLATE ISSUE RESOLUTION

ISSUE:

Issue #16: ISMP Cost: Are there ways to reduce ISMP costs? More specifically, can a municipality implement basin wide SWM criteria and bylaws to allow a reduction in the effort of ISMP components? This could be referred to as "ISMP-Light". ISMP-Lights would also have to include a commitment to adopting a riparian setback bylaw.

BACKGROUND:

The estimated cost of carrying out the full slate of ISMP components can range from $150k to $250k + depending on the size of a watershed and the amount of inventory and GIS mapping previously completed. It has been raised that if the land use in a watershed is static and new development is not occurring, then the only real pressures will come from re-development within a similar land use and other smaller scale problems. Perhaps for these types of watersheds, a reduced level of effort is warranted provided the municipality implements a suite of basin wide bylaws, controls, and new programs.

SUGGESTED COURSE OF ACTION:

It is suggested that if a municipality can commit to meeting the DFO's stormwater criteria (or equivalent see Issue #31) on all NEW impervious areas, then the "minimum effort" clauses in each ISMP clause could be re-written to reduce the level of effort required. A municipal commitment would entail changing bylaws and controls. An ISMP-Light would signify an ISMP that followed the "minimum effort" levels under each clause.

COMMENTS BY ENVIRONMENTAL SUB-COMMITTEE:

- Don't forget about the receiving environment and W.Q. impacts
- Must still include the stakeholder process to ensure that the level of protection is correctly chosen
- Can it still be called an ISMP ? perhaps .. if certain minimums are still in the process
- Consider a menu driven process to help make decisions on the work program components

RESOLUTION BY ENVIRONMENTAL SUB-COMMITTEE

Yes, the concept of "ISMP-Lights" can work. However, they must still include a stakeholder process to ensure that the proper level of protection has been selected (i.e. net gain in watershed health). Further, bylaws and programs must be created and implemented to address the minimum requirements such as the protection of stream setbacks, source control, and sediment control. Basically, ISMP lights ensure that every new sq. metre of impervious surface will have a source control associated with it, and that creek systems will have sufficient setbacks.

COMMENTS BY SILG:

- How are minimums identified?
- Guideline must be flexible.
- Do not like ISMP-Light name.
- Minimums provide a prescriptive approach for direction.
- Bylaw not required.
- State specific upset limit for single-family impervious area.

RESOLUTION:

The recommendation by the environmental sub committee was adopted. However, the term "ISMP Lights" was not adopted.

April 28, 2005

ISMP TEMPLATE ISSUE RESOLUTION

ISSUE:

Issue #17. ISMP Sign-off Process: Is it too formal? Is there a better way?

BACKGROUND:

Each ISMP was intended to develop a "Memorandum of Understanding" (MOU) between the municipality and the senior agencies. This MOU would allow a municipality a more streamline process for future environmental approvals, as the "hows", whys and whens will already be addressed. This process was developed by a sub-committee comprising both municipal, DFO, and WLAP representatives. In practice, however, no MOUs have been signed as the process is felt to be too formal.

SUGGESTED COURSE OF ACTION:

Consider developing a less formal process provided the intent of a streamlining future environmental approvals can still be met. It should be made clear that one of the main objectives of an ISMP is to eliminate the need to revisit stormwater management where CEA applications are involved. If developing a less formal sign-off process can not achieve this, the current sign-off process should be kept.

COMMENTS BY ENVIRONMENTAL SUB-COMMITTEE:

- Agreed. A more informal process is needed.

RESOLUTION BY ENVIRONMENTAL SUB-COMMITTEE:

It was agreed to revise the current "Memorandum of Understanding" process, and replace it with a more informal letter process between DFO and the municipality. The Province would not be involved at a local level, but would be at a regional level to ensure the commitments under the LWMP were being met.

One of the following two letters will be issued by DFO upon the completion of a watershed plan:

1. **"Letter of Endorsement".** Receiving this letter provides the municipality with certainty that the stormwater management plan could be used in support of future *Fisheries Act and Canadian Environmental Assessment Act processes*. To obtain this letter, the watershed plan must demonstrate that a no net loss in watershed health and no net loss in productive capacity of fish habitat has been obtained.
2. **"Letter of Support".** Receiving this letter indicates that strong measures to lessen the harmful impacts of development have been taken, and DFO is supportive of those measures. However, the basin is likely to still suffer a loss in overall watershed health. DFO reserves the right to re-open certain stormwater strategies within the basin at a later should an authorization or CEA process be required.

COMMENTS BY SILG:

- Change "watershed plan" to ISMP.
- Letter of support could be from any agency.
- Is a permit needed down the road?
- DFO is the only reason an ISMP is conducted.
- No net loss is a problem because the City of Surrey is different than other municipalities.
- Asking DFO to endorse is unfair, what about WLAP and Environment Canada.
- Intent letter is of good use, similar to WLAP Agriculture.
- Process gives certainty and documents time line. How long for certainty?
- For second letter, a municipality may not get DFO approval.

RESOLUTION:

The recommendation by the sub-committee was adopted.

April 28, 2005

ISMP TEMPLATE ISSUE RESOLUTION

ISSUE:

Issue #19: Water Quality Treatment: What is DFO/WLAP expecting for new impervious surfaces that are not addressed by source control measures.

BACKGROUND:

The current version of the ISMP Template does not explicitly address water quality, but strives to limit the increase of effective impervious areas. This impact results from a combination of point and non-point source pollution and hydrological changes. Under an ISMP, presumably many of the new impervious surfaces will be addressed by a volumetric reduction strategy, which if designed appropriately, can also deal with water quality. In any case, because the ISMP Template is tied to benthic scores, water quality will need to be addressed to ensure the scores do not decline.

However, for direct discharges to marine environments, a method to evaluate benthic community baseline condition is not outlined. For new impervious surfaces that aren't treated with LID measures in these areas, the DFO stormwater guideline or other applicable guidelines or BMP's could be used to address water quality. Is it DFOs intention that ISMPs should be addressing water quality issues on new impervious surfaces that? Yes – Under the *Fisheries Act* DFO can not allow discharge of deleterious substances unless specifically authorized by a federal regulation. Therefore as a minimum, discharges must receive appropriate (diligent) level of treatment to ensure that contravention of the *Fisheries Act (e.g., section 36(3)) does not occur.*

This is somewhat of a trick question as two major issues fall out of that answer:

- the separation of combined sewers create new impervious surfaces
- implies that existing impervious surfaces are OK or could be addressed over the long term.

SUGGESTED COURSE OF ACTION:

It is recommended that new impervious surfaces that are not treated by LID measures fall under DFO's stormwater guideline or other applicable guidelines or BMPs. It is mandatory that the ISMP address the potential conveyance of deleterious substances into the receiving waters from new impervious surfaces.

For combined sewered areas, it was decided that the ISMP Template process did not apply as this is a larger issue that should be the subject of a future discussion or deferred to the greater LWMP committee.

COMMENTS BY ENVIRONMENTAL SUB-COMMITTEE:

- The Terms of Reference for the ISMP Template development specifically excludes combined sewered areas. The financial impact of treating the new impervious surfaces could be significant. For these reasons, it was re-confirmed that areas with combined sewers are excluded from the ISMP template process.

- In areas where "ISMP-Lights" are to be used, water quality treatment is already implied, as all new impervious surfaces will require some sort of source control to address the volumetric reduction criteria. In almost all cases, addressing this criteria addresses most water quality concerns. However, spill and sediment control strategies are still required.

- In areas where the full ISMP process is to be used, water quality must be addressed either by source control or end-of-pipe BMPs. An ISMP must ensure that deleterious substances are not discharged to the receiving water environment.

COMMENTS BY SILG:

- With respect to guidelines or BMPs, ensure that the difference between source controls and BMPs (non-water quality) is addressed.
- Change the water from "it is mandatory" in Suggested Course of Action.
- Diversion as volumetric reduction treatment? no
- Separation, realistic connection to community as a whole.
- Remove "must" be addressed.
- Process is good.

RESOLUTION:

The recommendations by the sub-committee were adopted subject to the above changes.

April 28, 2005

ISMP TEMPLATE ISSUE RESOLUTION

ISSUE:

Issue #21: Water quality monitoring. Minimum baseline requirements?

BACKGROUND:

The Template calls for the following water quality sampling (Clause 13):

- Obtain dry-weather samples at all major storm sewer outlets and creek reaches during dry-weather baseflow conditions for temperature, conductivity, dissolved oxygen, fecal coliform bacteria, total coliform bacteria, copper, manganese, zinc, total extractable hydrocarbons, and chemical oxygen supply. Baseflow samples indicate what the aquatic community experiences most of the time, and will identify the problems with cross connections from sanitary sewers and other anomalies such as groundwater quality problems.
- Undertake wet-weather monitoring only when industrial areas occupy an area greater than 15% of the watershed or when the dry weather sampling program identifies a water quality problem that is not consistent with the upstream land use. Additional sampling may be required to find the source and extent of the problem.
- For areas where the above sampling exceeds the water quality guidelines, conduct sediment sampling to determine the nature and history of the contaminants.

The Province has commented to the SILG committee in the following manner:

“The ministry's biggest concern is that there will be a strong emphasis on IBI sampling and nothing else. Or, if there is something else, it too will be grab sampling based instead of continuous monitoring based. We think that if a water quality monitoring program is to be based on grab sampling, there needs to be continuous monitoring of some sort of parameter(s) to put the grab samples in context. Measuring temperature, using tidbits, is relatively inexpensive and cheap and we feel that should be a minimum and the data provided will be extremely useful when interpreting the grab samples. The health of the systems in question is event driven and grab sampling is more than likely to miss these events. Continuous monitoring will allow us to describe the frequency and extent of these events.”

SUGGESTED COURSE OF ACTION:

Adding continuous water temperature and conductivity to the existing flow monitoring programs is relatively inexpensive. Turbidity could be measured instead of conductivity, but would be more expensive. It is recommended that continuous water temperature and conductivity be added to the flow monitoring programs.

COMMENTS BY SILG:

- Add "it could be considered" to adding continuous water temperature and conductivity (in Suggested Course of Action).
- Continuous water temperature and conductivity applied for "the duration of flow monitoring programs".
- Does conductivity related TSS?
- Adding continuous monitoring.
- Suggest thing to be considered not a minimum.

RESOLUTION:

It is recommended that continuous water temperature and conductivity be added to the flow monitoring programs. The other water quality parameters listed the 2001 Template will continue to be collected as well.

April 28, 2005

ISMP TEMPLATE ISSUE RESOLUTION

ISSUE:

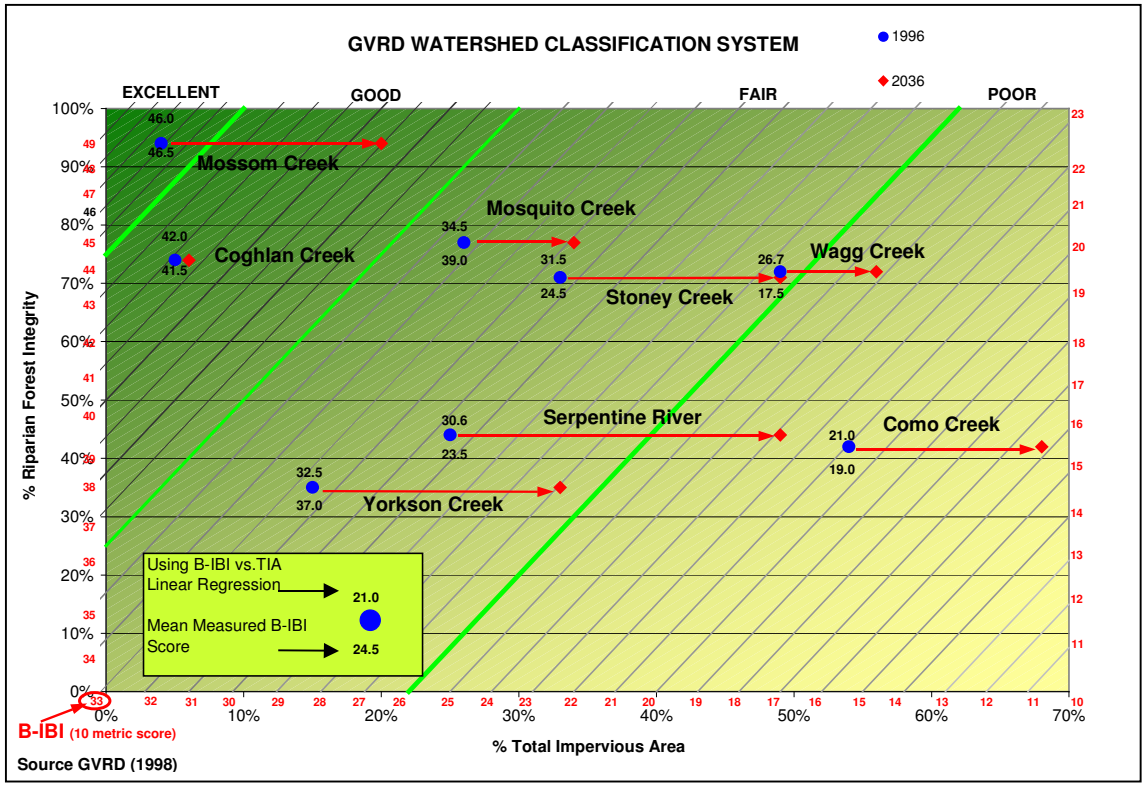
Issue #23: Watershed screening process using WCS: Add focus on growth demands

BACKGROUND:

The original draft of the ISMP template called for the watershed classification system to be used as a screening process for prioritizing ISMP implementation. However, in reality, municipalities are initiating ISMPs where current development pressures are strongest. The issue has been raised as to the effectiveness of including this screening tool in the ISMP template.

SUGGESTED COURSE OF ACTION:

The Template is only meant to serve as a guide. Most municipalities will develop their own priority systems. It is recommended that the screening tool be left in the Template but additional text be added to help deal with the extra pressure caused by rapid growth. For example:



The watersheds with the longest arrow closest to the top, left-hand corner will be experiencing the most pressure.

COMMENTS BY SILG:

- Change Total to Effective (above Figure)
- Proved text on what happens if it proves to be right (flooding, fish stocks)
- The Poor, Good and Excellent categories should be removed.
- Add year of development to chart. Eg Add 2030 and 2033 to Stoney Creek.

RESOLUTION:

The proposed course of action was adopted with the above comments noted.

June 2, 2005

ISMP TEMPLATE ISSUE RESOLUTION

ISSUE:

24. B-IBI: More clarification on sampling and science is needed, along with a consistent approach.

BACKGROUND:

The B-IBI system promoted in the ISMP Template is intended to measure the health of the aquatic community in the creeks of a watershed. It serves as the cornerstone of the ISMP process. By doing so, the B-IBI system is intending to measure the success and failure over time of SWM measures and source controls implemented in a watershed. The system also serves as a proxy for measuring the potential health of salmon habitat. The B-IBI system has already been used successfully in Washington State to re-evaluate the role of detention ponds. Further, it can be linked to the Watershed Classification System (WCS) to assist in comparing the actual health of a watershed to other watersheds with similar Effective Impervious Areas (EIAs) and Riparian Forest Integrities (RFIs).

Issues have been raised surrounding the variability of system. More specifically, the variability associated with climatic, sampling techniques, and creek gradients. Also, most research focuses solely only on creeks flowing year-round. Ephemeral creeks and soft bottom creeks require additional research to be able to use the WSC and accurately identify stream health.

SUGGESTED COURSE OF ACTION:

As a result of the above, the GVRD and King County have independently initiated two studies to help identify the variability in the B-IBI system for year round creeks. Both studies were initiated in 2003, and both have two seasons of B-IBI scores. The King County study involves over 100 watersheds. It is hoped that once both studies are published, the variability of the B-IBI system in year-round creeks will be fully understood. As well, the GVRD study examines the difference between different sampling techniques. Additional clarification will be provided in the Template text and clauses summarizing the above studies.

However, additional research is still required for ephemeral (seasonal) and soft bottom creeks. It is recommended that the GVRD take a lead in furthering this research. Until then, it is recommended that the existing B-IBI system be used, but not compared on the WSC system relationships. The scoring will provide an indicator of watershed health, but will not be comparable to other watersheds until the above research is complete.

COMMENTS BY SILG:

- A discussion developed between the B-IBI system and Environment Canada's CABIN system. Should the Template replace the B-IBI system with the CABIN system ? no. There is considerable Pacific Northwest research being done on linking stormwater practices to B-IBI. By moving to the CABIN system, it would be difficult for GVRD members to compare results.
- The CABIN system could be used as a supplemental measurement system to compare the health of a particular watershed to similar watersheds across Canada.

RESOLUTION:

The Template clause will be revised to summarize the two studies mentioned above, in a brief and simple format, and refer consultants to the relevant supporting documents. The B-IBI system will continue to be the key measure of watershed health within a watershed.

January 27, 2005

ISMP TEMPLATE ISSUE RESOLUTION

ISSUE:

25. Relate Recommendations to Implementation – Add Implementation Table example

BACKGROUND:

The May 2002 ISMP Template recommended a sign-off process that referenced an implementation table that would summarize the capital projects, bylaws, development standards, and SWM strategies recommended in an ISMP. The purpose of the table was to prioritize the positive and negative strategies in such a way that a no-net-loss in watershed health status could be achieved in any given year. Since no ISMPs had been completed as of May 2002, an example of such a table had not been produced.

SUGGESTED COURSE OF ACTION:

It is recommend that an example of an ISMP Implementation Table be included with the revised draft. SILG is requested to review the table submitted and approve if acceptable.

COMMENTS BY SILG:

- The implementation table is complicated
- The focus on change in B-IBI to measure the impact of each strategy/project may be beyond the ability of the B-IBI system's resolution

RESOLUTION:

The implementation table will be provided in the template as a possible example to follow to help track proposed watershed health changes in any given year. However, the table will not be listed as a core component.

December 9, 2005

ISMP TEMPLATE ISSUE RESOLUTION

ISSUE:

27. Should we call it an IWMP instead of an ISMP? Is there too much emphasis on stormwater?

BACKGROUND:

During the preparation of the ISMP Template in 2001, there was considerable discussion on the selection of the term "Integrated Stormwater Management Plan (ISMP)" versus "Integrated Watershed Management Plan (IWMP)". It was decided to use former as it was felt that the term "watershed plan" includes issues that are not necessarily related to urban stormwater such as bogs, wetlands, debris flows, and other non-urban development issues. However, many recent studies in Langley and Coquitlam have moved to the "watershed" terminology due to strong linkages such as the stability of groundwater aquifers for potable water, and lowland agricultural drainage, etc.

It was raised several times at the ISMP Review Workshop and has become and an issue requiring clarification.

SUGGESTED COURSE OF ACTION:

It's always difficult to change an accepted terminology midstream, but more importantly, it is probably best to refer to why the template was created in the first place. The underlying driver behind the ISMP Template is the Liquid Waste Management Plan and the legal commitments made to the Province regarding stormwater. As a result, it is suggested that the template name remain "ISMP", but it is understood that many municipalities will be using the more all-encompassing title of "watershed management plans". It is really up to an individual municipality to decide what they call a particular study.

COMMENTS BY SILG:

- Misc. discussions on ISMP vs. IWMP

RESOLUTION:

The template name remains "ISMP", but it is understood that many municipalities will be using the more all-encompassing title of "watershed management plans". It is really up to an individual municipality to decide what they call a particular study.

March 10, 2005

ISMP TEMPLATE ISSUE RESOLUTION

ISSUE:

Issue #28: Terrestrial Species and Habitat (Clause 11): Should it be removed from ISMPs?

BACKGROUND:

The ISMP Template focuses on rainwater related issues and it's impact within a watershed. It has been raised that Terrestrial Species and Habitat should be removed from the template as it is a separate study and doesn't relate to ISMPs.

SUGGESTED COURSE OF ACTION:

Understanding the Terrestrial Species and Habitat areas within a watershed could assist developing better ISMPs particularly in green field areas. It is acknowledged that this type of work should be competed on a more macro level as it tends to transcend watershed boundaries. For this reason, it is recommended that the clause be removed. However, the information should still be collected as part of a separate process (perhaps a City-Wide Environmental Sensitive Area (ESA) study) then inputted into the ISMP alternative analysis stage.

COMMENTS BY SILG:

- Culture, heritage, CMT
- Should it be expanded to Species at risk? Potential disaster if dropped, a backward step.
- Terrestial linkages! Needs to be updated.
- Species screening should be in the clause work program

RESOLUTION:

The proposed Course of Action was adopted with the above comments noted.

June 2, 2005

ISMP TEMPLATE ISSUE RESOLUTION

ISSUE:

30. Strengthen Groundwater Clause 5 to promote aquifer recharge for potable water

BACKGROUND:

Clause 5: Hydrogeology/Geotechnical Assessment focuses on identifying sub-surface flow regimes soil types and infiltration opportunities. The clause also identifies geotechnical hazards such as potential ravine instabilities. At the January 27, 2005 SILG meeting it was agreed to expand the geotechnical portion of the ISMP Template to more thoroughly cover potential geotechnical hazards as a result on implementing infiltration source controls. As a result, the Geotechnical components will be separated from this clause and summarized under a new clause.

The current groundwater clause mainly focuses on groundwater flow regimes relating to stream baseflows. However, several recent watershed studies have identified the need to replenish groundwater aquifers due to declining water levels and the need for sustainable potable water sources. Even if the aquifers are only used for irrigation and industrial purposes, many watersheds in the Lower Mainland will be considering the storage and re-use of stormwater in aquifers in the near future. Therefore, it is recommended that the groundwater clause be expanded to reflect the above linkages to stormwater.

SUGGESTED COURSE OF ACTION:

Expand the Hydrogeology clause to include linkages to groundwater aquifers and their use as potable and non-potable drinking water sources. Ensure that in watersheds where these aquifers exist, sufficient detail is provided in an ISMP to provide for the long-term stability of these sources. Include items in the template to assist with related issues such as stormwater quality prior to infiltration or injection.

COMMENTS BY SILG:

- Agree. This issue is already being pursued aggressively in the Township of Langley and some other member municipalities.

RESOLUTION:

The groundwater component will be strengthed to encourage the use of groundwater storage and re-use where applicable.

March 10, 2005

ISMP TEMPLATE ISSUE RESOLUTION

ISSUE:

Issue #31: SWM stormwater criteria: What criteria should we strive to meet? DFO, WLAP, combination, or other?

BACKGROUND:

Each municipality has their own stormwater discharge criteria. The Province has recommended criteria as part of the Provincial Guidebook. DFO has also recommended criteria as part of their Stormwater Control Guidelines (Draft). If a municipality wishes to use the "minimum effort" in the ISMP clauses as a result of Issue #16 being adopted, which criteria should they use?

SUGGESTED COURSE OF ACTION:

Suggest blending the criteria. The Provincial and Federal criteria are similar with the following exceptions: the DFO criteria do not include major storm events, and the Provincial criteria do not fully address water quality. There are other differences in the terminology used and targets established, but relatively minor. Most municipal criteria simply focus on attenuation of larger storm events and do not address volumetric reduction or water quality. However, the above criteria could be blended quite easily. It should be noted that by adopting a blended criteria, a municipality would not be committed to any future obligations, but instead could weigh the cost of simplifying their ISMP commitments versus changing their stormwater control bylaw.

COMMENTS BY ENVIRONMENTAL SUB-COMMITTEE:

- DFO are revising their criteria, and plan to seek SILG input in the coming months. Consideration is being given to wording that is more consistent with the Provincial Stormwater Guidebook. Specifically, the volumetric reduction section may use the Guidebook's "MAR" wording.
- The attenuation criteria should address consecutive storms
- The volumetric reduction target should state the initial moisture conditions and time to drain time.

RESOLUTION BY ENVIRONMENTAL SUB-COMMITTEE

It was resolved that a new blended criteria made sense, and since the DFO is revising their criteria, now is the time to make changes. Further, it was agreed that by meeting DFO's new criteria for new impervious surfaces, the minimum effort could be followed.

COMMENTS BY SILG:

- Stormwater guidelines are not regulations.
- Should DFO and Provincial Stormwater Guidebooks be incorporated?
- Updates for Environment Canada.
- Template should address criteria now.
- Individual cities have own bylaws.
- With respect to volume and rate, the DFO criteria are more applicable to freshwater environments.
- Water quality applies to both.

RESOLUTION:

The resolution by the sub-committee was adopted. It was strongly recommended that SILG be involved in the DFO's criteria review process.

April 28, 2005

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Appendix C

Background Development of ISMP Template

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CONTENTS

TABLES

1. INTEGRATING PAST GVRD STORMWATER INITIATIVES

This section provides general guidance on using existing GVRD stormwater documents prior to 2002. It also comments on the Stormwater Policies listed in the LWMP and on how they might be translated into stormwater management practices. It is not intended to be a comprehensive review, analysis and summary of past work.

This section was also written as part of the original 2002 work, and should be read in that context.

1.1 PAST GVRD STORMWATER RELATED WORK

The GVRD worked for several years with local municipalities to develop the 1996 Liquid Waste Management Plan (LWMP) and the Stage 2 LWMP for the GVS&DD area. Major studies completed by the GVRD have been aimed at providing local municipalities with the tools needed to create and implement effective stormwater management plans. Listed below are a few of the more pertinent stormwater-related documents:

- *Options for Municipal Stormwater Management Governance - Bylaws, Permits, and Other Regulations;*
- *Best Management Practices Guide for Stormwater Management;*
- *Liquid Waste Management Plan;*
- *Liquid Waste Management Plan - Stage 2,* including *Appendix G: Stormwater Management;*
- *Proposed Watershed Classification System for Stormwater Management in the GVS&DD Area;*
- *Assessment of Current and Future GVS&DD Area Watershed and Catchment Conditions;*
- *Stormwater Management Practices and Expenditures by Municipalities;*
- *Integrated Stormwater Management Strategy for Stoney Creek*
- *Brunette Basin Watershed Plan.*

Many of these documents are available on-line at www.gvrd.bc.ca/services/sewers/drain/stormwater_tech_group.html.

Local municipalities and agencies may find the following elements of the above documents particularly useful:

- watershed and goal setting processes;
- watershed and stream classification system;
- summaries of existing and future land use projections and impervious areas;

- list of elements that make up an effective stormwater management program;

- Best Management Practices (BMP) selection and application protocols;

- ability to tailor the structural and non-structural stormwater management practices to meet the local needs of the city and the region (i.e. rural, developing and urbanized cities and watershed; and

- draft by-laws to create the local legal authorities needed to develop, implement and enforce the various stormwater criteria and practices.

2. TRANSLATING STORMWATER POLICIES INTO PRACTICE

REVIEWING LWMP POLICIES

A review of the *Stormwater Management Plan*, Appendix G of the *Liquid Waste Management Plan Stage 2* (LWMP-2), reveals that stormwater has been classified as a major source of pollutants and is to be managed under the objectives of the LWMP.

Although the region is spending about $33M annually on stormwater management, "…*in many areas of the region, current approaches to stormwater management and land development do not adequately protect the environment of small streams in watersheds experiencing significant population growth".*[1]

As a result of this finding, the GVRD and its member municipalities have decided to implement an integrated planning approach to stormwater management. Within the next five years, at least two by-laws will be created to address two of the following stormwater issues: source control, flood protection, sediment and erosion control, impervious area, and protection of riparian areas. According to the LWMP-2, watershed plans will be developed and reviewed every 12 years.[2]

"From a municipal perspective, stormwater management involves meeting the drainage needs of the community, facilitating growth, and protecting the community's natural resources, all within financial capabilities and legislative authority. Municipalities must strive to maintain a balance between the expectations of their citizens, regulatory agencies, and the day to day operation and maintenance of the existing infrastructure."[2]

"Municipalities are expected to develop stormwater management plans, which are realistic, cost effective, and supported by the community. This requires an

[1] p.1 of Ex.Summ. LLMP-2.
[2] Liquid Waste Management Plan Stage 2 - Appendix G Stormwater Management Plan (p.7).

understanding, by all parties, of what is achievable and may be helped by broad based education and training initiatives, along with extensive public consultations." [2]

GUIDING PRINCIPLES FOR STORMWATER MANAGEMENT

Guiding principles for stormwater management are to:

- strive to meet the regional objectives for Liquid Waste Management;
- be consistent with the objectives of the Liveable Region Strategic Plan;
- develop, evaluate, and prioritize management efforts in the context of existing conditions and mandates, scientific understanding, and future opportunities;
- strive to plan on the watershed scale;
- recognize the limitations of current stormwater management technology;

In addition, the stormwater component of the Stage 2 LWMP should be strategic and flexible, as the science and regulations relating to stormwater are evolving quickly. Governments must balance environmental protection with other community objectives.

TRANSLATING LWMP POLICIES INTO ISMP INITIATIVES

The GVRD's stormwater planning documents and supporting studies appear to have already provided much of the initial translation of the LWMP policies into stormwater initiatives and stormwater program elements.

RECOMMENDATIONS FOR DEVELOPING THE TOR TEMPLATE

Section 6 of the LWMP-2, *Stormwater Management Practices and Expenditures Prior to 1997*, states that a wide variety of types and levels of stormwater management were being practised, and that few of these were funded by a stormwater utility service fee. Stormwater drainage and environmental problems were not a high-ranking municipal priority. The controlling factor in the size and effectiveness of a municipality's stormwater program was budgetary constraints. The final section of the LWMP-2 states, "…implementation of the recommendations put forth in the Stage 2 LWMP will be the responsibility of local governments." [3]

It is recommended that:

- the documents developed to date by the GVRD be used to guide the development of local stormwater management plans;

- to the extent there is agreement, various elements of the GVRD documents be incorporated directly into the TOR Template;

[3] Liquid Waste Management Plan Stage 2 - Appendix G Stormwater Management Plan (p.83)

- an uniform and agreed upon process be established to rate and rank watersheds. This should be used to determine the relative value of each watershed and to help guide future investments, including stormwater controls and watershed enhancement activities;

- municipalities within each watershed work together under the watershed ranking process to tailor local stormwater management programs for consistency with the above watershed ranking and rating process;

- a comprehensive stormwater/watershed management plan be developed for each major watershed to identify problems, solutions, priorities, regional funding, implementation responsibilities and pro-rate implementation costs;

- each municipality develop local funding to ensure long-term implementation of stormwater management plans developed during this phase of the LWMP;

- within a watershed, some consideration be given to those municipalities with small populations, affected watersheds and a reduced ability to pay for stormwater management from local revenues; and

- a process be developed such that all future developers pay, as needed, to mitigate the impacts of their developments on the watershed, including drainage and stormwater runoff, habitat mitigation and enhancement and other critical watershed functions and values.

3. SUMMARY OF MEMBER MUNICIPALITY INTERVIEWS - 2001

Selected members of the Stormwater Management Technical Advisory Task Group (SWTG) were interviewed during the study process to obtain input about unique goals, objectives, concerns and priorities faced by the member municipalities. This information was used to better understand the challenges of the municipalities, and to identify what is needed to create a locally-successful ISMP that can be readily implemented by the municipality.

The following SWTG members were interviewed:

- Barry Chilibeck, DFO
- Hugh Fraser, Corporation of Delta
- Tony Barber, City of North Vancouver
- Lambert Chu, City of Burnaby
- Melody Farrel, DFO
- Vincent Lalonde, City of Surrey
- Eric Emery, SFU Development (formerly City of Surrey)
- Igor Zahynacz, City of Port Coquitlam

The key points from the interviews are summarized in Table B-1. Highlighted conclusions and recommendations for development of the TOR template are as follows:

- **Primary Objectives of ISMP:** To integrate the needs of the community with drainage and environmental concerns. To ensure public safety and protect environmental values. To integrate the ISMP with other municipal plans and decisions.

- **Significant Deficiencies in Current ISMP:** Lack of integration with land use planning. Lack of stakeholder participation, commitment, consensus and buy-in. Lack of funds. Lack of enforcement.

- **Urbanization Versus Environment:** Engineers and biologist realize that development results in impacts on the environment, and that BMPs can minimize those impacts, but not alleviate them. Planners and council typically believe that zero impact can be achieved.

- **New Tool Needed:** An environmental impacts analytical tool is missing. Participants are open to implementing a new tool as an add-on to the tried-and-true traditional methods (e.g. hydrologic modelling).

- **Land Use Planning:** ISMP and land use planning must be fully integrated. ISMP should provide direct input into the land use planning process with regard to environmental sensitivities and possibly development density recommendations.

- **ISMP Process:** Tailored to the needs of the municipality and watershed. A consultative process with wide representation of all parties with a vested interest in the watershed was favoured. It is crucial to obtain commitment from the stakeholders and set clear goals. Regulatory requirements must be satisfied, and the final ISMP decisions should be made by council.

- **Funding:** Three funding mechanisms were favoured: stormwater utilities, development cost charges, and cost sharing with other agencies and organizations. The first two would be based on a degree of impact (i.e. percentage impervious and use of BMPs) rates.

Table C-1
Summary of SWTG Committee Interviews

Interview Questions	Summary of Highlights
1. What should be the primary objectives of ISMP?	▪ Balance resource values and societal values against economic constraints. Balance stormwater management issues with environmental protection while accommodating development. Integrate community needs with drainage and environment management. Ensure public safety and protect environmental values. Achieve a sustainable community. ▪ Integrate with other municipal plans and decisions. Link ISMP with land use planning decisions (reverse the planning process: ISMP then OCP) ▪ End product should form a basis for short-term and long-term capital plans. Ensure that input is obtained from all stakeholders.
2. What significant "road blocks" have you encountered with previous stormwater management plans?	▪ Lack of integration with land use planning. It can be hard to get buy-in and support from planning. Should reverse process; instead of engineering providing services to make the land use work, should be asking first whether development can be accommodated in the watershed. ▪ Limited scope. Process is driven by development and new development gets priority. Focus on water conveyance and flood protection and not environment. ▪ Lack of public participation. Process can be difficult because people have their own agendas (pro-development or anti-development). High turn over in agency staff, therefore, very soft buy-in. Can be very long process. Conflicting agency requirements (federal, provincial, municipal). ▪ Lack of follow through commitment. Lack of enforcement. Lack of funds. Lack of identification of funds available. Lack of authority on private property and downstream landowners. Need an independent audit to ensure that ISMP objectives have been met; DFO biologists do not have the expertise.
3. Should ISMP include mitigative measures and their respective costs for various levels of environmental watershed protection (i.e. hold the line, improve conditions)? How should it be measured?	▪ Yes, very useful for cost-benefit analysis. ▪ Difficult to measure. Could be done with: performance measures based on qualitative judgement, characterising stream flows and volumes, benefits before and after development, km of stream protected, degree of flood protection, hydrology, flow ratios (Q2:baseflow), total impervious area and riparian integrity, financial and social costs.
4. Do you believe that current stormwater management technology (BMPs) can completely mitigate development impacts? Does your engineering staff, planning staff and council believe this?	▪ No, not completely, cannot replace the natural environment. There are always impacts, LIDs/BMPs can only minimise them. ▪ Engineering and biologist staff don't believe impacts can be completely mitigated, however, planners and Council do.

Interview Questions	Summary of Highlights
5. Do you believe that both development and environmental protection can be achieved simultaneously? Does your engineering staff, planning staff and council believe this?	▪ It is possible to mitigate the impacts of development, but some degradation will occur. Zero impact is not possible. Urban areas will never be pristine. Perhaps compensation can be made in other watersheds. The development and land use planning process needs to be rethought, and money has to be spent. Land development and environmental protection are conflicting goals; therefore, trade-offs are required.
6. Currently there is no proven and accepted methodology of quantitatively assessing the environmental impacts of development and the benefits of implementing BMPs. Should ISMP continue with qualitative assessments that are difficult to justify or should we use the best available science with tools/applications that are still evolving?	▪ There is a missing tool to assess environmental impacts. This has been the short-coming with previous plans. Need to quantify environmental impacts and compare existing and future conditions to evaluate whether goals and objectives are achieved. There needs to be standard methodology to ensure consistency among the plans. ▪ Suggestions of performance measures, flow monitoring, water quality monitoring, biological monitoring are costly and done over the long term. ▪ It's hard to convince people to use new science and implement change, so we should continue to use the tried and true methods, and add on the new science method. It should be a simple method that is widely accepted and understood. Hold workshops to educate people. ▪ It was suggested that a research organisation be formed under the LWMP to do research, monitoring, etc. and pool the resources for everyone to access. Currently each municipality does its own research and monitoring. It is very costly, and the information is not widely shared. There is probably a lot of redundant work being done.
7. How should ISMP influence, guide, and integrate with Official Community Plans, Neighbourhood Concept Plans, Recreation and Parks Master plans, and the GVRD's Liveable Region Strategic Plan?	▪ ISMP and OCP need to work hand-in-hand. Planners and engineers must work together. Ideally, the ISMP should direct the OCP. ISMP should be the basic building block of the other municipal plans. There is no longer the money to manage the impacts of traditional development. ISMP should make land use recommendations. ▪ In Surrey, the NCP takes into account drainage plans and governs over the OCP; therefore, land use can be modified.
8. Should ISMP provide recommendations to change land use?	▪ Yes, but difficult under the current system. ISMP should indicate sensitivities to be considered in land use planning process. Decision makers will have a clear understanding of all the issues so they can make an informed decision. ISMP could make recommendations for development densities.
9. Should ISMP cost out mitigative measures for a number of land use/development scenarios to enable planners to better assess the true cost of various land use/development scenarios?	▪ Responses ranged from yes to probably too difficult. ▪ Land use planning process should look at options for development and evaluate their pros and cons, benefits and costs. Provincial legislation should mandate that the ISMP be considered in the OCP. Right now it covers land servicing and creek setbacks, but not environment issues.

Interview Questions	Summary of Highlights
10. Should the Steering Committee administering and guiding the ISMP involve people outside city staff? What role should they play in influencing stormwater management and planning? Should the Steering Committee make ISMP recommendations and final decisions?	▪ Existing process ranges from public disinterest in stormwater with city staff making the recommendations and decisions to a full stakeholder process with extensive consultation and group recommendations and decision making. ▪ The stakeholder process can be extensive, guided by a non-biased facilitator, with a consultative committee that consists of representatives from all parties with a vested interest in the watershed. The consultative committee is charged with the responsibility of developing the ISMP, and takes ownership of the process and plan. Recommendations and decisions are made by consensus. ▪ Typically, the city staff administer the project and process because the city is putting the money forward. City staff and its consultant direct and undertake the project and its process. A wide representation of stakeholders is invited. Stakeholders provide input and are in an advisory capacity; they do not make recommendations and decisions. The city staff and consultant consider all the problems, issues, opinions, etc. to ensure that the community values are addressed and then make ISMP recommendations. The final decision is made by council, which also represents public opinion. ▪ Large consultative processes are not easy or simple. Wide representation of involvement ensures that the community values are being explored, that everyone has a say, and increases buy-in. It can also be a huge, exhaustive, expensive process, and it may be difficult to get everyone to endorse the plan. It is crucial to set benchmarks for what needs to be achieved.
11. How have you involved formalized committees such as Citizen Advisory Committees (i.e. environmental groups, stream keepers, developers, land owners) in stormwater management and planning? Was it successful? How often did you meet? Should the committee be involved in making recommendations and decision making?	
12. What stormwater related concerns do the public have in your community? How do you address them?	▪ Flood risk, erosion of private property, winter flooding of agricultural lands, lowland flooding with upland development, creek preservation, loss of fish habitat, fish protection, slope stability, spill management, water quality.
13. What is the best forum to educate your community about the level of sophistication and true meaning of stormwater management?	▪ Mailouts, workshops, newspapers, local television, local groups such as developer associations, streamkeepers, environmental groups, (it's important to involve leaders in the community), school kids' programs, hands-on interactive models, graphic simulation of alternatives, pamphlets, questionnaires, pledge programs. Websites and open houses may not be well accessed or attended.
14. How should the general public be involved in the ISMP process?	▪ All participants thought that the general public should be included to identify local concerns and issues, receive education about stormwater management, and provide input into the project and, hopefully, endorse the plan. Council represents the public and generally makes the final decisions. Only a few participants thought that the general public should be making ISMP recommendations and decisions.

Interview Questions	Summary of Highlights
15. In circumstances where either development or environmental protection must take precedence, who should make the final decision?	▪ Council, regulatory agencies, majority consensus of involved participants.
16. How will you fund stormwater programs and initiatives?	▪ Drainage capital from tax base or borrowing, development cost charges.
17. Ideally, how would you like to fund stormwater programs and initiatives?	▪ Taxes ▪ Stormwater utility. Should be based on degree of impact (indicator such as effective impervious area). Have incentives to reduce utility rate (disconnected roof leaders, etc.). ▪ Cost sharing / financial partnerships with other agencies and organisations with a vested interest (i.e., federal, provincial, municipal governments, developers, NGOs (Ducks Unlimited), BC Hydro, etc.). ▪ Development cost charges.

4. REVIEW OF CONTINENTAL ISMP EXPERIENCE - 2001

4.1 INTRODUCTION

The objective of the continental survey was to learn what has been done in terms of ISMP development in other areas of the US and Canada, how it was approached, whether it was successful, and what can be learned from others' experiences.

The initial results of the survey are presented below in the form of comments from interviews with Tom Schueler of the Center for Watershed Protection in Washington DC and Dr. Rich Horner of the University of Washington, and a summary of comments from other agency contacts.

4.2 CONTINENTAL SURVEY RESULTS

OVERVIEW OF STORMWATER MANAGEMENT PLANNING

Stormwater management planning began as part of the land use and planning processes. Its primary function was to support economic development by identifying the infrastructure (i.e. flood control) needed to support the conversion of forested lands to developed cities and towns. It was never intended to assess or mitigate the impacts of development on the environment or to develop comprehensive watershed preservation plans.

Stormwater management planning today has expanded significantly to become an holistic approach for the preservation and utilization of the various resources within a watershed. It is intended to balance the land use needs of society with the natural values and functions of the watershed, in essence, to insert resource values into the land use planning process.

There is an inherent conflict in land use/development and the preservation/protection of the environment. We attempt to manage this conflict through planning, technical strategies and implementation of stormwater management initiatives. How these are done is critical. One thing we have learned is that good stormwater management begins and ends with good land use planning.

INTERVIEW WITH TOM SCHUELER, CENTER FOR WATERSHED PROTECTION,

Tom Schueler, of Washington, DC, has been involved in the creation and implementation of well over 100 watershed and stormwater management planning processes and programs. He has indicated that although there are many master drainage plans, currently

there are very few examples of what we refer to as ISMP. The distinction is the addition of the preservation and restoration of watershed values into the traditional flood control/water quality type of stormwater management plan.

Most plans to date focus on just one or two main objectives, such as installing regional detention facilities, reducing flooding, removing phosphorous, enhancing habitat or protecting a reservoir's water quality. Another way of stating the difference between master drainage planning and stormwater management planning is that ISMP attempts to address and mitigate the accumulative, negative affects of development within a watershed. A traditional master drainage plan typically addresses only the impacts of each new individual development site with little emphasis on the various environmental/watershed values that have been lost because of that new development. That is why there are so few examples of successful integrated stormwater management plans.

The US Environmental Protection Agency has recently come to realize this and is now beginning to take a watershed-based approach to stormwater management. It realizes that regulating for just negative water quality impacts, as defined in the federal *Clean Water Act*, does little to address the natural values within a watershed or mitigate the accumulative negative impacts of development.

Tom Schueler suggests using a workbook recently completed by him and his staff: *Stormwater Management Manual: Watershed Selection Factors*. The book is based on the management concept that some watersheds are already significantly affected by development and are irreparably damaged to the point where they are not worth the investment to restore them. It may not be physically possible to restore the environmental factors within some developed watershed. The measurement of a watershed is the percent of impervious area within it. The book presents a six-step screening process to evaluate and rank individual watersheds. Watersheds containing streams with greater than 25 percent impervious area should be placed in a separate category for the purpose of attempting to regulate stormwater. Rather than stormwater management, based on achieving water quality standards, the goal of our planning processes is watershed restoration.

Two other publications mentioned by Tom Schueler were:

- *National Pollutant Removal Database* (an updated review of BMP effectiveness); and
- *Stream Restoration Practices and Assessment.*

INTERVIEW WITH RICH HORNER, UNIVERSITY OF WASHINGTON,

Rich Horner, of Seattle, WA, has a similar perspective to Tom Scheuler's. He referred us to an EPA 1997 publication entitled *Institutional Aspects of Urban Runoff Management* by Rich Horner, Eric Livingston and Eric Schaeffer. He also discussed his earlier work with the GVRD Watershed Classification System and indicated how directly applicable it was to our current efforts in creating an ISMP template.

Other cities in the US that, in his opinion, have good stormwater management programs included: Austin, TX; King County, WA; Montgomery County, MY; Orlando, FL; Bellevue, WA; Seattle, WA; Alexandria, VR; and Ft. Collins, CO.

4.3 WHAT HAVE WE LEARNED FROM 20 YEARS OF ISMP PLANNING?

WHAT IS ISMP?

Over the years, we have learned that ISMP involves a complicated public decision making process. Comprehensive stormwater/watershed management planning involves:

- a vision for the watershed to manage growth;
- a public planning process;
- a dynamic public and cultural goals setting process;
- setting and accommodating watershed priorities;
- land use plan with a myriad of policies and goals;
- a technical flood control plan;
- an inventory and protection/restoration plan for the environment;
- mitigation of the impacts of development on water quality;
- regulatory concurrence and guidance;
- public education and involvement;
- a consensus building process;
- community, business, developer, land owner, and elected official support;
- funding, staffing, organisation, equipment and training;
- a long-term commitment for successful implementation.

WHAT HAVE WE LEARNED?/ WHAT HAS WORKED WELL?

We have finally realized that the impacts of development on a watershed are usually permanent and that it often takes years of public education to create an awareness to do things differently.

There are many things that have worked well in the planning process including:

Engineering	Technical advances in the use of regional detention, on-site drainage improvements, BMPs, floodplain management, modelling and flow routing.
Modelling	Advances in the types of models available, from the Rational Method to single event and continuous simulation.
Water Quality	Improvements in monitoring techniques, identification of sources, effects and treatment.
Habitat	Inclusion of habitat factors in the planning process.
Implementation	Creation of local funding, through utility formation, and increased public awareness.

WHAT DOES NOT WORK?

Why a plan or the planning process fails is usually a combination of one or more factors including:

Planning	▪ We have not learned how to mitigate the impacts of development. ▪ We have not used public education to create public consensus. ▪ We may not be ready to make the cultural changes (i.e. in land use) that are required.
Technical	▪ We have not prioritized our planning processes to reflect the land use impacts to the watershed's natural functions locally or regionally. ▪ We have not learned how to fix affected watersheds; it takes cultural will and public commitment.
Implementation	▪ We have not planned well enough for success; i.e. we have not created the local tools needed for implementation including: ▪ Comprehensive stormwater program ▪ Legal authorities ▪ Funding ▪ Ongoing education ▪ Monitoring ▪ Inspection/enforcement ▪ Capital facilities ▪ Design standards ▪ Development review ▪ Maintenance ▪ Water quality/habitat ▪ Flood control ▪ Stakeholder outreach ▪ Spill response

WHAT NEEDS TO BE IMPROVED?

Successful ISMP requires a cultural that will ensure that the critical elements of the process are all working together including:

Planning Process	▪ Changes need to occur in the land use planning process to do a better job of converting environmental policies into practice, and learning how to assess watershed functions and balance those with other watershed priorities.
Technical Strategies	▪ Science needs to focus on measuring true watershed health, including learning how to fix affected watersheds.
Implementation Planning	▪ Plan for success by creating adequate local tools consisting of comprehensive stormwater management programs and adequate local funding to assure their future implementation.

4.4 IMPLICATIONS/RECOMMENDATIONS IN CREATING THE TOR TEMPLATE

HOW DOES A MUNICIPALITY DO IT RIGHT THE FIRST TIME?

Listed below are topics, presented in the form of recommendations, on how to correctly implement ISMP. Please keep in mind the need to tailor this information to suit a specific watershed, and its political and financial situation.

- **Process:** Should be an open public process with well-defined goals and objectives, as well as a distinct beginning and end.

- **Stakeholder Involvement:** Should be from the beginning of the process. Often, special outreach techniques are needed towards the end of the project to spread the word and create consensus.

- **Criteria:** Needs to be universally understood and accepted.

- **Regulation:** It is key to ensure correct implementation, but should also be flexible enough to allow creativity and innovation.

- **Standards:** Should be based on the goals for the watershed, and on proven science.

- **Computer Modelling:** Tailored to the needs of the watershed and drainage issues, usually continuous flow simulation provides the most accurate information.

- **Land Use Planning:** Ensure that the land use process incorporates the changes necessary to preserve, protect and enhance the environmental factors of the watershed as the land area is developed over time.

5. REGULATORY REQUIREMENTS - 2001

Legislation does not explicitly regulate stormwater discharges; however, there are regulatory requirements that significantly influence stormwater management. They are listed, according to organization, in Table C-2.

Table C-2
Regulatory Requirements Related to Stormwater Management

Agency	Statute/Regulation
DFO	*Fisheries Act* ▪ Concerned with any project, work or undertaking that could result in "harmful alteration, disruption or destruction" of fish habitat or "deposit of a deleterious substance" in fish-bearing waters. ▪ Policy objective: No-net-loss of productive capacity of habitat. Net gain of productive capacity for fisheries resources through fish habitat conservation, restoration and development.
Environment Canada	*Fisheries Act* ▪ Administers the pollution prevention provisions that prohibit the discharge of deleterious substances into waters frequented by fish. ▪ Regulates response to spills and inspections of industrial facilities, requests for remedial plans and specifications.
Water, Land and Air Protection	*Water Act* ▪ Requires approval for all short-term use, storage and diversion of water and alterations and work in and about streams. *Water Protection Act* ▪ Prohibits large scale diversion or removal of water between watersheds or outside of B.C. *Fish Protection Act* ▪ Protects fish stocks and fish habitat through the possible regulation of riparian areas, water withdrawals and stormwater runoff management. ▪ Requires review of subdivision and development applications. *Streamside Protection Regulation* ▪ Protects riparian areas that support fish life processes from residential, commercial, and industrial development.
Ministry of Agriculture and Foods	▪ Responsible for managing farmlands and farming practices (SWM related activities: development of agricultural BMPs and runoff control strategies, and participation on committees and task groups).
GVRD	▪ Develop and administer the LWMP, manage of inter-municipal drainage areas, Environmental Management Plan, Green Zones Plan, and Liveable Regions Strategic Plan.
Municipalities	▪ Responsible for planning, operating, and maintaining SWM systems with significant influence over land development and SWM on private property. ▪ Responsible for meeting the drainage needs of the community, facilitating growth, and protecting the community's natural resources. Must provide adequate drainage and flood control for public safety.

It is imperative that the TOR template satisfy regulatory requirements.

6. KEY ISMP ISSUES

6.1 DEVELOPING A SUCCESSFUL ISMP PROCESS

A successful ISMP is created through a dynamic planning process that integrates science, biology and engineering with land use planning and local community values. The balance between land use and the environment is the heart of the watershed planning process. This balance is based upon a subjective analysis provided by the citizens within the community. It is based on the their interpretation of the impacts caused by development versus the need to protect the surrounding natural environment. It is based upon their desire to sustain the current quality of life and yet protect the natural features of the watershed. These natural features provide numerous subjective benefits to the community in the form of flood control, groundwater recharge, summer low flows, habitat for fish, birds, animals and plants. However, it is difficult to put an economic value on these features; therefore, only the local residents can correctly assess them.

It is important that the overall planning process be flexible and tailored to the unique environmental, land use and community values present within each municipality and watershed of Greater Vancouver.

6.2 INTEGRATION OF LAND USE PLANNING

Traditionally, land-use planning and stormwater management planning have been conducted as separate processes by different groups of people. With increased awareness about the importance of stormwater management in environmental stewardship, and about how land use and land development should incorporate stormwater management practices, it is no longer appropriate for these planning processes to be separate. Land use planning and stormwater management planning must be integrated if effective management of stormwater resources is to occur. The TOR Template presents such an opportunity.

Future land use plans are set out in the Official Community Plan (OCP) produced by each municipality. Land use is determined by many planning factors but does not currently consider the hydrologic and environmental impacts of the development. The traditional approach has planners and engineers working independently. The planner develops the land use/development plan, and the engineer is responsible for servicing and mitigating the impacts of the development. Managing the consequences of pre-determined development plan can be a costly way of doing business. Mitigation costs can be prohibitive.

Better, more integrated solutions could be found if planners and engineers worked together on development plans and associated mitigative works. Several development

and stormwater management alternatives could be simultaneously evaluated and effective impervious reduction measures could be investigated, taking into consideration:

- development densities and their locations within a watershed;
- improved development standards (perhaps using design charrettes) with innovative drainage techniques; and
- low impact development (LID) standards / stormwater management BMPs.

The costs associated with each alternative would show the true cost of the development scenarios, and the preferred alternative could be selected. The optimum land development scheme could be achieved by balancing development densities and design standards with stormwater management techniques. This approach could reduce infrastructure costs while protecting the environment.

The ISMP process should include land use planning tasks to be undertaken by the planner on the study team. Tasks may include:

- reviewing existing and proposed future land use;
- identifying sensitive areas and striving for their protection;
- identifying land use planning constraints and opportunities in relation to watershed management;
- investigating setbacks, and greenway opportunities;
- identifying and evaluating development and redevelopment options that will not only minimize impervious areas, but also accomplish land use planning objectives;
- identifying and evaluating options for innovative development standards and BMPs;
- estimating cost implications;
- selecting a preferred development and mitigation strategy; and
- identifying potential changes to land use plans and guidelines for future development processes.

The Integrated Stormwater Management Plan should make both stormwater management and land use recommendations. The OCP process should mandate that the ISMP is considered whenever the OCP is updated and new land use designations are established. All municipal plans such as OCPs, Recreation and Parks Master Plans, and Strategic Transportation Plans and the GVRD's Liveable Region Strategic Plan should consider the conclusions and recommendations of the ISMP reports.

6.3 NEW ENVIRONMENTAL TOOL NEEDED

Over the last decade, general motherhood statements regarding environmental protection have been applied to stormwater management plans although there was no clear understanding of the causes of environmental impacts nor in the benefits of mitigative measures. Scientific research has recently improved our understanding of the factors adversely affecting the ecological health of creeks, and the presence or absence of fish by

identifying and prioritizing four primary factors: changes in hydrology; disturbance to the riparian corridor; disturbances to fish habitat; and deterioration in water quality.

However, this new science currently has no proven methodology for quantitatively assessing the following:

- the environmental impacts of land development and/or redevelopment;
- the relative benefits of the various stormwater management BMPs/land use planning decisions/land development schemes on watercourse health;
- the overall gain/loss of ecological health attributed to a proposed stormwater management strategy; and
- the success of the original stormwater management strategy, over time.

In the past, these items have been qualitatively assessed, rather than systematically analysed because the tools for comparison were unavailable. This has constrained ISMP development.

A standard environmental analysis methodology is required to ensure consistency among ISMP throughout the GVRD. Through discussions with the SWTG, the use of a new tool to address the above-mentioned deficiencies is proposed. It is intended to use the GVRD's *Watershed Classification System* to evaluate watershed health and the effectiveness of stormwater management alternatives. This provides a quantitative approach to environmental planning.

This methodology may be incorporated into the ISMP process as an environmental decision-making tool that can supplement hydrologic modelling. More information on this new methodology is provided in Section 10.

7. INPUT FROM WORKSHOPS

Six workshops were held with the SWTG during this study. The dates and topics of discussion are listed below.

Table B-3
Summary of SWTG Workshops

Workshop	Date	Topic of Discussion
# 1	Nov 30, 2000	Presentation and discussion regarding findings from SWTG interviews and continental survey, ISMP framework and process flowcharts (Figures 9-1 and 9-2).
# 2	Dec 21, 2000	Presentation and discussion of watershed screening approach, matrix of ISMP components and study costs for various types of watersheds. An attempt to narrow the scope for low priority watersheds was unsuccessful. It was decided to establish a minimum and maximum effort for each ISMP component.

# 3	Apr 25, 2001	Discussion regarding application of ISMP process regarding parallel initiatives, watershed sizes, and plan development decision making process.
# 4	Jun 7, 2001	Presentation of TOR Template and discussion of solutions to resolve major issues. Reached agreement on watershed size, use of classification system, and no-net-loss working objective.
# 5	Jul 19, 2001	Discussion regarding TOR Template.
# 6	Aug 30, 2001	Submission of draft report. Discussion regarding computer models, minimum efforts for ISMP components, and water quality objectives.

These workshops formed the basis for the development of the ISMP TOR Template.

Appendix D

Hydrologic/Hydraulic Computer Models for ISMP

KERR WOOD LEIDAL
associates limited
CONSULTING ENGINEERS

CONTENTS

TABLES

1. INTRODUCTION

This appendix presents a brief review of two commonly used runoff computation methods, the Rational Method and the Santa Barbara Urban Hydrograph method, and eight commonly used hydrologic and/or hydraulic models. The models, listed in ascending order of sophistication, are listed below.

- HEC-1
- HEC-RAS
- HYDSYS
- OTTHYMO
- QUALHYMO
- HSPF
- SWMM
- MOUSE

The review includes a comparison of common application and typical data requirements, as well as the advantages and disadvantages of each model, including ease of operation and typical costs. The review was completed in 2001; therefore, some comments may be slightly out of date. Table D-1 summarizes this comparison and allows a quick review of each model's uses, strengths, and weaknesses.

MODELLING RELEVANT TO ISMP TEMPLATE

The following table outlines modelling capabilities desired for ISMP modelling consistent with the requirements outlined in the template.

Table D-2
Preferred ISMP Modelling Capabilities

Preferred ISMP Modelling Capabilities	Application
Design events	To undertake hydrotechnical analysis and address flooding concerns.
Continuous simulation	To analyze typical runoff flows and durations to determine stormwater impacts on the environment.
Infiltration and groundwater regeneration	To simulate proper infiltration and groundwater regeneration during continuous simulation.
Good statistical output summaries	To efficiently analyze continuous simulation results, and develop Exceedance-Duration Curves to identify impacts, assess solutions, and size BMP facilities.
Facility routing capabilities	To assess and size diversion pipes, ponds, inlet/outlet control structures, etc.
Separate impervious and pervious area calculations	To model and assess infiltration and runoff processes relative to existing and future land use, and LID standards.
Impervious surfaces not directly connected to conveyance system	To model and assess infiltration and runoff processes relative to existing and future land use, and LID standards.

Table D-1
Summary of Hydrologic/Hydraulic Computer Models and Their Applications

	Model or Method	Type of Model	Simulation Events	Common Applications	Input data required	Model Sophistication*	Advantages	Disadvantages	Linkage to other Models or GIS	Ease of Operation**	Software Cost
1	**Rational Method**	Peak flow estimation formula	Single Design Peak Flow	▪ **Predicts peak flow rates** used for conveyance sizing. ▪ Used on small urban basins.	Runoff coefficient, rainfall intensity, drainage area	Low	Simple straight forward formula	Small urbanized basins only and used to size conveyance systems, not detention facilities	N/A	Not difficult	N/A
2	**Santa Barbara Urban Hydrograph Method (SBUH)**	**Hydrologic Model** Lumped Parameter Model	Single event	▪ **Produces hydrographs** for sizing drainage facilities such as culverts, pipes, channels, etc. ▪ Used on small to medium urban basins.	Rainfall, land use and land cover data, drainage characteristics etc.	Low	Better analytical approach than Rational Method	Single Event Used on small to medium urban basins.	N/A	Moderately Difficult	N/A
3	**HEC-1**	**Hydrologic Model** Lumped Parameter Model	Single event	▪ **Produces hydrographs** for sizing drainage facilities such as culverts, pipes, channels, etc. ▪ Used on urban, rural, and undeveloped basins.	Rainfall data, land use data, land cover, slope and flow path and simple conveyance data. Card formatted text file	Low	Simple	Single event model, requires separate hydraulic inputs	GIS linkage through *Watershed Modeling System* (WM.)	Moderately Difficult	Free (not supported) $1,600 (supported)
4	**HEC-RAS**	**Hydraulic Model**	Steady state/ Unsteady state	▪ **Predicts open channel water surface profiles and velocities** for floodplain delineation	Channel characteristics, reach topology Dialogue format	Medium	Offer hydraulic simulation through bridges and culverts; reasonably accurate water surface profile; simulate mix flow regimes	Single event; lack of pipe drainage network design capability	GIS linkage through *Watershed Modeling System* (WM.)	Not difficult	Free (not supported) $750 to $1,600 (supported)
5	**HYDSYS**	**Hydrologic/ Hydraulic Model** Lumped Parameter Model	Single event Multi event	▪ **Simulates hydrographs and facility routing, perform simple calculations** for pipe network design, and pipe inventory management. ▪ Used on urban, rural, and undeveloped basins.	Rainfall, land use and land cover data, drainage characteristics such as flow path, time of concentration, pipe network, pipe characteristics etc. Dialogue format	Medium	Separation of impervious areas into indirectly and directly connected	Incapable of addressing complex hydraulic situations	No	Moderately Difficult	$1495 for 6000 pipe/channels, manhole/nodes
6	**OTTHYMO Visual OTTHYMO SWMHYMO**	**Hydrologic Model** Lumped Parameter Model	Single event Multi event	▪ **Simulates hydrographs and facility routing** for analysis and design pipe channel/network ▪ Used on urban, rural, and undeveloped basins.	Meteorological records, land use and land cover data, drainage characteristics such as flow path, time of concentration, pipe network, pipe characteristics etc. Card formatted text file or Dialogue format	Medium	Multi Event simulation Several different hydrology methods can be used	Incapable of addressing complex hydraulic situations	No	Moderately Difficult	Free (not supported)
7	**QHM (QUALHYMO)**	**Hydrologic/Water Quality Model** Lumped Parameter Model	Single event Multi event Continuous	▪ **Produces hydrographs, statistical output summaries, water quality predictions** for ISMP, BMP effectiveness, flood, erosion studies ▪ Used on urban, rural, and undeveloped basins.	Meteorological records, land use and land cover data, drainage characteristics such as flow path, time of concentration, pipe network, pipe characteristics etc.	Medium	Continuous runoff simulation model. Excellent pond routing routines	Incapable of addressing complex hydraulic situations	No	Moderately Difficult	$1,200
8	**HSPF**	**Hydrologic / Water Quality Model** Physically based model	Single event Multi event Continuous	▪ **Produces hydrographs, statistical output summaries, water quality predictions** for detention evaluation, erosion study, flooding duration study, and seasonal flow analysis, water quality studies. ▪ Used on rural and undeveloped basins.	Meteorological records, land use and land cover data, drainage characteristics such as flow path, time of concentration, pipe network, pipe characteristics etc. Card formatted text file	High	Continuous runoff simulation model	Extensive input data required; may need separate hydraulic inputs	GIS linkage through *Better Assessment Science Integration Point and Non-Point source* (BASINS)	Difficult	Free (not supported)
9	**SWMM**	**Hydrologic/ Hydraulic/Water Quality Model** Physically based model	Single event Multi event Continuous	▪ **Produces hydrographs, statistical output summaries, water quality predictions** for design of hydraulic conveyance and storage systems, water quality studies. ▪ Used on urban basins.	Meteorological records, land use and land cover data, drainage characteristics such as flow path, time of concentration, pipe network, pipe characteristics etc.	High	Continuous simulation; Extran Block provides sophisticated hydraulic analysis; Groundwater regeneration	Difficult to create consistently stable model with reliable results	see below	Variable (see below)	Variable (see below)
	EPA-SWMM	"	"	"	Card formatted text file	"	"	Minimal graphic representation, proprietary graphic software available but expensive see below	Linkage to EPA WASP and DYNHYD receiving water quality models, and HEC STORM, eQUAL-II and others.	Difficult	Free
	PC-SWMM	"	"	"	Dialogue format	"	Graphic interface with EPA-SWMM Relatively low cost	Difficult to create consistently stable model with reliable results	Linkage to GIS through PCSWMM-GIS stand alone add-on module	Moderately Difficult	$400
	XP-SWMM	"	"	"	Dialogue format	"	Graphic interface with modified SWMM engine; Modifications to software engine have increased model stability and have added features	Costly	Linkage to GIS through XP-GIS add-on module	Moderately Difficult	$7,495 (500 nodes) to $13,995 (5000 node)
	MIKE-SWMM	"	"	"	Dialogue format	"	Graphic interface with EPA-SWMM	Costly	Linkage through MOUSE GIS	Moderately Difficult	$1,600 (100 pipes) $7000 (unlimited pipes)
10	**MOUSE**	**Hydrologic/ Hydraulic/Water Quality/Sediment Transport Model** Physically based model	Single event Multi event Continuous	▪ **Produces hydrographs and water quality predictions** for ISMP, design of hydraulic conveyance and storage systems, water quality studies. ▪ Used on urban basins.	Meteorological records, land use and land cover data, drainage characteristics such as flow path, time of concentration, pipe network, pipe characteristics etc. Dialogue format	High	Continuous simulation; stable hydraulic analysis; Groundwater regeneration	Very Costly	Can be linked to SWMM blocks: runoff, transport and extran for; Linkage through MOUSE GIS.	Moderately Difficult	$2,500 to $21,500 (50 to15,000 pipes)7 separate modules average $6,000 each.

2. Santa Barbara Urban Hydrograph Method (SBUH)

The Santa Barbara Urban Hydrograph (SBUH) method was developed to calculate flows from small to medium sized urban basins using input data that are readily available and equations that are easily understood.

APPLICATION

At this time, the SBUH method represents a better approach for designing a highway runoff detention facility, which requires a hydrograph analysis. The SBUH method models runoff by analyzing a given time period of rainfall to generate a hydrograph, which is sensitive to variations in the rainfall preceding and following the peak unlike intensity duration models which are only sensitive to the peak rainfall intensity. SBUH was specifically developed to model runoff from an urbanized, mostly impervious land use.

DATA INPUT

Produces hydrographs for sizing drainage facilities such as culverts, pipes, channels, etc.

ADVANTAGES

Simple.

DISADVANTAGES

Single event hydrology.
Hydrological parameters are estimated based on engineering tradition or judgement.

3. HEC-1

HEC-1, the Hydraulic Engineer Center-1 model by the U.S. Army Corps of Engineers, is a hydrologic model used to simulate the rainfall-runoff processes within a drainage basin, though it is primarily restricted to the simulation of a single rainfall event. The transformation of excess precipitation to direct runoff in HEC-1 is performed by using either the unit hydrograph or the kinematic wave methods.

APPLICATION

HEC-1 is typically used to simulate flow hydrographs for an open channel system during a single rainfall event. If a detailed hydraulic analysis were needed, then these flows would be input into a hydraulic model, such as HEC-2 or HEC-RAS.

DATA INPUT

Rainfall data, land use data, land cover, slope and flow path and simple conveyance data will be needed.

ADVANTAGES

Simple.

DISADVANTAGES

One of the disadvantages of HEC-1 is that it is primarily intended to simulate a single storm event and cannot perform long-term simulations. Another disadvantage of HEC-1 is that it does not contain a direct link to other hydraulic models. Therefore, the process of simulating both hydrologic and hydraulic conditions can be slightly more cumbersome than other models that perform both types of simulations.

Hydrological parameters are estimated based on engineering tradition or judgement

SOFTWARE COST

- Free (not supported).
- http://www.hec.usace.army.mil/software/software_distrib/index.html

- $1,600 (supported).
- Hastead Methods .Inc. - http://www.hastead.com/software/hecpack/default.asp?p=

4. HEC-RAS

HEC-RAS, the Hydraulic Engineering Center- River Analysis System by the U.S. Army Corps, is a one-dimensional, steady-state hydraulic simulation flow model that calculates water surface profiles using a backwater analysis technique. It can also model subcritical and supercritical mixed flow regimes, as well as the transitions between these regimes. This model uses the momentum equation in situations where the water surface profile is rapidly varied such as mixed flow regimes (i.e., hydraulic jumps), bridge hydraulics, and river confluences (i.e., stream junctions).

APPLICATION

HEC-RAS is commonly used to simulate the peak water surface elevations along open channel systems, floodplain delineation and determination of scour conditions at bridge crossings. HEC-RAS can also be used to design improvements to a stream channel, to culverts, and to bridge openings.

DATA INPUT

Typical data inputs for HEC-RAS include channel geometric cross-sections, flow rates, bridge structures, culvert geometries and material data. Flow rates are determined using published flow values or by developing a separate hydrologic model.

ADVANTAGES

HEC-RAS provides sophisticated bridge and culvert modelling capabilities that can be used to model multiple bridge and/or culvert openings at a single roadway crossing.

HEC-RAS uses the actual bridge opening geometry in its analysis, including the bridge deck, piers, and abutments, and simulates the losses commonly associated with them. It does not simplify the shape of a bridge opening during pressure flow conditions; instead, it represents the actual geometry of the bridge opening.

Culverts can be box, circular, arch, pipe arch, or elliptical in shape, and multiple culverts of differing size and shape can be modelled at a single crossing. It uses culvert nomograph relationships to establish hydraulic conditions through culverts with a variety of entrance and exit conditions. HEC-RAS also has many options for simulating different culvert shapes and can simulate multiple culvert types at a single location. HEC-RAS is, therefore, one of the most accurate and commonly used hydraulic models in the simulation of flow conditions through bridge openings and culverts.

Finally, HEC-RAS provides additional capabilities, including an alternate subarea conveyance computational methodology, an automatic Manning roughness calibration routine, and bridge scour analyses. Also, in cases of roadway weir overflow, the submergence effect is accounted for in high tailwater conditions.

DISADVANTAGES

One disadvantage of HEC-RAS is that it is a steady-state model incapable of simulating changes in flow conditions over time, such as throughout a given rainfall event.It is, therefore, difficult to use the model for certain applications, such as the sizing of detention facilities. HEC-RAS is also not designed to simulate the hydraulics of drainage pipe networks.

SOFTWARE COST

- Free (not supported).
- http://www.hec.usace.army.mil/software/software_distrib/hec-ras/hecrasprogram.html

- $750 to $1,600 (supported).
- BOSS International - http://www.bossintl.com/html/hec-ras_overview.html
- Hastead Methods .Inc. - http://www.hastead.com/software/hecpack/default.asp?p=

5. HYDSYS

The HYDSYS model is both a hydrologic and simplistic hydraulic mode. It will simulate drainage from different rainstorms for different land use. It models gravity networks and calculates flows from urban, rural and undeveloped area runoff by using several types and combinations of analytic methods such as Illinois Urban Drainage Area Simulator (ILLUDAS), rural drainage simulation using U.S. soil conservation Service (SCS) curve number method and the Rational Method.

APPLICATION

The HYDSYS model can be used to generate flow for specific recurrence and design pipe net work as well as detention/retention storage and water quality treatment volume. It can also be used as a pipe inventory management tool. The HYDSYS system can keep a record for manhole size, type and location, and pipe inspection data. The record management function can be helpful in prioritizing infrastructure upgrade.

DATA INPUT

Data input requirements are similar to those of its competitive product. They are meteorological data, single event rain fall record, land use characteristics such as land cover type, flow path, slope and time of concentration, pipe network and storage location.

ADVANTAGES

The HYDSYS offers similar function and output as most hydrologic and hydraulic modelling too. Its primary advantage is its ability to be a pipe inventory management tool, which can record maintenance history, inspection dates and comments, video reference, and pipe colour-coding according to different criteria.

DISADVANTAGES

Only single event or multi event hydrology.
No groundwater simulation
Hydrological parameters are not physically-based and are estimated based on engineering tradition or judgement.

Cannot perform continuous simulations.

SOFTWARE COST

- $1,495 for 6000 pipes/channels/manhole/nodes.

Expertware Development Corporation - http://www.civilsystems.com/hydsys.html

6. OTTHYMO, SWMHYMO and Visual OTTHYMO

The OTTHYMO model is a hydrologic/hydraulic model. It is typically used for analyzing flow for urban areas; however, it has been applied to rural watershed. SWMHYMO and Visual OTTHYMO are graphical user interfaces surrounding the OTTHYMO engine.

APPLICATION

OTTHYMO is typically used as a tool to generate flow for stormwater management analysis. The flow data information can be applied to watershed planning and storm drainage system analysis.

DATA INPUT

Data input requirements are are meteorological data, single event or multi-event, land use characteristics such as land cover type, flow path, slope and time of concentration. Muskingum-Kunge is used to route hydrographs typical channel cross-sections. It is based on the continuity equation and the storage-discharge relation. The open channel cross-sections are described with X - Y co-ordinates. Other inputs include: the average longitudinal slope, the variation of Manning's roughness coefficient across the width, and a constant (Beta), which is a function of the kinematic wave celerity.

ADVANTAGES

The OTTHYMO offers similar function and output as most hydrologic modelling tool.

DISADVANTAGES

OTTHYMO is for single event or multi event modelling only.

Hydrological parameters are not physically-based and are estimated based on engineering tradition or judgement.

SOFTWARE COST

SWMHYMO

- $1,250.
- J. F. Sabourin and Associates Inc.
  http://www.SWMHYMO@jfsa.com/html/swmhymo.htm

VISUAL OTTHYMO

- $1,950 for single licence.
- Greenland International Consulting Inc.
  http://www.grnland.com/sftware/VisOTT/visott.htm

7. QHM (QUALHYMO)

The QHM (formerly QUALHYMO) watershed model is used for producing hydrographs, statistical output, and water quality predictions for ISMP, BMP effectiveness, flood, erosion and water quality studies. The model is ideally suited for the selection and sizing of stormwater BMPs, particularly, flow control and treatment ponds.

Watershed quantity processes include surface runoff, base flow, winter runoff, soil freeze-thaw, snowmelt, and snow removal. Watershed water quality processes include soil erosion and urban runoff pollutants. Simulation of stormwater control ponds includes flow routing, mixing, transport, removal, bypass, and treatment by sediment removal and first-order reduction processes. Channel processes include flow routing and quality effects including mixing, junctions, transport, distributed and point inputs, and streambank erosion.

APPLICATION

Produces hydrographs, statistical output summaries, water quality predictions for ISMP, BMP effectiveness, flood, erosion studies. The model can applied to urban, rural, and undeveloped basins.

DATA INPUT

Meteorological records, land use and land cover data, drainage characteristics such as flow path, time of concentration, pipe network, pipe characteristics, etc.

ADVANTAGES

Continuous simulations.
Water quality simulations.

DISADVANTAGES

The hydraulic routing capabilities within the QHM (OTTHYMO) are incapable of addressing complex situations that are best addressed by using a dynamic flow-routing model.

Many of the hydrological parameters are not physically-based and must be estimated based on engineering tradition or judgement

SOFTWARE COST

- $1,200.
- Scientific Software Group.
  http://www.scisoftware.com/products/qhm_overview/qhm_overview.html

8. HSPF

The Hydrologic Simulation Program - FORTRAN (HSPF) model is a hydrologic model used to simulate continuous long-term rainfall-runoff processes within a drainage basin.

The model has two primary components to the hydrologic model (HSPF) and a hydraulic model usually HEC-2 or HEC-RAS. The routing of flows from the hydraulic HEC-RAS through the hydrologic HSPF model is defined by a series of tables (FTABLEs) that relate stage-storage and stage-discharge in each reach of the principal conveyance system. These hydraulic relationships must be generated by separate hydraulic analyses of each conveyance reach included in the model.

HSPF simulates the long-term hydrologic response of a drainage basin and provides a long-term flow record within the principal creek conveyance system. The HEC-2 or HEC-RAS portion of the model is used to simulate the hydraulic conditions along the creek, such as the water surface profile and boundaries. Although the models are separate tools, they are implicitly linked since each model is used to generate input data for the other. In particular, many of the stage-storage and stage-discharge relationships, used in the HSPF model to represent specific reaches of each creek, are generated from the hydraulic model. These relationships directly affect the routing and attenuation of flows that are predicted by the HSPF model. Once calibrated, the hydrologic model generates the final flow values input into the hydraulic model.

APPLICATION

Because of its ability to produce long-term flow records, HSPF is commonly used in the evaluation of detention facilities. HSPF is able to simulate extended or multiple storm events, which often represent the worst-case conditions needed for the design of these facilities. Statistical analysis of the long-term flow record can also be used to predict peak flow rates corresponding to specific return intervals, such as the 25-year or 100-year frequencies. Flow duration curves can be produced that summarize flow conditions for the entire long-term simulated gauge record. This information can be used to assess such issues as erosion, flooding duration and/or water quality treatment. Analysis of seasonal flows can also be useful in the evaluation of fish passage through a structure or in the evaluation of flow and/or inundation patterns within a wetland.

HSPF is generally used to assess the effects of land use change, reservoir operations, point or nonpoint source treatment alternatives, flow diversions, etc. The model applications usually used in rural and undeveloped watersheds.

DATA INPUT

HSPF can be data-intensive. It needs continuous rainfall records, land use information, stream flows, meteorological records, and often stage and discharge or stage and storage data for conveyance or storage facilities.

ADVANTAGES

The primary advantage of HSPF over other hydrologic models is its ability to produce long-term runoff simulations by using continuous rainfall data that represents actual rainfall distributions and ranges of antecedent conditions. The simulated runoff records are then used to estimate the frequency of peak stormwater flows as well as the frequency of low flow conditions throughout the basin.

DISADVANTAGES

One of the disadvantages of HSPF is that it requires extensive amounts of input data, such as continuous rainfall and evaporation data. In addition, to perform channel and reservoir routing, a separate hydraulic analysis is generally required to determine the necessary input for the HSPF model. The hydraulic routing capabilities within the HSPF model are incapable of addressing complex situations that are best addressed by using a dynamic flow-routing model.

SOFTWARE COST

- Free.

9. SWMM

The Storm Water Management Model (SWMM) is a comprehensive computer model for analysis of quantity and quality problems associated with urban runoff. It was originally based on the United States Environmental Protection Agency's (U.S. EPA's) version. It can:

- Perform single-event, multi-event and continuous simulation of long-term precipitation records.
- Model storm sewers, or combined sewers and natural drainage.
- Predict flows, stages and pollutant concentrations.

It has three modules: Runoff, Transport, and Extran. The Runoff module is used to compute the rainfall-runoff response of the defined drainage basins.

Flow routing in SWMM can be performed in the Runoff, Transport and Extran blocks, in increasing order of sophistication. The Runoff block performs non-linear reservoir routing that is incapable of simulating backwater or reverse flow conditions. The Transport block solves the kinematic wave equations and, therefore, can only simulate backwater effects within a single conduit reach. The Extran Block solves the complete dynamic flow routing equations (St. Venant equations) and can therefore simulate backwater effects, flow reversal, surcharging, looped connections, pressure flow, and interconnected ponds. Extran is particularly useful in the analysis of complex urban hydraulic systems.

SWMM has an impressive longevity. It has been used in scores of U.S. cities as well as extensively in Canada, Europe, Australia and elsewhere. A large body of literature on theory and case studies is available, partly documented in a bibliography of SWMM-related publications. The model has been used for very complex hydraulic analysis for combined sewer overflow mitigation, as well as for many stormwater management planning studies and pollution abatement projects, and there are many instances of successful calibration and verification. It has public domain status. Because extensive feedback has been received from users on needed corrections and enhancements, the model is continuously updated.

The model is designed for use by engineers and scientists experienced in urban hydrological and water quality processes. Although the user's manuals explain most computational algorithms, an engineering background is necessary to appreciate most methods being used, and to verify that the model results are reasonable.

APPLICATION

The modeller can simulate all aspects of the urban hydrologic and water quality cycles, including rainfall, snowmelt, surface runoff, groundwater simulation, flow routing through drainage network, storage and treatment. Statistical analyses can be performed on long-term precipitation data and on output from continuous simulation. SWMM can

be used for planning and design. The planning mode is used for an overall assessment of an urban runoff problem or proposed abatement options.

DATA INPUT

Depending upon the simulation objective, input data requirements can be minimal to extensive.

For hydrologic simulation in the Runoff Block, data requirements include area, imperviousness, slope, roughness, width (a shape factor), depression storage, and infiltration parameters. Additional data are required if simulation of snowmelt, subsurface drainage, and infiltration/inflow options are employed. The subsurface drainage option is especially useful in locations where true overland flow rarely occurs because of flat, sandy soils.

Input data for flow routing includes shape and dimensions of closed conduits and open channels, slope, roughness; and for Extran, invert and ground surface elevations. Additional information is required for the description of weirs, orifices, pumps and storage, if simulated. Extran can also simulate dynamic boundary conditions, e.g., tides. Storage-indication routing may be performed in the Transport and Storage/Treatment Blocks, with appropriate data on volume vs. outflow.

ADVANTAGES

In general, one of the advantages of SWMM-based models is that the hydrological calculations are physically-based. This means that the model maximizes the number of parameters that can be measured and minimizes those which must be estimated based on engineering tradition or judgement. The physical basis enables the same model to be used for all antecedent design conditions, and both frequent and extreme events it is suitable for continuous (multi-year or typical year) modelling.

In general, one of the advantages of SWMM-based models is their ability to analyze a wide variety of hydraulic facilities. The results of hydrologic analyses can be easily used to perform hydraulic analyses. Dynamic flow routing is provided through the Extran module, giving the model computational capability to address complex hydraulic conditions.

As previously described, SWMM-based models are typically used to evaluate and design both closed storm drain systems as well as open channel systems. This includes the design of conveyance pipelines, open channels, detention facilities, combined sewer overflow systems, and bypass pipelines.

Quality processes are initiated in the Runoff Block and include options for constant concentration, regression of load vs. flow, and buildup washoff, with the latter requiring the most data. Additional options include street cleaning, erosion, and quality contributions from precipitation, catchbasins, adsorption, and base flow. EPA

Nationwide Urban Runoff Program data are often used as starting values for quality computations. Quality routing in subsequent blocks (except for Extran) requires few additional data, except for the Storage/Treatment Block in which several removal processes can be simulated.

DISADVANTAGES

Technical limitations include lack of subsurface quality routing (a constant concentration is used), no interaction of quality processes (apart from adsorption), difficulty in simulation of wetlands quality processes (except as can be represented as storage processes), and a weak scour deposition routine in the Transport Block.

One disadvantage of the SWMM-based models is that, even though the Extran module is capable of computing very complex hydraulic conditions, it can be difficult to create a consistently stable model that produces reliable results. The modeller must carefully review the results of the model and is often required to perform extensive adjustments to the Extran input parameters to produce both stable and reliable results.

9.1 EPA-SWMM

One of the biggest impediments to EPA-SWMM usage is the user interface, with its lack of menus and graphic output. The model is still run in a batch mode (the user constructs an input file with an editor), unless third-party software is used for pre- and post-processing (i.e. PC-SWMM, XP-SWMM, MIKE-SWMM as described below).

SOFTWARE COST

- Free.
- http://www.ccee.orst.edu/swmm/

9.2 PC-SWMM2000

PC-SWMM'2000 is one of several graphical interface programs currently being sold by private vendors that are use the EPA-SWMM engine. PC-SWMM is supplied by Computational Hydraulics Int. (CHI) and works in conjunction with the Runoff, Transport, Extran, Rain Temperature, Storage/Treatment, Combine, and Statistics modules of EPA-SWMM.

SOFTWARE COST

- $400.
- Computational Hydraulics Int. (CHI) – http://www.chi.on.ca/

The purchase cost of PCSWMM'2000 is by far the lowest of XP-SWMM, MIKE-SWMM, and MOUSE.

9.3 XP-SWMM

XP-SWMM is another proprietary program that provides a graphic interface for modified version SWMM model engine. It can be purchased from XP Software.

XP-SWMM includes some additions and revisions to the solution techniques and modelling options. For example, the simulation of weirs within Extran has been modified to produce more stable results. In addition, expansion/contraction losses and exit/entrance losses are explicitly computed within Extran. Another revision within Extran is that the simulation of open channels was modified so that the main channel can fill up before being allowed to overflow onto the adjacent floodplain.

SOFTWARE COST

- $7,495 (500 nodes) to $13,995 (5000 node).
- XP Software - http://www.xpsoftware.com/

9.4 MIKE-SWMM

MIKE-SWMM is another proprietary program based on the EPA SWMM model and has the same general model structure as SWMM. It can be purchased from the Danish Hydraulic Institute (DHI) or from Boss International.

SOFTWARE COST

- $1,600 (100 pipes) to $7,000 (unlimited pipes).
- DHI Water & Environment - http://www.dhisoftware.com/mikeswmm/
- BOSS International - http://www.bossintl.com/html/mike_swmm_overview.html

10. MOUSE

MOUSE is another model used to conduct hydrologic and hydraulic analyses of drainage systems, as well as water quality and sedimentation analysis with a graphic interface.

Like the previous SWMM-based models, MOUSE is a link-node based model. It can be used to simulate backwater effects, flow reversal, surcharging, looped connections, and pressure flow. Unlike SWMM, though, it uses a self-adapting time step, rather than a constant time step, which is intended to provide more efficient and accurate results.

MOUSE is also capable of performing the continuous simulation of long-term rainfall records as well as water quality and sediment transport computations.

APPLICATION

MOUSE is typically used to evaluate and design both closed storm drain systems as well as open channel systems. This includes the design of conveyance pipelines, open channels, detention facilities, combined sewer overflow systems, and bypass pipelines.

DATA INPUT

Meteorological records, land use and land cover data, drainage characteristics such as flow path, time of concentration, pipe network, pipe characteristics etc.

ADVANTAGES

MOUSE is supposed to provide more stable and reliable results than SWMM-based models.

DISADVANTAGES

Similar to the proprietary SWMM models, MOUSE is another relatively expensive software package to purchase.

SOFTWARE COST

- $2,500 (50 pipes) to $21,500 (15,000 pipes).
- 7 separate modules, average $6,000 each.
- DHI Water & Environment - http://www.dhisoftware.com/mouse/index.htm
- BOSS International - http://www.bossintl.com/html/mouse_overview.html

3. CLOSING STATEMENT REGARDING THE USE OF MODELS

It is important to realize that there are many hydrologic and hydraulic modelling tools that exist in the market today. Each model is based on different methods and its target results and functions are also very diverse. To be compliant with the ISMP template, the computer model should be capable of the following tasks:

- Separate impervious/pervious area calculations;
- Impervious surfaces not directly connected to conveyance system;
- Continuous simulation with infiltration and groundwater regeneration;
- Good statistical output summaries; and
- Facility routing functions.

No one product is capable of solving all stormwater management problems. Moreover, the modeller's experience and knowledge is critical in all modelling/simulation projects. Often, the model input relies heavily on the modeller's judgement and the accuracy of the existing known data. However, some products stand out as better choices for ISMP. They are listed as follows:

- QUALHYMO
- HSPF
- SWMM
- MOUSE

SWMM is the choice for a good overall planning and design tool. It is a well-established, versatile modelling product that is capable of analyzing hydrologic, hydraulic and water quality issues. It is physically-based with excellent infiltration and groundwater regeneration functions for continuous simulation. QUALHYMO may be good in some applications, but it is a lumped parameter model, and it has simplistic hydraulic capabilities. HSPF is best applied to rural watersheds and, therefore, has limited application in the GVRD area. MOUSE is an expensive model. Therefore, SWMM may be the preferred modelling choice depending on the application.

Appendix E

Template Questions and Answers

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CONSULTING ENGINEERS

The following questions represent a summary of the key issues raised after the release of Draft #1 (August 2001). Answers endorsed by the SWTG are provided in italic:

GENERAL COMMENTS:

1. Many wording changes have been suggested and have been incorporated

2. An executive summary will be provided.

SPECIFIC QUESTIONS:

1. "Watershed Classification System is based on impervious area and riparian forest integrity and is applied to urban streams. If watershed system is totally enclosed, the Watershed Classification System can not be used. How will no-net-loss objective be applied? How will no-net-loss objective be applied to the enclosed system watersheds tributary to river systems? How will no-net-loss objective be applied to the watersheds that are drained by means of man-made drainage canals with no riparian corridors? Does it mean that watershed health rating should be based on different criteria or it simply would not apply and conventional master drainage plans could be used?"

   The Watershed Classification System can still be applied to systems described above. However, the system will obviously show that the watershed has poor health. This may still be useful to assess the impact of possible long term solutions such as day-lighting projects and changes to development standards.

   For totally enclosed systems it will be impossible to measure the benthic community in order to establish the current health of the system, but the watershed will have a score of 10 – the lowest score possible. In these cases, yes, coventional master plans should be followed provided the stakeholder process supports that direction.

   For semi-enclosed systems and ditch systems the same benthic monitoring and scoring system can be used to determine a B-IBI score. The score can still be used to determine the no-net loss objective over time.

   "It is understood that regulatory agencies will be a part to the ISMP process. Does it mean that ISMP recommendations will be signed-off by those agencies when ISMP is complete? Or they still have to examine if no-net-loss objective is met for each particular project?"

   Excellent question, probably the key to the whole ISMP process. A committee was struck in November to review this exact question. A memorandum is being prepared and should be available shortly. It is hoped that by conducting ISMP as defined by the TOR template, and meeting the no net loss objective, a streamlined approval process will be available. Furthermore, it is hoped that even if the regulatory agencies elect not to participate in the full ISMP process for a particular basin (ie. are only involved in Phase 2 on Figure 9-1 (now Figure 1)), the same approval process will be available.

This is obviously contingent on the no-net loss objective and a public stakeholder process being followed.

2. "Member municipalities have to undertake ISMP for each of their urban watersheds every 12 years. Does it mean one watershed in 12 years or all watersheds every 12 years?"

   The LWMP commitment is to study all watersheds in the next 12 years. Should the ongoing performance monitoring program show that watershed health is slipping, refinement or further implementation of the plan may be required. The actual capital works based on recommendations in the ISMP may take 50 to 100 years to implement.

3. "It is not clear whether or not the ISMP should only be undertaken for urban watersheds or for all watersheds in the municipality."

   The screening process identified in Section 12 (now Section 2.1), calls for ISMP to be completed for all watersheds where the total impervious area is greater than 3 % and is scheduled for future development. All other watersheds are exempt from ISMP but may be subject to other plans outside the GVRD's LWMP. Section 12 will be clarified in the final report.

4. "If the existing watershed health is in poor condition then no-net-loss still is the objective?"

   Yes, even though a watershed health is rated as poor, it can not be allowed to deteriorate further, and there may even be opportunities to improve watershed health. In fact, several watershed plans currently underway are focussed on basins in the poor category and the stakeholder processes may recommend a 'net gain' objective.

5. "We support the recommendation to conduct selective sampling to give a good snap shot of the water quality at the time a sample is taken. However, it may not reflect possible contamination cumulated in the waterbody and could not catch any spill or illegal wastewater discharge occurred outside the sampling time."

   Agreed. The water quality program outlined in the ISMP template will not address cumulated effects, and spills. However, since the ISMP template includes biological indicators (B-IBI), and if a score is lower than expected in a particular reach, it may indicate a water quality problem in a particular sub-catchment. Therefore, an inconsistent, lower than expected score, should trigger a recommendation of an additional water quality/sediment sampling program.

   "We think there is a need to sample for sediment quality which helps assess the existing level of stream contamination and establish a baseline inventory for future comparison. To catch worst case scenarios, the location of the sampling should be set in a deposition zone of a major stream downstream of a watershed. The suggested parameters to be monitored are particle size, TOC, and exotic compounds such as PCBs, PAHs and metals."

   The template adopts the approach that water quality and sediment sampling results are well documented for typical urban areas and basins with a range of impervious areas. If there is reason to believe that a watershed is atypical, or has significant industrial areas, additional sampling should be required. We will add your recommendations to the template where this will apply.

"The suggested frequency is once or twice per year. There are provincial sediment quality objectives and federal standards on sediment quality. If the data do not show any problems, sampling can be discontinued unless Spill has occurred or there are signs which warrant a reassessment of the sediment quality. On the other hand, if the sampling results show concerns with high levels of contamination, further investigation may be needed to identify potential sources of the contamination."

"The other suggested method which can effectively detect possible spill or illegal discharge of contaminated water into a stream is real-time in-stream temperature monitoring. Temperature patterns in the water can change when there is a spill or other point sources of contaminant discharge. One of the useful types of equipment is called a Tidbit which can record water temperature every 15 minutes. The equipment is inexpensive (less than $200 per piece), has a size of a lollypop, and is not easily visible once installed in the water. It has a memory of over 300 days, therefore, does not require a high monitoring cost."

Agreed. In-stream temperature is an extremely useful and inexpensive parameter to measure particularly when there is already a flow monitoring and data logger station installed on the watercourse. We will recommend that instream temperature be required for basins with impervious areas greater than 30 %, or with industrial, commercial, and institutional land uses greater than 10 %.

6. "Due to cost associated with benthic community sampling and difficulties in assessing the data, we recommend a stepwise approach that may trigger the need for this kind of sampling. For example, when a source of contamination is identified which may potentially require costly site remediation, analyzing for benthic community to determine the impact of the contamination may be needed. Under such a circumstance, we would also suggest that additional samples be taken for toxicity test. Municipalities may not be able to afford benthic community sampling in each watershed."

   It is strongly recommended that the benthic community be sampled and the B-IBI 10 scoring system be used. The cost of benthic sampling ranges from $600 to $800 per site for 3 replicates plus collection. That works out to roughly $1000 to $1500 per site. The 'minimum effort' would then be $1500. Considering the value of the information and the baseline that it can provide, it is felt that it should be the cornerstone of the ISMP process. However, we do agree that in the years following an ISMP, cheaper systems such as the % EPT or B-IBI 5 could be used to monitor trends.

7. "First I generally see a good direction in the document on how to conduct an ISMP, but I don't see direction on how to protect environmental resources. There needs to be a clearer direction identified in the document for the plan to work towards. A target of no-net-loss of fish habitat is inadequate. The plan should also acknowledge the protection of wildlife species that use aquatic, riparian or immediately adjacent habitats. I was my understanding that the guidelines in draft DFO stormwater document "Urban Stormwater Guidelines and Best management Practices for Protection of Fish and Fish Habitat, Nov. 2000 Draft" and the WLAP Instream Works Document Type 11 were to be incorporated into this planning document to provide direction on achieving no-net-loss. I couldn't find the guidelines in the document. As I have mentioned in previous meetings, for the WLAP instream works Type 11 application requirements, there is a need for the ISMPs to be the technical rational to whether the guidelines will be achieved, or be addressed as best as possible. This is critical to ensure that contradictions do not occur between the LWMP-ISMP process and works in and about a stream such as approvals for outfalls or BMP construction."

Two part answer:

A. Addressing the "Urban Stormwater Guidelines and Best Management Practices for Protection of Fish and Fish Habitat, Nov. 2000 Draft"

The ISMP template proposes to use a system based on continuous simulation modelling and statistical reporting summaries using flow-duration-exceedance curves. This type of system will predict the responses of a watershed to different land use scenarios and development standards/BMPs, and will compare it with the existing watershed conditions. The proposed system meets the intent of the above guidelines by mandating the future hydrological response for an entire watershed must match the existing hydrological response (assuming the riparian forest integrity remains constant) in order to meet the no-net loss objective. The template applies over the entire watershed, while the Urban Stormwater Guidelines can be applied to smaller sites, Also, the guidelines focus on greenfield development, and use release rates associated with pre-development conditions. Application of the guidelines in re-development areas will be difficult. For development in greenfield areas, the overall hydrology must match the pre-development hydrology meaning the DFO guideline must be met for this to occur. Additional clarification and cross-referencing will be made in the template.

Of interest, for greenfield developments, the template also meets the criteria laid out in the Provincial Stormwater Guidebook by meeting the 0 to 50 % MAR, 50 – 100 % MAR, and MAR + criteria by ensuring that the flow-duration-exceedance curves in the pre and post conditions equal each other.

B. WLAP Instream Works Document Type II

Agreed. More cross-referencing is required. We will add the references in the template.

8. "In section 11.2 (now Section 3.1) we say that consensus was reached with the SWTG to form a regional ISMP objective. With the information provided in sections 5 & 7 (now Appendix B Sections 4 and 6), and what has been presented to the SWTG so far, I cannot see achieving the objective of "no net-loss" in many cases, especially where significant urbanization occurs. We need to discuss this statement at our next meeting and make revisions.

The intent of the ISMP template is to provide a flexible process whereby trade-offs and enhancements can be made within a watershed in order to achieve an overall no net loss objective. Obviously, in smaller watersheds, the no net loss objective will be very difficult if not impossible to achieve at reasonable cost.

The key to meeting the no net loss objective is based on the following facts:

- *many of the lower mainland watersheds are already impacted by urban development;*
- *mistakes have been made in the past and can be corrected; and*
- *if a watershed is large enough, the right combination of tradeoffs and improvements/enhancements will result in the working objective being met.*

Also, I think a generic checklist of specific items that can be incorporated into ISMPs should be developed so that many of the items could be immediately incorporated into municipal policy and by-laws even before starting to spend money on initial research on each watershed (sample policy/by-law wording could also be developed)."

Agreed. It was recommended at Workshop #2 that since there will be up to 12 years separating the first watershed ISMP and the last ISMP, developing/changing municipal policies and bylaws should occur on a City-wide basis at the same time.

9. Since the ISMP template provides for a detailed riparian corridor assessment and establishes a mechanism for assessing the benefits of increasing setbacks, the process appears to be ideal at implementing the new Streamside Directive. Could additional wording be provided to facilitate this process ?

Agreed. Additional wording will be added to facilitate implementing the Streamside Directive. This will not add a significant amount of time to the ISMP process since most of the effort is in assessing the health of the corridor.

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WEXFORD CREEK ISMP

KWL applied the ISMP Template approach to Wexford Creek in Nanaimo. This represents the first pilot study of the template approach. The draft report and plan has been reviewed by the City of Nanaimo and key stakeholders (Inter-agency and Advisory Groups). The essence of key comments from regulatory agencies are summarized as follows: Answers endorsed by SWTG.

MINISTRY OF WATER, LAND AND AIR PROTECTION

- **Good approach.** Provides environmental stewardship goals with complimentary technical analysis that will complement the future development potential. Recommendations are generally supportable.

- **To much emphasis on B-IBI.** MWLAP is concerned that there is too much emphasis placed on B-IBI given both the lack of a regional index for east coast Vancouver Island streams and that it is only one of many indicators of stream health.

  Valid point for seasonal creeks. Most of the research has focussed on creeks that maintain baseflows through the summer months. The Wexford Creek ISMP recommended a modified method to address seasonal creeks, and should be confirmed. However, the ISMP process is built around maintaining/improving watershed health, and the indicator with the highest correlation to health is the B-IBI scoring system. Suggestion: no change.

- **Too much emphasis on fish.** MWLAP has difficulty with the terms "no net loss" and "net gain" as environmental goals because they speak strongly to the protection of aquatic ecosystems and fish habitat, and not to other environmental and ecological values. Don't like the perception that DFO and fish are the driving force behind the ISMP. What happens when the watershed does not have fish, or small populations of fish?

  The preservation of fish and fish habitat is driving this process. However, in the absence of fish, more emphasis will be placed on community values (ie. sustainability goals), recreational amenities, and terrestrial species and habitat.

- **Require protocols for environmental sampling and assessments.** ISMPs require repeatable protocols or standardized methodologies for fish and benthic sampling and habitat assessments. Would like to see a few selected reference sites within the watershed that are sampled rigourously for fish populations, channel and riparian conditions using the Urban Salmon Habitat Protection (USHP) or similar methodology. This will require higher fieldwork costs.

  Suggestion: incorporate USHP into the "maximum effort" heading for five to 6 representative locations. Leave minimum effort the same. Incorporating a full USHP protocol into the ISMP process will double the cost of the bio-physical inventories or more, and is not recommended.

- **Water quality monitoring.** Drop it entirely except for possible inclusion of a small suite of parameters for long-term monitoring that would be sampled in August / September.

  Suggestion: Disagree. We still need to monitor water quality in dry weather conditions to identify non-typical conditions, especially in watersheds with older infrastructure and higher percentages of industrial, commercial, and institutional land uses. Leave as is for maximum effort.

- **Performance monitoring.** Would like the results of the environmental inventory to define the monitoring approach and collect the first stage of monitoring data. Focus the environmental assessment to evaluate the current conditions of the watershed as well as collect baseline data for monitoring watershed change. Monitoring to include: B-IBI, fish populations, physical habitat parameters (including riparian), a small suite of water quality under low flows, and watershed level indicators (riparian forest and imperviousness).

  This is significantly increasing the ongoing performance monitoring effort and costs. The template is using B-IBI and the watershed classification system as an early warning indicators. If they slip, the above measures could then be used. Add to maximum effort .

- **Baseflow augmentation goals.** Suggest a baseflow goal of 10% mean annual discharge.

  Good suggestion. Consider adding to main text.

- **Stakeholder Process.** Would like to see more opportunities for stakeholder review and input into the plan. (The Wexford study included two meetings (at the beginning of the process, and after alternative development. The draft report/plan was distributed for review. One more meeting is schedule to address the comments and finalize the plan)).

- **Importance of Riparian Corridor:** Difficulty in understanding why riparian areas are significantly important in the ISMP.

  Hydrology and Riparian Forest Integrity are linked in the determination of watershed health. Therefore, riparian forests should be assessed in an ISMP. Although the streamside directive could be regarded as accomplishing the preservation of riparian areas, the ISMP will provide an additional mechanism to implement the directive.

FISHERIES AND OCEAN CANADA

- **Successful study process.** Overall the study process balances the needs of the environment with the requirement to protect private property against flooding.

- **Standard methodology for biophysical assessments.** A standard methodology for the biophysical assessment should be agreed upon and used.

- **B-IBI as a relative measure over time, but not indicator of watershed health.** B-IBI provides a quantitative measurement that was developed in the U.S., it may not provide a good assessment of watershed health for watercourses on the east coast of Vancouver Island where summer low flows are chronic. The benthic sampling provides a good benchmark level indicator for the watershed, but DFO has some reservations regarding its use for the classification of watershed health.

- **Strive for net gain.** DFO generally requests compensation ratios of 2:1 or greater, therefore to be consistent with the precautionary approach to habitat compensation, the City should strive towards Net Gain to ensure a No Net Loss of fish habitat.

The ISMP template addresses the overall riparian forest health, but does not address like for like compensation within the wetted perimeter of the creek. Suggestion: leave template definitions the same and recommend that like for like compensation issues be dealt with at the authorization stage.

- **B-IBI scores must not decline.** DFO concurs with the concept of increasing B-IBI scores and Watershed Classification System ranking through environmental improvements prior to major development. The scores and rankings must not decline.

- **Sign-off strategy.** DFO proposes to "sign on" to the Wexford Creek plan and that it will be used as a template for future development. *Fisheries Act* authorizations will be required for individual projects that result in harmful alteration disruption or destruction of fish habitat (HADD), but justification for these projects will not be required.

  Suggestion: forward Nanaimo DFO a copy of the proposed ISMP approval process

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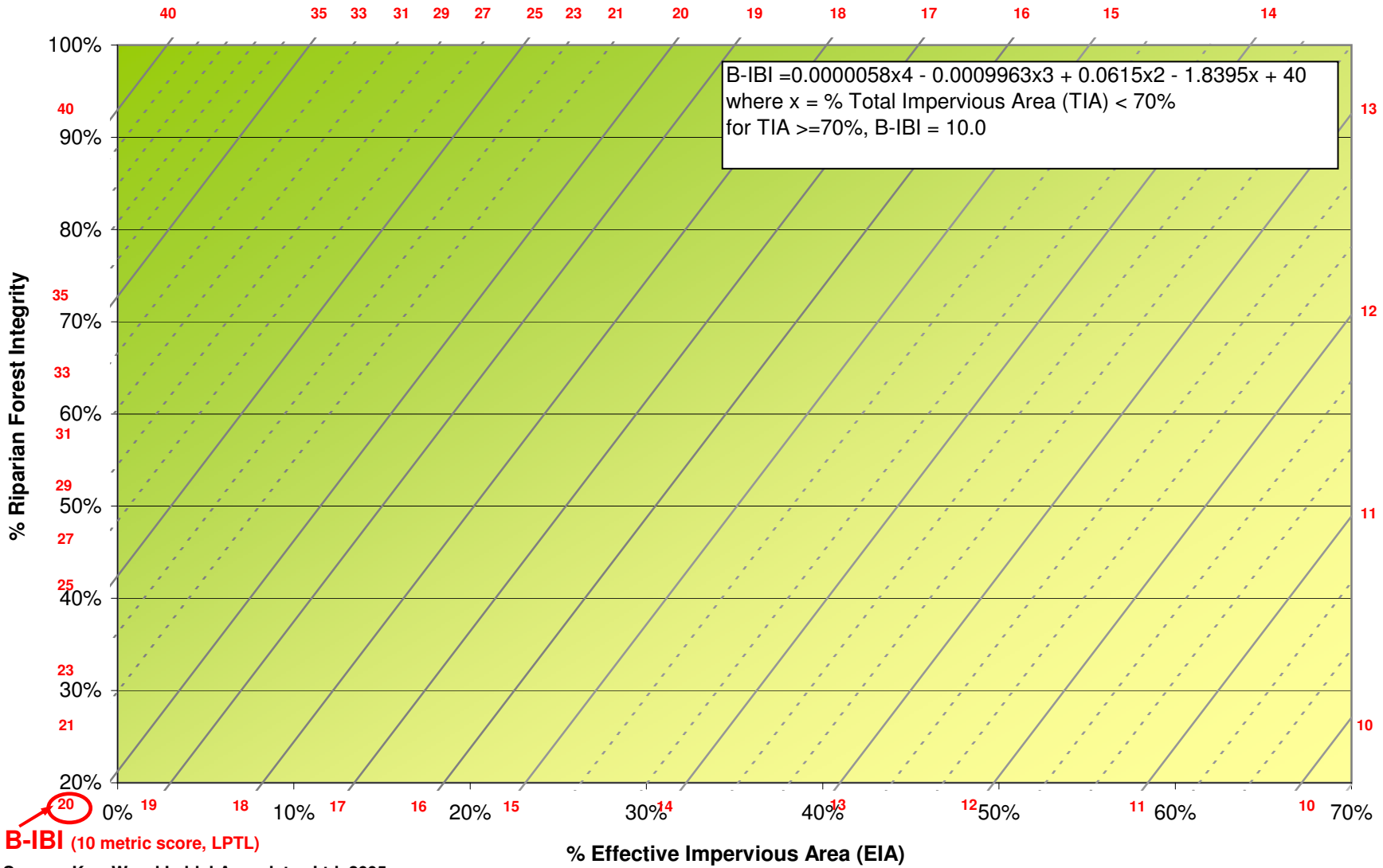
Appendix F

Blank Copy of GVRD Watershed Health Tracking System – Permanent Creeks

KERR WOOD LEIDAL
associates limited
CONSULTING ENGINEERS

GVRD WATERSHED HEALTH TRACKING SYSTEM - Permanent Flow Creeks



Source: Kerr Wood Leidal Associates Ltd. 2005

Appendix G

Sample ISMP Implementation Table

KERR WOOD LEIDAL
associates limited
CONSULTING ENGINEERS

Appendix G
Sample Implementation Strategy for Integrated Stormwater Management Plans

	Description	Location	Trigger	Impacts to Habitat	Compensation	Benefits	Relative Impact (B-IBI)	35(2) [2] Req'd	Cost Estimate	Flood Risk Management	Implemented By	Time Frame
Immediate Flood Management and Erosion Rehabilitation Works												
1.	Design and construct modifications to McDonald West Branch diversion inlet structure	Below Upper Levels Hwy	Existing structure not hydraulically operating effectively Modify inlet to address flooding, erosion and environmental protection	None. Modifications to existing structure within existing footprint.	None.	Minimizes downstream flooding, erosion and changes in hydrology due to existing and new development. Protects creek channel and instream habitat from high flows associated with development.	+2.5	Yes	$104,000	High Priority	DWV	2004
2.	Construct debris interceptor and remove bedload at Marlowe Place	Marlowe Place (East Branch)	Debris management required for mountain creek	No fish. Intermittent creek. Low habitat value. Moderate impacts to instream habitat.	Compensate with riparian reforestation and instream complexing.	Provides debris management. Increases culvert conveyance and reduces flood risk. No net loss of habitat or ecological health.	0	Yes	$93,000	High Priority	DWV	2007
3.	Assess and rehabilitate three Palmerston Ave erosion sites	Downstream of Palmerston Ave	Creek is eroding bank and threatening adjacent property and adding excess sediment load to creek	Cutthroat present. Moderate habitat value. Significant impact/improvement to 60 m length of streambank and riparian area. Difficult access.	Investigate bio-engineering solutions. Compensate with riparian reforestation and instream complexing.	Stabilizes the creek bank and reduces sediment loads to creek. Provides instream complexing and improved riparian. Net gain in habitat and ecological health.	0 [3]	Yes	$195,000	*N/A*	*DWV*	*2008-2009*
4.	Assess and rehabilitate Lythe Court erosion site	Upstream of Lythe Court (West Branch)	Creek is eroding bank and threatening adjacent property and adding excess sediment load to creek	Tailed frogs and potentially cutthroat present. Moderate habitat value. Significant impact/improvement to 10 m length of streambank and riparian area.	Investigate bio-engineering solutions. Compensate with riparian reforestation and instream complexing.	Stabilizes the creek bank and reduces sediment loads to creek. Provides instream complexing and improved riparian. Net gain in habitat and ecological health.	0 [3]	Yes	$65,000	*N/A*	*DWV*	*2009*
New Development Area												
5.	Design and construct modifications to McDonald Centre Branch diversion inlet structure	Above Upper Levels Hwy	Modify inlet to address erosion and environmental protection	None. Modifications to existing structure within existing footprint.	None.	Minimizes downstream flooding, erosion and changes in hydrology due to existing and new development. Protects creek channel and instream habitat from high flows associated with development.	+1	Yes	$69,000	High Priority	*Developer*	*2004-2005*
6.	Apply low impact development techniques to remaining homes to be built	Upper new development area	*For environmental protection*	*None.*	*None.*	*Mitigates insidious stormwater impacts of development. Indirectly protects existing habitat by mitigating development impacts (i.e. increased frequency and duration of frequently occurring events).*	*0* [4]	*No*	*N/A*	*N/A*	*Developer*	*2004-2009*
7.	Construct culvert crossing	Upper new development area	Road crossing creek	Tailed frogs and potential cutthroat present. Moderate habitat value. Moderate impacts to instream and riparian habitat.	Compensate with low impact development techniques applied to remaining homes to be built and riparian reforestation and instream complexing.	Achieves no net loss of ecological health.	0	Yes	N/A	*N/A*	*Developer*	*2004*
8.	Proceed with new development tributary to McDonald	Upper northwest corner of development area	Development Permits	No direct impacts to habitat, but significant indirect impacts of increases in hydrology that destroys and washes out habitat.	Compensate with above diversion inlet modifications.	Achieves no net loss of ecological health.	-1	No	N/A	*N/A*	*Developer*	*2004-2009*
Stormwater Program												
9.	*Update District policies, bylaws and standards to include environmental aspects of stormwater management*	*For District-wide implementation*	*LWMP, ISMP, Regulatory requirements for environmental protection*	*None.*	*None.*	*Indirectly protects/preserves existing habitat and existing watercourse health.*	*0*	*No*	*N/A*	*N/A*	*DWV*	*2004*
10.	*Develop and enforce bylaw to maintain/preserve existing riparian areas*	*Throughout creek length*	*ISMP and Streamside Protection Regulation*	*None.*	*None.*	*Maintains/preserves existing riparian corridor and habitat.*	*0*	*No*	*N/A*	*N/A*	*DWV*	*2004*
11.	*Proceed with Public Education Program with emphasis on flood risk of private creek crossings and restoring riparian areas and protecting water quality*	*Throughout Lower McDonald /Lawson watersheds*	*Homeowner's actions are negatively affecting creek – increasing flood risks, destroying riparian areas and habitat, and deteriorating water quality*	*None.*	*None.*	*Protects and may enhance existing habitat, riparian areas and water quality from adjacent landowners' impacts*	*0*	*No*	*N/A*	*N/A*	*DWV*	*2006*
Single Family Redevelopment Area in Lower Watershed												
12.	Ensure McDonald Lower diversion inlet structure is operating effectively. Modify if required	Fulton Ave	Ensure inlet operates effectively to minimize flooding	None. Modifications to existing structure within existing footprint.	None.	Minimizes downstream flooding. No net loss of habitat or ecological health.	0	Yes	$70,000	Moderate	DWV	2009
13.	*Develop and enforce standards and bylaws for single family redevelopment LID areas*	*Lower McDonald /Lawson watershed and District-wide*	*For environmental protection*	*None.*	*None.*	*Mitigates insidious stormwater impacts of development. Indirectly protects existing habitat by mitigating development impacts (i.e. increased frequency and duration of frequently occurring events).*	*0*	*No*	*N/A*	*N/A*	*DWV*	*2004-2005*
14.	*Investigate and enforce land use planning tools to increase riparian setbacks in lower watersheds*	*Lower McDonald /Lawson watershed*	*To partially restore riparian area in lower watershed*	*None.*	*None.*	*Increases riparian area and quality.*	*0*	*No*	*N/A*	*N/A*	*DWV*	*2006*

Appendix G
Sample Implementation Strategy for Integrated Stormwater Management Plans

	Description	Location	Trigger	Impacts to Habitat	Compensation	Benefits	Relative Impact (B-IBI)	35(2)[2] Req'd	Cost Estimate	Flood Risk Management	Implemented By	Time Frame
15.	Proceed with single family redevelopment in Lower McDonald	Lower McDonald watershed	Building Permits	Increases EIA from 20% to 40%. No direct impacts to habitat, however causes increases in hydrology that destroys and washes out habitat.	Enforce low impact development standards to mitigate impacts (Item 11).	Single family redevelopment.	-1	No	N/A	N/A	Landowners	2009-2014
	Apply low impact redevelopment standards and riparian setbacks (Items 10 & 12).			Mitigates hydrology and water impacts and increases riparian area and quality.	Meet 20% EIA target. Dedicate riparian setback to District and reforest.	Achieves no net loss of ecological health.	+1					
Commercial Redevelopment Area at Creek Outlet												
16.	*Develop and enforce standards and bylaws for redevelopment LID areas for commercial*	*Lower McDonald /Lawson watershed and District-wide implementation*	*For environmental protection*	*Indirectly protects existing habitat by mitigating development impacts (i.e. increased frequency and duration of frequently occurring events).*	*None.*	*Mitigates insidious stormwater impacts of development. Indirectly protects existing habitat by mitigating development impacts (i.e. increased frequency and duration of frequently occurring events).*	*0*	*No*	*N/A*	*N/A*	*DWV*	*2004-2005*
17.	Proceed with commercial redevelopment	Lower McDonald watershed	Building Permits	Increases EIA from 50% to >80%. No direct impacts to habitat, however causes increases in hydrology that destroys and washes out habitat.	Enforce low impact development standards to mitigate impacts (Item 16).	Commercial redevelopment.	-0.5	No	N/A	*N/A*	*Landowners*	*2009-2024*
	Apply low impact redevelopment standards (Item 16).			Mitigates hydrology and water impacts.	Meet 50% EIA target.	Achieves no net loss of ecological health.	+0.5					
Moderate Priority Hydrotechnical Improvements												
18.	Remove bedload at Queens culvert	Queens Ave (Centre Branch)	Sediment accumulation in culvert is reducing conveyance capacity	Cutthroat present. Moderate habitat value. Moderate impact to streambed.	Compensate with instream complexing and reforesting riparian area.	Increases culvert conveyance and reduces flood risk. No net loss of habitat or ecological health.	0	Yes	$37,000	Moderate Priority	DWV	2009-2014
19.	Construct debris interceptor at Upper Levels culvert	Upper Levels Hwy (East Branch)	Debris management required for mountain creek	No fish. Intermittent creek. Low habitat value. Minor impact to streambed.	Not likely required.	Provides debris management. No net loss of habitat or ecological health.			$39,000			
20.	Remove bedload at Westhill Drive culvert	Westhill Drive (East Branch)	Sediment accumulation in culvert is reducing conveyance capacity	No fish. Intermittent creek. Low habitat value. Moderate impact to streambed.	Compensate with instream complexing and reforesting riparian area.	Increases culvert conveyance and reduces flood risk. No net loss of habitat or ecological health.			$37,000			
21.	Construct debris interceptor and remove bedload at Langton Place culvert	Langton Place (East Branch)	Debris management and flood conveyance improvement	No fish. Intermittent creek. Low habitat value. Moderate impact to streambed.	Compensate with instream complexing and reforesting riparian area.	Provides debris management. Increases culvert conveyance and reduces flood risk. No net loss of habitat or ecological health.			$93,000			
Long Term Hydrotechnical Improvements												
22.	Construct debris interceptor at Inglewood culvert	Inglewood Ave	Debris management required for mountain creek	Cutthroat present. Moderate habitat value. Minor impact to streambed.	Not likely required.	Provides debris management. No net loss of habitat or ecological health.	0	Yes	$39,000	Long-term Priority	DWV	2014-2024
23.	Construct debris interceptor at Mathers culvert	Mathers Ave	Debris management required for mountain creek	Cutthroat present. Moderate habitat value. Minor impact to of streambed.	Not likely required.	Provides debris management. No net loss of habitat or ecological health.			$39,000			
24.	Remove bedload at Queens culvert	Queens Ave (West Branch)	Sediment accumulation in culvert is reducing conveyance capacity	Cutthroat and tailed frog present. Low-moderate habitat value. Moderate impact to of streambed.	Compensate with instream complexing and reforesting riparian area.	Increases culvert conveyance and reduces flood risk. No net loss of habitat or ecological health.			$56,000			
25.	Remove bedload at Westhill Court culvert	Westhill Court (East Branch)	Sediment accumulation in culvert is reducing conveyance capacity	No fish. Intermittent creek. Low habitat value. Moderate impact to streambed.	Compensate with instream complexing and reforesting riparian area.	Increases culvert conveyance and reduces flood risk. No net loss of habitat or ecological health.			$37,000			
Water Quality Enhancements												
26.	Provide spill control for highway drainage	Upper Levels Hwy	Protect water quality in the event of accidental spills	None.	None.	Protects water quality and habitat from toxic spills.	0	No	N/A	N/A	Ministry of Transportation	if required
TOTAL												

Notes:
Red text indicates Flood Protection Works. Green text indicates Environmental Protection works. Blue text indicates Flood Protection and Environmental Protection works. Black text indicates proposed development/redevelopment.

Italic text represents implementation items common to both McDonald and Lawson Creeks.

The order of implementation depends on land development activities in the area.

DWV – District of West Vancouver

1 B-IBI Scores: # / # = theoretical predicted B-IBI / measured B-IBI. Theoretical predicted B-IBI scores are adjusted by 0.5 minimum based on changes to percent impervious and/or the riparian forest integrity in the Watershed Classification System. Numeric values are given for quantitative assessment purposes, and are not expected to be identically replicated in the measured B-IBI scores. It is understood that benthic organisms are part of the natural environment and B-IBI scores will fluctuate according to natural systems. The B-IBI monitoring is intended to identify increasing or declining trends and be compared results noted in the future *Receiving Environment Monitoring for Stormwater Discharges in the GVRD* report.

Although the no-net-loss policy dictates that the B-IBI scores remain above 41/25, the final scores at the completion of this plan are higher. These additional points provide the District with a factor of safety should some of the above 'positive' strategies not achieve their predicted benefits. Alternatively, if the 'positive' strategies do achieve their intended benefits, the District could elect to bring forward later strategies such that the B-IBI scores remain slightly above 41/25.

2 35(2) is Authorization for Harmful Alternation, Damage or Destruction of Fish Habitat.

3 Channelization and erosion, and their repair impact the ecological health of urban creeks and the B-IBI, but is not measured in the form of percent impervious or riparian forest integrity as per the Watershed Classification System. Therefore the predicted B-IBI impact associated with erosion rehabilitation or channel complexing has not been estimated. Rehabilitation of erosion sites benefits the creek health by minimizing sediment input to the creek and creating habitat complexity.

4 Low impact development provides backup to diversion for mitigating changes in hydrology.