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DISTRICT OF CENTRAL SAANICH

Integrated Stormwater Management Plan

Watershed Reports: Hagan-Graham, Tetayut, McHugh-Noble

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PROJECT V19760100 - INTEGRATED STORMWATER MANAGEMENT PLAN
FILE LOC.: VICTORIA

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EXECUTIVE SUMMARY

The District of Central Saanich is distinguished as the first municipality on Vancouver Island to commission an Integrated Stormwater Management Plan (ISMP) pursuant to the guidelines and recommendations of the British Columbia Stormwater Planning Guidebook (BC MWLAP, 2002). ISMP is a complex process that integrates ecological, social and cultural considerations along with engineering to develop stormwater management, policies, more correctly termed “rainwater management,” that will be more holistic and sustainable. This ISMP report should be thought of as the first step in a new approach to rainwater management in the District.

The ISMP project has been conducted for Council under the supervision of the Engineering Department and the guidance of a broadly-composed Stakeholder Advisory Committee (SAC). This project has collected a large volume of hydrologic and meteorological data, performed a stream function (health) assessment for each of the watersheds, created computer watershed models, assessed the condition of built infrastructure, consulted widely with stakeholders, identified options and recommendations and produced an implementation plan for consideration by the District. The ISMP establishes an achievable vision for the three watersheds through integrating engineering, planning and environmental values for each distinctive neighbourhood.

The three major watersheds addressed in this report (Hagan-Graham, Tetayut (formerly Sandhill) and McHugh-Noble) cover an area of approximately 3900 hectares (ha), contain 32 km of creek and receive approximately 858 mm of precipitation in a typical year. This represents one of the most important District assets by any measure, with implications for everything from agriculture to recreation to biodiversity. Certain reaches of the creeks are in near-pristine condition; unfortunately more than half of the total creek length in the District is classified as “non-functional” by the commonly accepted Proper Functioning Condition (PFC) method of ecological classification and the general trend is one of decline. A variety of issues are apparent in various parts of the watersheds, including stream bank erosion, high sediment loads, excessive seasonal inundation of lowlands that reduce agricultural values, invasive species, poor water quality and encroachment in riparian areas by humans and animals.

Issues in the watersheds can be principally attributed to the extensive direct modification of creeks and wetlands for drainage purposes (such as ditching) and the incremental effects of development, creating increased runoff volumes and peak flows and reduced groundwater recharge. These changes have occurred gradually over a number of decades and are by no means a recent phenomenon. Climate change in this region is serving to exacerbate the runoff characteristics and will be an increasingly important factor in the decades ahead. Water quality impacts from the direct transfer of contaminants from roads and paved areas into creeks are also evident.

Historically, stormwater management has been approached from the point of view of hydraulic efficiency; that is, removing rainwater from the land and into fast conveyance systems as quickly as possible. As elsewhere, this approach has led to cumulative deleterious downstream effects in the District because the streams cannot handle the volume and instead erode or flood in areas and at a frequency that is not natural. Stormwater (rainwater) management practice has shifted toward source controls, rainfall capture and use of more natural methods of conveyance that slow, filter, absorb and detain water.

The project team has determined that increasing rainfall capture (the proportion of rainfall that is allowed to infiltrate into the ground as opposed to immediately entering drainage systems) is one of the most important strategies in rainwater management for the District and one supported by modern practice and experience. The effects of increased rainfall capture include reducing peak flows in creeks, reducing runoff volumes and increasing summer base flow in creeks, which are all desirable effects. Rainfall capture can be achieved by individual property owners (downspout disconnection and rain gardens), through new municipal policy for commercial and industrial areas and through the District's own design standards and practices. Individual homeowners, acting in sufficient numbers, can have a significant impact on the health of the watersheds. Another important general strategy is to increase rainwater detention capacity in the watersheds by increasing riparian zones, implementing new ponds and wetlands and, where feasible, making better use of existing ponds.

One of the most important and persistent issues in the watersheds is the seasonal inundation of lowland farming areas (Maber Flats and Martindale Valley). It is clear that complete elimination of this flooding is neither practical nor desirable. In the winter months, these areas act to cushion the downstream watercourses from the impacts of large storms and provide valuable habitat, especially for migratory bird species. It is also important to note that these areas were historically wetlands as evidenced by historical maps and the deep organic soils. Nonetheless, better control of flooding during the agricultural "shoulder" seasons (spring and fall) could have a major positive impact on agricultural values in the District and should be able to be implemented without serious conflict with other watershed values. This report recommends that the District consider certain integrated drainage and watercourse improvement projects that demonstrate multiple benefits (drainage improvements, peak flow reduction, wetland restoration, increased wildlife habitat, fish enhancement and restoration of opportunities for First Nations cultural practices).

Stormwater modelling conducted as part of this project has indicated that for Maber Flats, a combination of hydraulic improvements in the watercourse between the Flats and Centennial Park, a constructed wetland of 5-10 ha. in area within the Flats area and a new adjustable control structure could achieve better control of flooding in the "shoulder" agricultural seasons as well as the additional benefits cited above. A number of issues would have to be carefully addressed as part of this initiative including compatibility with agricultural land reserve standards, interactions with agricultural drainage systems, changes in cropping patterns, long term effects on organic soils and the specific requirements for agricultural, habitat, and rainwater management objectives month by month through the year. This report provides a framework for this initiative and addresses approximate costs and possible funding mechanisms.

A combination bioinfiltration / detention facility of approx 0.5 ha. in the hydro right of way (ROW) near the western stormwater discharge from Keating Industrial Park is recommended to address water quality issues as well as erosion issues in Stephens Creek (a.k.a. "Stinky Ditch").

In Martindale Valley, modelling has indicated that a combination of hydraulic improvements in the vicinity of Dooley Road, a detention pond of approx 1.5 ha. on the west flank of the Valley near

Martindale Road and a new adjustable control structure at Dooley Road could achieve better control of flooding in the "shoulder" agricultural seasons as well as control of peak flows into Saanich.

Desirable locations for other, smaller ponds and wetlands dispersed through the watersheds have been identified.

Water quality impacts are best addressed by regular monitoring / servicing of oil and grit traps, use of riparian buffer zones, directing contaminated "first flush" runoff though bioinfiltration devices, which clean the water using natural processes, and encouragement of Best Management Practices (BMP's) for development, stormwater maintenance and agriculture. A host of BMP and Low Impact Development (LID) guidelines are available to guide the implementation of new rainfall capture, detention and bioinfiltration practices and these are covered in considerable detail within this report and its appendices.

This report recommends that the District consider adopting a single integrated stormwater management (ISM) bylaw to which other related bylaws would refer and making complimentary revisions to the District Policy Manual and other bylaws and instruments. This report provides some guidelines with respect to content as well as implementation. The ISM bylaw would set standards that would mandate more widespread adoption of BMPs such as rainfall capture and bioinfiltration of first flush runoff for new developments and redevelopments and integrate important elements of the Capital Regional District model Bylaw to Regulate Discharge of Waste into Sewers and Watercourses. As anticipated in the current Official Community Plan (OCP), certain changes are recommended to reinforce the connection with ISMP.

The District has a very large watershed area and a limited tax base and must look to innovative approaches to implement improvements in a cost-effective manner. External funding sources are possible for certain projects and these are described in the report. Some changes, such as improved seasonal drainage in fertile agricultural areas or property value enhancement through creek restoration, can produce a net economic benefit to the District and mechanisms might be found to partially or fully self-finance such projects. In any case, judicious selection of expenditures, the use of external funding sources and the contributions of individual property owners and non-profit groups can all help provide leverage for the District's efforts.

The project team has been continually impressed by the amount of knowledge and interest expressed by residents and stakeholders throughout the public consultation process. One of the most important recommendations of the Stakeholder Advisory Committee is the establishment of a "Healthy Watersheds" (or similar) Committee to help maintain momentum on the various ISMP initiatives. This committee is essential to ensure the implementation of the recommendations in this report and to provide an on-going source of community feedback and monitoring. One of their most important functions however, will be community outreach and education to ensure that all citizens of Central Saanich become participants in improving the management of rainwater in their community. Of course, coordination of ISMP related activities will remain the primary responsibility of District staff and additional resources will be required, commensurate with the District's increased role in rainwater management.

The Implementation section of this report includes a detailed Implementation Plan, with a proposed list and schedule of activities, programs and projects arranged according to priorties. In each case, the linkage with ISMP objectives is described, the resources required for implementation are identified and possibilities for funding are listed. Despite the level of detail, the Plan must be regarded as a guideline and roadmap that will need to be regularly updated and amended as the District gains experience with the ISMP process.

The Plan attempts to strike a reasonable balance between the urgency to implement ISMP objectives and the reality that resources are limited. Considering that the rainwater management issues in Central Saanich developed over many decades, they cannot be expected to be resolved quickly. Some of the more complex projects and programs are naturally suited to an incremental, collaborative approach which will take some time to fully implement correctly. A hasty program of major physical works is likely to be suboptimal and have unintended consequences. Fortunately, some of the complex issues can be approached incrementally, and the Plan breaks these projects into more manageable pieces, with partial benefits accruing in the short term.

A draft version of this final report has been on the District's web site for several months and hard copies were made available in the Mayor's office, the Library and distributed to the ISMP Stakeholder Advisory Committee members for review and comment. A consultation meeting was held with farmers/landowners and others who may be impacted by all future works. The District collected and assembled the feedback from these consultations and the report has been updated to reflect those comments.

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APPENDIX 18 GREEN STORMWATER INFRASTRUCTURE

APPENDIX 19 CDS

1. INTRODUCTION

1.1 What is an Integrated Stormwater Management Plan?

An Integrated Stormwater Management Plan (ISMP) is the product of a comprehensive approach to stormwater planning. It differs from traditional “drainage studies” in that the ecological, social and cultural dimensions of rainwater management are considered simultaneously with the hydraulic and engineering dimensions. ISMP recognizes that rainwater management is a complex issue with many stakeholders and that an integrated approach is required to identify proper policy directions.

“The purpose of an ISMP is to provide a clear picture of how to be proactive in applying land use planning tools to protect property and aquatic habitat, while at the same time accommodating land development and population growth” (BC MWLAP, 2002)

Section 2 of this Report “Principles of Integrated Stormwater Management” provides an overview of the ISMP process.

1.2 The Central Saanich ISMP project

Work on the Central Saanich ISMP project was initiated July 30, 2007 with the commissioning of a consultant team under the direction of Mr Roland Rocheleau, Project Manager and Mr Nirmal Bhattacharyya, P.Eng. both of the Engineering Department of the District and a Stakeholder Advisory Committee (SAC) led by Councillor Alistair Bryson. The SAC has wide representation from the community and related agencies and is described in more detail in Section 4.

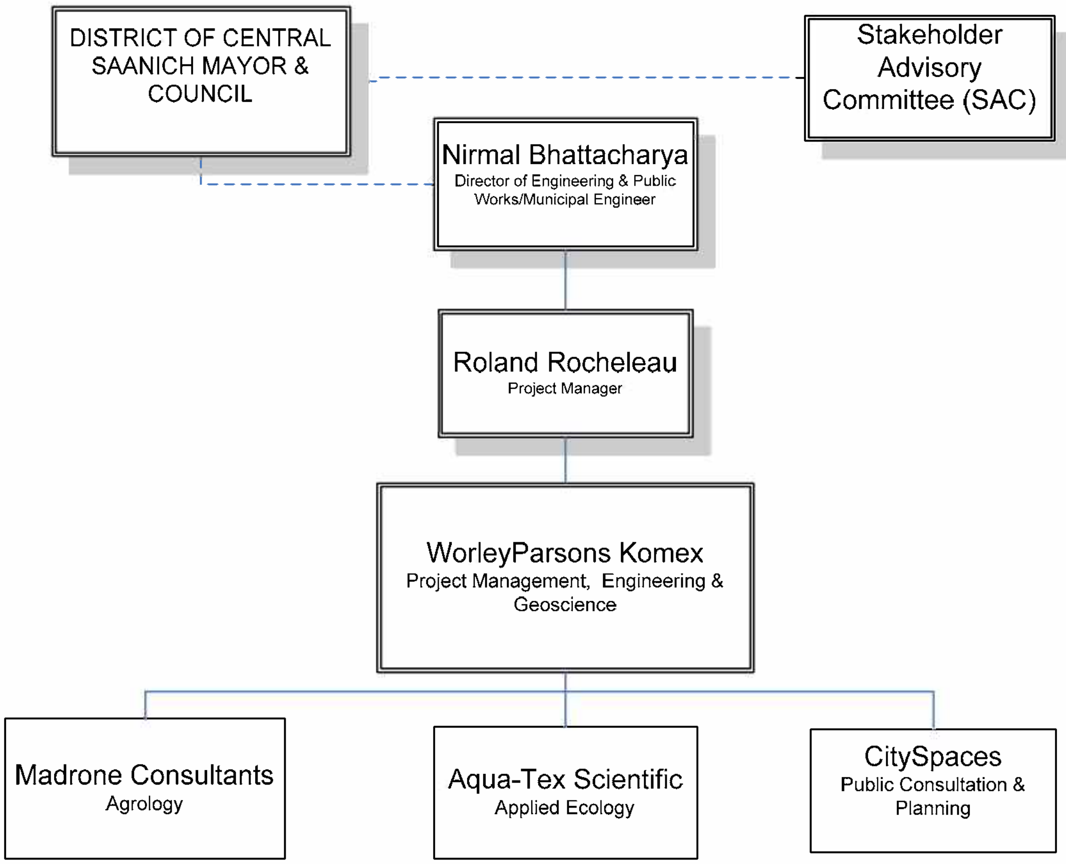
Figure A depicts the structure of the project team.

The consultant team consisted of the following principal elements:

Table A Consultant Team

Team Members	Primary Areas of Responsibility
WorleyParsons	Project Management, Hydrology, Engineering
Aqua-Tex	Aquatic Ecology, rainwater best management practices
CitySpaces	Public Consultation, Planning and Policy
Madrone Consultants	Agriculture

Figure A Project Organization



1.3 Goals and Objectives

The goals and objectives of the Integrated Stormwater Management Plan were outlined in the RFP.

"The goals of the integrated stormwater management plan (ISMP) are:

1. *To establish a practical and supportable vision for each watershed that will result in development of stormwater management solutions and policies that maintain, restore and enhance the watershed, address stormwater quality and meet engineering, environmental, economic and land use needs;*
2. *To protect the community including all land uses from excessive flooding, erosion and destruction of private and public property;*
3. *To promote community development while recognizing neighbourhood values and unique characteristics of the area;*
4. *To integrate engineering, planning, economic policies and options, which recognize the integral relationship between the District of Central Saanich and its natural and built context; and*

5. To recognize the potential impacts of stormwater discharge on marine environments and minimize discharges that have either public health or environmental impact implications.

The objectives of the three ISMP's are:

1. To document the existing conditions of the watershed including the stormwater infrastructure, biophysical inventory, and existing and future land use patterns;

2. To identify the required stormwater management infrastructure and policies necessary to balance the protection of residents and property with protection of the stream, creeks, aquatic habitat, aquifers and marine environment;

3. To ensure that the study's recommendations balance the diverse stakeholder preferences and senior governmental legislative requirements and provide for a consensus of support for the social, economic and environmental interests of the community;

4. To analyze and evaluate options that balance the multiple needs of the community that will assist the District in its decision making process; and

5. To recommend an integrated approach to achieve cost effective solutions which will assist the District in establishing stormwater policies, a stormwater infrastructure program and financial tools that support the District's land use plan."

- Request for Proposals, District of Central Saanich, 2007

1.4 Project Scope and Process

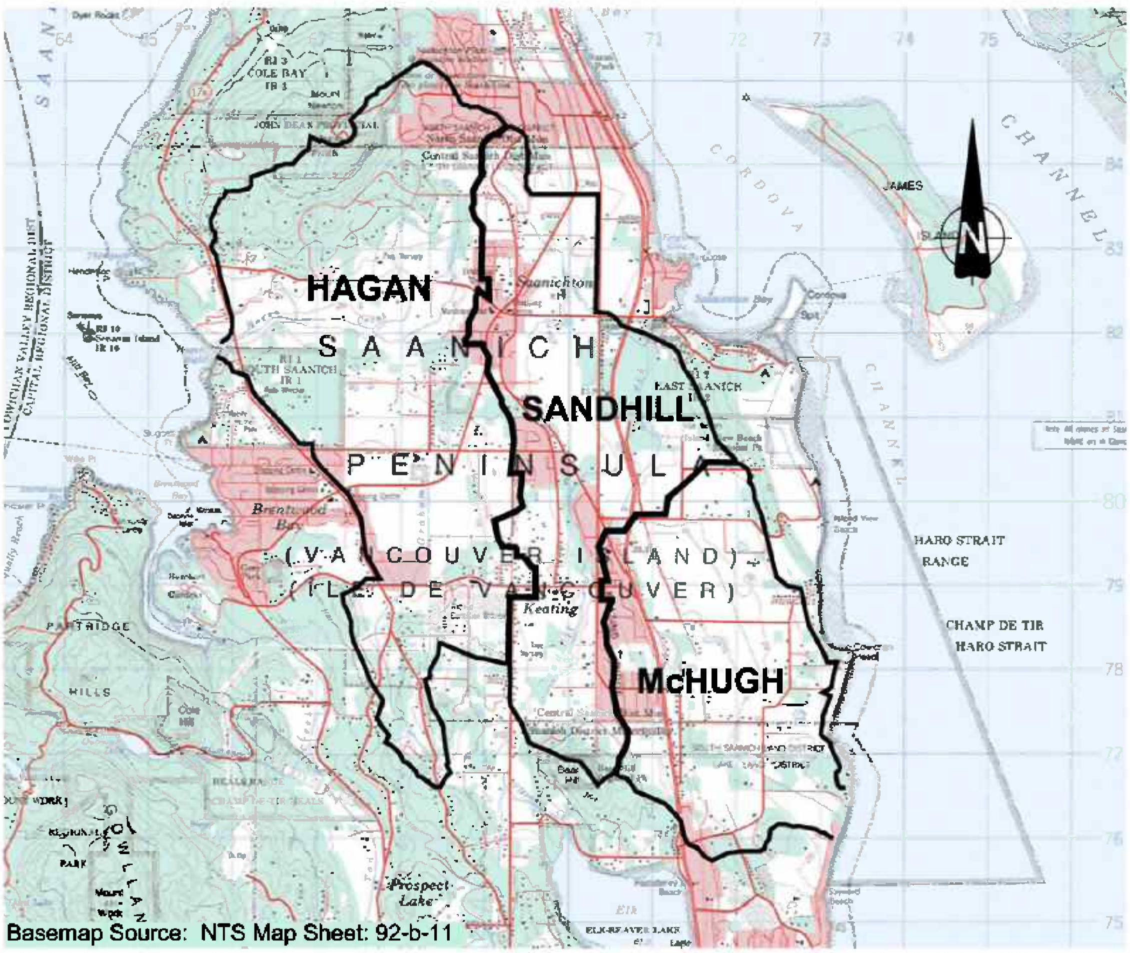
The ISMP project focussed on the three main watersheds in the District, namely:

Table B Watershed Description

Watershed	Watershed Size (ha.)	Receives rainwater from	Exports Water to
Hagan-Graham	1780	Saanich, North Saanich	Saanich Inlet (within the District)
Tetayut (formerly Sandhill)	1150	Saanich, North Saanich	Saanichton Bay (within the District)
McHugh-Noble	970	Saanich	Ocean via Saanich

The approximate watershed boundaries are illustrated in Figure B. Note that these watersheds are mostly but not fully contained within the District and interactions with adjoining Districts (North Saanich to the north, Saanich to the south, and Tsartlip and Tsawout First Nations) must be considered.

Figure B Central Saanich Watersheds



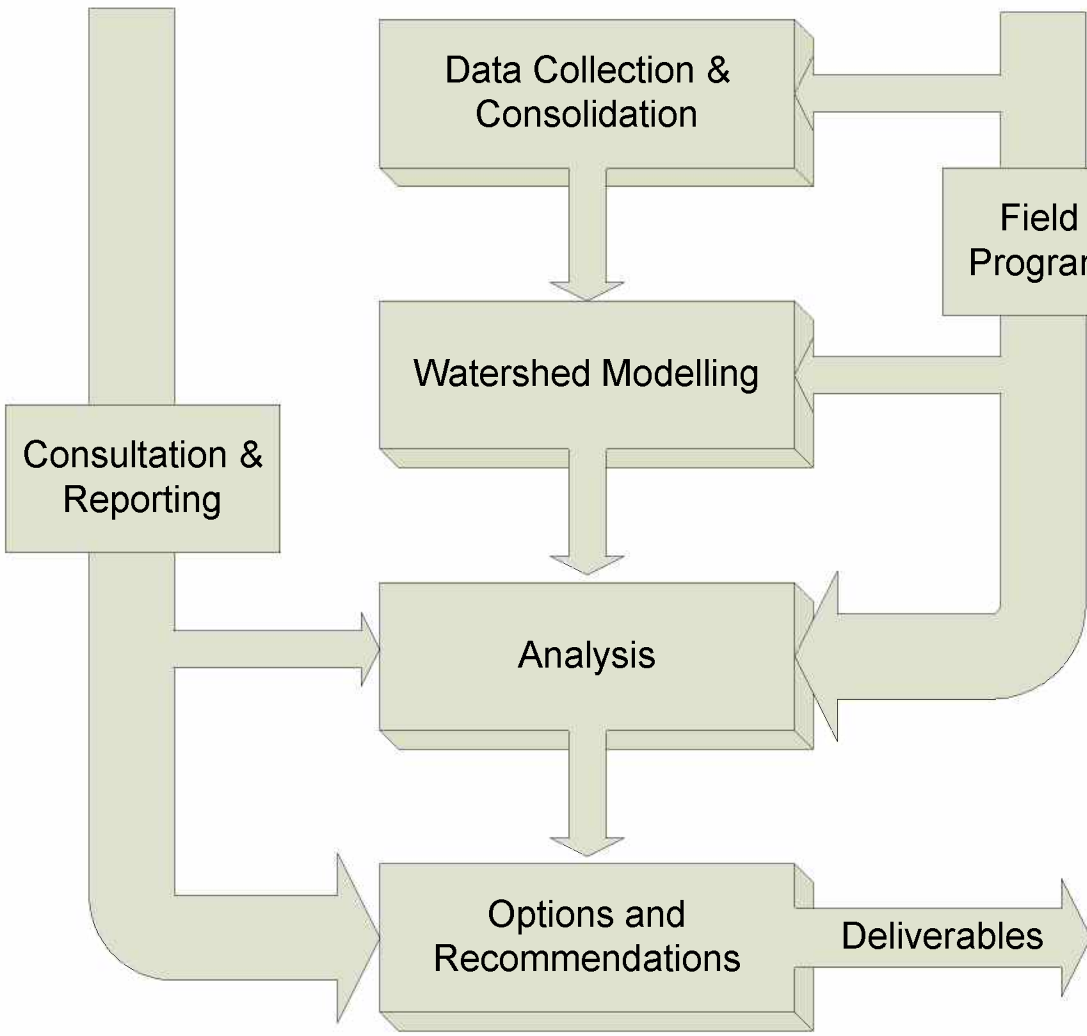
The ISMP project consisted of the following principal elements listed below in Table C.

Table C Project Scope

Project Phases	Scope
Public Consultation	Three meetings with SAC (initiation, 50%, 90%), briefings to Council, two open Houses (50% and 90%), three Creeks and Community workshops, many other consultations with community groups
Data Collection & Review	Review and interpretation of existing studies and data
Field Work	Field traverses to assess ecological and hydrological conditions of creeks and condition assessment of built infrastructure
Consolidated Watershed Maps	Compilation of data into comprehensive maps of the watersheds, including topography, soils
Flow and Meteorological data	Installation of 8 continuous flow monitoring stations, level gauges, regular collection of flow data and weather data from several weather stations in and near the District
Hydrologic Modelling	Creation of comprehensive (computer) hydrologic models for each of the three watersheds
Watershed Analysis	Integrated consideration of the ecological, hydrologic and other data for each catchment
Issues and Opportunities	Identification of principal issues in each catchment, identification of causes and assessment of opportunities for improvement
Solutions	Comparison of physical and policy options, recommendations, implementation planning

Many of these principal elements were concurrent or interactive, as illustrated in Figure C below.

Figure C Project Flow Diagram



2. PRINCIPLES OF INTEGRATED STORMWATER MANAGEMENT

2.1 Introduction

The Integrated Stormwater Management Plan (ISMP) prepared for the three watersheds develops goals, objectives and action plans to accomplish District objectives in a holistic manner.

Integrated Stormwater Management Planning is a developing field, with new and innovative strategies and solutions continually emerging and many uncertainties still remaining. Unlike its predecessor it is not a prescribed methodology or supported by a catch-all situational knowledge-base. It is at this point a concept; an ideological change of perspective on stormwater in a region-specific context inspired by an improved understanding of the cause-effect relationships between urban development, changes in watershed hydrology, and consequences for aquatic ecology. There is no single set of objectives, but a broad range of recommended strategies which must be customized and fitted to the needs of a particular region.

A number of these strategies involve the preservation and restoration of elements key to the natural ecology and hydrology. Other strategies include countermeasures to control adverse impacts of development. See Section 2.11.3 for more detail on these.

These recommendations and strategies are founded in defensible stormwater science, but can serve at best as guidelines for establishing region-specific goals, objectives, priorities and action plans. A common, science-based understanding is a necessary first step, but as this understanding continues to improve it begs the question of balance between management and science: what is the appropriate blend of policy, regulation and the complex products of science to ensure effective results?

A fundamental realization for local governments is that there remain significant scientific uncertainties underpinning the current understanding of watershed hydrology, ecosystem function and the likely effectiveness of different recovery approaches. Equally prevalent is that significant progress has been made linking stormwater impacts to development practice and altered hydrology – what is tried and tested is no longer true, and decisions need to be made in the face of these uncertainties. Letter of the law regulations will no longer suffice: an interactive, dynamic and adaptive approach to regulation and management must be instigated and iterated. The unexpected becomes the mode as humans and nature co-evolve, and systems must be implemented which permit the monitoring, evaluation and revision of management strategies; flexibility and resilience must be engineered into the very core of the management system.

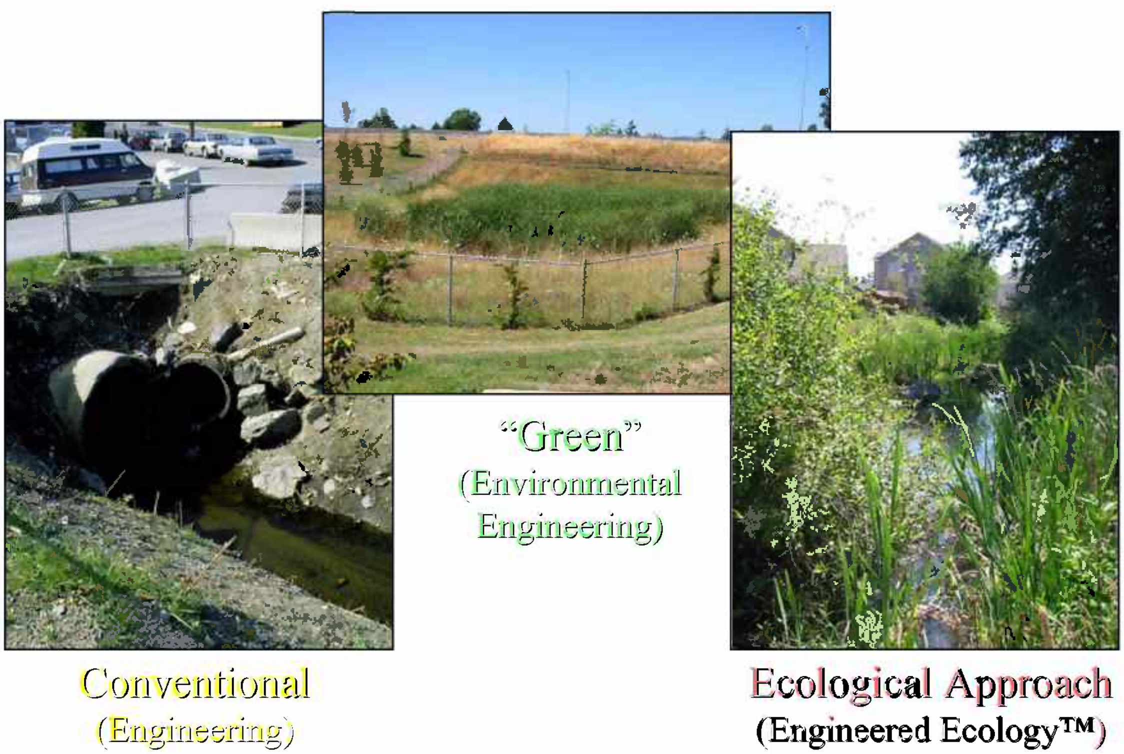
2.2 Traditional Stormwater Management

The traditional, conventional approach to stormwater management is drainage-focussed and reactive in nature with the primary objectives being to protect life and property from flooding. Erosion risks arise as unaddressed consequences of development. Land development creates impervious area and stormwater problems, and afterwards municipal or highway engineers develop 'pipe and convey' methods to drain these areas and 'solve' these problems. Stormwater is consequently collected, concentrated, and conveyed away from developments and discharged into natural watercourses as quickly and efficiently as possible.

Strictly focussed on surface runoff and drainage, the traditional approach ignores infiltration and evapotranspiration entirely, severely altering natural water balance. Much larger portions of the total annual rainfall volume are converted to surface runoff and result in many serious consequences.

What conventional engineering failed to realize was that altering water balance at a single point affects water balance progressively more at each subsequent point downstream. Stormwater problems were being solved in engineering terms, but the local and downstream effects of development were left unconsidered. By addressing them with instance-based reactive measures, stormwater-related problems were perpetuated rather than solved, detrimental downstream effects aggravated and additional reactive measures are necessitated. For example, a commercial development introduces large quantities of impervious area and the resultant stormwater runs off and causes flooding in surrounding residential areas. To solve the residential flooding problem, engineers would build ditches and piped drainage systems to discharge the stormwater into a nearby stream. Photo A compares different approaches to engineering for this type of discharge point.

Photo A Engineering Approaches to Stormwater Management



This hypothetical cause and effect string illustrates the fact that short-sighted and reactive problem solving is an ineffective stormwater management strategy. Successive missteps can escalate what is initially a local, relatively insignificant and inexpensive stormwater problem into a complex system of mutually perpetuating issues that plague an entire community.

Habitually creating and draining impervious areas throughout the length of a stream compounds these effects, and results in significant cumulative impacts. Increased runoff volumes and velocities surcharge streams and erode both sides and bottom; this material then deposits downstream and reroutes flow to create positive feedback. In the winter, streamflows originate as runoff and are flashy, contaminated and turbulent; while reduced groundwater and baseflow recharge cause low or even non-existent flows in the summer. These conditions are not supportive of sustaining vegetation in the riparian[1] corridor, which in addition to ecological destruction also increases erosion problems as reinforcing root systems are lost. Altering the functioning condition of streams in this fashion is damaging and unsustainable.

2.3 Integrated Stormwater Management

2.3.1 Reactive to Proactive: Blending Policy, Science and Site Design

Integrated stormwater management planning recognizes the need for a fundamental change in perspective regarding stormwater and land use decisions – these changes are illustrated in Figure D below. Rather than engineering-based ‘solutions’ that protect people and property from the effects of stormwater, a science-based and interdisciplinary understanding is applied to collectively manage development and watershed hydrology. The traditional scope of stormwater management is extended as diverse teams of specialists integrate hydrology, geoscience, ecology, biology, engineering, planning, landscape architecture, community values and social and economic contexts to develop proactive and innovative solutions that preserve and restore natural hydrology and eliminate stormwater and its effects at the source.

An essential part of the pre-emptive problem solving required of an ISMP is developing goals, objectives and action plans to accomplish distinct objectives in a holistic matter. Habitat and ecological enhancement planning addresses risks to water quality, aquatic resources and stream corridor ecosystems associated with erosion and sediment deposition from relatively small events. Larger, extreme events that cannot be effectively contained require flood risk mitigation planning to protect life and property from excessive flood flows. Land development planning is necessary to ensure that future development decisions integrate environmental and flood risk objectives into site-design practices, preserving or when possible restoring the natural water balance. Finally, such a holistic scope requires detailed and adaptable financial and

[1] The term riparian is derived from the Latin word “riparius” meaning “of or belong to the bank of a river” (May, 2003). Riparian areas are areas of vegetation adjacent to streams, rivers, lakes, and wetlands; all of which can or are influenced by perennial or intermittent water. Occurring at the land water junction along natural waterways forming a buffer between uplands and stream, riparian areas have been termed as the “zone of influence” or “hotspots of interactions” between terrestrial and aquatic ecosystems, riparian zones (Groffman *et al.*, 2003). “The distribution, structure and composition of riparian plant communities are largely determined by climate, light and water availability, topographic features, chemical and physical properties of the soil (including moisture and nutrient content), the existence of tributary and groundwater flows, and natural disturbance regimes” (May, 2003).

implementation planning, providing resource and support opportunities for new efforts and ensuring effective operations, maintenance and performance monitoring.

Figure D Paradigm Shift (BC MWLAP, 2002)

TRADITIONAL is defined as:		INTEGRATED is defined as:
✓ Drainage Systems	⇨	✓ Ecosystems
✓ Reactive (Solve Problems)	⇨	✓ Proactive (Prevent Problems)
✓ Engineer-driven	⇨	✓ Interdisciplinary Team-driven
✓ Protect Property	⇨	✓ Protect Property and Resources
✓ Pipe and Convey	⇨	✓ Mimic Natural Processes
✓ Bureaucratic Decisions	⇨	✓ Consensus-based Decisions
✓ Local Government Ownership	⇨	✓ Partnerships with Others
✓ Narrow Scope of Work (drainage focus only)	⇨	✓ Holistic Scope of Work (stormwater integrated with land use)

2.4 Land Use

2.4.1 Land-Use Impacts on Rainwater Management

In a naturally vegetated watershed, smaller and relatively frequent rainfall events constitute the majority of the total annual rainfall volume, and that these events have zero resultant surface runoff as the rainfall volume is well within the infiltration and evapotranspiration capabilities of trees, vegetation and naturally permeable soils. When areas are developed, natural hydrology is altered and every rainfall event results in surface runoff due to the replacement of natural landscape with impervious areas. The effects of altered hydrology manifest in stream corridors; resultant damages accumulate and cascade downstream through the watershed much in the same way as stormwater itself. The total volume of stormwater and the magnitude of its detrimental effects are proportional to watershed's impervious area. The sum of impervious areas in a watershed is called the Total Impervious Area (TIA). When runoff from a portion of an impervious area is directed to infiltration area, or captured for reuse, this effectively "disconnects" the impervious area from the receiving stream. The remaining "connected" impervious area is called Effective Impervious Area or EIA. It is the percentage of EIA that determines in large measure how runoff will affect stream health.

Decisions and policy pertaining to land use changes must be made with a full awareness of their potential stormwater impacts; and in turn stormwater management principles must influence land use and site planning.

2.4.2 Population, Development and Redevelopment

Population growth in an area can indirectly lead to increased impervious areas which can have detrimental impacts on stormwater. In 2006 the population of Central Saanich was 15,745 people (Statistics Canada, 2006). The 2006 census also showed a slower annual population growth rate of 0.5% compared to 1% for the previous five-year census period. Over the same period the annual growth rate in total dwellings was just over 1% indicating a slight decrease in household size. This slow and steady growth of Central Saanich over the last ten years points towards an increase in the densification of urban areas, which, for Central Saanich means an increase in impervious area within the three urban zones or villages, namely Keating, Brentwood Bay and Saanichton.

In addition to population increases, historical development of areas within the Municipality of Central Saanich exacerbate impacts on stormwater quality as well as quantity. The Municipality has seen much development since it's inception in 1950 and from 1956, a Zoning Bylaw has regulated land uses. To this day, almost seventy percent of Central Saanich's land base remains farms and rural non-farm holdings with the Agricultural Land Reserve (ALR) covering the majority of the district (Central Saanich OCP, 2008). An Official Community Plan (OCP) has been incorporated into the planning and development of Central Saanich since 1979. Since then the OCP has been revised three times (1985, 1990, 1999 and 2008). Development of the region has taken place in smaller urban centres and the industrial park of Keating Cross-Road, seeing rapid growth during the 1970's, late 1980's and early 1990's. The 1999 OCP concluded that there was sufficient residential capacity to satisfy housing in Central Saanich till 2015, based on a six year average growth rate of 70 new dwellings per year.

The approach of the OCP towards development is to protect agricultural land and to focus growth around existing urban centres. As part of this OCP, a housing capacity study has been completed indicating a latent capacity for an additional 750 – 1050 new dwellings. At an average annual growth rate of 1% (from 2001 – 2006), this would provide sufficient capacity to the year 2021 with the majority of this housing capacity in mixed-use residential/commercial developments.

2.5 Historical Condition

The Municipality of Central Saanich belonged, prior to 1950's, to the South Saanich Land District. In 1951, Ward 6 (Central Saanich) officially separated from South Saanich to become its own municipality with its own leadership (Green and Castle, 2005).

Once a primarily forested region, Central Saanich is now almost 70% ALR (Central Saanich OCP,2008). This change in land use is evident over time by comparing and contrasting archived air photos for the region. The change from a primarily forested to a region of agriculture and urban development has reduced the ability of the landscape to respond to stormwater / rainwater run-off. Historically, the vegetated landscape would have functioned to attenuate stormwater by acting as a shield between precipitation and the ground surface, thus reducing erosional activity and the volume of sheet flow by allowing for percolation and filtration through permeable surfaces. The ability of the present landscape to absorb and manage stormwater has been significantly reduced due to the clearing of trees for agriculture and an increase in impervious surfaces as a result of urban development.

In the past, this landscape was dominated by Garry Oak woodlands and meadows and coniferous forest with a few large wetlands (*e.g.* Maber Flats and Martindale Valley). Today, the majority of Garry Oak has disappeared (see Figure E and Figure F on following pages) while patches of coniferous forest remain such as in Centennial Park. Air photos dating as early as 1929 show a major alteration in the landscape as a result of forest clearing for agriculture and other land uses.

Figure E Garry Oak presence circa 1800 indicated by orange checkered polygons (Image source: CRD Natural Areas Atlas)

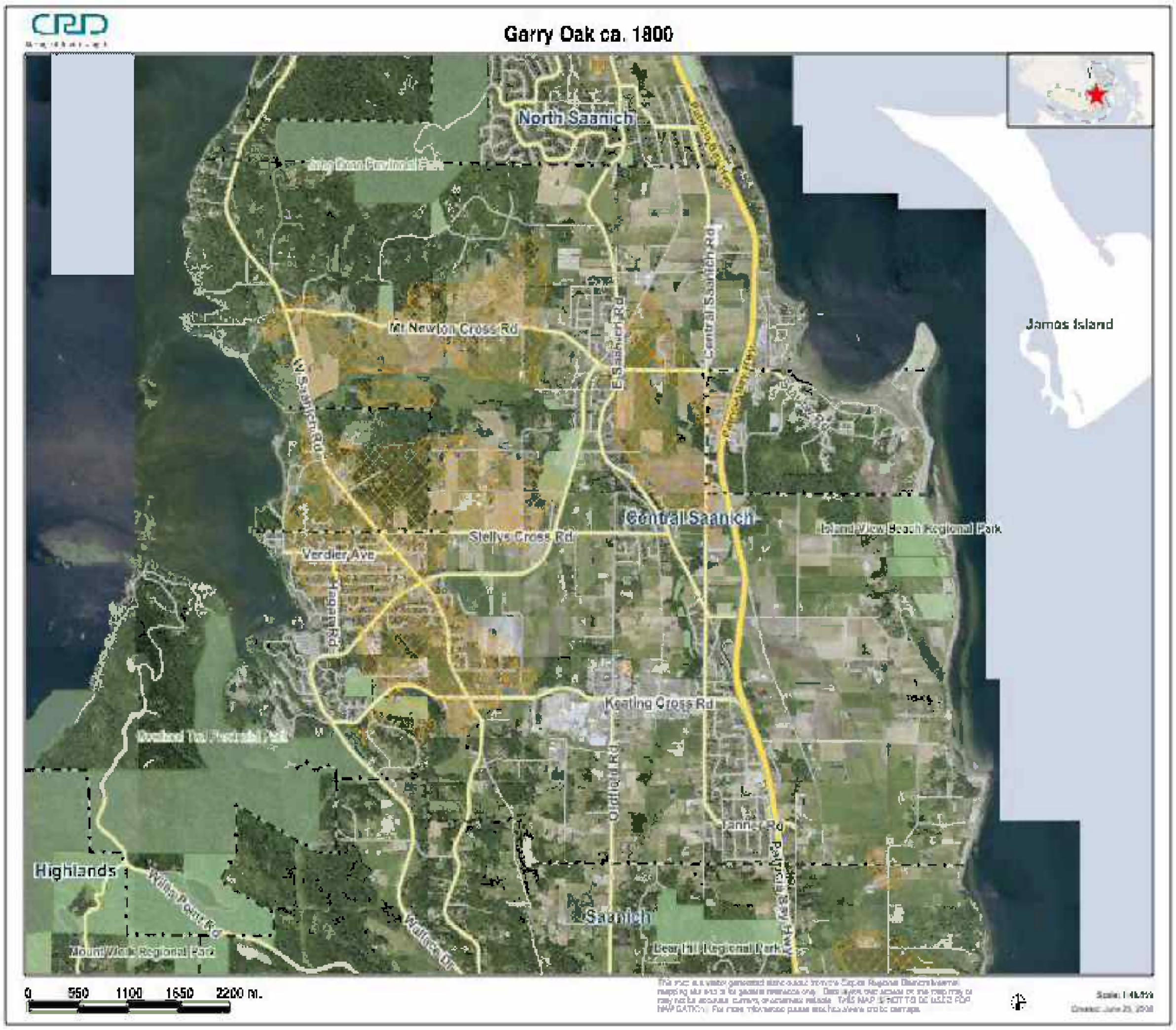
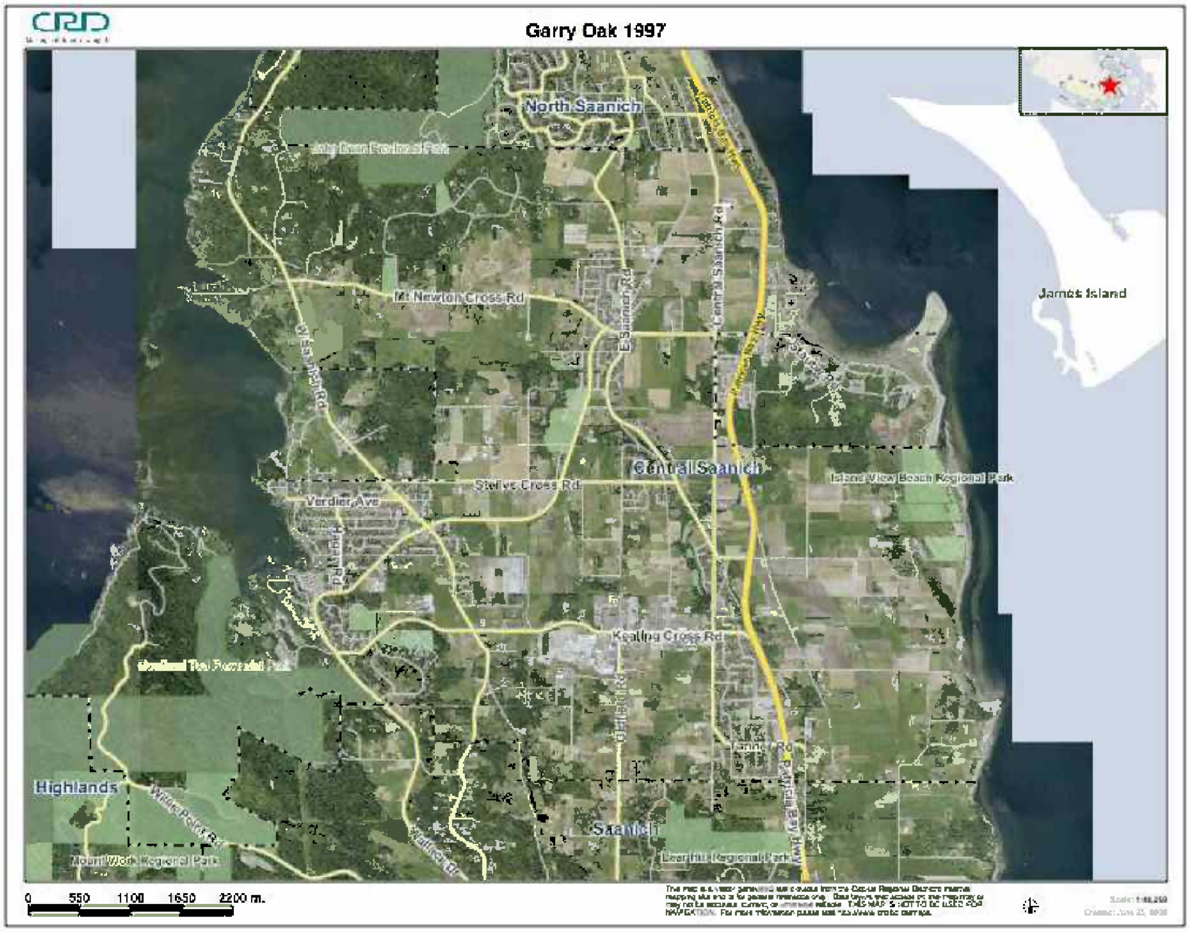


Figure F Garry Oak presence in 1997 is non-existent. (Image source: CRD Natural Areas Atlas).



Not only were forests cleared, but wetlands areas were drained and creeks ditched throughout the Municipality. Perhaps the most obvious areas, revealed by comparing historical maps to present maps, are those areas surrounding Maber Flats and Martindale Flats. In early maps (D'Heureuse, 1860 and South Saanich, 1859)), both areas are shown as being swamp-like with boundaries exceeding those present now. In some cases, references to a Maber Lake also indicate the presence of a significant aquatic environment here (Delcan, 2003).

Roads and railways have also impacted the hydrology of watersheds. The Canadian Northern Pacific Railway (closed in 1935) once ran through Central Saanich along what is now Wallace Drive on its way to Sidney in North Saanich (Virgin, 1959). Veyaness Avenue was also once a railway corridor connecting Victoria and Sidney. The large, elevated base typically required to support the railway ties effectively acted as a berm due to its size and component materials. As such, the old railway, and now the existing roads throughout the watersheds hamper the flow of the water. A good example of this is along Wallace Drive near Maber Flats. Culverts under the road allow for the movement of water but they create a bottleneck backing water up in Maber Flats whose soils do not allow substantial infiltration.

Historically, the First Nations groups in the area, the Tsartlip and Tsawout, were able to utilize the functioning watersheds for cultural practices such as harvesting cranberries at Maber Flats, fishing for salmon and other fish species in the creeks, as well as bathing, and other cultural rituals.

For more details of the specific watersheds see Section 3.3.

2.6 Agricultural Land Use

Central Saanich is the most agricultural jurisdiction on Vancouver Island. Almost 70% of the total area resides in the ALR (Central Saanich OCP, 2008). According to the Statistics Canada census in 2001, there were 167 farms reported, covering an area of 2649 ha, with an average size of 16 ha. The majority (68%) were owned and the remainder leased.

More than half of this area was dedicated to crops (rather than livestock). In 2001, crops were grown on 1637 ha of farmland, amounting to 62% of active farm use. The remaining area was reported as summer fallow (209 ha), managed pasture (120 ha), unmanaged pasture (235 ha) and 'other' (447 ha). The last category includes unimproved land and woodland.

The main crop types are field crops (1013 ha), fruits, nuts, grapes, and berries (80 ha), vegetables (194 ha) and 'other' (i.e.: not specified in census response) 350 ha.

According to the 2006 farm census, the most common fruits grown are grapes and strawberries. Some 10 farms grew grapes on a total 12 ha, and 28 farms grew strawberries on 23 ha.

A total of 136 ha were dedicated to nursery production and there were 85 ha of Christmas tree plantations.

Less than half of the farmland (767 ha or 46%) was irrigated.

Livestock farming is active in Central Saanich. In 2001, 71 farms raised poultry, including hens and chickens, turkeys and others. The census reported 24 farms active in the farming of cattle and calves: 5 were dairy and 14 had beef cattle. The dairy farms had an average of 60 head, beef cattle operations averaged 15 head. Other livestock farms include pigs (13 farms), sheep and lambs (20), horses and ponies (52) and goats (5).

Comparing these numbers with results from the 1996 census indicates a significant (20%) downward trend in the number of farms, while average farm size increased somewhat (11.4 to 15.9 ha). The 2006 census showed only two operating dairy farms, down from five in 2001, and the number of beef cattle operations declined from 14 to 12.

The 2006 farm census shows that of the total land tilled for seeding, most farmers plowed the previous crop residue into the soil. About one quarter reported leaving most crop residue on the surface, and the remainder practiced zero-till agriculture.

Of course, clearing of trees to create arable land and ditching of watercourses to prevent the meandering and flooding of the creek systems has dramatically altered the hydrology of the area. Ecological function has been reduced which has also ultimately reduced the productivity of the landscape the agricultural community relies so heavily upon for crop production.

Seasonal inundation of farmland due to poor drainage conditions is a significant concern in Maber Flats and Martindale Valley, limiting both the effective growing season as well as the variety of crops that can be grown. These areas do not meet the prevailing standards for drainage of agricultural lands, the Agricultural and Rural Development Subsidiary Agreement (ARDSA) Agricultural Drainage Criteria (BC MOAFF, 2002).

2.7 Other Land Use

Two major industrial/commercial enterprises exist in the Municipality of Central Saanich, Butler Brothers Supply Ltd. and Keating Industrial Park. Established in the 1940's, the Butler Brothers Supply Ltd. started out as a small logging and gravel pit company (Virgin, 1959 and Green and Castle, 2005). Today, the company supplies ready-mix concrete and other aggregates. Keating Industrial Park, formed in the late 1970's/early 1980's to serve as an industrial and commercial centre for the community, is another area that has altered drainage patterns in the area (Delcan, 2003). The high concentration of impervious surfaces in the Industrial Park have led to increased stormwater runoff to the Hagan Creek Watershed via tributaries to Graham Creek. The eastern portion of the industrial area contributes runoff to Tetayut watershed.

2.8 Land Use Considerations in Developing an ISMP for Central Saanich.

Every jurisdiction has particular characteristics that affect the approach to rainwater management in that jurisdiction. Every ISMP is unique. The prominent characteristics that affect the ISMP in the District of Central Saanich are mainly related aspects of land use and include the following:

- Low rate of development / redevelopment – The shortage of land available for development and the density zoning profile result in a comparatively low growth rate; therefore the effect of policy changes affecting new developments or redevelopments is limited and more emphasis must be placed on voluntary or cooperative enhancements within developed areas in order to achieve rainwater management objectives.
- Land use distribution – more than two thirds of the area of the District is within Agricultural Land Reserve (ALR) and most of this is actively farmed.
- Drainage works and dykes - a large proportion of the farm land is poorly drained and/ or subject to seasonal inundation and the District has more km of drainage ditches than any other jurisdiction on Vancouver Island. Some lowland properties are protected by dykes.
- Severely modified watercourses – Approximately 50% of the watercourse (creek) length in Central Saanich has been so extensively modified through ditching, straightening and bank disturbance as to render them Non-functional according to PFC criteria.
- Ridges and lowlands – The developed urban areas of the District tend to be located on comparatively well drained upland areas, whereas many of the lowlands are agricultural areas with poor drainage. This implies that enhanced rainfall capture in the developed areas has considerable potential to benefit agricultural areas in the District.

- Limited Tax Base – The sheer length of creeks and drainage works and the area of the District requiring active rainwater management is so large compared to the tax base that innovative and cooperative approaches are required to compensate for the limited resources available.

2.9 Guiding Principles

Understanding how rainwater / stormwater forms and moves through the environment is a guiding principle of stormwater management.

The stormwater planning guidebook (Stormwater Planning: A Guidebook for British Columbia, B.C. Ministry of Water, Land and Air Protection, May 2002) has been used as a reference in creating many aspects of the integrated stormwater management plan for the District of Central Saanich as well as provide further ideas and focus. The guidebook was used during project planning, to formulate a stormwater runoff bylaw, as the foundation for ideas on best management and low impact development practices and as background for formulating and building consensus within the community.

2.9.1 The Water Balance

The hydrologic or water cycle is a familiar concept to many. In its simplest form, rain falls from the sky, evaporates from land, lakes, rivers and oceans or is transpired by plants and vegetation, condenses into clouds and precipitates once again in another location. A more detailed portrayal of the hydrologic cycle can be seen below.

In a global context, water is never created nor destroyed, but constantly recycled and transported through a complex network of hydrologic pathways. Any and all quantities of water introduced to a particular land region (a component 'cell' of the global water cycle comprising intersecting hydrologic pathways) via incoming pathways may temporarily remain within the region, but must eventually exit via outgoing pathways and continue through the global cycle. This concept is known as Water Balance. Water entering as rainfall has five potential exit paths:

a) Evaporation: Water from surfaces such as the ground, plants, lakes, ponds and pools evaporates into the air

b) Transpiration: Trees or other vegetation absorb water re-introducing it to the air as vapour via transpiration

c) Interflow: Water infiltrates the ground percolating laterally into natural watercourses through shallow soils

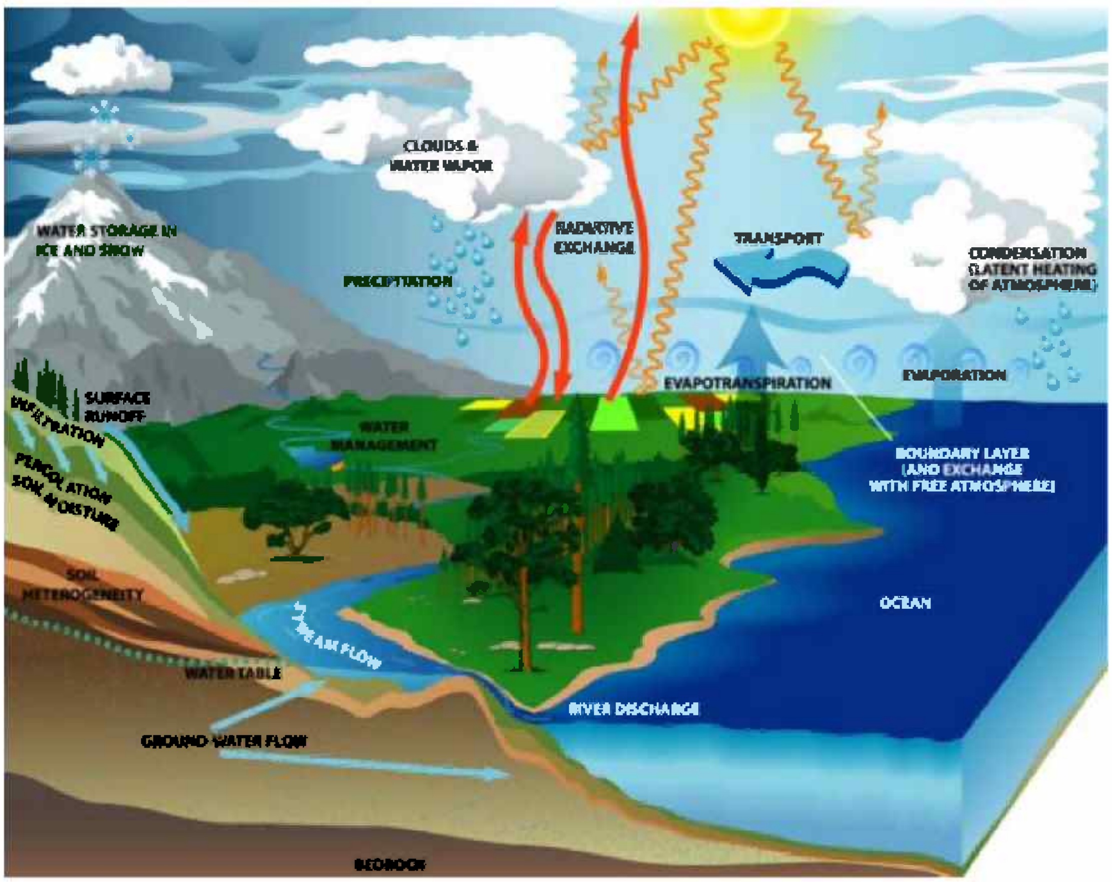
d) Deep Groundwater: Water infiltrates the ground entering deeper soils and groundwater via vertical percolation

e) Surface Runoff: Flow of water across the land surface

Evaporation and transpiration convert liquid water to the vapour phase and both reintroduce it into the air, and so due to this similarity these processes are collectively referred to as - *evapotranspiration*. Similarly, interflow and deep groundwater infiltration are both consequences of water absorbing into and percolating through soils, and are collectively referred to as *infiltration*.

The principles of the water balance were used during the modelling process and are expanded on in Section 6 where hydrologic modelling is discussed. With an appropriate understanding of watershed hydrology, it becomes apparent that the traditional ‘pipe and convey’ approach to stormwater management, ignoring water balance and simply mitigating peak conveyed flows, is incomplete. This is why the integrated approach to stormwater management is developing rapidly with new ideas and innovations.

Figure G Hydrologic Cycle (Pennsylvania Department of Environmental Protection, 2006)



2.9.2 Climate Change

The release of greenhouse gases (carbon dioxide, methane and nitrous oxide) into the atmosphere leads to a warming effect of the earth; this is essential to the maintenance of life as we know it on earth. However, substantial increases in greenhouses gas emissions , largely from human activities, such as the consumption of fossil fuels, waste management and industrial agriculture methods has accelerated warming of the earth on a global scale. Rising sea levels attributable to melting ice sheets at the poles and thermal expansion of the oceans may lead to the inundation of low lying coastal communities.

The effects of climate change must now be considered for management of stormwater as its effects may lead to more intense, frequent and / or longer rainfall events and unpredictable extreme events.

Climate change policy is a relatively new and emerging issue for BC communities; recognition that local governments play a large role in mitigating the root causes of green house gas emissions is an important step that could have many benefits. For instance, many sectors that are significant greenhouse gas emitters (buildings, transportation, waste management) fall under municipal jurisdictions. Central Saanich's OCP sets a new direction in terms of climate change policy and positions the municipality at the forefront of addressing this issue.

To address climate change and plan for the resultant adaptation, land-use, infrastructure and design at the neighbourhood, site and building scales require consideration. Related strategies that focus on doing on current or future actions to stop or slow down global warming while also planning on how to adapt to changing environmental conditions seem to be the way of the future. Climate change is addressed in more detail in later sections of this report.

2.10 Urban vs. Natural Water Balance: Proper Functioning Condition (PFC)

Traditional methods of conveying stormwater (built structures and infrastructure, considered as 'urbanization') have led to a decrease of vegetated landscapes in conveyance areas. Proper Functioning Condition (PFC) is a qualitative assessment tool with a standardized approach based upon quantitative science that measures the state and health (physical functionality) of riparian-wetland areas. PFC is discussed further in Section 2.10.2 below.

Many studies have documented the ecological, economic and social benefits of vegetated landscapes, specifically their capacity to provide terrestrial and riparian habitat, moderate stream flows, moderate air and water (stream) temperatures, intercept and evaporate rainwater and snow, and remove pollutants using physical, chemical and biological mechanisms such as adsorption[2], plant uptake, filtration, sedimentation, detention and microbial action (see Burton *et al.,* 2000; CWP, 2003; May, 2003; Capiella *et al.,* 2005; Capiella *et al.,* 2006; Mayer *et al.,* 2005).

As a landscape is developed, these services are either degraded or lost entirely. In terms of stream health, these losses of ecosystem services generally fall into one of four categories:

- hydrologic - a shift in the hydrologic regime from a subsurface regime to a surface dominated one due to the replacement of forest cover with impervious surfaces;
- biological - loss of aquatic species and terrestrial species due to physical degradation of habitat;
- physical - loss of riparian forest quality and quantity due to fragmentation and;

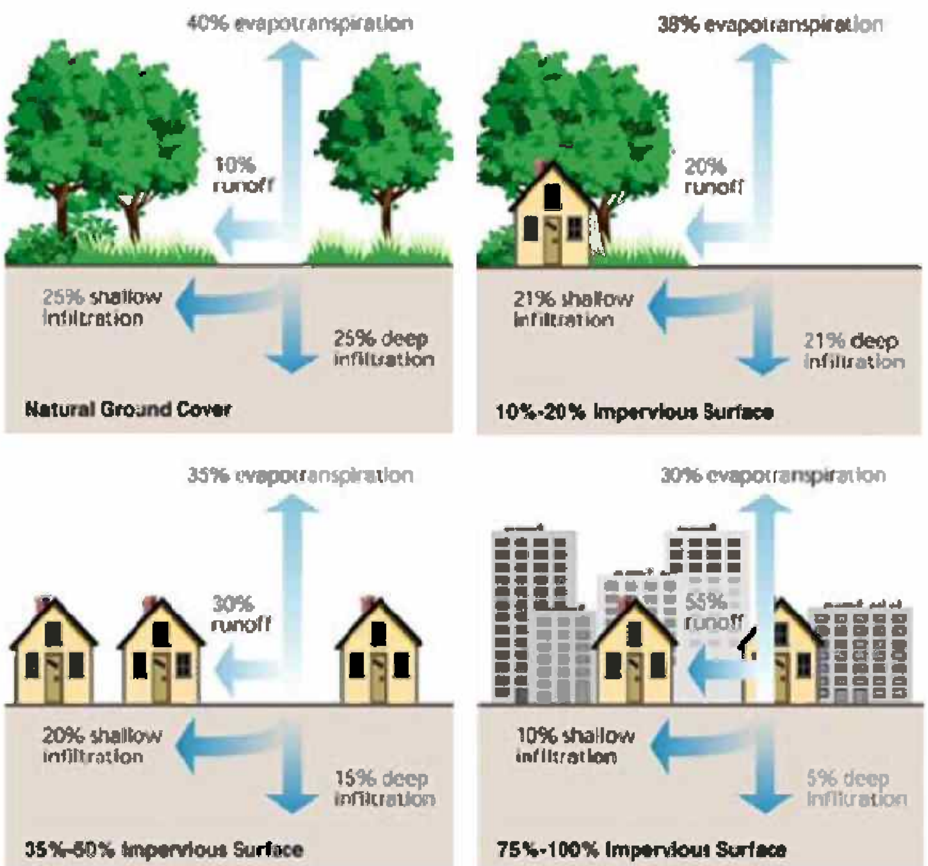
[2] Adsorption is a chemical process that removes heavy metals by using the charged particles within the soil to attract and bind to the metals.

- water quality issues- degraded water quality due to non-point source pollution and stormwater run-off (Groffman *et al*., 2003)

2.10.1 The Effects of Development / Urbanization on Waterway Health

The earth's hydrologic cycles are broken when vegetation is removed from the landscape. Urbanization alters the hydrological cycle of the landscape by creating large areas of impermeable surfaces that reduce the capacity of the land to infiltrate water back into the groundwater table (CWP, 2003; Groffman *et al.,* 2003; White et al., 2005). Urbanization results in large amounts of terrestrial and riparian vegetation being removed from a landscape and replaced with impervious surfaces (*i.e.,* driveways, parking lots, homes, offices, schools, highways, and paved walkways). These impervious surfaces are then serviced by storm drain infrastructure designed to efficiently carry runoff from an urbanized area into the nearest waterbody, usually a stream. Physical changes to the drainage pattern of the watershed also become evident as shown in Figure H.

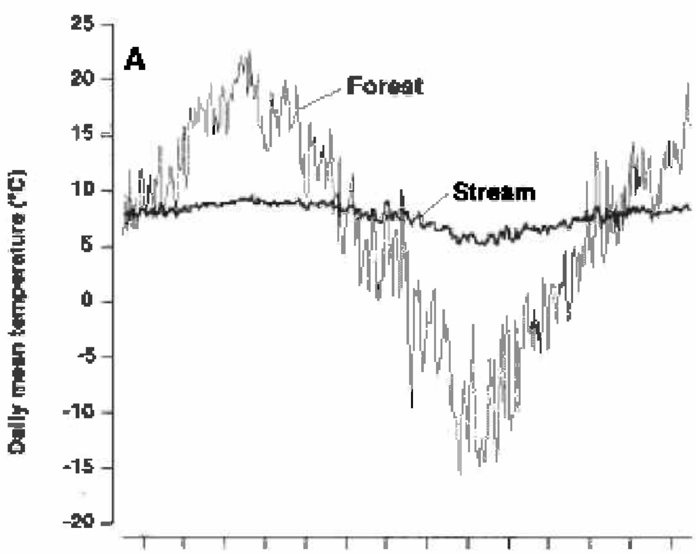
Figure H Various changes in impervious surfaces leads to changes in run-off, infiltration, groundwater recharge and vegetative cover (CWP, 2003).



Streams convey greater and more frequent flows and they try to accommodate these changes by eroding stream banks and or the channel bottom (also referred to as channelization / downcutting) causing downstream channels to widen (lowering water depth), become incised or both (Hammer, 1972; CWP, 2003; McBride *et al.,* 2005; Pennsylvania Department of Environmental Protection, 2006). Increased flows also undercut stream banks and dislodge trees and shrubs that originally held the stream bank together, providing habitat, large wood, and shade. In contrast, during a high flow event, a balanced system would access the floodplain depositing sediment, nutrients, and reducing the velocity of the water (Groffman *et al.,* 2003; May, 2003).

Groundwater levels are also affected due to the channel incision and reduced infiltration rates. A lowered water table dries out the riparian soils and removes the soil moisture on which riparian plants depend. The plants then die and the stream banks fall apart without the roots to hold them together (Groffman *et al.,* 2003; Smol, 2007). When in balance with the landscape, groundwater flows and the riparian canopy buffer the temperature of the water, keeping it cool all year round as temperature is fundamental to aquatic life (see Daily mean temperatures of a forest and stream in Figure I) (Leavitt, 1998; Nakano *et al.,* 2000; Snyder *et al.,* 2003; Smol, 2007; CWP, 2003; Mayer *et al.,* 2005).

Figure I Daily mean temperatures of a forest and a stream (Nakano et al., 2000)



Stormwater also carries pollutants[3] (*i.e.,* sediments, organic detritus, phosphorus and nitrogen forms, metals, hydrocarbons, and synthetic organics) that attach to the soil particles and enter directly into the receiving water or become soluble in the water (CWP, 2003; May, 2003). Thermal and pollution impacts on streams from urbanization, have resulted in reduced water quality, biological abundance and diversity of aquatic species (Burton *et al.,* 2000; CWP, 2003; Snyder *et al.,* 2003). Runoff from impervious surfaces tends to be much warmer than the local stream temperature, dramatically affecting the aquatic diversity in the stream (Booth, 1991; CWP, 2002; CWP, 2003; May 2003; Irwin *et al.,* 2007**;** Yli-Pelkonen, 2006).

2.10.2 Measuring the Health of Aquatic Resources

Impervious cover (IC), also called catchment imperviousness, is commonly portrayed as the dominant driver of stream degradation based upon the widespread correlation between imperviousness and stream condition (CWP, 2003). It is a common indicator used as a percentage to determine the effect of urbanization on aquatic systems (Chester *et al.,* 1996; CWP, 2003). The Center for Watershed Protection (CWP) (2003) concluded that on average, most stream quality indicators begin to decline when watershed imperviousness reaches 10% with severe degradation occurring when IC extends beyond 25% (May, 2003).

Measuring the quality (or “condition”) of an ecosystem requires watershed managers to physically measure and examine the aquatic areas. The challenge arises in determining what method will be applied to measure the condition of a system, how much time will be dedicated to collect the information, and how to integrate other interested stakeholders into the process.

2.10.3 Proper Functioning Condition (PFC) Assessment.

An assessment method that addresses the previously mentioned challenges is called the Proper Functioning Condition (PFC) Assessment. Jointly developed by the U.S. Bureau of Land Management, the U.S. Forest Service and the Natural Resources Conservation Service (NRCS), the PFC assessment measures the state and health of riparian-wetland areas. PFC assessment can be applied in a variety of settings to gain consistent information that helps people to begin to discern what is working well, what may be limiting the system (*i.e.,* upstream/in-stream activities, etc), what management can do, and how the system is functioning overall (Prichard, 1998). The PFC assessment is not based upon values (*i.e.,* whether the stream is visually pleasing, suitable habitat for fish, etc), but rather on stream function (*i.e.,* whether the stream is stable from a hydrologic, vegetative, and soil perspective) (Prichard, 1998). Use of the PFC concepts and the assessment process increases awareness and understanding of riparian-wetland functions and builds capacity for cooperative decision-making and management that benefits both the land and dependent communities” (Riparian Coordination Network, 2002).

[3] It should be noted that are two common types of stormwater pollutants: particulate and solids. In the context of stormwater, particulates are pollutants that are physically attached to particles and are easily kept in suspension in the water column, requiring physical removal (filtration or detention) to settle out. These include total suspended solids (TSS), phosphorus (TP), most organic matter (as estimated by COD), metals, and some herbicides and pesticides (Burton *et al.*, 2000; May, 2003; CWP, 2003). Solutes are nutrients or pollutants that are dissolved and are normally taken up by vegetation or micro-organisms in the soil. For example, Nitrate (NO3-N) is one such example of a soluble pollutant from lawn fertilizer. Plant uptake of pollutants is known as a process called phytoremediation (Capiella *et al.*, 2005).

PFC utilizes 17 criteria to determine stream health, thereby enabling users to rank rehabilitation priorities. The result of the PFC assessment is qualitative indicator identifying whether the system is in Proper Functioning Condition (PFC), Functional-at-Risk (FAR; with an upward or downward trend), or Non-Functional (NF).

When a system is classified as PFC, it is in state of "resistance" enabling it to withstand disturbance without "coming apart" during high flow events. Functional-at-Risk (FAR; with an upward or downward trend) has elements of a resilient system by remaining in a functional context, but has a soil, water, or vegetative attribute(s) that makes the system susceptible to degradation. A Non-Functional (NF) system is a system that is one that is not clearly able to dissipate energies associated with high flow events (due to a lack of adequate vegetation, landform, etc) and thus cannot reduce erosion, improve water quality, provide habitat, etc. These ratings provide a "means of prioritizing areas for restoration so that when development occurs, resources can be allocated to the most critical areas" of the system, thereby preventing degradation of healthy areas by the rehabilitation (of function) of areas currently at risk or may soon be (Barraclough & Lucey, 2005).

The assessment is checklist based upon the *capability* and *potential* of the system characterized by the interaction of the three components, hydrology, vegetation, and soils. Potential is defined as the potential natural community a system could achieve "given *no* political, social, or economical constraints" (Prichard, 1998). Capability is defined as what *could be* achieved given current political, social, or economical constraints. Therefore, in the context of urban system, it is recognized that some systems can or may be constrained by various limitations that may be insurmountable (*i.e.,* urban land use, major roads, zoning, political barriers, etc); not precluding rehabilitation, but may limit the ecological function of the system.

Completed PFC assessments are outlined in Section 5.1.3.

2.10.4 How Peak Flows Affect Watercourses

Peak flows occur in stream systems during, or after rain events, and are the flows that contain the largest volume and, often, the highest velocity. As land use changes from a natural to a more urbanized setting, reflecting traditional methods of conveyance, impervious surfaces increase. Run-off into the streams is amplified as there is less area for water to infiltrate into the soil and it runs off into the streams instead. Consequently, peak flows occur more quickly and are higher than under a more natural, forested condition. This can result in excessive scour and erosion from increased flow velocity and more frequent flooding due to an increased flow volume. While erosion and flooding are natural phenomena within stream systems, they can lead to the destruction of important channel and floodplain habitats if they occur too frequently or are excessive (Pritchard *et al*., 1998). On average, a stream should flood its banks approximately once every two years under natural conditions.

Streams have built in buffers to mitigate erosion and flooding if they remain functional. Riparian vegetation plays a key role in this regard. Vegetation functions to filter sediment, create floodplain areas by trapping sediment and other debris, and protect banks with stabilizing root structures and as physical barriers in the case of large woody debris. Large wood may also act as weirs to direct water toward the centre of the channel reducing the amount of energy deflected toward the banks. These attributes all act to dissipate energy from high and peak flow events thus maintaining ecosystem health.

While vegetation can act as a physical buffer to high volumes and velocities, floodplains create areas for high volumes to escape and slow down therefore reducing volumes and velocities in the main channel by providing space for the channelized flow to spread out. As the water slows down, it has less energy to carry sediment, and the sediment settles on to the land and renews the soil. Consequently, scour of the channel is reduced, protecting channel and floodplain habitats, and flooding is managed by slowing and storing water in the floodplain.

2.11 Action at the Site-Level: Controlling Stormwater at the Source

Controlling stormwater at site-level is a measure that has many benefits. The quality and quantity of stormwater discharge from an area / development can be controlled to meet certain parameters and to not have any detrimental downstream impacts.

Detrimental stormwater effects at the watershed scale are due to cumulative effects at the development level. In order to achieve watershed objectives it is necessary to focus efforts one scale smaller, and work towards managing stormwater at its source and mimicking natural hydrological mechanisms through land development. Two such examples are low impact development and preservation / restoration of natural ecology and hydrology.

2.11.1 Low-Impact Development

Low-impact development (LID) is a development strategy at the lot or subdivision scale that helps to manage stormwater. The strategy is for development areas to closely mimic the previously undeveloped land in terms of hydrology. This means that rainwater will be collected, infiltrated and distributed over a parcel of land in a similar fashion to the pre-developed state of the land. LID is considered, in terms of stormwater management, a countermeasure to control adverse impacts of development. The adverse impacts include damage to streams, lakes, wetlands and other natural aquatic systems generally due to an increase in runoff volume and velocity from impervious surfaces (CRD, 2008).

Minimizing impervious areas, concentrating communities, controlling point and non-point sources of pollution, facilitating groundwater recharge, regulating peak runoff rates and volumes and implementing site-level stormwater source controls can all be associated with low-impact development. Examples of low impact development are green roofs, living walls, rain gardens, permeable pavement and bioswales (CRD, 2008). Some of these examples are further discussed in Section 2.11.3, Appendix 1 and Appendix 2.

2.11.2 Preservation of Natural Ecology and Hydrology

The preservation and restoration of elements key to the natural ecology and hydrology are key to improving or at least maintaining stormwater control. Elements are riparian corridor vegetation and buffer zones, natural hydrologic features (such as ponds, wetlands, floodplains and groundwater recharge areas), significant in stream features (such as channel complexity and sinuosity, access to floodplains, large woody debris (LWD), adequate spawning gravel) and other aquatic habitat features.

2.11.3 Stormwater Best Management Practices and Source Controls

In developing strategies to improve stormwater management, Best Management Practices (BMPs) and sources controls are considered. These are forms of proactive stormwater management, reflecting the fundamental paradigm shift from traditional to integrated stormwater management planning.

One of the primary goals of integrated stormwater management is to address the more frequent rainfall events and restore them to their natural hydrologic pathways and reduce the overall volume of surface runoff. Three main strategies are to minimize impervious areas, install hydraulic disconnects by infiltrating stormwater back into the ground or reusing it at the site level, and to store runoff and release it at controlled rates to mitigate the effects of increased impervious areas. In order to accomplish these objectives, accepted stormwater BMPs are continually developing as knowledge and experience in ISMP development progresses.

Overall aims of this type of management are to protect both property and resources by connecting the natural and built environments, mimic the natural hydrologic condition at a watershed scale by managing both quantity and quality of surface runoff, and to control runoff volumes as well as runoff rates.

Below is a list of principle uses and applicability of selected stormwater BMPs that is intended to function as a first point of reference for potential BMP application. It is not meant to serve as an exhaustive reference or design manual for stormwater BMPs, but to assist the District of Central Saanich in the planning phases of BMP selection and/or application Appendix 1 and Appendix 2 contain a greater level of detail on BMPs.

Volume Reduction

Traditional stormwater management focussed only on implementing infrastructure sized to pipe, convey and control peak rates for extreme storm events to prevent flooding and property damage. Unconsidered, however, was that the bulk of annual rainfall volume is small, frequently recurring rainfall events which under natural watershed conditions would not convert to surface runoff. Instead it would be infiltrated into soils and groundwater, evaporated from surfaces and absorbed and transpired by natural vegetation. The result is a drastic increase in total runoff volumes and decrease in groundwater recharge. This causes large fluctuations in water levels and flow rates in natural watercourses, surcharging and eroding them with increased runoff during the wet season while lowering water levels or even drying them out during the dry season due to low groundwater tables.

Therefore, reducing the volume of stormwater discharge (compared to traditional conveyance volumes) is the underlying principle of integrated stormwater management. Many BMPs expand on this principle.

Best Management Practices

In general, Best Management Practices (BMPs) are measures taken to mitigate the detrimental environmental impacts of land use and land development. There are generally two different types of stormwater best management practices: structural and non-structural. Structural BMP's are designed to compensate for the adverse impacts of development (*i.e.,* increased flooding, erosion and sedimentation, damage to aquatic and terrestrial habitat, reduction in groundwater recharge and water quality, etc), and are generally employed after development has taken place (CWP, 2003). Non-structural BMP's, however, are designed to prevent these impacts from happening in the first place and consist of two categories: pre-development or redevelopment (planning & design) to minimize impacts and education and training (*i.e.,* PFC – Creeks and Communities).

However, an Economic Rationale for Integrated Stormwater Management, divides stormwater BMPs into three types: Planning, Engineering, and Design (MOE, 2005).

Planning BMPs

Planning BMPs are proactive, pre-emptive strategies used to reduce the amount of stormwater runoff produced onsite, by recognizing and preserving significant existing site conditions (both natural and man-made) and integrating them into development form through site-adaptive planning. Exemplary planning BMPs have developed into a distinct set of design principles known as Low-Impact Development (LID) principles which are discussed in Section 2.11.1.

Engineering BMPs

Typically related to roads and drainage structures, Engineering BMPs include both more conventional BMPs (re-routed flow patterns and diversion channels to lengthen travel times, detention/retention facilities which control release rates, etc.) as well as more innovative BMPs such as vegetated swales, constructed wetlands, and infiltration basins. Engineering BMPs are conventionally designed to remediate flooding and property damage risks associated with larger storm events.

Many engineering BMP implementations have applicability as both site-level source controls and as larger-scale facilities serving a number of development sites. Certain BMPs have inherent qualities which lend themselves to a particular scale of application, but it should be noted that most Structural BMPs can be scaled up or down depending on the specific requirements of the site, group of sites, or catchment.

Engineering BMPs are discussed below and in Appendix 1 and Appendix 2.

Design BMPs

Design BMPs are site-level structural measures that prevent excess stormwater from leaving development sites and surcharging natural watercourses. They are relatively new to the ISMP process, and the term 'Source Control' is sometimes used to describe them exclusively. Promoted infiltration, grading features such as depressed storage cells, and disconnection of drains and downspouts are all examples of Design BMPs.

Implementing LID strategies, preserving natural features and reducing impervious area cannot completely eliminate negative downstream effects and hence are not a complete stormwater management strategy. Integrating natural watershed function and human activity with LID principles supplements the performance of stormwater BMPs and source controls, embodies the underlying values of integrated stormwater management, and represents a small component and good starting point for an effective ISMP.

A Note on Engineering and Design BMPs

In many circumstances the differences between Engineering BMPs and Design BMPs become contextual in nature and somewhat complicated to distinguish. Either directly or through adaptation, many Engineering BMPs can be applied in site-level source control contexts and many Design BMPs can be applied in larger-scale catchment contexts. With this in mind, Engineering and Design BMPs are sometimes referred to collectively as Structural BMPs.

Additional Information on BMP's

Detailed information on general and agriculture-specific BMP's is contained in Appendix 1 and Appendix 2, respectively. Appendix 3 provides specific examples of where and how BMP's could be adopted in the District.

3. REVIEW OF EXISTING DATA

This project has endeavoured to make full use of relevant existing reports, maps, and data. Much of this has been provided from the District files; the balance has been obtained from a variety of other sources.

3.1 Summary of Existing Studies

Key materials reviewed include:

a) Central Saanich Official Community Plan and Local Area Plans
b) Design Standards and Specifications
c) Hagan Creek Master Drainage Plan, Dayton and Knight, 1994
d) Stormwater Management – Policies and Design Manual, Dayton & Knight Ltd., September 1994.
e) Graham Creek Drainage Study, Delcan, 2003
f) Central Saanich Land Use Bylaw
g) DCC Bylaw
h) Topographic, legal, address, utility maps
i) Digital Orthophotos
j) List of existing operational problems or concerns
k) Agricultural Land Reserve boundary and Agricultural Land Use Inventory information
l) Stormwater Quality Annual Report, Saanich Peninsula, 2005, CRD
m) Natural Areas Atlas
n) Soils of Southern Vancouver Island
o) Aquifers of the Capital Regional District
p) District of Central Saanich Atlas
q) Local climate change studies and data
r) Sanitary Sewerage Planimetric Mapping, District of Central Saanich
s) Storm Drain Planimetric Mapping, District of Central Saanich
t) Historical maps, photos and data from early settlement periods
    i. Undated, unmarked circa 1926
    ii. BC244 #33 & 52, June 20, 1946
    iii. BC1670 #17 & 18, April 11, 1954
    iv. BC5091, #134, 135, and 168May 15, 1964
    v. 15BC80005, #52, 53 & 54, May 7, 1980
    vi. 15BCB97005, #102 - 104, 176 and 177 March 14, 1997
    vii. Historical Survey, from F.B. 2/58 Saanich (J.Trutch)

A complete list of materials is provided in Section 11. Many of these materials are referenced and discussed in other parts of this report. In the early and mid 1990’s, the District commissioned drainage studies in the Hagan-Graham watersheds. The following sections summarize key points, issues and opportunities outlined by these two reports.

3.1.1 Hagan Creek Master Drainage Plan

A Master Drainage Plan for Hagan Creek was conducted by Dayton and Knight for the District of Central Saanich in September of 1994 (Dayton and Knight, 1994). The report's goals were to preserve environmental resources, protect life and properties and to integrate land uses and future development with the existing community plans.

The drainage concerns in the Hagan Creek drainage area outlined in the report were:

- Annual flooding of Maber Flats,
- Limited channel capacity in the creek downstream of Stelly's Cross Road,
- Bank erosion from the lower reaches of Hagan Creek,
- Water quality issues from the runoff from an industrial park

The report examined three structural alternatives to control or reduce the impact of the drainage concerns and these have been summarized in Table D below:

Table D Dayton and Knight Hagan Creek Structural Alternatives

Alternative	2008 Cost
1. Building of a detention facility on a 10 ha parcel of non-subdivided land at Maber Flats with dykes to delimit the area, on the land between Wallace Road and White Road	$ 2,247,000
2. Increasing the hydraulic efficiency of the main drainage channel through pipe enclosures and channel improvements. This would free up Maber Flats and contain all post-development flows but rely on traditional stormwater abatement structures, which are no longer favoured	$ 9,272,000
3. Combination of channel improvements and flow diversion. Excess flows (above 2 year return period) diverted west at Wallace Drive instead of flowing downstream	$ 12,023,000

The stormwater management solution recommended by Dayton and Knight included:

- Constructing a detention pond in the area of Maber Flats (Alternative 1). The detention facility at Maber Flats would offer more efficient land uses by reclaiming presently subdivided land and controlling flooding
- Installation of rain gauges. Two rain gauges would be installed: one placed adjacent to Stelly's Cross Road and the other adjacent to West Saanich Road. This data would be used to calibrate future drainage models

- Monitoring of stormwater coming from the industrial park. The stormwater was shown to have a high organic content. Surveying the stormwater from the area would determine a potential source of the pollution and ensure that no further stormwater contamination arises

The cost of all of these recommended solutions (converted to 2008 dollars) was calculated by Dayton and Knight as $ 3,954,000.

3.1.2 Graham Creek Drainage Study

The District of Central Saanich commissioned Delcan to conduct a drainage study of parts of Graham Creek in 2003 (Delcan, 2003). The main goals of the study were to examine the water quality and quantity coming from the Keating Industrial Park and to prepare an integrated stormwater management plan for Graham Creek.

The study found that the quality of stormwater from the Keating Industrial Park had improved in recent years. Although turbidity was observed in the area, no point source of contamination could be identified. During the early 90's, the water quality from the industrial park showed high organic content indicating possible cross-connection or discharges of brewery-type waste into the stormwater system. The quantity of stormwater from the Keating Industrial Park was identified as a remaining issue. The volume of runoff from the area was calculated to be five times that of pre-development conditions because of the increase in impervious surfaces in the area and this would exacerbate downstream flooding.

The purpose of the drainage study for Graham Creek was to find ways to minimize the flooding and erosion in the creek and to improve the stormwater quality going into it. The eventual goal was to return the creek to a more natural flow pattern. The report recommended that a series of wetlands or detention ponds be created in the area of Maber flats by building dykes around the 10 ha area most affected by flooding. It was claimed that the creation of these wetlands would return Graham Creek to a more natural flow pattern and reverse some of the man-made changes to the hydrology. In addition to this, flows and flooding would be controlled for up to a 200 year storm event. The quality of the water would be controlled through a combination of physical, chemical and biological processes.

Delcan included an order of magnitude cost estimate for the construction of a small wetlands/storage area adjacent to Keating Industrial Park. The cost of the wetlands construction would be $ 224,000 (converted to 2008 costing) and does not include land purchase. The study does not break the cost down further and it is important to note that this estimate is not for the large detention facility in Maber Flats recommended by the Dayton & Knight and the Delcan study.

In addition to the construction of the detention pond, the study also recommended that the District of Central Saanich update the master drainage plan for the entire watershed.

3.2 Hydrological and Hydro-geological Information

Information relating to the hydrological and hydrogeological characteristics of the three Central Saanich watersheds was obtained from the following documents:

- Aquifers of the Capital Regional District (Kenny, 2004)

- Intensity, Duration, Frequency (IDF) curves for the Victoria International Airport
- Current and historical data from Water Survey of Canada flow monitoring stations
- Current and historical climate station data from Environment Canada

3.2.1 Aquifers

According to the CRD Aquifers report completed in December 2004, there are approximately 6 aquifers within Central Saanich, as described in the table below. Table E and Figure 3 show the location of each aquifer.

Table E Aquifers Within the Study Area

Aquifer Name	Aquifer Number	Area (km^2)	Aquifer Type	Location and Boundaries
North-Central Saanich	608	81	Partially confined granitic bedrock	Hagan Graham, Tetayut, and McHugh-Noble Watersheds. South of Tatlow Road (North Saanich), south to Bear Hill (Saanich), west by Saanich Inlet, east by Cordova Channel of Georgia Strait.
Hagan	611	2.1	Partially confined, fine to coarse sand and gravel deposits.	Hagan Graham Watershed. Hagan Creek to the west, Wallace Drive to the east, Hovey Road to the south, and the base of Mount Newton to the north.
Keating	612	8.5	Unconsolidated fine to coarse sand and gravel deposits.	Hagan Graham and Tetayut watersheds. West Saanich Road to the west, Lochside Drive to the east, Bear Hill to the south, and Hovey Road to the north.
Durrance	613	0.093	Partially confined, unconsolidated fine to coarse sand and gravel deposits.	Tetayut Watershed. Durrance Road and Wallace Drive
Karmutsen	614	16	Partially confined, volcanic bedrock	Hagan Graham and Tetayut Watersheds. Observatory Hill to the south, West Saanich road to the north, Elk Lake to the east, and

Aquifer Name	Aquifer Number	Area (km^2)	Aquifer Type	Location and Boundaries
				Brentwood Bay to the west.
Cowichan Head	615	3.4	Partially confined, unconsolidated medium to coarse gravel	McHugh-Noble Watershed. Georgia Strait to the east, Mount Newton Cross Road to the north, Dooley Road to the south, west boundary approximately 1.5 km west of the shore.

3.2.2 Intensity, Duration, and Frequency Curves

Intensity, Duration, and Frequency (IDF) curves indicate the rainfall intensity that may be expected for storms of a given return period. IDF curves are generated from the statistical analysis of historical rainfall data collected from a climate station, in this case, Environment Canada's Victoria International Airport climate station.

Two IDF curves were identified in the study area, both for the Victoria International Airport, and are presented in Appendix 14. The IDF curve found on the District of Central Saanich's web based Standard Drawings database is based on rainfall data collected between 1965 and 1979. The more recent IDF curve available from Environment Canada (Environment Canada, 2000) is based on rainfall data between 1965 and 1998. As shown on Table F below, a summary of the intensities versus return periods for a storm duration of 24 hours, there are marginal differences between the two IDF curves. Due to the additional data, the more recent curve is able to provide forecasting for the 50 and 100 year storms.

Table F Intensity (mm/hour) of a 24 hour storm

Return Period	1965-1979 Intensity (mm/hr)	1965 – 1998 Intensity (mm/hr)
2 year	2	2.1
5 year	2.8	2.8
10 year	3.2	3.1
25 year	3.8	3.7
50 year	n/a	4.0
100 year	n/a	4.2

3.2.3 Water Survey of Canada

There are two historic and one active Water Survey of Canada hydrometric stations within the study area:

- Active - Sandhill Creek at Pat Bay Highway (No. 08HA060) located on Tetayut Creek just east of the Pat Bay Highway near the Saanich Historical Artifacts Society.
- Historic – Graham Creek at Stelly's Cross Road (No. 08HA071). WorleyParsons installed a station at this abandoned location for this study.
- Historic – Hagan Creek Near the Mouth (No. 08HA063) located in lower Hagan Creek near West Saanich Road.

These records were obtained to help verify the flow data gathered from the monitoring stations set up by WorleyParsons and assist in model verification.

3.2.4 Environment Canada – National Climate Data

There are approximately 77 current and historical climate stations in the vicinity of Central Saanich. However, only two of those stations have up to date precipitation and temperature records that meet World Meteorological Organization standards. Those stations are the Victoria International Airport (Climate ID 1018620) and Saanichton (Climate ID 1016940) Command and Data Acquisition (CDA) stations.

Climate data for both the Victoria International Airport and Saanichton weather stations is publically available on Environment Canada's National Climate Data and Information Archive. For the hydrologic modelling part of this study, rainfall data collected at a frequency of an hour or less is required. While Environment Canada's online archive provided daily rainfall data, hourly rainfall data was only available by request for the Victoria International Airport. According to Environment Canada, Saanichton rainfall data is only recorded daily, therefore hourly data was not available.

3.2.5 Water Demand and Supply in Central Saanich

Municipal water usage for Central Saanich in 2007 was 3,251,749 cubic meters. Of this, 57% was Residential and 43% Industrial, Commercial and Institutional (ICI). Of the total usage, 17.5% was Agricultural (Reilly, 2008). By way of comparison, the three main watersheds in Central Saanich receive 33 million m3 of rainfall in a typical year, or about 10 times the total water demand. Most of the water used for agriculture adds to the water balance in the watersheds, while only a small portion of that used for other purposes (that used for gardening, irrigation or certain utility purposes) enters the watersheds.

Farmers use considerable amounts of groundwater for crop irrigation. In some cases, this is extracted from aquifers contained within the local watershed. In other cases, it is drawn from aquifers that contribute baseflow to more than one watershed. In most cases, it is difficult to determine where the recharge for a given well comes from without hydrogeological investigations. The relevant aquifers were described in Section 3.2.1. Records on groundwater withdrawal rates are not currently available. It is possible that groundwater withdrawals could be having a significant influence on creek baseflow rates, however, a groundwater production survey and hydrogeological investigations would be required to determine this.

3.3 Ecological Information

Information was gathered and reviewed from the following sources:

- Government databases
- Peninsula Streams Society
- Public Library
- Victoria archives-maps
- BC and Saanich archives
- BC land titles office
- Aqua-Tex files

Central Saanich is found within the Coastal Douglas Fir biogeoclimatic zone. This zone encompasses the southeastern fringe of Vancouver Island, the Gulf Islands, and the Georgia Strait area of mainland British Columbia. Characterized by its Mediterranean-like climate, this region experiences warm, dry summers, and mild, wet winters. Upland vegetation communities are typified by Douglas-fir, salal and Oregon grape while moister areas contain grand fir, western red cedar, bigleaf maple, red alder, skunk cabbage, Indian plum, salmonberry, and red elderberry (Ministry of Forests, 1999).

The Municipality of Central Saanich encompasses Hagan and Graham Creek (the Hagan-Graham Watershed), Tetayut (Sandhill) Creek (the Tetayut Creek Watershed), and McHugh ditch (Noble Creek Watershed).

The Hagan-Graham watershed (watershed code 920-189600), is composed of two main streams, Hagan Creek and Graham Creek and has a drainage basin of approximately 1780 hectare (ha). Located in the western portion of Central Saanich, with overlap into Saanich and North Saanich, it drains areas between the Kildeer Road area in the south and Mount Newton in the north. Graham Creek flows north then west into Hagan Creek near Malcolm Road and Mount Newton Crossroad. Hagan Creek flows south and then west, with the addition of Graham Creek flows and a number of small tributaries upslope of Mount Newton Crossroad, into Hagan Bight. The majority of the Hagan-Graham watershed drains into Saanich Inlet from Hagan Bight on the western side of the Saanich Peninsula.

Historical maps from 1859 and 1860 show extensive wetlands in the Maber Flats area of Graham Creek (low-land area between Keating Crossroad and Wallace Drive) and extending to the west. In some records, this area is described as Maber Lake (Delcan, 2003). There is some discrepancy, however, over the presence of a defined channel extending north of Maber Flats connecting to Graham Creek in Centennial Park. The 1859 map shows a distinct channel in this location while the 1960 map shows an extension of the wetland and no channel. Anecdotal information suggests that the channel from Maber Flats to Centennial Park was once only a small channel with a low flow that was deepened to drain the Maber Flats area for agricultural purposes. It has also been suggested that a channel once flowed from Maber Flats west to Brentwood Bay. Although no obvious channel exists presently, in the Brentwood Bay area a drainage ditch could be the downstream portion of this channel. These maps also show wetland character adjacent to Hagan Creek in Mount Newton Valley where agricultural fields exist today. These fields continue to absorb floodwaters during the winter despite the presence of deep ditches.

Fish presence in the Hagan-Graham Watershed is limited due to the large waterfall at the mouth of Hagan Bight acting as a natural fish barrier. However, electroshocking by the Hagan-Kennes Watershed group in Hagan Creek between Hagan Bight and Malcolm Road revealed the presence of cutthroat trout (*Oncorhynchus clarkii clarkii*), threespine stickleback (*Gasterosteus aculeatus*), and a few sunfish (Peninsula Streams, 1997). Additionally, a search through the Ministry of Environment's Fisheries Information Summary System (FISS) also indicates the historical presence of the following fish species: Dolly Varden (*Salvelinus malma*), coastal cutthroat trout (*Oncorhynchus clarkii clarkii*), and coho salmon (*Oncorhynchus kisutch*). In Graham Creek the FISS lists the presence of cutthroat trout (*Oncorhynchus clarkii clarkii*), pumpkinseed sunfish (*Lepomis gibbosus*), and threespine stickleback (*Gasterosteus aculeatus*).

A number of restoration initiatives have been conducted by local stewardships groups, namely the Hagan-Kennes Watershed Society, Peninsula Streams and affiliates, in an attempt to improve fish habitat and manage the excess sediment load. These activities include:

- riffle and large wood additions along with native riparian planting and trail realignment in Graham Creek in Centennial Park;
- enhancement of a pond and channel planting in Hagan Creek near Malcolm Road;
- native riparian planting along Hagan Creek just upstream of West Saanich Road ;and
- a weir placement near the Bryson farm to capture excess sediment moving through the system as well as riparian plantings and a fence installation to keep animals off the banks.

Tetayut Creek (alias' Sandhill and Shady Creeks) watershed (watershed code 920-140700) consists of one main channel and 3 small tributaries, flowing from the Bear Hill Park (south) and Dean Park (north) areas, which generally intercept the main channel in the lower reaches below the Patricia Bay Highway. Tetayut Creek proper starts near Bear Hill and flows north then north-east to its outlet in Saanichton Bay (BCGNIS, 2008) draining approximately 1150 ha. The creek travels through a landscape supporting agricultural activities, urban residential properties, and an industrial centre before traversing its last leg through the Tsawout First Nations lands.

Historically, the main stem of Tetayut Creek flowed generally along the same path as it does now; the pond areas were not present until agricultural activity required them for irrigation. Wetland areas are shown on an 1860 map of the Saanich Peninsula in the northern area of the Tetayut watershed as well as along the eastern shore near Saanichton Bay (map 1860). The 1859 map, however, does not show the same extensive wetland area in the northern portion of the watershed but does have a tributary located in the same vicinity (map 1859).

The upstream reaches of Tetayut Creek have been almost entirely formed into ditches and in-line ponds. As irrigation requirements are large for this area, Tetayut Creek is diminished of flows especially in the summer months. This low base flow has threatened the fish populations. Consequently, the Haig-Brown Fly Fishing Association introduced a pump station just downstream of Keating Cross Road in order to pump groundwater into Tetayut Creek to augment the low summer flows. This pump is in operation generally from May to September and is monitored by the Peninsula Streams Society (pers. comm. Ian Bruce, 2008).

Fish presence in the Tetayut Creek watershed has been historically quite significant with the following species being common: chum salmon (*Oncorhynchus keta*), coho salmon (*Oncorhynchus kisutch*), cutthroat trout (*Oncorhynchus clarkii clarkii*), prickly sculpin (*Cottus asper*), pumpkinseed (*Lepomis gibbosus*), and steelhead trout (*Oncorhynchus mykiss*). Anecdotal information has suggested that these populations have been decreasing over the years. There have also been historical reports of octopi that are no longer observed, migrating into the lowest reaches of Tetayut (pers. comm. Gwen Underwood).

A Water Survey of Canada hydrometric station exists just downstream of the Patricia Bay Highway within the Saanich Historical Society site. In use since around the 1950's this station has collected discharge flow measurements for Tetayut Creek. The Peninsula Streams Society and affiliates use this site as a monitoring station to collect data on such parameters as temperature, dissolved oxygen content, and fecal coliform counts.

A number of restoration initiatives have been conducted by local stewardships groups, namely the Tsawout Nation, Haig-Brown Fly Fishing Association, Peninsula Streams and affiliates, in an attempt to improve fish habitat. These activities include the following:

- implementation of a groundwater pump in Sandhill Park to augment summer flows;
- channel structuring, bridge creation, pond regrading and riparian planting in Adam Kerr Park;
- bank stabilization of slumps in the lower reaches at the Historical Society property; and
- the removal of a wood-stave culvert is also being planned in order to improve water flow and habitat in the lowest reaches (pers. comm. Ian Bruce, 2008).

McHugh ditch is part of the Noble Creek watershed (watershed code 920-130800). Dug for the purposes of draining Martindale Flats, the deep, wide ditch now extends from south of Island View Road to its confluence with Noble Creek in the vicinity of Hunt and Noble Roads. This watershed drains approximately 970 ha from the Martindale Valley vicinity as well as areas in Saanich.

Historically, as outlined on old maps of the vicinity and verified by soils maps, a large wetland area existed in the Martindale Valley that drained into Noble Creek at the southern end of the valley (maps 1859, 1860). Currently, this area is referred to as Martindale Flats and still experiences flooding during the winter months although the extent is not what it once was. The valley is now used for agricultural production and is mainly fields and ditches. During the winter months, migratory birds utilize the flats as overwintering habitat although not in the same numbers as is typically observed in Maber Flats (Pers. comm. Michael Simmons, 2008).

While McHugh ditch is not considered suitable for fish populations there is a possibility that some species may migrate upstream from Noble Creek. Fish populations in Noble Creek include the following species: cutthroat trout (*Oncorhynchus clarkii clarkii*), prickly sculpin (*Cottus asper*), pumpkinseed (*Lepomis gibbosus*), and threespine stickleback (*Gasterosteus aculeatus*) (Ministry of Environment, FISS data query 2008).

Improvement projects have been undertaken in upper reaches of Noble Creek in order to improve salmon habitat by removing silt transported via McHugh ditch, creating a cattle watering station, adding large woody debris, rock weirs, and gravel (Jancowski, 2000).

While monitoring and rehabilitation activities can be beneficial for increasing awareness of water quality issues and increasing ecological function, they can also be moot if land use upstream does not improve as well. Upstream activity has a great impact on ecological functioning in downstream areas and if upstream areas are not targeted restoration projects in downstream areas will not be as successful as they should be.

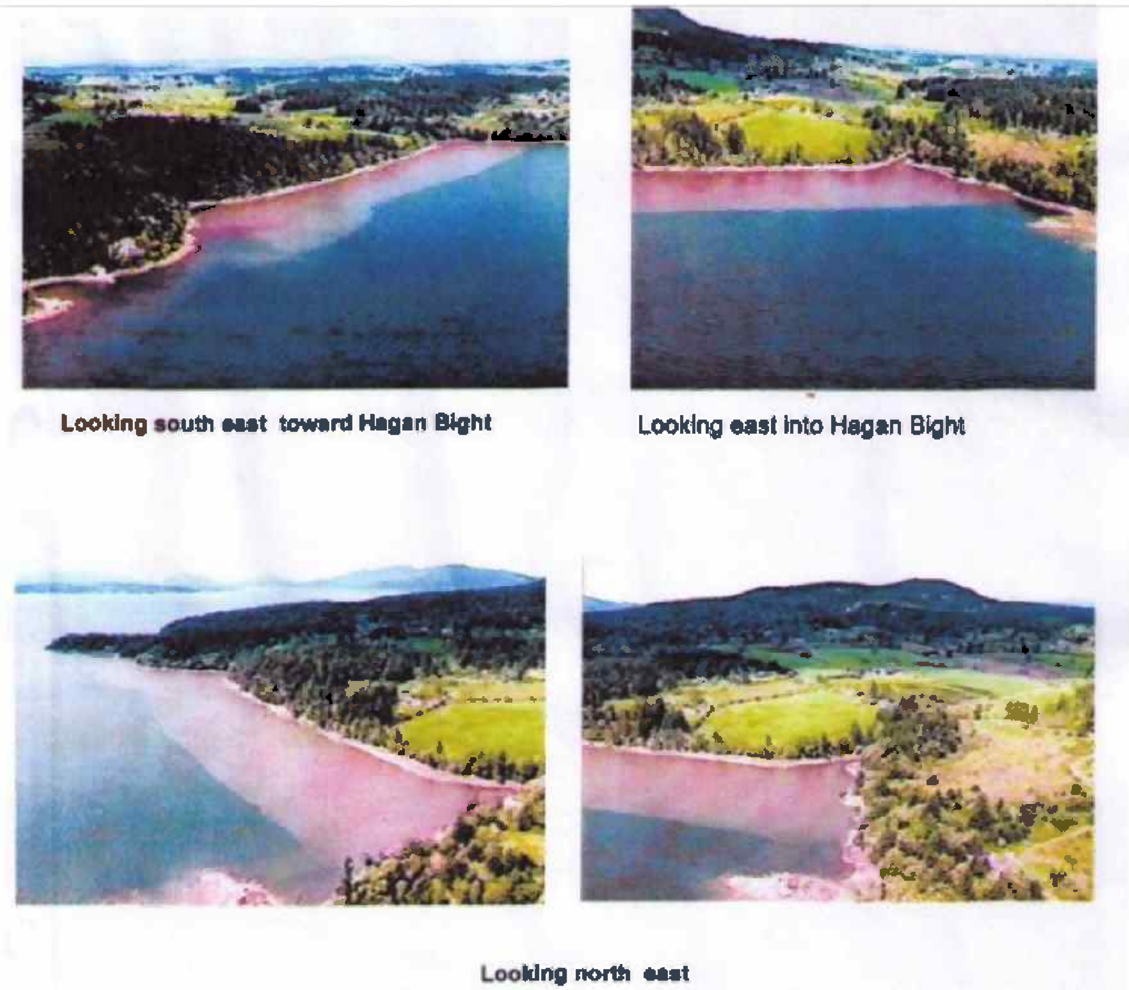
3.4 Water Quality Information

The Peninsula Streams Society (including its numerous member groups) has been involved over the past number of years in monitoring the water quality of both Hagan and Graham Creek. The purpose of the water quality monitoring program is to assess the stream condition in terms of fish habitat and other ecological requirements, specifically focusing on the impact of stormwater run-off. The monitoring program has been and continues to be conducted with cooperation from the District of Central Saanich.

Delcan (2003) noted that there were significant levels of fecal coliforms occurring in the 1990's. These high levels of fecal coliforms were likely due to agricultural activities and cross connections with the storm drain and sewer drain systems. In 1997, the Hagan-Kennes group sampled Stephens Creek (Stinky Ditch) that drains into Graham Creek, noting observations of oil film, odour, diesel fuel, and grey milk-coloured water; upon sampling, the group concluded that the water in the ditch had excessively high fecal levels. The most recent study was completed in 2007 by the Peninsula Streams Society (Penn. Streams, 2007). Peninsula Streams concluded that there were high levels of fecal coliforms, turbidity, metals, and high temperatures in the Hagan-Graham system (Peninsula Streams Society database). For instance, an industrial area that discharges into a ditch connected to Graham Creek had fecal coliform levels that exceeded recreational swimming standards (>200 CFL/100mL) 28 times; levels of cadmium, iron, manganese, phosphorus, zinc, and copper "chronically exceeded" CCME aquatic life criteria and levels of Total Extractable Hydrocarbons (TEH) were higher than contaminated site regulations for 18 of the 26 samples taken over the sampling period. Nitrogen levels were noted to be below aquatic life criteria; whereas phosphorus levels had at times exceeded them (likely due to agricultural activities).

One of the pre-eminent concerns that have been extensively documented is the excessive turbidity consistently noted to occur during storms and winter months. The main cause of this turbidity is the ditching and grading of stream channels (*i.e.*, ditches) late in the season prior to the onset of the autumn/winter rains. These high sediment loads can also be attributed in part to increased imperviousness throughout the watershed and a lack of best management practices to store and treat runoff. The images below (Figure J) are examples of the amount of sediment that can be moved through this watershed. This plume was captured flowing from Hagan Bight into Saanich Inlet in the late 1990's. It is extensive and hugs the western shoreline of the Saanich Peninsula from Hagan Bight north. In regard to other physical parameters (*i.e.*, TDS, Conductivity, pH), the system has been relatively stable over the past few years (except for temperature and dissolved oxygen). The fluctuations in the parameters measured for the Hagan and Graham Creek samples sites are consistent with prior years (reference).

Figure J Sediment plume from Hagan Creek into Saanich Inlet after rainfall event circa 1996 (Peninsula Streams)



Tetayut Creek was sampled in 2003 and 2005 for physical water quality parameters and for fecal coliforms. The Peninsula Streams Society who completed the sampling concluded that in 2003, 5 of 14 samples exceeded recreational guidelines for fecal coliforms. In 2005, of the two samples taken, one exceeded the recreational guidelines for fecal coliforms. The levels of fecal coliforms are likely due to agricultural activities and cross connections with the storm drain and sewer drain systems. Peninsula Streams Society also concluded that “all temperature, pH, dissolved oxygen and specific conductance measurements collected since 2003, except for one single measurement below DO levels, were of acceptable levels and within the British Columbia Approved Water Quality Guidelines” (Peninsula Streams Society, 2008).

3.5 Soils and Agricultural Use

Information on the soils of Central Saanich was obtained from both Regional and Provincial government sources. The BC MOE document "Soils of Southern Vancouver Island (Jungen, 1985) provides maps indicating the location and extent of soils within the District of Central Saanich, as shown in Appendix 5. The accompanying book provides a general description of the soils, the environments in which they occur, soil composition, and their drainage characteristics.

Improved resolution was provided in the "Soils of Central Saanich" layer on the Capital Regional District's Natural Areas Atlas (CRD, 2008), shown in Appendix 5. The layer provides information on the location and extent of soils within Central Saanich, but does not provide information on the soil types. Soils of Southern Vancouver Island was consulted to determine the characteristics of the soil types on the CRD mapping.

Generally, the soils mapping from the two sources were consistent. The taxonomy of the soil often differed (for example, somenos vs shawnigan soils) however the soil description (*i.e.* gravely sandy loam) were normally similar. A summary of the soils within Central Saanich, is provided in Table G below.

Table G Central Saanich Main Soil Types

Soil Name	Description	Drainage	Locations
Somenos	Gravelly sandy loam or very gravelly sandy loam (till)	Well	South of Keating Cross Road, west of the Pat Bay Highway, east of Willis Point, south towards Elk Lake, and outside of Tetayut Creek
Tagner	Silty clay loam or silt loam (marine deposit)	Poor	Band around Martindale Valley, Hagan Creek, north part of Tetayut
Saanichton	Clay loam to silty clay loam	Well	Hagan watershed aside from gravel pit and Maber Flats and Hagan Creek, south part of Tetayut
Metchosin	Humic (organic deposit)	Very poor	Martindale Valley and Maber Flats
Quamichan	Very gravelly to gravelly loamy sand (marine deposit)	Rapid	Gravel pit at Keating Cross Road
Dashwood Creek	Very gravelly loamy sand to gravelly sandy loam (marine deposit)	Well	Eastern flank of Martindale Valley

Soil Name	Description	Drainage	Locations
Sprucebark	Cobbly, gravelly to very gravelly loamy sand (morainal deposit)	Rapid	Keating Cross Road between West Saanich Road and Wallace Drive

Source: Soils of Southern Vancouver Island (Jungen, 1985)

Generally, the southern portion of Central Saanich is comprised of well drained Somenos type soils while the northeast portion consists of well drained Saanichton soils. To the east towards the Martindale Valley, Tagner soils appear and are similar to Saanichton soils, however they are poorly drained. Organic Metchosin type soils are found in areas prone to flooding – the Martindale Valley and Maber Flats. Smaller areas of well drained gravel and cobble deposits are found in the area of Butler Brothers pit at Keating Cross Road, just east of the Butchart Gardens, and on the eastern flank of the Martindale Valley.

3.6 Consolidated Watershed Data

Data from all three watersheds in Central Saanich were consolidated to form an overview of the total Central Saanich watershed area. Consolidating the watershed data helps in preparing a stormwater management plan that integrates solutions between the three watersheds. The data was collected and layered to form a comprehensive base map that included relevant watershed information within the municipality. The base map was put together in AutoCAD using several sources of data, reference maps and external information.

3.6.1 Sources

A summary of all sources collected to form the consolidated watershed database follows:

- Municipality of Central Saanich
  - Stormwater infrastructure information
    - Storm drain specs
    - Ditches
    - Culverts
    - Dykes
  - 2 m contour map of Central Saanich
- CRD
  - Natural areas atlas
- WorleyParsons & Aqua-Tex
  - Watershed boundaries
  - Monitoring stations
  - Creek walks / site visits

- Ground-truthing
- Surveying
- Photo point monitoring

- Water Survey of Canada
  - Meteorological station locations
- Public Consultation
  - Crest level gauge locations

3.6.2 Comprehensive Base Map

Sources for the comprehensive base map include the CRD natural areas atlas (CRD, 2008), contour maps and utility drawings from The District of Central Saanich (DCS, 2007) and meteorological station locations from the Water Survey of Canada.

Aqua-Tex and WorleyParsons worked in conjunction with input from the SAC to identify photo points and locations of crest level gauges. Ground-truthing was performed by WorleyParsons to verify key areas of the watersheds.

The CRD Natural Areas Atlas 2007 orthophoto data was used for the base layer of the map. The data was the most recent orthophoto available of Central Saanich and is of excellent quality. Drain, ditch and creek data was overlaid onto the base layer from Central Saanich utility drawings. Ground-truthing by WorleyParsons identified discrepancies between supplied creek data and actual watershed creek flow paths. Appropriate adjustments to the creek layer were made on the base map.

A 2 m interval contour map of Central Saanich was then layered onto the map. Using the contour data WorleyParsons constructed boundaries for Hagan Graham, Tetayut and McHugh-Noble watersheds and layered them onto the base map. In order to finalize the watershed boundaries, WorleyParsons ground-truthed the topography and ditching of key areas in Central Saanich and adjusted the base map accordingly.

Photo-point monitoring points outlined by WorleyParsons, Aqua-Tex and the SAC were added to the base map. This information was augmented by the locations of crest level gauges and meteorological sites added as the final layer to the map.

The comprehensive base map is included in Appendix 4.

3.7 Existing Policy and Regulation

The recommendations of this ISMP will be considered by Central Saanich Council for incorporation into the District’s policy and regulatory framework. The purpose of this section is to inventory and provide summary comment on existing policy and regulation that may interface, and need to be harmonized, with the recommendations of this plan. A detailed table summary of this inventory follows.

Related regulation by other levels of government has also been highlighted in this section to assist in the understanding of the District's storm water management efforts and coordinate with other agencies and levels of government.

Recommendations for new and amended policies and regulations that result from the recommendations of this plan are found in Section 8.3.

3.7.1 Official Community Plan and other Council Policy

Official Community Plan

Central Saanich's Official Community Plan (OCP) has been recently reviewed and updated by amending Bylaw No.1600 adopted on November 3, 2008. This OCP review process coincided with, and anticipated, the completion of this ISMP after the new OCP.

The key policies of the Official Community Plan relating to this Integrated Stormwater Management Plan are;

"Section 7. Environment: Preserving Healthy Abundant Ecosystems

7.2.2 Protection of Water Resources

Objective "To preserve, protect and enhance the water resource, in particular the quantity and quality of surface waters, groundwater, aquifers, and the supporting watershed environment and to protect the quality of ocean waters, and to maintain creeks and streams in their natural state, free from development impacts."

"Section 3. Agriculture and Rural Lands: Strengthening Farming and Preserving Character

3.2.2 Support for Agriculture

Policy 2 *Support drainage, storm water management, and irrigation projects that improve the productivity of farmland and participate in suitable programs offered by senior government agencies. The District is participating in the development of an Integrated Storm Water Management Plan that will assist with the management of storm water and drainage issues on agricultural lands."*

"Section 10. Municipal Infrastructure: Building and Maintaining Healthy, Efficient Utilities and Buildings

10.2.4 Stormwater Management

Objective To adopt an environmentally sound, integrated stormwater management strategy

The new OCP further sets out in 7.2.2 Policy 3 that "*at the time of completion of the Integrated Stormwater Management Plan, consider amending this OCP and other District Bylaws to adopt recommended policies/practices for the management of rainwater and the District watersheds."*

A listing of OCP policy relative to this ISMP follows in table format. The most significant policy additions in the revised OCP are considered to be the expanded use of Development Permit areas and guidelines.

- The new Riparian and Sensitive Aquatic Ecosystem Development Permit Area incorporates the Province's Riparian Areas Regulations and will play a significant role in regulating new development and land disturbance activities in proximity to watercourses.
- Landscaping guidelines in the Residential Multi-family and Commercial Mixed-use Development Permit areas now include storm water management guidelines that encourage the natural infiltration of stormwater into the ground.

Council Policy

In addition to policy contained within the Central Saanich OCP. Council adopts formal policy that is compiled in a Policy Manual. These policies are considered to supplement and operationalize the broad policies of the OCP. There is no current adopted Council policy for stormwater management. Recommendations for Council policy on stormwater management follow in Section 8.3.

3.7.2 Existing Source Control Regulation

The existing Central Saanich Bylaws that provide some manner of source control stormwater management include:

- Bylaw No. 1237 - A bylaw for the regulation and protection of natural watercourses, ditches and drains;
- Land Use Bylaw No. 1309 – Schedule 4, Engineering Specifications and Standard Drawings (primarily for subdivision approval); and
- Bylaw No. 1600 – OCP Development Permit Area for Residential Multi-family and Commercial Mixed-use.

Table H illustrates the types of land development that are regulated by these bylaws. Whereas communities with high growth rates and significant future development potential will focus on the application of new policy in growth areas, Central Saanich, with its low growth rates and limited development potential, is challenged to introduce regulation of existing developed properties. In this respect both new development and existing development types are listed in this table.

Bylaw No. 1237 – Protection of Natural Watercourses has potential broad application to all aspects of new and existing development respecting the quality of stormwater. In particular it prohibits the discharge of any waste into a storm sewer or watercourse. The bylaw's definition of prohibited waste is broad and technically specific. The prohibition applies equally to all new and existing development and to activities during construction. The District receives few complaints respecting these regulations and when received, are most often referred to the water quality specialists at the Province.

The Engineering Specifications and Standard Drawings are interpreted to apply to the subdivision of land. These specifications include a discretionary requirement that stormwater systems be designed for "zero increase in runoff." This regulation is considered effective for its limited purpose. Ownership of SWM facilities in new subdivisions is typically assumed by the District together with on-going maintenance responsibilities.

The Development Permit Guidelines for Residential Multi-family and Commercial Mixed-use DPA encourage the natural infiltration of rainwater in landscaped areas. In view of the current zoning regulations (refer to Table I in Section 3.7.4, C-1 Zoning example) the effectiveness of these guidelines may be reduced given the inability of development permit guidelines to effectively reduce any development established by zoning regulation. Where stormwater management facilities are provided the development permit is an effective tool to ensure construction and on-going maintenance.

Table H Central Saanich – Existing Regulations for Stormwater Management at Source

	New Development (including building alterations and additions that require a building permit)				Existing Development		
	New Commercial, Industrial, Institutional and Multi-family Residential	**New Agricultural Uses**	**New land subdivision (all uses)**	**New single and two-family residential development (On existing lots)**	**Existing Commercial, Industrial, Institutional and Multi-family Residential**	**Existing single and two-family residential development (on existing lots)**	**Existing Agricultural Uses**
SWM Quality Controls	1. Bylaw No. 1237 – general requirement for no discharge of waste 2. Bylaw No. 1237 Paved or impervious parking lots require oil and grease separator (post 1997) 3. Bylaw 1600 – OCP DPA - Guidelines for new development	1. Bylaw No. 1237 general requirement for no discharge of waste			1. Bylaw 1237 general requirement for no discharge of waste		
SWM Quality Controls During Construction	1. Bylaw 1237 – general requirement for no discharge of waste						
SWM Quantity Controls	1. Bylaw 1600 – OCP DPA - Guidelines for new development	None	1. Schedule 4 to LUB may require "zero increase" in runoff	None	1. None, except those completed under Land Use Bylaw Schedule 4 "zero increase" requirement	1. None, except those completed under Land Use Bylaw Schedule 4 "zero increase" requirement	None
SWM Quantity Controls During Construction	None	None	None	None			
SWM Facility Maintenance	1. Bylaw No. 1237 Maintain parking lot oil and grease separator	None	None	None	1. Bylaw No. 1237 Maintain parking lot oil and grease separator	None	None

3.7.3 Other Related Legislation

Provincial Riparian Area Regulation

These regulations are clearly set out in Section 11.1 of the OCP and have been incorporated into the Riparian and Sensitive Aquatic Ecosystem Development Permit Area Guidelines.

Provincial Agricultural Land Commission Act and Right to Farm Legislation

In practicable terms this legislation reduces the District's authority over lands in the agricultural land reserve and prohibits the District from exercising its land use control powers to prohibit or restrict the use of land for a farm business in a farming area unless approved by the Province. There is potential that the use of land within the Agricultural Land Reserve (ALR) for integrated stormwater management facilities (e.g. a constructed and managed wetland) will be considered a non-farm use and require approval by the Agricultural Land Commission (ALC).

Federal Department of Fisheries and Oceans, Fisheries Act:

The key components of the Fisheries Act related to stormwater management are the conservation and protection of fish and fish habitat and pollution prevention. The Act applies to all marine and freshwater resources, whether in private or public areas. Fish habitat means spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes. Regulations state that no person shall carry on any work or undertaking that results in the harmful alteration, disruption or destruction of fish habitat.

3.7.4 Land Use and Other Regulatory Bylaws

An inventory of relevant Land Use Bylaw regulations and summary comment are also listed in Table I below. Recommended amendments follow in Section 8.3.

The scope of this ISMP also includes an inventory of other District Bylaws that may pertain to its implementation. Their relevant sections are listed in the following table. They include:

- Protection of Natural Watercourses Bylaw;
- Erosion Control and Tree Cutting Bylaw;
- Soil Removal and Deposit Bylaw;
- Tree Protection Bylaw;
- Watercourses and the Sea Bylaw;
- Proposed CRD Model Bylaw to Regulate Discharge of Waste into Storm Sewers and Watercourses; and
- Proposed Surface Water Run-off Bylaw No. 1606, 2008

Table I District of Central Saanich - Bylaws Pertaining to the Central Saanich Integrated Storm Water Management Plan

	Bylaw Title	Date	Description	Comment
1.0	**Official Community Plan Bylaw** **No. 1600**	Nov. 3, 2008	7.1.3 Reference to ISMP – policy to manage stormwater to ensure no negative impact on marine environment in Saanich Inlet.	No change recommended Riparian DPA will control water quality from new residential, commercial and industrial activity adjacent to watercourses Protection of Natural Watercourses Bylaw has the potential to prevent contaminants from entering all watercourses
			7.2.2 Protection of Water Resources Policy 1 – District to enforce existing watercourse bylaw and if warranted establish additional regulatory measures to protect water quality	The regulations of the existing Protection of Natural Watercourses Bylaw are comprehensive. Enforcement is generally on a complaint basis and high compliance levels through municipal enforcement will likely be difficult to achieve Other regulatory and compliance strategies should be pursued.
			7.2.2 Policy 3 – When ISMP complete consider amending OCP and Bylaws and adopt policy/practices to implement recommendations	Replace this policy with new ISMP policy
			10.2.4 Stormwater Management Objective: *to adopt an environmentally sound, integrated storm water management strategy*	Delete this policy upon adoption of ISMP policy and regulations
			10.2.4 Policy 1 - Support for facilities to mitigate downstream impacts – including agriculture	No change recommended Watershed (System) improvements for agricultural benefit are recommended in this Report
			10.2.4 Policy 2 – Continue to enforce regulation respecting water courses	Regulations that directly relate to watercourses include; • OCP Bylaw - Riparian DPA • Land Use Bylaw – Section 25(a), 28, Schedule 4 – Engineering Specifications and Standard Drawings, Section 3A (zero increase in run-off) • Protection of Watercourses Bylaw • Erosion Control and Tree Cutting Bylaw • Soil Removal and Deposit Bylaw
			10.2.4 Policy 3 – Direct storm water to creeks only if no harm to fish, flows, quality and creek banks	No change recommended Riparian DPA, Protection of Watercourses Bylaw and Surface Water Runoff Bylaw have potential to meet this objective

	Bylaw Title	Date	Description	Comment
			10.2.4 Policy 5 – Set standards and regulations for new development and on-going drainage management	No change recommended Standards and regulation are recommended in this Report
			10.2.4 Policy 6 – Adopt policy from forthcoming ISMP and Surface Water Runoff Bylaw	Delete this policy upon adoption of ISMP policy and regulations
			10.2.4 Policy 7 – Refer to Model CRD Bylaw for new policy, standards and practices	No change recommended In most part, the content of the CRD Model Bylaw is recommended in this report
		Riparian Development Permit Area (and Sensitive Aquatic Ecosystem DPA)	Applies to residential, commercial and industrial activities, generally on lands 30 metres each side of a stream – includes most all land disruption (damage to vegetation, disturbance of soils, construction, paving, flood protection works, roads, trails, docks, wharves and bridges, sewer and water services, drainage systems, utility corridors, subdivision – requires that a development permit be issued based on report and recommendation by a QEP (Qualified Environmental Professional) demonstrating no harm to fish habitat	Riparian DPA will control water quality from new residential, commercial and industrial activity adjacent to watercourses
		Marine Shoreline DPA	11.2 No reference to SWM guidelines	Limited potential for SWM improvement
		Sensitive Terrestrial Ecosystems DPA	11.3.6 (m) No alteration to natural drainage systems that alter availability of water to ecosystem	Limited potential for SWM improvement
		Light Industrial / Arterial Commercial DPA	11.4 No reference to SWM guidelines	Potential for SWM guidelines to regulate quality and quantity discharge from new development – new guidelines are recommended in this report
		Residential Multi-family and Commercial Mixed Use DPA	11.5.15 (g) Rain gardens, bio-swales and permeable materials are encouraged to absorb storm water and reduce irrigation needs	Includes new SWM guidelines
			11.5.15 (n) Minimize storm water runoff and promote natural infiltration	
			11.5.15 (o) Maximize vegetation to absorb and break down storm water and airborne pollutants	
		Brentwood Bay and Moodyville Commercial Mixed Use DPA	11.6 No reference to SWM guidelines	Potential for SWM guidelines to regulate quality and quantity discharge from new development – new guidelines are recommended in this report
		Tourist Commercial DPA	11.7 No reference to SWM guidelines	Potential for SWM guidelines to regulate quality and quantity discharge from new development – new guidelines are recommended in this report

	Bylaw Title	Date	Description	Comment
		Marina DPA	11.9 No reference to SWM guidelines	Limited potential for SWM improvement
2.0	**Land Use Bylaw** **No. 1309**	Jun 28, 1999	**25(a) Composting Uses** – Composting is prohibited within 15 metres of a natural watercourse or constructed ditch – application of finished compost is not regulated in this bylaw	Complimentary regulation No change recommended
			28 Setbacks – (3) buildings and structures to have a minimum 15 metre setback from natural boundary of watercourses (5) buildings and structures to have a minimum 10 metre setback from the sea	Complimentary recommendation No change recommended
			Zone Regulations: Example: C-1 Zone – 50% lot coverage – FAR- 1.0 – parking rates by specific commercial use - no minimum area for landscaped open space, no maximum area of impervious surfaces, parking lot setbacks create a leave strip that may or may not be landscaped, Table 4 Screening requirements will typically leave a 1 metre wide strip at the property line A typical application of these regulations will result in estimated impervious surfaces at 90%	Potential to regulate lot coverage by impervious materials and/or require an owner of proposed paved or roof area to manage and dispose of surface run-off and storm water as set out in regulation
			Section 42(5) – requirement to grade and drain to dispose of surface water and eliminate sheet flow of drainage water	Amendment recommended to harmonize with infiltration and retention concepts
			Section 42 (14) Parking lot setbacks create potential landscaped areas – 1 metre from a lot line in A (Agriculture), R (residential) or RE (Estate residential) zones and 2.5 metres in all other zones	May assist with SWM facilities at property lines however internal SWM facilities may be compromised by a 2.5 metre setback at property lines. A future review for complimentary SWM regulation may be considered
			Section 49 Screening Requirements do not contribute to potential landscaped areas for SWM facilities - a 1 metre wide property line strip with a hedge or fence is insufficient for SWM facilities and alternative berms do not facilitate infiltration	A future review for complimentary SWM regulation may be considered
			Schedule '4' – Engineering Specifications and Standard Drawings Section 3 – Design Criteria for Strom Drains sets out that subject to the requirement and/or approval of the municipal Engineer, the principles of storm water management - "zero increase in run-off" may be incorporated into the design of storm drains.	Recommended amendments to compliment SWM concepts and remove barriers to innovative stormwater management methods

	Bylaw Title	Date	Description	Comment
3.0	**Protection of Natural Watercourses Bylaw** **No. 1237**	Oct. 6, 1997	Regulations prohibit the fouling, obstruction or impeding the flow of a stream, ditch, drain or sewer located on public or private property. Prohibits the discharge of any domestic waste, trucked liquid waste or prohibited waste into a storm sewer or watercourse. Residential land uses shall only discharge natural precipitation, uncontaminated water and water resulting from lawn and garden maintenance, non-commercial car washing and building and driveway washing.	The regulations of the existing Protection of Natural Watercourses Bylaw are comprehensive. Enforcement is generally on a complaint basis and high compliance levels through municipal enforcement will likely be difficult to achieve. Other regulatory and compliance strategies should be pursued.
4.0	**Erosion Control and Tree Cutting Bylaw** **No. 993**	Nov 5, 1990	Erosion Districts (lands considered subject to flooding, erosion, land slip and avalanche) are mapped on Schedule "A" to the bylaw. The cutting of trees within an Erosion District requires a permit – which may be issued or denied. A report by a qualified person may be required	Complimentary regulations No change recommended
5.0	**Soil Removal and Deposit Bylaw** **No. 1544**	Nov 19, 2007	Numerous exemptions including less than 40 cubic metres, ALR Lands, approved subdivisions, Mines Act approvals, approved construction works, composting pursuant to the Land Use Bylaw etc. Regulations 13(a) permits not to be issued if the works will foul, pollute, obstruct, damage or destroy any watercourse 27. All watercourses to be kept free of silt, clay, sand, rubble, debris or any other things arising from the works, and 28 no watercourse to be altered or diverted without permission.	Complimentary regulations No change recommended
6.0	**Tree Protection Bylaw** **No. 1595**	Jul 28, 2008	Protected trees re defined as; garry oak, arbutus, pacific dogwood, pacific yew, sore pine, trembling aspen, nesting tree protected by the Wildlife Act, a replacement tree, a tree designated for retention in another permit, a tree protected by covenant, any tree with a dbh exceeding 60 cm, and a tree of botanical, historic or cultural value as listed in a schedule to the bylaw (none listed). Bylaw does not apply to lands in the ALR, C-8 Tourist Display Garden Zone or generally municipal lands	Complimentary regulations No change recommended
7.0	**Watercourses and Sea Bylaw** **No. 1187**	May 21, 1996	Duplication of Land Use Bylaw regulations found in Section 28 These regulations; govern the setbacks of buildings and structures (excluding fences) from watercourses and the sea; prohibits the placement of fill in, or within a setback distance of a watercourse and established setbacks for building housing animals and manure and areas for	Complimentary regulations These regulations are duplicated in the Land Use Bylaw This Bylaw may be repealed

	Bylaw Title	Date	Description	Comment
			manure storage from watercourses and the sea	
8.0	**Potential Surface Water Runoff Bylaw No. 1606**	Proposed	Primarily regulates source control of water quantity. WorleyParsons have previously commented on this draft bylaw	Subsequent to the adoption of this bylaw consider incorporating this regulation into a comprehensive ISM Bylaw
9.0	**Potential Adoption of CRD Model Bylaw to Regulate Discharge of Waste into Storm Sewers and Watercourses**	Proposed	Primarily regulates source control of water quality. Duplicates parts of the District's Protection of Natural Watercourses Bylaw No. 1237. Includes Codes of Practice to regulate existing businesses such as Automotive and Parking operations. Development and Construction, Building and Window Washing, Carpet and Upholstery Cleaning, Landscape and Garden operations and Painting operations	Codes of Practice and the regulation of existing businesses have potential application in Central Saanich where new development regulations may have limited effect.

3.8 Knowledge Gaps and Scope Adjustments

After assessing the existing information, it became clear that there were gaps in the information set required to complete the ISMP.

Hydrological Information

Reliable rainfall and streamflow data are key components to developing any ISMP as they provide the information base upon which mitigation measures can be assessed. Review of the relevant hydrological information available for the three main watersheds of Central Saanich revealed the followings "gaps".

- There was no continuous flow monitoring within the Hagan-Graham watershed;
- There was no continuous flow monitoring within the Noble Creek – McHugh Ditch watershed;
- Partial watershed continuous flow monitoring within the Tetayut (Sandhill) watershed was ongoing and conducted by the Water Survey of Canada. This data is provided on an annual basis in May for data collected and analysed from the previous year;
- Quarter hour meteorological data from the University of Victoria's School-based weather station network was found to have some consistency issues and the systems located in the District have only been operating for a short time period; and,
- Long term hourly meteorological data from the Environment Canada station located at the Victoria International Airport is outside the District of Central Saanich's boundaries. To ensure this data was representative of conditions in Central Saanich, correlation between the Airport and the school based weather station network was required.

In order to provide sufficient watershed flow data for accurate modelling of the watersheds, the number of continuously recording flow monitoring stations installed and operating in the Creeks was increased to eight, as compared to the minimum specification of four stated in the ISMP Request for Proposals (DCS, 2007). Crest level gauges were also installed. This was to collect enough data for meaningful modelling of the watersheds. This required additional collection and processing of data. All of the monitoring equipment was left in place as District property (with the exception of the single WSC station) for continued use.

The period from the start of the project to the change of scope date had comparatively few sizeable storms, resulting in less data on which to base the modelling. To compensate, increased reliance on historical meteorological and flow data was required to bolster the data set. Additional time was needed to process this data and much of it required purchase.

As-Built Infrastructure

Existing information on the drainage infrastructure within the District of Central Saanich was limited to the Central Saanich drainage plans and plans of portions of the Patricia Bay Highway drainage system obtained from the Ministry of Transportation (copies of the latter provided with this report in Appendix 13. Where there were piped drainage systems, the size of the pipe was often noted on the drainage plans, however no cross sections were provided. The drainage plans also showed the locations of the ditches and creeks in the three watersheds, but did not provide any information as to their size, shape, or elevation. Culvert information was not available. Detailed creek profiles for several reaches in Hagan Creek (produced in 1999) were provided by Peninsula Streams Society and were of great value; this type of information was unavailable for other creek reaches (Berrang, *et al,* 1999).

A brief review of the two main sources of information, the Central Saanich Drainage Plans and the Pat Bay Highway plans identified some discrepancies between the two, especially within the Tetayut watershed. Groundtruthing was necessary in order to confirm or refute the information contained within the plans. A field survey was also needed in order to confirm the watershed divides assumed from topography, as well as confirm drainage pathways within each watershed.

The main information gaps were related to the hydraulic characteristics of the watershed, information necessary to construct the stormwater models. Specific data required included elevations, cross-sections, and materials of construction for the pipes, ditches, creeks, and culverts within the watersheds. Therefore, several trips into the field were necessary to obtain critical pieces of data such as pipe sizes and shapes, depths and widths of creeks and ditches, culvert sizes, and invert elevations. Additional field work was required to gather sufficient elevation data for analysis of hydraulics in critical areas – principally Martindale Valley and Maber Flats so as to be able to develop more accurate analyses of the hydraulic conditions in those problematic areas.

4. PUBLIC CONSULTATION: KEY MILESTONES

4.1 Importance of Public Consultation

One of the principles of public participation is that the product is enhanced by the participation of those who will be impacted by the decisions flowing from the project. In the case of the ISMP for Central Saanich, there a number of key stakeholders who potentially are impacted by decisions made as a result of recommendations from this study. These key stakeholders were identified at the outset of the project and encouraged to participate in three key areas:

f) Stakeholder Advisory Committee

g) Creeks and Communities Workshops

h) Public Open Houses

Particular efforts were made to engage First Nations and members of the agricultural community. Participation of NGO's with an interest in the health of the environment in general, and in creeks and streams, in particular, was appreciated.

In addition to identifying issues and providing comments on the recommendations, a number of stakeholders were involved in collecting data for the study. Their participation has brought local knowledge and history to the project and has tested the recommendations through the lens of practicality and pragmatism.

4.2 Process / Methodology

4.2.1 Stakeholder Advisory Committee

The Stakeholder Advisory Committee (SAC) played a central role in all aspects of the ISMP development. Functioning as a form of 'democratic oversight,' the SAC brought together a variety of stakeholder representatives in an effort to ensure the integrated and holistic scope of the ISMP. SAC membership and representation is detailed below.

- District of Central Saanich Council
  - Represent the Council and keep them informed of SAC project progress.
- District of Central Saanich Staff
  - Included representatives from both Engineering and Planning departments, as well as additional representation as required from Finance, Parks and the District Administrator.
- Communities of Saanich and North Saanich
  - In recognition of the holistic scope of the ISMP and the irrelevance of cadastral divisions to watershed hydrology, representatives from neighbouring communities brought to light unique conditions and community needs for portions of the study area outside District jurisdiction.

- Department of Fisheries and Oceans, Ministry of Environment
  - Representatives from these agencies were required to ensure that environmental requirements are addressed and fulfilled in such a way as to ease future implementation of ISMP recommendations with minimal involvement of federal and/or provincial officials.
- Ministry of Agriculture, Local Farms Groups
  - As the majority of land in question is zoned for agriculture and protected within the ALR, balancing the needs of the agricultural community with their role in the watershed and other land interests was a primary issue for the ISMP.
- Tsawout and Tsartlip First Nations
  - First Nations lands are major portion of the watersheds, and contain the outfalls for the two larger watersheds (Hagan-Graham and Tetayut) . First Nations representatives bring a host of historical knowledge and insight into all facets of the ISMP, and in particular watercourse preservation.
  - Help with all facets – particularly watercourse preservation
- Peninsula Streams Society, Haig Brown Fly Fishing Association
  - Local stewardship groups brought invaluable knowledge of local streams and watercourses, and helped to represent fisheries aspects.
- Public at Large
  - Following an advertisement for general members, several members of the Public at Large took an active role on the SAC to represent different aspects prevalent to the people of the community not well-represented otherwise on the SAC.

The SAC as a whole was consulted at multiple stages through the duration of the project via a series of meetings with the Project Team; twice per watershed in question and at both the 50% and 90% project completion points. These meetings gave the project team an opportunity to update the SAC on the progress of the ISMP and to allow for input and questions from the council. Important issues from these meetings are presented in section 6.3. The SAC helped to accomplish a variety of objectives including:

- Initially reviewing the ISMP terms of reference;
- Gathering background information and identifying key watershed issues, concerns, goals and objectives;
- Securing buy-in to the study process and identifying what the community values and is willing to support;
- Reviewing the results of the technical analyses and solution evaluation criteria; and
- Commenting and providing input on the preferred alternatives and recommendations.

The diversity of SAC membership compiled a variety of both local and regional knowledge and experience of issues, concerns and opportunities; and in addition to including, representing and minimizing detrimental impacts to the various parties involved, served as a valuable resource optimizing the opportunity for bilateral flow of information.

4.2.2 Public Open Houses

There were two Open Houses held in the Fire Training Room at the municipal hall as part of the consultation process for the ISMP. An introductory Open House was held in October 25, 2007 and a second Open House to discuss the projects recommendations, was held on October 16, 2008. Both Open Houses were advertised in the Peninsula Review, on the District of Central Saanich website through word of mouth and email networks of organizations represented on the Stakeholder Advisory Committee.

Copies of the ads, materials and surveys for the various public consultation events are contained in Appendix 11.

Introductory Open House

Approximately twenty-five people attended the introductory Open House. Participants were provided with information about the Integrated Storm Water Management Planning process and were asked to indicate on large maps, areas where there are concerns with flooding or poor drainage, erosion, loss of riparian habitat, excessive runoff or contamination and to identify any other issues. Participants were also asked to help in the data gathering process and to provide photographs or other documentation of flooding or other concerns.

October 2008 Open House

A highly engaged group of residents participated in the October 2008 Open House. Approximately thirty people attended. The process and draft recommendations were available on story boards, and the consultant team presented the findings of the work in a PowerPoint presentation. A lively and useful discussion followed the presentation. A questionnaire was distributed at the Open House and also was posted on the District of Central Saanich website. To date, eight completed questionnaires have been received and four individuals have expressed an interest in participating on a volunteer group to continue progressive work on stormwater issues. A high level of support was expressed for the draft recommendations. (of those who responded, 100% agreed or strongly agreed with the recommendations, except for one respondent who disagreed with formation of a volunteer group.)

4.2.3 Creeks and Communities Workshops

The following quotation describes a successful approach to popularizing watershed health issues and educating the public on assessing creek health. (Riparian Coordination Network, 2002).

"Healthy watersheds and riparian-wetland areas are critical to providing communities with the economic, ecological, and social benefits that come from the reliable availability of adequate supplies of clean water. The storage of water in riparian-wetland areas is important to ensuring a life-sustaining supply of this precious resource. Riparian-wetland areas are also unique features that connect landscapes and communities, providing unlimited opportunities to bring people together to create a common vision for

productive and sustainable conditions. While there is growing agreement regarding the importance of watershed and riparian-wetland function, there continues to be considerable disagreement about existing conditions and appropriate treatments. This disagreement has led to an environment of lawsuits and regulatory approaches, often leaving out the people most affected by the decisions. However, there is increasing evidence that effective solutions arise from the workings of citizens and stakeholders."

"A better approach to managing riparian wetland areas is to facilitate efforts designed to build capacity within communities to confront and resolve the complex and contentious problems surrounding these resources. People are now recognizing that using the best science to make management decisions is not enough. Successful management of these resources is dependent upon bringing communities of people together, working at the landscape level."

"As an assessment tool, the Proper Functioning Condition (PFC) process provides a qualitative and standardized approach for assessing the physical functionality of riparian wetland areas. It can be applied in a variety of settings to gain consistent information that helps people begin to discern what is working well, what may be limiting, how management could be improved, or what further evaluations might be appropriate… The PFC ratings of streams within a watershed can guide the prioritization of restoration and management activities to those areas with the highest probability for positive change with a reasonable investment... Use of the PFC concepts and the assessment process increases awareness and understanding of riparian-wetland functions and builds capacity for cooperative decision-making and management that benefits both the land and dependent communities".

In order to incorporate these concepts into the District of Central Saanich and surrounding communities, the consulting team hosted three Creeks and Communities Workshops. These workshops were set up with a PowerPoint presentation presented by Cori Barraclough and Patrick Lucey of Aqua-Tex discussing Proper Functioning Condition theory and process followed by a field trip to practice the assessment in real time.

The first two workshops, held on September 29 and October 22, 2007 at the Municipal Hall used Graham Creek and Tetayut Creek as examples visiting the Maber Flats area, Centennial Park and Adam Kerr Park. The third workshop, hosted by the Tsawout First Nation, made field stops at Centennial Park and the Saanich Historical Artifacts Society site.

Participants ranged from interested community members, to community stewardship group members, to municipal employees, to city councillors, and Tsawout First Nation band members.

4.2.4 Other Consultations

To determine the type of bird activity occurring in Central Saanich a group of bird enthusiasts from the Victoria Natural History Society with particular knowledge of the Maber and Martindale areas was consulted. The birders group conducts bird counts in Central Saanich and vocalized concerns over a loss of overwintering habitat for bird species. The group provided expertise on bird numbers, species and habitat type within key areas of Central Saanich. See Appendix 11 for more information on bird habitat.

4.3 Summary of Issues / Values

Area	Issues	Values
Flooding	• Martindale Valley flooding • Maber Flats flooding • Rock weir obstruction in Centennial Park • Seasonal flooding on Central Saanich Road • Dooley road culvert causes potential hydraulic restriction • Shoulder season flooding limits agriculturally productive season	• Bird Habitat • Retention of organic soils
Agricultural	Shoulder season flooding limits agriculturally productive season Contamination from road runoff, including salt, impacts on water use and organic farm classification	• Retention of organic soils • More local food production (100 mile diet) • Economic viability of farms
Habitat	• Reduction in spawning/fish habitat due to marginalization of habitat • Threats via ditching • Erosion of soils • Perceived conflict between fisheries habitat and agriculture and urbanization	• Migratory bird habitat Maber and Martindale Flats • Habitat value for fish, aquatic organisms, amphibians, birds, vegetation, other wildlife
Water Quality	• Poor water quality Stinky ditch • Occurrences of sewage flow and other pollutants entering Tetayut • Keating Cross Road and its role as polluter source via high EIA • Poor water quality leading to fish kills • Poor water quality affecting fish habitat viability • High sediment load in creeks • High temperatures in summer	• Ability to sustain fisheries habitat • Ability to maintain clean water • Reduction in health risk for human population , wildlife population, and vegetation community • Agriculture *i.e.* irrigation…less chemicals on the field
Cultural	• Loss of fish population for fishing especially wild salmon • Loss of ability to swim/bathe in creeks due to water quality problems • Octopi used to migrate into lower Tetayut from Haro Strait no longer migrate this far	• Connection with the landscape • Food production, especially fish • Bathing practices-historically used to occur in the lower reaches of Tetayut Creek
Social	• Interests of First Nations, agriculture, residential and industrial uses may be in conflict	• Respect for First Nations cultural practices • Appreciation of rural character
Economic	• Economic viability of farms • Cost of ISMP implementation	• Local food production • Cost of healthy watersheds

5. FIELD PROGRAM

5.1 Biophysical Inventory

Four days were spent walking the watercourses in the respective watersheds of Hagan/Graham, Tetayut, and McHugh-Noble. Hagan Creek and Graham Creek were assessed on February 7, 2008, February 11, 2008, and February 15, 2008. Tetayut Creek was assessed on February 15, 2008 and June 12, 2008. McHugh ditch and Noble Creek were assessed February 15, 2008.

Physical attributes of the creeks were examined and highlighted in Section 9, Analysis and Results. Vegetation composition was also noted along with any wildlife observed.

The aim of the assessment was to create a baseline summary of the health of the creeks and to determine where and why ecological function may be limited.

5.1.1 Biophysical Assessment Objectives

In order to be able to create a stormwater management plan with an integrated methodology, examining the 'natural' water courses within a watershed and surrounding communities is essential as the majority of stormwater run-off end ups in these systems. This assessment aimed to:

- Determine the health of the streams within Hagan-Graham, Tetayut, and McHugh-Noble watersheds using the Proper Functioning Condition method.
- Determine if and where stormwater may be negatively impacting these watercourses.
- Create an inventory of reaches indicating those in Proper Functioning Condition (PFC), Functional-at-Risk (FAR), or Non-Functional (NF) conditions.
- Create a prioritized list of recommendations for improvements.

5.1.2 Photo Point Monitoring

The technique known as Photo Point Monitoring (PPM), pioneered by Dr. Fred Hall in 2001, was employed from December 2007 to August 2008 in order to track changes in the creek systems over time. PPM involves repeat photography of a specific location using landscape objects to line up the images to make them as identical as possible. An overlap of 90% is the standard (Hall, 2001). In this way, any major changes occurring over time and through different seasons can be captured in photographs.

With the help of the Peninsula Streams Society network, the project team was able to recruit volunteers to be responsible for taking photographs once a week during the winter and early spring periods and once every two weeks in the late spring and summer months. PPM training took place at two workshops, one in December 2007 the other in January 2008, and was conducted by Aqua-Tex staff.

Fourteen sites located throughout the District of Central Saanich were selected by field staff with the aim of providing representative photographs for the major watersheds.

1. The photopoint sites are found in the following locations on Figure K:

2. McHugh Ditch from Martindale Road
3. Martindale Flats from Welch Road
4. Martindale Flats from Mallard Avenue
5. Tetayut Creek at Keating Crossroad
6. Tetayut Creek at Tetayut Road
7. Graham Creek at West Saanich Road
8. Maber Flats from Maber Road
9. Graham Creek at Wallace Drive
10. Graham Creek in Centennial Park
11. Graham Creek at the CRD pump station, Cultra Ave.
12. Hagan Creek at Mount Newton Crossroad
13. Hagan Creek at Haldon Road
14. Hagan Creek at 1251 Mount Newton Crossroad
15. Hagan Creek at West Saanich Road

Laminated field cards were created for volunteers to match the photographs to maintain consistency. A selection of these photographs are included in Appendix 10.

The study team sincerely thanks the efforts of all the volunteers for giving up some of their time and providing these photographs.

Jeanette Bourgoin

Dan Claxton

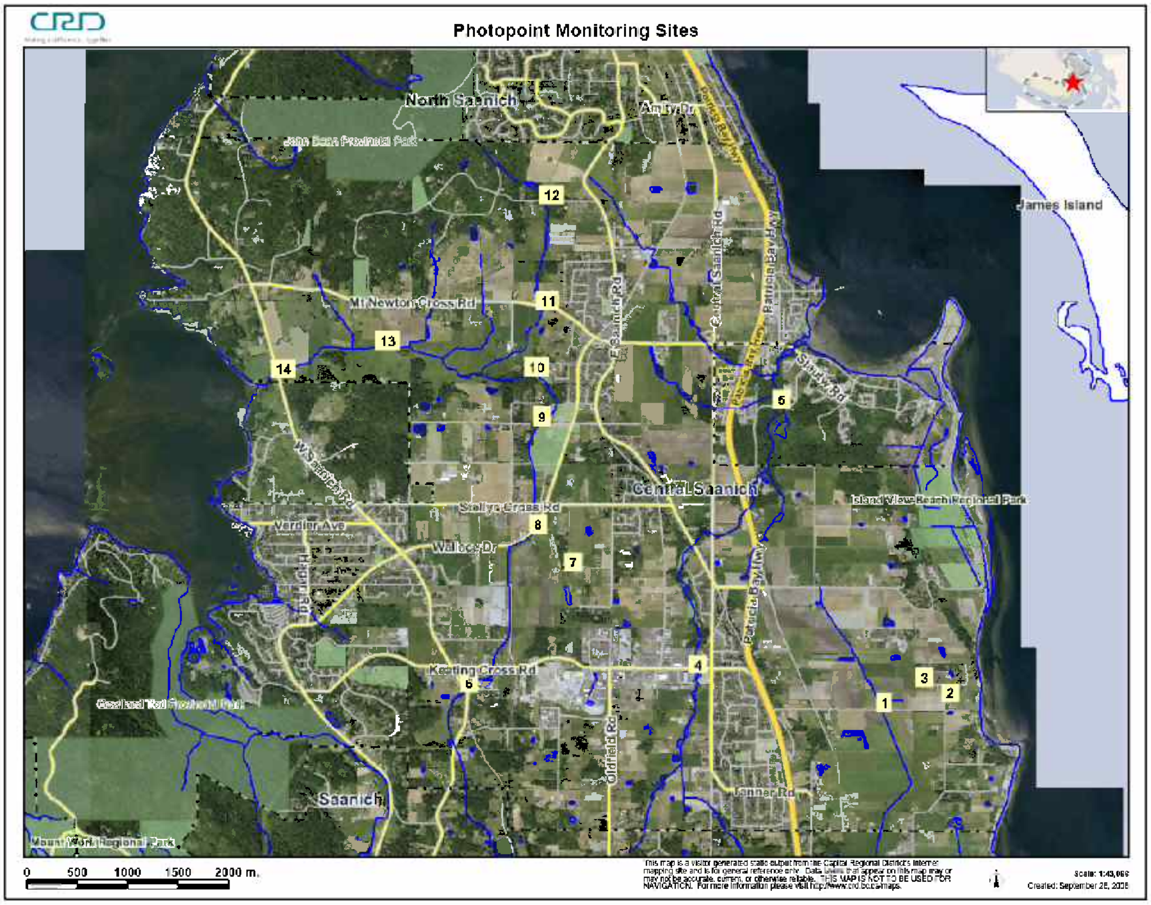
Phil Graydon

Janet Haigh

Bill Langford

Tracy LePard

Figure K Photopoint Locations



5.1.3 Proper Functioning Condition Stream Assessment

The Proper Functioning Condition (PFC) assessment involves using a standard checklist to consistently assess the hydrology, soils and vegetation of riparian areas. The checklist and its summarization are used to classify the health or state of physical processes of the riparian-wetland area. The PFC assessment method was chosen because it could provide a quick and defensible method for assessing riparian and stream channel condition. A PFC assessment method is also available for wetland ecosystems. A detailed explanation of the PFC assessment methods and example of the checklist can be found in Appendix 8.

This methodology was originally developed for the US Bureau of Land Management by a team of fifty scientists specializing in hydrology, soils/geology, vegetation, and biology. They developed the Riparian-Wetland Functional Checklist of seventeen hydrology, vegetation, and soils/geology attributes that must be considered when evaluating riparian areas to determine their physical functionality. The assessment is used to identify any significant attributes that may be out of balance with the natural processes necessary for the system to function properly. The PFC teams commonly use Rosgen stream channel typing to determine whether the stream fits the expected landscape setting or is outside the natural range of variability (Rosgen, 1996). Rosgen channel typing is described in Appendix 9.

The PFC method has been tested and utilized for over a decade in wild land environments managed by the United States Department of the Interior (USDI/ BLM), United States Department of Agriculture (USDA/Forest Service), and private agricultural lands in coordination with the Natural Resources Conservation Service (USDA/NRCS). The methodology has been applied in Canada, Mexico, and several other countries. It is currently being taught in a number of universities and is now being used in metropolitan areas where it is successfully being applied to collaboratively resolve issues associated with urban streams and wetlands.

Appropriate use of this assessment requires an interdisciplinary team of individuals with journey-level skills in hydrology, vegetation, soils/geology, and ecology in order to adequately perform a field assessment using the Riparian-Wetland Functional Checklist. For assessment purposes, the team divides the stream into a series of finite segments (reaches), each having common attributes and processes. Results of the assessments are provided to land management agencies and citizen groups to build a mutual understanding of the physical processes that are governing the stream and watershed. Managers, landowners, and concerned citizens have used PFC assessments for development of management strategies designed to bring about outcomes that are realistic and achievable. PFC assessment findings for stream and riparian zones provide indicators of the limits of the watershed's capacity to produce certain values. An accurate portrayal of the physical processes and their present condition is essential in designing plans to manage the watershed for values important to the community.

For this particular project, a full scale PFC assessment was not conducted due to time and budget constraints. However, the basic methodology, a "simple" PFC, was used while conducting the fieldwork throughout Central Saanich.

Throughout Central Saanich, for the Hagan-Graham, Tetayut, and McHugh Ditch/Noble Creek Watersheds, the assessment areas were stratified by defined segments (reaches) of stream that, for the most part, shared common processes and attributes. In some locations reaches were defined by the bordering roads due to access and private property restrictions. The total number of reaches defined and assessed for all four watersheds are:

- Hagan Creek-7 Reaches;
- Graham Creek-11 Reaches;
- Tetayut Creek-10 Reaches; and
- McHugh Ditch/Noble Creek: 3 Reaches.

While exceptions to these common processes and attributes existed within each reach, they were limited in nature and not large enough to create additional reaches. For Hagan Creek, the assessment started at Hagan Bight and ended at Dean Park Subdivision. The Graham Creek assessment began at its confluence with Hagan Creek near Malcolm Road and continued upstream to its headwaters between West Saanich and Old West Saanich Road. Tetayut Creek was traversed starting at its crossing at Tetayut Road and concluded just south of Bear Hill Road in its headwaters. Finally, McHugh Ditch/Noble

Creek was examined from Martindale Road in the North to the outlet of Noble Creek into Haro Strait near Parker Park. All reaches were numbered sequentially from downstream to upstream (Figure E through H).

Each reach was classified according to Rosgen's stream classification system and the team's estimate of the potential for the reach when possible (Rosgen, 1996). In some areas a Rosgen channel type was not applicable. Rosgen channel types are delineated in Appendix 9 and on the PFC checklist for each reach. The Rosgen channel type is based on the valley form, geology, and gradient that should occur if the stream were allowed to reach its full potential (See Appendix 9). Changes in potential channel type are a primary criterion for reach delineation followed by recognizable changes in present channel characteristics and vegetation that are often associated with management practices or varying ownerships.

5.1.4 Significant Ecological Features

During the biophysical assessment, areas of ecological significance were noted. These include areas of remnant creeks, good spawning areas, large trees, and good waterfowl habitat amongst other things.

Graham Creek (see Photo B), through George May Park upstream of its confluence with Hagan Creek exhibits remnant character with a sinuous channel, healthy riparian vegetation, and large wood within the channel. Large wood acts as a buffer along the edges of the creek dampening the effect of erosional forces and captures gravels, sediments, and other materials which aid in the creation of floodplain areas. Large wood also provides areas for fish to hide and rest in slower moving water. Floodplain areas allow the creek to flow up and over its banks where it is then met by vegetation and flat ground which slows and dissipates the energy of the creek. The large trees and riparian vegetation provide shade maintaining appropriate stream temperatures as well as stabilizing the banks with their root systems. Healthy riparian vegetation along the banks also increases the water storage capacity of the soils to maintain the water table in this area. This section of Graham Creek, and upstream to the northern area of Centennial Park, have habitat that is suitable for fish spawning with gravels and large wood.

Other areas of remnant creek habitat include Tetayut Creek in Cooperidge Park, Tetayut Creek in areas of its lower reaches downstream of the Historical Artifacts Society, Hagan Creek downstream of the Graham Creek confluence, and Hagan Creek west of Larkvale Road (see Photo C). These sections, similar to Graham Creek in George May Park, exhibit good riparian cover, large wood, gravels, and floodplain areas. These areas provide good fish habitat, although Tetayut Creek does experience low flows in the summer months which impacts fish suitability.

Photo B Graham Creek, George May Park

Photo C Gravels in Hagan Creek downstream of Graham Creek confluence

Areas with large, mature trees are ecologically significant as they provide habitat for a wide range of bird species, including owls (a barred owl was observed in Centennial Park during a Creeks and Communities workshop). Tree roots stabilize slopes and store water in the root zones below the surface. Microsite cycling of water also occurs with evapotranspiration processes whereby the trees absorb water at their roots and release it through their leaves with the help of solar energy. As such, they play a cooling role with respect to climate. Locations where large trees exist in the District of Central Saanich include (see Photo D): Graham Creek in Centennial Park and George May Park; Hagan Creek at Hagan Bight, downstream of the Graham Creek confluence, in the section west of Larkvale Road, and in the area of Haldon Road; Tetayut Creek in Cooperidge Park, in the areas of Central Saanich and East Saanich Road, and downstream of the Patricia Bay Highway.

Photo D Large trees in Cooperidge Park

The watersheds in Central Saanich also provide habitat for waterfowl, especially in Martindale Valley and Maber Flats during the flood season (see Photo E). Depending on the time of year, the Martindale and Maber areas host a variety of waterfowl, from dabblers with shallow water requirements to divers with deeper water requirements.

Photo E Maber Flats during flooding in February 2008

5.2 Infrastructure Inventory

5.2.1 Stormwater System Inventory

Key elements of the stormwater system of Central Saanich were inventoried by Central Saanich and WorleyParsons staff during the summer of 2008. Key points of ditches, watercourses and culverts were outlined by WorleyParsons staff. Data collected from the field at these points was entered into the models of each watershed for verification and calibration. Data collection was performed using a GPS survey instrument and included culvert height and ditch profiles (all height and profile measurements are taken with respect to sea level).

During the stormwater system inventory the current condition of the culverts was assessed and recorded including construction materials and sizes. The stormwater system inventory is included in Appendix 13.

5.2.2 Groundtruthing

Drawings of the Central Saanich stormwater drainage network were provided by the District of Central Saanich. The stormwater drainage maps were used to identify all pipe, culvert and overland drainage routes that convey runoff to each of the three major watersheds of Central Saanich. Areas where uncertainty existed close to watershed boundaries were visually inspected during rainfall events to verify the direction of flow and identify the receiving watershed. This type of visual ground truthing was also completed to determine the drainage area represented by each flow monitoring station and clarify drainage routing where field notes conflicted with the drawings.

The headwaters of Hagan Creek are situated north of the District of Central Saanich boundaries. Drawings of the Dean Park subdivision stormwater drainage network were checked at the District of North Saanich office to verify drainage routes were similar to pre-development routing. The subdivision was also visually inspected to understand any stormwater control measures that had been implemented in the subdivision in order to account for these in the SWMM model.

5.3 Hydrologic Evaluation: Flow Monitoring / Sampling Program

The scope of the hydrologic evaluation within the District of Central Saanich consisted of setup and ongoing monitoring of seven continuous flow monitoring stations strategically located within the three watersheds as well as data collection from the single pre-existing WSC station in the Tetayut watershed. The four primary stations were installed in September of 2007. A fifth primary monitoring station was added near the confluence of Graham and Hagan Creeks in November. Supplemental continuous flow monitoring instruments already in possession of the District (flo-totes) were installed by Central Saanich staff in key storm culverts located in the Graham Creek and McHugh watersheds in February and March of 2008, respectively. Three crest level gauges were installed in areas prone to flooding; two in Maber Flats and one in Martindale Flats.

Meteorological data was acquired from the University of Victoria School-based Weather Station Network at three locations, two of which are located in the District of Central Saanich, for the period of flow monitoring.

Monthly measurement of flows and water levels were undertaken at each of the flow monitoring stations on the three creeks. These manual measurements were used to correlate staff gauge readings and continuous water level measurements with flows through the development of stage-discharge curves for the stream cross-section at each flow monitoring station.

5.3.1 Locations / Rationale

The overview map located in Appendix 4 shows the location of the seven new flow monitoring stations installed for the ISMP and the Water Survey of Canada Station on Tetayut Creek. All flow monitoring sites were selected with the data requirements of the ISMP in mind. To ensure this goal was fulfilled, stormwater modellers were consulted early in the process and provided input regarding the location of flow monitoring sites. As a result of this consultation, the fifth and final flow monitoring site was installed approximately 250m downstream of the confluence of Hagan and Graham Creeks. This site was beyond the originally envisioned data requirements of the ISMP, but provided modellers with further information on the response of both Hagan and Graham Creeks to rainfall events.

Flow monitoring within each watershed was previously conducted by the Water Survey of Canada (WSC). All of these stations have been removed with the exception of the WSC flow monitoring station located on Tetayut Creek in Heritage Park on the east side of the Pat Bay Highway, which is still active. Where possible the locations of previous sites were preferentially selected as the ISMP continuous flow monitoring sites. Using similarly located sites permitted the use of flow datasets collected by the WSC from when the sites had been active. Previous WSC locations were on Graham Creek at Stelly's Cross Road and Hagan Creek at West Saanich Rd. Noble Creek had a WSC gauge near its mouth, but this location is well outside the District of Central Saanich southern boundary and was deemed not useful for purposes of the ISMP.

Accurate streamflow gauging requires an area with a relatively flat, constant – geometry streambed and relatively undisturbed flow, unaffected by tidal influence. All current and historic WSC locations have these attributes. The final location of newly developed flow monitoring stations on Hagan-Graham, McHugh and Tetayut Creeks were selected based on the presence of these attributes while ensuring access was possible at most flow levels.

In addition to the five flow monitoring sites set up by WorleyParsons, the District of Central Saanich installed two Marsh McBirney Flo-Totes in their possession at strategic locations selected by WorleyParsons and Aqua-Tex field staff. One of the Flo-Totes was installed in the stormwater discharge pipe at the headwaters of Stephens Creek (Stinky Ditch) that drains the Keating Industrial area early in 2008. This area was of interest due to the low permeability surface and very fast rainfall-runoff response time. The second Flo-Tote was installed in March 2008 in the south culvert entering Martindale Ditch. This instrument was installed to characterise the runoff-response from a portion of the developed Tanner-Keating Ridge area.

5.3.2 Equipment / Methodology

The following equipment was used to set up each flow monitoring site:

- Onset HOBO Level Logger;
- Water Survey of Canada Hydrometric staff gauge, and;
- PVC tubing to protect the level logger from streamflow debris and provide added security.

A single Onset HOBO Barologger was used to collect atmospheric pressure data for the entire district to correct the level loggers in the streams. Both the Barologger and the Level Logger are pressure transducers that measure absolute pressure. This Barologger was centrally located at the Graham Creek flow monitoring site at Stelly's Cross Road. Pressure transducers were chosen due to their low cost, high reliability, simple but robust operation and easy low profile installation. A Water Survey of Canada Hydrometric staff gauge was installed in the vicinity of the pressure transducer as a fixed point of reference so that the pressure measured can be correlated to a water level.

To measure flow on a monthly basis a SonTeck Doppler Flow Meter was used. This is a manual streamflow monitoring device that measures the velocity of water at a point in a stream cross section. Typically 20 or more velocity measurements are taken to represent each cross section. Each velocity is representative of a portion of the cross sectional area the product of which is a flow value. Flows determined for each measurement point in the cross section are summed resulting in a flow measurement for the whole stream. Under ideal conditions, this method of open channel flow measurement is accurate within ± 15 – 20%.

In addition to the flow monitoring stations three crest level gauges were installed. These gauges are simple devices that measure the highest water level reached between monitoring intervals. They were installed in two locations in Maber Flats; one on the Hannam property and the other approximately 25 m east of the NE corner of the Slugget property The third gauge was installed in the Martindale Valley approximately 40 m north of Martindale Rd.

5.3.3 Geomorphology / Discharge data

Monthly measurement of flows and water levels was completed for each flow monitoring site. These manual measurements support the staff gauge readings and continuous water level measurements through the development of stage-discharge curves for the stream cross-section at each staff gauge. It is this stage discharge curve that allows the continuous water level measurements collected by the level loggers to be converted into flow values. Appendix 12 shows the stage discharge curve developed for Graham Creek.

Trials in several natural streams have shown that the mean velocity along a vertical line at any location in a stream occurs (on average) at 2/3 of the depth (or 1/3 up from the bottom) for streams less than 75 cm depth (French, 1985). Once the site is chosen, streamflow gauging consists of:

- measuring the total width of the flowing stream;
- dividing the total width into smaller sections with no one section representing greater than 10% of the flow;
- measuring the depth of water in each section;
- measuring the velocity at 2/3 of that depth in each section;
- multiplying that velocity by the total flow area of that section; and
- adding the flow in each section together to provide a total flow measurement

Appendix 12 provides an example of a manual discharge measurement including the cross section and velocity profiles of the stream.

5.3.4 Contribution to Models

Continuous water levels collected and converted to flows are integral to the modelling process as they permit correlations to be made between meteorological data and the runoff response of the watershed. This information is used in the following ways:

- to develop a rainfall-runoff response within the watershed, and;
- to capture the runoff decline to base flow levels in the watershed as the wet season subsides.

The field data is used to calibrate the watershed models. Section 6.7 discusses calibration of the watershed models in more detail.

5.4 Water Quality

Five locations within the three watersheds were sampled on twelve separate occasions from October 22, 2007 to September 16, 2008. A monthly sampling routine was chosen as the Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME 2001) technical guidance document recommends a minimum of four samples per year in order to account for seasonal or hydrological variability.

Sampling was conducted during a single day between 0600 and 1700 hours. All data were collected on site using a YSI 556 MPS handheld water quality meter and recorded in a field notebook. Water temperature, pH, dissolved oxygen, total dissolved solids (TDS), conductance and specific conductance were measured on each sampling date.

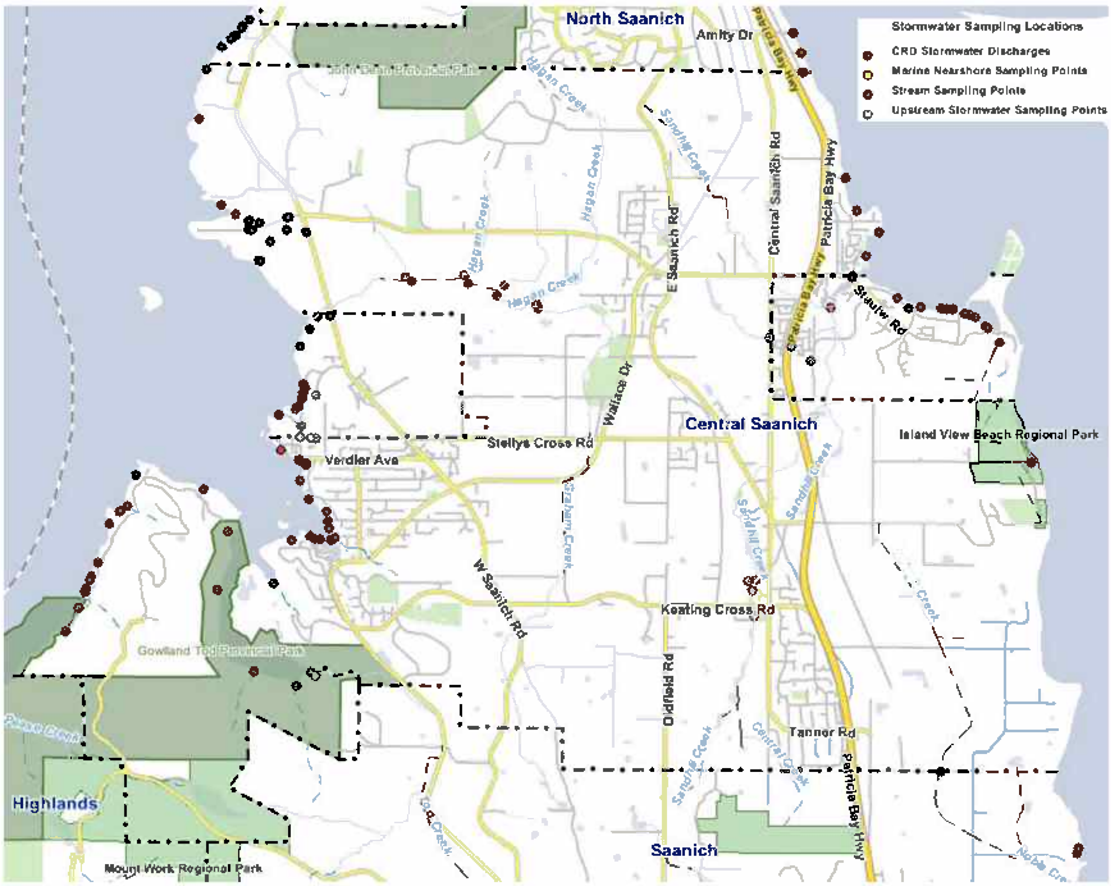
Equipment was calibrated in the morning prior to the day's sampling activities. Equipment calibration entailed the use of laboratory standards, which were properly stored according to manufacturer's specifications and inspected for expiry dates prior to use. Conductance was calibrated using a standard solution developed by MB Labs. To obtain maximum sample accuracy, a calibration solution of 282.9uS/cm was used as it was within the same range as the samples being measured. Dissolved oxygen was calibrated according to manufacturer's directions using barometric pressure obtained from the Willows School station (www.victoriaweather.ca website). The pH was calibrated using a 3-point calibration procedure (pH standards 3, 7, & 10) adjusted for the current temperatures of the standards. Between calibration solutions, the probe was rinsed with clean water and excess water was removed to ensure there was no carry-over contamination. The results of the calibration were recorded in the field book with the field data for each date. Since there were no manufacturer's specifications for temperature calibration, a pocket thermometer was used in the field for comparison.

Performance of the equipment was periodically checked throughout each sampling day. The probe was rinsed off between sample sites to reduce potential contamination and error. Furthermore, the probe was allowed to stand in the stream until readings stabilizes prior to taking any measurements. Upon completion of the sampling day, the equipment was checked, cleaned and stored. Field data were entered into an excel matrix and graphed for analysis. These graphs are presented in Appendix 7.

The Capital Regional District is also involved in water quality sampling focused on stormwater discharge points along the coast of the Saanich Peninsula and associated upstream areas; these locations are outlined in Figure L. Stormwater samples are tested primarily for parameters such as fecal coliforms, metals, and polyaromatic hydrocarbons (PAHs). However, those outlets that are creeks are further monitored for temperature, pH, dissolved oxygen, specific conductance, turbidity, nitrate, and phosphorus (Cameron, 2006). Creek locations monitored in the District of Central Saanich include the following: Hagan Creek at Tsartlip First Nation, Tetayut Creek at Tsawout First Nation, Tsawout Creek at Tsawout

First Nation, and Tod Creek (Cameron, 2006). One of the primary concerns for the CRD sampling program is the level of fecal coliforms and associated public health risks especially for shellfish harvesting.

Figure L CRD Stormwater Sampling Locations (CRD Natural Areas Atlas, 2008)



5.4.1 Water Quality Parameters

Temperature

Temperature regulation of streams is extremely important as it affects both freshwater and marine life. Fluctuating, or extreme, temperatures can affect photosynthesis and respiration rates, spawning, uptake of toxic substances, and the behavioural patterns of organisms. Temperature also mediates chemical processes (*i.e.,* chemical solubility and uptake, and the rate of chemical reactions) (EPA, 2008). For instance, aquatic macro-fauna such as fish are cold-blooded and sensitive to temperature changes; as a result, sustained temperatures in excess of 21°C are stressful to them (Burton et al., 2002). The effects of high temperatures within streams often include: a reduction in dissolved oxygen; susceptibility to disease; effects on osmo-regulation; change in uptake of pollutants; susceptibility to the toxic effects of pollutants; modified feeding and behavioural patterns, including physical activity, reproduction, growth, migration, distribution, intra- and inter-specific competition, predator–prey relationships, community composition, and parasite–host relationships (CCME, 1999). High water temperatures during summer seasons are extremely problematic, as stream flows tend to be their lowest, creating critical conditions for aquatic life. Temperature influences the chemical composition of the water column. For instance, ammonia exists in two forms: non-ionic (NH3) and ionic (NH4+) the toxicity of which is largely determined by the temperature and pH of the water. In most instances, the general sensitivity of aquatic organisms to toxic substances increases with water temperatures.

In order to protect aquatic life, the BC Ministry of Environment has specified water quality guidelines for stream temperature. For instance, the guidelines recommend the following values for streams with an unknown fish distribution:

- a mean weekly maximum temperature (MWMT) of 18 °C;
- a maximum daily temperature of 19 °C; and
- a maximum daily incubation temperature (Spring and Fall) of 12 °C.

Hagan/Graham Creek is home to stickleback, cutthroat trout and coho salmon (stocked). It cannot support anadromous (sea-run) fish due to the falls at its mouth. Tetayut (Sandhill Creek) is home to both anadromous (sea-run) and non-anadromous (freshwater only) cutthroat trout and both Coho and Chum salmon. Noble Creek once supported anadromous cutthroat, but recent records indicate that they may no longer inhabit the creek. For the associated temperature guidelines for these species, see Table J below.

Table J Optimum Temperature Ranges of Specific Life History Stages of Salmonids and Other Coldwater Species[4]

Species	Incubation	Rearing	Migration	Spawning
Salmon				
Chinook	5.0-14.0	10.0-15.5	3.3-19.0	5.6-13.9
Chum	4.0-13.0	12.0-14.0	8.3-15.6	7.2-12.8
Coho	4.0-13.0	9.0-16.0	7.2-15.6	4.4-12.8
Pink	4.0-13.0	9.3-15.5	7.2-15.6	7.2-12.8
Sockeye	4.0-13.0	10.0-15.0	7.2-15.6	10.6-12.8
Trout				
Brown	1.0-10.0	6.0-17.6	—	7.2-12.8
Cutthroat	9.0-12.0	7.0-16.0	—	9.0-12.0

[4] http://www.env.gov.bc.ca/wat/wq/BCguidelines/temptech/temperature.html

Species	Incubation	Rearing	Migration	Spawning
Rainbow	10.0-12.0	16.0-18.0	—	10.0-15.5

pH

pH is a measure of acidity or alkalinity of a solution. Per the European Inland Fisheries Advisory Commission (1969), there is no definite pH range to ensure that a fishery remains unharmed or damaged; rather, there is a gradual deterioration as the pH values move outside of a safe range (in Burton et al., 2002). For instance, although the Guidelines for Aquatic Life recommend a range of 6.5 – 9 in order to protect aquatic life, a lower pH within the guidelines range may be acceptable from a regulations standpoint, but may also increase the toxicity of more common pollutants (*i.e.*, ammonia) (Burton et al., 2002).

Dissolved Oxygen

Dissolved oxygen (DO) is the most fundamental parameter in water, as it is essential to the metabolism and productivity of all aerobic aquatic organisms and affects the solubility and availability of nutrients (CCME, 2002). DO is the measure of the amount of dissolved available oxygen (in mg/L) in the water column. The dissolved oxygen content within water is largely based on the balance between the input of oxygen (from the atmosphere), temperature (warm water is able to hold less oxygen) and the amount of decomposing organic matter (*i.e.*, duckweed, leaves, manure, algae).

Anthropocentric activities (*i.e.*, forestry, road building, construction, urbanization, and agriculture) tend to increase the amount of organic inputs into the system consequently reducing the amount of dissolved oxygen from increased metabolism. Shade and evapotranspiration by vegetation keep the stream temperatures stable and cool. Removal of vegetation by land clearing activities increases stream temperatures thereby reducing the amount of dissolved oxygen in the water and directly affecting aquatic life. For example, low levels of dissolved oxygen can facilitate the release of nutrients bound to sediments, which may increase algal production and reduce DO levels further when the algae decompose.

Dissolved oxygen may vary due to the species of algae present; light penetration; nutrient availability; temperature; salinity; water movement; partial pressure of atmospheric oxygen in contact with the water; thickness of the surface film; and bio-depletion rates. The Canadian Water Quality Guidelines for the Protection of Aquatic Life recommend that dissolved oxygen levels do not fall below 6.5mg/L at any point in time. Upon comparing the historical data with the data collected for this study, the reliability (i.e., the accuracy) of the recent data is in question and has, therefore, been omitted from this report. Although the dissolved oxygen data has been omitted from this report, the dissolved oxygen levels for most samples sites was quite low (similar to historical trends) and has been generally discussed in each section.

Total Dissolved Solids

Total dissolved solids (TDS) is a measure of the total present content of all organic and inorganic material that is in a molecular or ionized form contained within a liquid. Materials smaller than 0.45μm are considered to be dissolved. The primary sources of TDS are agricultural run-off, increased urbanization within a watershed and point source discharge from industrial sectors. Common chemical constituents include calcium, chloride, phosphates, nitrates, sodium and potassium. Per the CCME guidelines, "the composition and concentration of total dissolved solids are important in determining the diversity and abundance of plants and animals in aquatic ecosystems as the chemical density of the aquatic environment influences the osmotic regulation of metabolism and biotic distribution" (CCME, 2002). Therefore, any major change in the quantity of chemical composition of the total dissolved solids can affect the structure and function of a system (CCME, 2002). In general, BC coastal streams tend to have TDS concentrations <75 mg/L, while those in the interior of the province can have up to 750 mg/L. Criteria for TDS range from 1000mg/L for sensitive species to 3000mg/L for other species (Ministry of Environment, Lands and Parks, 1998).

Conductance

Conductance and specific conductance are both measures of the ionic or the total dissolved solids content in a sample of water (Specific conductance is conductivity corrected to 25°C). As major ions of other physical /chemical characteristic of streams can vary depending on the source of the water (*i.e.*, groundwater, surface water), specific conductance can serve as an indicator of the source of the water (it is also commonly used as an indicator of salinity) (Burton et al., 2002). Natural waters are found to vary between 50 and 1500 µS/cm whereas coastal streams in BC have specific conductivity values of 100 µS/cm, while interior streams can measure up to 500 µS/cm (Ministry of Environment, Lands and Parks, 1998). Due to its natural variability, there is no criterion recommended for this variable.

Total Suspended Solids (TSS)

Although not measured during this study, the parameter total suspended solids (TSS) is worth discussing as the agricultural activities within the watershed have a direct impact on the erosion and sedimentation of the streams. Furthermore, the researchers performing the water quality analysis commented on the levels of turbidity5 and anticipated levels of TSS throughout the study. Total suspended solids (TSS) are measured in mg/L and are representative of the amount of suspended matter within the water column at the time of sampling. Per the CCME Guidelines, suspended matter may consist of "silt, clay, fine particles of organic and inorganic matter, soluble organic compounds, plankton, and other microscopic organisms" (CCME, 1991). In natural systems, stream channels are in balance with the landscape setting (*i.e.*, stream meander and sedimentation is a natural process occurring over time)6, with natural disturbances (*i.e.*, flooding or bankfull events) occurring on a long time horizon. Anthropocentric activities such as forestry, road building, construction, urbanization, and agriculture alter this balance by increasing the amount of sedimentation within aquatic systems; agriculture and construction being the cited as the largest causes of

[5] Turbidity is a measure of water clarity and can provide an estimate of the concentrations of suspended materials, such as clay, sand, silt, finely divided organic and inorganic matter, and plankton and other microorganisms in water (CCME, 2002).

[6] In balance with the landscape setting means that slope, stream discharge volume, sediment load, particle size, and vegetation work in equilibrium (LTMCP, 2008). Stream stability is achieved when the stream has developed a "stable dimension, pattern and profile such that, over time, channel features are maintained and the stream system neither aggrades nor degrades" (Doll *et al.,* 2000).

sedimentation within a stream. The deposition of fine sediments within a stream can be detrimental to aquatic organisms as sedimentation reduces streambed composition, permeability and stability (CCME, 2002). Such alterations in the physical environment can decrease egg-to-fry survival rates and benthic macroinvertebrate production (due to smothering), clogging and abrasion of gills, behavioural effects (*i.e.*, movement and migration), blanketing of interstices between gravel, cobbles, and boulders (affecting spawning gravels and other habitat changes) (CCME, 2002). Increased TSS levels decrease the visibility through the water, thereby interfering with the food intake for filter-feeding invertebrates and predatory fish. Detrimental to aquatic life, suspended matter is likely to be carrying toxic pollutants because pollutants adhere to the sediment. These pollutants can be resuspended and become more biologically active by pollutant transformation, desorption, or uptake by organism ingestion during high stream flow events where sediment disturbance occurs (Burton et al., 2002). Resuspension of sediment contributes to both increases in biological (BOD) and chemical oxygen demand (COD); negatively impacting dissolved oxygen (DO) levels (Burton et al., 2002). Finally, anthropocentric activities negatively impact aquatic habitat quality by reducing flushing flows and altering the naturally occurring sediment transport regime.

In order to preserve aquatic life, the CCME suggests "during clear flow periods, anthropogenic activities should not increase suspended sediment concentrations (or non-filterable residue levels) by more than 25 mg/L over background levels during any short-term exposure period (*i.e.*, 24-hours). For longer-term exposure (*i.e.*, 30 days or more), average suspended sediment concentrations should not be increased by more than 5 mg/L over background levels. During high flow periods, anthropogenic activities should not increase suspended sediment concentrations by more than 25 mg/L at any time when background levels are between 25 and 250 mg/L. When background levels exceed 250 mg/L, suspended sediment concentrations should not be increased by more than 10% of the measured background level at any one time" (CCME, 2002).

5.5 Meteorological Data

The publically available rainfall data from Environment Canada's National Climate Data and Information Archive (Environment Canada, 2008) provide only daily rainfall values. Improved resolution was required in order to capture storm characteristics, such as intensity and duration. Historical rainfall data was purchased from Environment Canada for the Victoria International Airport. Rainfall data was provided on 15 minute intervals between the dates of August 1, 1964 and December 31, 2005. Since the collected data must be verified before releasing it to the public, a year long process, more recent data was not available from Environment Canada.

More recent rainfall data was purchased from the University of Victoria's school based weather network for the weather station at Keating Elementary School at 6843 Central Saanich Road. The weather station was selected as it was considered the most central to the three watersheds within Central Saanich. Rainfall data in 15 minute intervals from June 30, 2006 to September 2008 was provided by the University of Victoria.

6. WATERSHED MODELLING

In order to assess the current and future condition of the three main watersheds in Central Saanich, a representative model was constructed for each watershed on PCSWMM.net stormwater modelling software. These models were constructed using information from a number of sources including field data, anecdotal accounts, site mapping, and data provided by Central Saanich.

6.1 PCSWMM.NET

WorleyParsons utilized PCSWMM.NET to conduct the hydrologic modelling of the project. PCSWMM.Net was selected for the following reasons:

- PCSWMM uses the most recent USEPA "SWMM" engine (modelling equations).
- PCSWMM maintains an "open standard" database, storing native SWMM data as ARCView shape files, enabling excellent integration with the District's intended GIS system. Since the District intends to assume, maintain and build the model over a number of years, use of an open standard database is a more secure route and not dependant on the fortunes of one vendor.
- Any entity in PCSWMM can be linked to an internal (*i.e.* project) database containing any information related to the selected "point of interest". For example, externally created pdf files, Word documents, Excel calculations, AutoCAD files, databases, JPEG files, video clips, technical specifications, inventory data (e.g. ecological inventory), etc. can be linked to any PC SWMM program entity. This feature was particularly useful when collecting and recording data from the field program.
- PCSWMM provides a direct link to Google Earth enabling effective utilization of this software tool in delineation of watershed areas and/or localized areas of particular interest, thus assisting with identification of their pertinent attributes required for modelling.
- PCSWMM contains an analysis feature that makes it possible to compare multiple design storms and stormwater management scenarios simultaneously.

One of the limitations of the model is the difficulty in incorporating a groundwater routine that would provide accurate base flows within each watershed. This limitation is common to all commonly used commercial stormwater modelling systems. The method used to work around this limitation is described in Section 6.3.3

6.2 Methodology

The PCSWMM model is built upon hydraulic and hydrologic characteristics of a study area, in this case, a watershed. The watershed is divided into a collection of smaller subcatchments, each containing characteristic properties such as the fraction of impervious area, drainage pathways, slopes, and soil types. From the characteristics of a subcatchment, the rate and volume of surface runoff and infiltration and rainfall interception are computed. The surface runoff from a subcatchment can either be specified to drain into an adjacent subcatchment or into a node, the entry point into the drainage system.

PCSWMM routes surface runoff through a drainage system comprised of nodes which are linked to subcatchments and both open and closed conduits. Therefore, pipes, channels, and culverts are all modelled as conduits in PCSWMM. Node and conduit characteristics such as entry losses, exit losses, roughness, and elevation govern the flow rates and elevation of water in the conduits. Runoff from subcatchments flows through the drainage network to an outfall, the exit point of the drainage system.

In addition to runoff, stream baseflows, the portion of streamflow originating from groundwater rather than runoff, must be accounted for. For this project, baseflows were added into the model by specifying a direct inflow into a node, separate from subcatchment runoff.

Once the PCSWMM model is constructed for a watershed, the model is run with rainfall data over a specified period of analysis. The rainfall is applied onto each watershed, from which runoff and flows through the drainage system are calculated. The resulting model outputs are compared to streamflow data collected in the field (see section 5.3 for details on the field monitoring program). The hydraulic and hydrologic characteristics of the model are then adjusted to reasonably reflect measured conditions, resulting in a calibrated model.

6.2.1 Continuous versus Event Modelling

For the majority of the analyses performed in this project, continuous modelling was employed. Continuous modelling involves using actual rainfall data to assess the existing drainage system and any proposed improvements. The advantage of continuous modelling over the more conventional event based modelling is that the conditions prior to the storm of interest are created based on actual events. Event based modelling requires the modeller to specify these initial conditions, which are often difficult to quantify. With continuous modelling, initial conditions such as antecedent soil moisture and infiltration recovery are calculated, providing an output which is more reflective of actual conditions.

Event based modelling was used in this project to assess climate change scenarios and to convey information where the use of continuous models may distort the information desired. Determining the duration of flooding is an example where event based modelling may be preferred. As rainfall events may occur concurrently, it is difficult to isolate the flooding impacts of a single rain event with continuous modelling.

6.3 Hydrology

6.3.1 Watershed Delineation

Watershed boundaries were determined using the CRD Natural Areas Atlas 2 m contour interval topographic map. Topographic high points were traced from each creek mouth to the creek headwaters thereby defining the watershed. Where required the 2007 orthophoto was utilized to identify surface features and help locate areas of uncertainty on the map for later ground truthing. Information on stormwater pipes, ditches, culverts and creek alignment was also overlayed onto the topographic map to determine if the minor stormwater drainage network was consistent with the major overland flow routes. Ground-truthing by WorleyParsons identified discrepancies between supplied creek and drainage pipe data and actual watershed creek flow paths. Appropriate adjustments to the creek and drainage alignments were made and the watershed boundaries changed accordingly if required. A list of each watershed and the drainage area associated with it is provided below.

Appendix 4 contains base maps for each watershed which outline their boundaries and drainage areas.

6.3.2 Subcatchment Delineation and Characteristics (Watershed Descriptions

In general, the subcatchments within each watershed were delineated in the model based on land use, topography, soil characteristics, aquifer boundaries, and stormwater drainage infrastructure. Maps illustrating the subcatchments of each watershed are shown in Appendix 15.

Each watershed is unique and their features are described in the following sections.

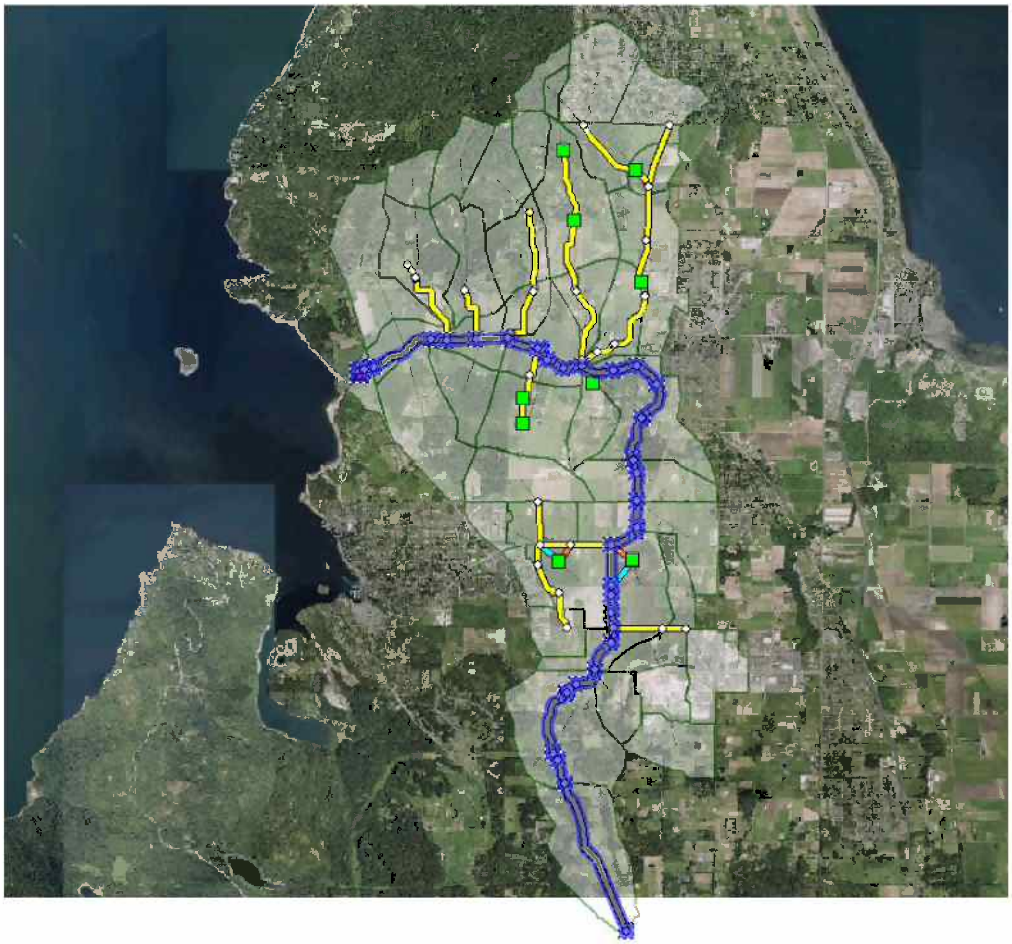
Hagan Graham

The total area of the Hagan-Graham sub-catchment is approximately 1,780 hectares (ha), with 90% of the catchment located within the District of Central Saanich, the remaining 10% is located in the District of North Saanich and the District of Saanich. The elevation of the watershed ranges from sea level to approximately 300 masl on the slopes of Mount Newton. For modeling, the Hagan Graham catchment was divided into 12 main sub-catchments, 4 located in the Graham Creek sub-catchment and 8 in the Hagan Creek sub-catchment. The sub-catchments were selected based on topography (2m resolution) and drainage characteristics.

The headwaters of Graham Creek are located south of West Saanich Road, in the District of Saanich, at Latinen Swamp and flows northward across Maber Flats through Centennial Park and west to the confluence with Hagan Creek. Hagan Creek headwater is located in North Saanich on the south side of Mount Newton and flows southward under Haldon Road and Mount Newton Cross Road to the confluence with Graham Creek. Downstream of the confluence Farley Creek, Peel Brook, Thomson Brook and Ronald Brook, all draining the south slope of Mount Newton, join Hagan Creek. Hagan Creek flows under West Saanich Road to Hagan Bight. These drainage areas determined the major sub-catchments within the model.

Each major sub-catchment was divided into smaller sub-catchment areas based on surficial geology/soil type and land use, as described below in Figure M. The majority of runoff in the watershed is generated from areas of high percentage of directly connected impervious area (DCIA) and undeveloped areas with low infiltration rates. In the Hagan Graham watershed the majority of runoff is generated from the undeveloped upper slopes of Mount Newton, the Maber Flats area; and the developed areas including Dean Park (North Saanich); Keating Industrial Park and the residential area west of Maber Flats. Approximately 11.5% of watershed is considered directly connected impervious area (DCIA).

Figure M Hagan Graham Model Sub-Catchments



Surficial Geology/Soil Type

The surficial geology within the watershed was described by Thurber Engineering (1993) as primarily consisting of marine clay but with colluvium overlying shallow bedrock at the higher elevations. Graham and Hagan Creeks have recently left alluvial deposits of organic silty sand and gravel above the marine clay (Thurber, 1993). Through Centennial Park a section of Graham Creek appears to be carved into the Quadra Sands and Gravel (Thurber, 1993). The Maber Flats area is the result of the recent lake deposits comprising of silts and organic soils (Dayton and Knight, 1994).

For modeling, soil types in the catchment were grouped into four main soil groupings (A through D) based on the runoff potential (Dayton and Knight, 1994), as shown in Table K below.

Table K Soil Types and Green-Ampt Parameters

		Green-Ampt Parameters		
Soil Type Group	**Drainage Characteristic**	**Suction Head (mm)**	**Hydraulic Conductivity (mm/hr)**	**Moisture Deficit**
A	High infiltration	60.96	29.97	0.332
B	Moderate infiltration	109.98	10.92	0.263
C	Slow infiltration	290.07	0.51	0.108
D	Very slow infiltration	320.04	0.25	0.097

A-soils have high infiltration rates even when thoroughly wetted. B-soils have moderate infiltration rates when thoroughly wetted, C-soils have slow infiltration rates when thoroughly wetted, D-soils have very slow infiltration when thoroughly wetted. The soil types were grouped by Dayton and Knight based on data presented in the Soils of Vancouver Island (Appendix 5).

The surficial geology/soil types (A through D) were represented in the model with the corresponding Green-Ampt infiltration parameters. Areas with shallow bedrock and/or poorly draining soils, such as the upper slopes of Mount Newton and Maber Flats, use Green-Ampt parameters that generate maximum runoff, while areas with wells draining soils such as the gravel pit area have Green-Ampt parameters that generate minimal runoff.

Land Use

Within the model four different land uses were assumed in the watershed; a general description of land uses within the watershed and the approximate percentage of catchment area are presented below:

- Forest - 670 hectares
- Agricultural/cleared land – 900 hectares
- Residential - 140 hectares
- Industrial – 70 hectares

Each land use type was represented in the model through adjustment of several of the input parameters including: % imperviousness; depression storage depth (mm) and surface roughness (n); with % imperviousness being the most significant with regards to runoff generation. Forest areas have zero % imperviousness, and high depression storage depth and surface roughness; while residential and industrial areas have high % imperviousness, and low depression storage depth and roughness.

Hagan-Graham Model Representation

Model parameters required for each sub-catchment include: catchment area, slope (average gradient of overland flow path) and flow path width (this parameter is used by the model to generate sheet flow path length). Unlike many other hydrological models, no estimate of time of concentration is required as this parameter is dictated by the flow path width, slope and roughness parameters. The flow path width is a key calibration parameter, with a narrow width used to increase the time of the hydrograph peak and a wide width used when the time to peak is short.

Maber Flats was represented in the model as an area of low infiltration and high runoff. However due to the flatness of the area (used to be a lake) annual flooding of the sub-catchment was incorporated in the model using two storage nodes: one east of Graham Creek and the other west. These off-line detention storage nodes were used to represent the long term flooded areas of the Flats. Storage nodes simulate evaporation losses however infiltration and drainage back into the creek and ditches are not explicitly represented in the model, these losses from the storage nodes were simulated using an artificial pump which conveyed water out of the storage node back into the main drainage channel at a varying rate based on the depth of flooded water in the storage. The pumping rate at each node was used as a calibration parameter. The rate of pumping was adjusted to simulate the duration of flooding observed during the 2007-2008 calibration period.

There are two major sources of Graham Creek baseflows: one in the vicinity of the gravel quarry south of Maber Flats were groundwater flows discharges into Stephens Creek (Stinky Ditch) and the second where Graham Creek is carved into the Quadra Sands and Gravel in Centennial Park. Baseflows are represented in the model by adding dry weather flows to the model nodes at these two locations. The baseflow rate was estimated on a monthly basis by baseflow separation from the annual hydrograph as observed at the three locations within the watershed.

The model was calibrated using flow data collected at three locations in the watershed during 2007-2008.

The other two watersheds were modelled in a similar way and more concise descriptions of the methodology for these follows.

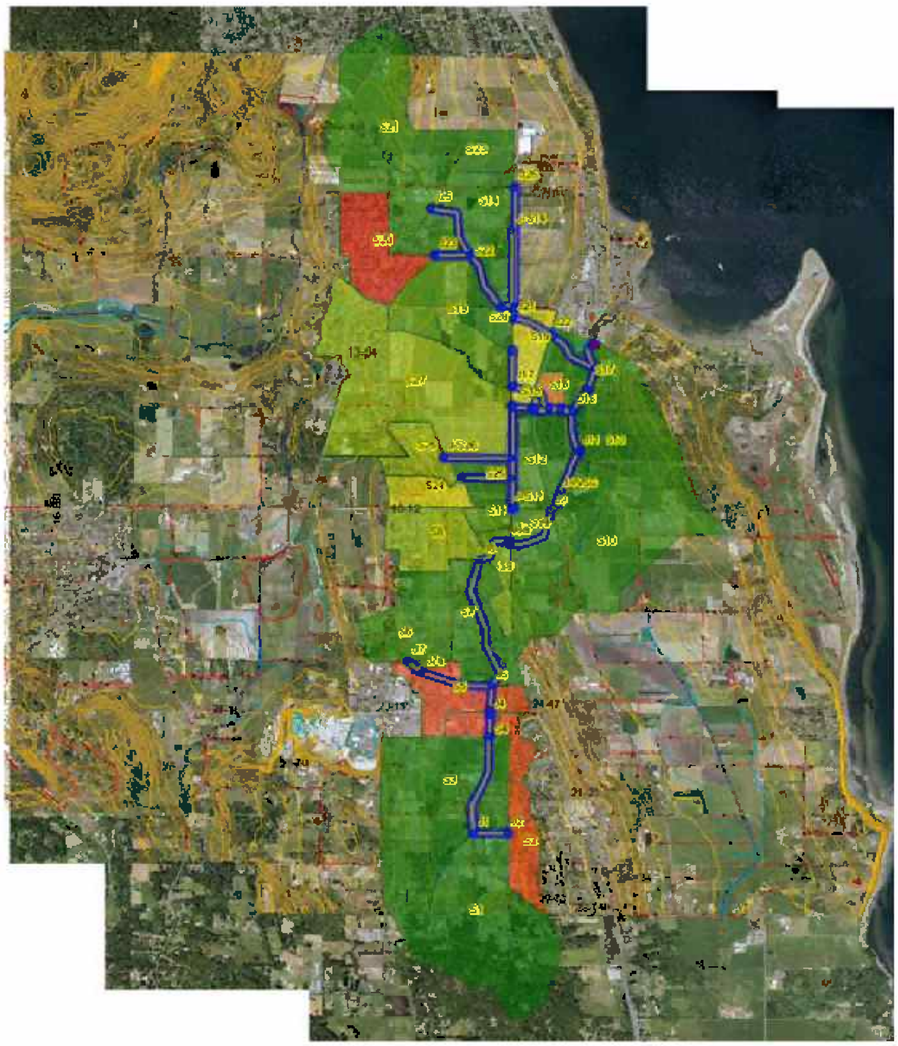
Tetayut (Sandhill)

Total area of the watershed is approximately 1,150 ha. Approximately 15% of the watershed is impervious. A general description of land uses within the watershed and their percentage of area are as follows:

- Agricultural - 85%,
- Commercial / Residential - 14%,
- Industrial - 3%,
- Other - 2%

Figure N below shows a representation of the model with its subcatchments, major flow paths, and impervious areas.

Figure N Tetayut Model Sub-Catchments



Subcatchments highlighted in red are greater than 40% impervious. Subcatchments highlighted in yellow are 20% - 40% impervious and subcatchments highlighted in green are less than 10% impervious. The yellow lines highlighted in blue represent major flow pathways within the watershed including ditches, Tetayut Creek, and underground stormwater conveyance structures. The blue circles represent major nodes, or key surface water runoff collection points. The red triangle represents the outfall for Tetayut watershed.

According to the document, Soils of Southern Vancouver Island (Jungen, 1985), there are several soils types in the Tetayut watershed. Descriptions of the soils are presented in Table L below:

Table L Tetayut Watershed Soils

Name	Soil Type	Drainage Characteristics
Somenos	Gravely sandy loam	Well drained
Sprucebark	Gravely loamy sand	Rapidly drained
Saanichton	Silty clay loam	Well drained
Tagner	Clay loam	Poorly drained
Quamichan	Very gravely loamy sand	Rapidly drained
Made Land	Fill	N/A
Rock Outcrop	Bedrock	N/A

The major water pathways within the Tetayut watershed are Tetayut Creek, several of its tributaries, and various ditches. Tetayut Creek begins in the southern portion of the watershed, near Bear Hill, and flows northward before emptying into Saanichton Bay in the Tsawout First Nations reserve lands. Several tributaries in the northern part of the watershed that transport water from agricultural and residential areas, merge with Tetayut Creek in the Tsawout First Nations reserve lands. There are also numerous ditches which carry residential and agricultural stormwater runoff, that does not infiltrate into the soil, into Tetayut Creek.

McHugh-Noble

The total watershed area drained by the McHugh Ditch and Noble Creek is approximately 970 hectares, 60% of which is located in the District of Central Saanich. The remaining 40% is located within the District of Saanich. The elevation of the watershed ranges from 70 masl at Tanner/Keating Ridge on the west side of the watershed down to 16 masl in the Martindale Valley. The McHugh-Noble watershed was discretized into 20 subcatchments, as shown in Figure O below. Initially, the watershed was divided based on drainage pathways dictated by topography (CRD, 2008). Key divisions included Tanner/Keating Ridge, the western and eastern flank of Martindale Valley, and the Martindale Valley.

Figure O McHugh-Noble Model Sub-Catchments

The subcatchments were then further divided based on the soil types present, as summarized in Table M and shown in Appendix 5.

Table M McHugh-Noble Main Soil Types

Soil Name	Description	Drainage	Locations
Shawnigan/ Somenos	Gravelly sandy loam or very gravelly sandy loam (till)	Well	Tanner/Keating Ridge and area east of Pat Bay Highway south of Martindale Road
Qualicum	Very gravelly to gravelly loamy sand (marine deposit)	Rapid	Small band east of Pat Bay Highway both north and south of Martindale Road.
Parksville	Sandy loam or loamy sand (marine deposit)	Poor	East of Qualicum soils located east of the Pat Bay Highway and north of Martindale Road.

Soil Name	Description	Drainage	Locations
Cowichan/ Tagner	Silty clay loam or silt loam (marine deposit)	Poor	Martindale Valley outside of Metchosin soils area
Metchosin	Humic (organic deposit)	Very poor	Centre of Martindale Valley
Dashwood Creek/ Quamichan	Very gravelly loamy sand to gravelly sandy loam (marine deposit)	Dashwood - Well Quamichan - Rapid	Eastern flank of Martindale Valley

The subcatchments were further broken down based on land use. The areas of high fraction impervious cover, *i.e.* residential areas, were generally located on highly pervious soils whereas agricultural areas were located on organic, poorly drained soils. A general description of land uses within the watershed and the approximate percentage of catchment area are presented below:

- Forest -130 hectares (13%)
- Agricultural/cleared land – 636 hectares (66%)
- Residential – 194 hectares (20%)
- Highway – 7 hectares (1%)

Impervious areas constituted 9% of the total watershed area and 5% of the total watershed were directly connected impervious areas. Creeks are generally considered to be at risk once the percentage of impervious areas within a watershed exceeds 10% (BC MWLAP, 2002). The McHugh-Noble watershed currently falls just short of this criteria.

Finally, the subcatchments were adjusted to account for drainage of impervious areas such as the Patricia Bay Highway and Tanner/Keating Ridge based on the Central Saanich drainage plans and Ministry of Transportation drawings. These areas are served by piped stormwater sewer systems which occasionally directed drainage counter to that assumed by the topography.

6.3.3 Baseflows

Groundwater modelling per se was outside the scope of study, however, it was nonetheless necessary to represent groundwater contributions to base flow in the models. Baseflows were incorporated into the model as dry weather inflow via a monthly time series, that is, a given baseflow for each month of the year. Otherwise, during dry time periods or in between rain events, the model would show the base flow as zero.

Creek flow values were obtained and plotted in PCSWMM from the information gathered from the flow monitoring stations installed in each watershed. The baseflow values were obtained by averaging the lowest stream flow for seven consecutive days in each month.

More sophisticated representation of groundwater impacts on baseflows would require hydrogeological investigations.

6.4 Hydraulics

In PCSWMM, the drainage network of each watershed was characterized through a series of nodes, conduits, weirs, storage units, and outfalls. Using data collected from groundtruthing, field visits, and elevation and channel surveys, the properties of each drainage network were added into the models. Key parameters inputted into the model from field data include culvert sizing, culvert invert and channel elevations, and channel cross sections. Channel roughness and entry/exit losses were added based on text book values. Additional drainage network data for Tetayut and the McHugh-Noble watershed were provided by drainage plans for the Patricia Bay Highway. For McHugh-Noble, additional data on McHugh ditch was also acquired from a 1981 drawing from the Ministry of Agriculture detailing ditch grading from Island View Road to Martindale Road.

The stormwater models were built and assessed based on the information collected and made available to WorleyParsons. Information that could not be accounted for in the model are generally in regard to ditch use and maintenance, such as irrigation pumping, ditch cleaning, weir adjustments, and the presence of blockages, such as hay bales and debris.

6.5 Climatology

Rainfall and evaporation data is an important input parameter for the model to calculate flows and volumes within the water pathways of each watershed.

6.5.1 Rainfall

The primary sources of rainfall data used for the model came from the following locations:

- Keating Elementary School as a part of the University of Victoria's School-Based Weather Station Network
- Victoria International Airport climate station operated by Environment Canada.

The Keating Elementary School data was used to help calibrate the model for two reasons. First, it had the most representative rainfall for the three watersheds. And second, rainfall data was available immediately and in the same time intervals the monitoring stations were collecting data. Environment Canada rain data is not readily available because it takes about a year to verify the rain data collected before releasing that data to the public. Currently, rainfall data is only available through the end of 2006 for the Victoria International Airport climate station.

The benefit of YYJ data was that there was a record of rainfall for approximately 50 years. From this data, WorleyParsons was able to determine the time periods when the 2, 10, 25, and 100+ year - 24 hour rain events occurred. A rainfall data set of two weeks prior and one week after these events occurred was input into the model to determine peak flows and volumes of stormwater within each watershed.

Table N below shows 24 hour recurrence intervals and the corresponding dates input into the model.

Table N 24 Hr Rainfall Recurrence Intervals

	24 Hr Rainfall Recurrence Interval			
Parameter	2yr	10yr	25yr	100yr +
Depth of Rainfall (mm)	50.7	71.2	87.1	134.7
Date of Rain Event	1/28/1999	12/9/1987	12/25/1972	10/16/2003
Time Period Entered into Models	1/14/99 - 2/4/99	11/26/87 - 12/16/87	12/11/72 - 1/1/73	10/2/03 - 10/23/03

Extended time periods were entered into the model to account for antecedent moisture conditions so that the model could calculate accurate peak flows and volumes.

6.5.2 Evaporation Data

Monthly average daily lake evaporation data from Environment Canada's weather station at Saanichton, BC was used in the model (1970 to 2000). This data is presented below in Table O.

Table O Average Daily Evaporation Values (Saanichton, BC, Environment Canada Climate Normals 1970 to 2000)

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Evaporation (mm/day)	0.0	0.0	0.0	2.0	2.8	3.3	3.7	3.2	2.1	1.1	0.8	0.0

This data was used in the PCSWMM model to estimate evaporation losses from the watershed. Evaporation losses only occur from the catchment when the ground is wet; while water is lost as evaporation from storage nodes anytime there is water stored at the node.

6.6 Model Limitations/Sensitivity Analysis

The SWMM family of models were primarily designed for urban stormwater modelling; when modeling largely rural catchments, as is the case with this ISMP, significant adjustment of key calibration parameters is required to adequately simulate runoff from non-urban areas. These parameters include: % imperviousness, catchment slope, overland flow path width and infiltration. Some of these parameters may require adjustment by an order of magnitude or more and will not be representative of actual catchment conditions. Adequate representation of the falling limb of the hydrograph can be difficult within SWMM models for rural catchments; adjustment of slope and catchment width can be used to manipulate runoff output.

Water that infiltrates is 'lost' from the model and does not generate baseflows in the creeks. While a groundwater and aquifer routine are included in PCSWMM, they were not implemented during this project.

Representation of the flooding of sub-catchments requires creative method to be implemented as in SWMM models only nodes can flood, and not catchments, and the flood water is either lost from the system or put back into the node as soon as capacity allows. For urban catchments this simulation of flooding is typically sufficient, however, for rural catchments where evaporation and infiltration losses are significant, the standard process of flooding nodes is not suitable. Other methods to model rural sub-catchment flooding are required. One such method is presented in the Hagan Graham Model Representation section of 6.3.2.

At the time of writing this report PCSWMM.NET version 2.14.375 did not include an automatic calibration function but did included a limited sensitivity analysis tool. This tool allows for sensitivity analysis of percent impervious, slope and catchment width parameters. Two of these parameters are relatively easy parameters to estimate; catchment width however is often used in the SWMM model as a calibration parameter. The graph below (Figure P) shows an example of the sensitivity analysis tool output, with two hydrographs shown, one for the existing model output, the other the model output with the catchment width parameter increased by 100 percent.

Figure P Example Sensitivity Analysis

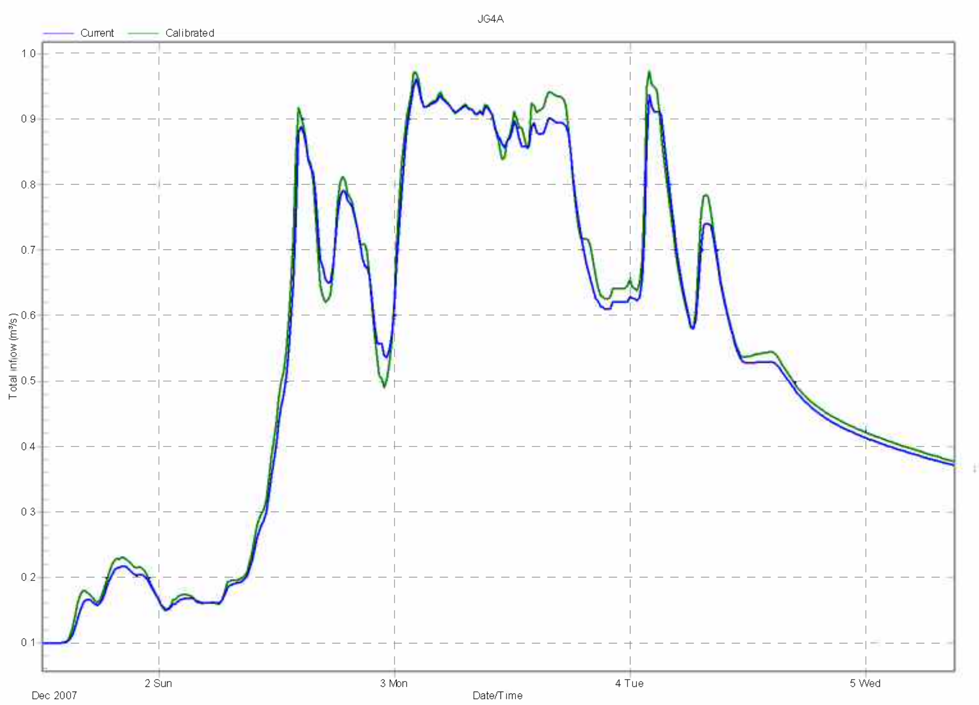


Table P below presents the percentage change in peak flow rates and total discharge volume with each of the three sensitivity analysis parameters adjusted by +/- 20%. The results of the sensitivity analysis show that the model is slightly sensitive to percent impervious and flow path width parameters, and not sensitive to catchment slope.

Table P Sensitivity Analysis Results – Percent Change in Flow

	Parameter Increase +20%		Parameter Decrease -20%	
Parameter	**Peak Flow**	**Volume**	**Peak Flow**	**Volume**
% Imperviousness	+0.2%	+0.9%	-0.2%	-0.8%
% Slope	+0.02%	0.0%	-0.02%	0.0%
Width	+0.3%	+0.3%	-0.4%	-0.2%

6.7 Calibration and Verification

Calibration is the method in which stormwater model parameters are adjusted so that the modelled conditions reasonably match actual conditions. In this manner, the model evolves from simply outputting data to providing results.

6.7.1 Calibration

In the construction of the watershed models, certain parameters such as invert elevations were quantified based on field measured data. Other parameters, however, are difficult to quantify in the field, such as channel roughness or subcatchment flow lengths, and were estimated or assumed based on textbook values. The intent of calibration is to adjust these estimated values so that the model reasonably reflects the measured behaviour of the watershed.

As described earlier in Section 6.6, certain parameters in the model are more sensitive to change than others. In terms of PCSWMM subcatchments, more sensitive parameters include % impervious area, the hydraulic conductivity of soil, flow length, and the depth of storage in both pervious and impervious areas. For the nodes and conduits, the more sensitive parameter is pipe roughness. The models were calibrated through adjustment of the most sensitive parameters first, followed by refinement with the less sensitive parameters. Parameters were optimized until an accuracy level of +/- 20% for peak flows and volume were attained.

Field data was collected for each watershed using stream gauging equipment, crest level gauges and anecdotal evidence from farmers. Section 5.3 outlined the flow monitoring program in detail and Appendix 4 contains a map which outlines all monitoring locations.

6.7.2 Calibration Events

Approximately one year of calibration data (September 10, 2007 to September 6, 2008) was collected from the field monitoring stations, coinciding with the one year of rainfall data collected from the University of Victoria School-Based Weather Station Network at Keating Elementary School (Section 6.5). Four specific rainfall events of varying total rainfall were used for calibration. The model was run for two weeks prior to and one week after the rainfall event in order to account for antecedent conditions and attenuation. The specifics of each calibration rainfall event are summarized in Table Q below.

Table Q Calibration Rainfall Events

Date of Rainfall	Total Rainfall (mm)
October 18 to 21, 2007	44.5
November 26 to 30, 2007	16.5
April 14, 2008	5.3
May 2 & 3, 2008	4.5

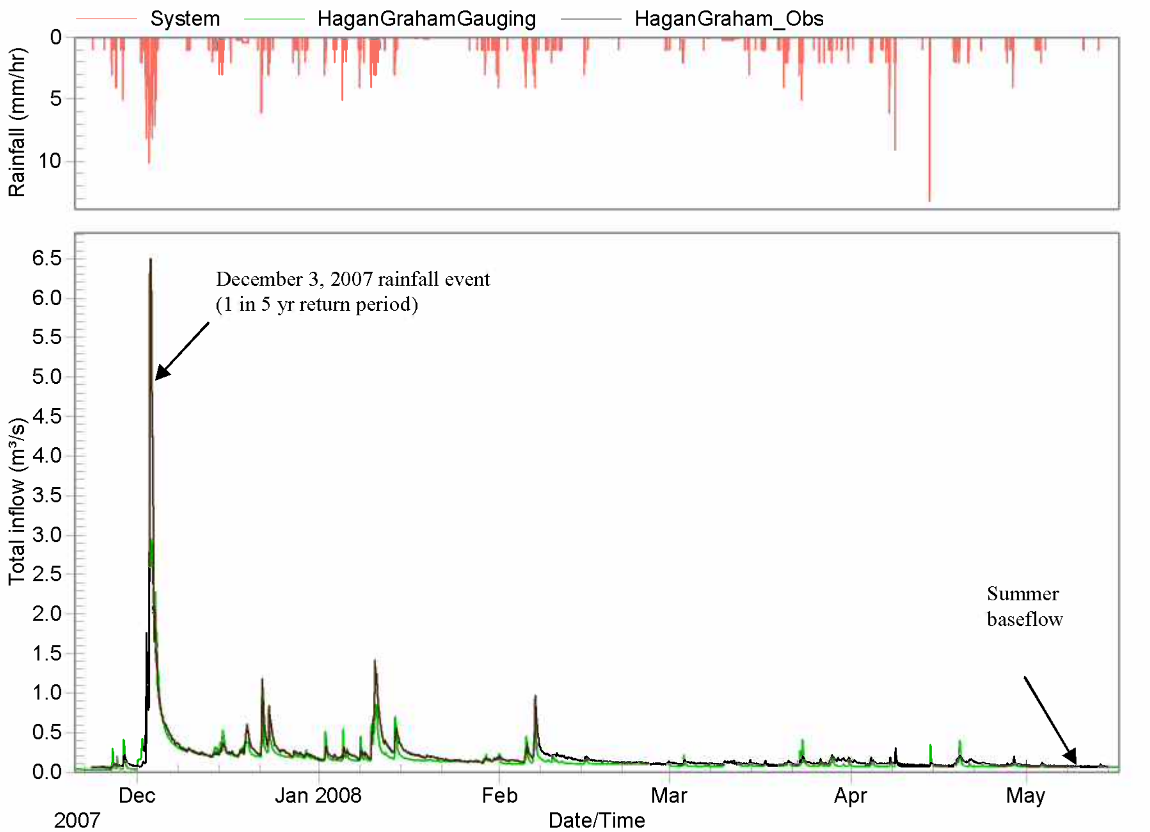
6.7.3 Verification

Once the model met the desired calibration accuracy level for the four storm events, verification of the model was completed to assess its compatibility with the remaining rainfall data. The desired accuracy level was +/- 20% for the entire rainfall and stream flow dataset.

The simulated hydrograph and observed hydrograph for the Hagan Graham watershed at Stelly's Cross Road are presented below in Figure Q.

The correlation between the calibrated model and the actual flow data was very good during dry weather events but deteriorated slightly during wet weather. This is likely due to the fact that the PCSWMM models do not directly account for recharge of groundwater through infiltration. The volume of rainfall that infiltrates in the model is considered to be lost from the system. In reality, infiltrated rainfall serves to recharge groundwater, raising the groundwater elevation, and increasing the amount of groundwater discharge into streams. While monthly baseflows determined from measured stream flow data are accounted for in the model, the model cannot account for increased baseflows due to infiltration. Despite this, the overall accuracy of the three models met the +/- 20% target.

Figure Q Calibration Period Hydrographs



7. ANALYSIS AND RESULTS

The field team from Aqua-Tex conducted basic Proper Functioning Condition assessments over four days on the four major streams/stream systems in the Central Saanich area (refer to Section 5.1.3 for detailed methodology). The Hagan/Graham watershed was assessed on February 7, February 11, and February 15, 2008. McHugh ditch and Noble Creek, along with a small section of Tetayut Creek, were assessed February 15 as well. The portion of Tetayut Creek from the Patricia Bay Highway to the headwaters near Bear Hill was surveyed on June 12, 2008.

The following are short summaries of what was observed during the field visits along with a condition statement and channel form (based on Rosgen classification) if applicable. Results are tabulated in Table R below. Additionally, a colour-coded map in the Figures Section (Figure 11) shows the areas assessed and their PFC status. A second map shows the locations of active floodplain within the stream channels (Figure 10). Where applicable, reaches have been designated as PFC (Proper Functioning Condition), FAR (Functional- at- Risk), or as NF (Non-Functional). FAR ratings must include a trend statement. In other words, if at risk, the system must be characterized as being in an upward trend toward PFC, a downward trend to NF, or in no apparent trend in either a positive or negative direction.

Table R Results of PFC Analysis in Central Saanich Creeks, 2008

PFC Category	Hagan-Graham Creeks	Tetayut Creek	McHugh-Noble Creek	Total Km Assessed	% of Reaches Assessed
Total # of Reaches	18	10	3		
Non-Functional	3.7	0.15	2.9	6.75	53 %
Functional-at-Risk with a downward trend	0.45	0.45	0.0	0.90	7%
Functional-at-Risk with no apparent trend	1.2	0.0	0.0	1.2	9%
Functional-at-Risk with an upward trend	0.0	0.0	0.0	0.0	0%
Proper Functioning Condition	2.1	1.65	0.17	3.92	31%
Total Km Assessed	7.45	2.25	3.07	12.77	100%
Total Km of Main Channel	10.6	5.5	4.6		

7.1 Hagan Graham

This section will summarize the biophysical and hydrologic evaluation of the Hagan – Graham watershed and identify the significant issues and opportunities in the watershed.

7.1.1 Biophysical Evaluation

Reaches of Hagan Creek

Hagan Creek Reach 1 - Hagan Bight to the Concrete Dam: A channel, PFC

A large waterfall separates Hagan Bight from the mouth of Hagan Creek creating an impassable barrier to fish. The walls of this confined channel are formed of bedrock and the roots and rock structures are solid, and have been so for some time as indicated by the occurrence of moss upon them. This strong substrate is essential to preventing any extensive erosion activity.

Red alder (*Alnus rubra*), big leaf maple (*Acer macrophyllum*), and Douglas-fir (*Pseudotsuga menziesii*) dominate the canopy with a small presence of Western redcedar (*Thuja plicata*) and Arbutus (*Arbutus menziesii*) as well. The understorey is composed of sword fern (*Polystichum munitum*) with the addition of tall Oregon grape (*Mahonia nervosa*) in low numbers and an unknown evergreen. Some young vegetation is present to act as replacement bank stabilizers and provide shade when the older trees die.

At the north-western edge of the dam, a channel of water has skirted its edges creating a headcut in the channel. At the moment, it has not been able to migrate far upstream due to the bedrock substrate acting as a strong barrier. However, if the headcut moves further upstream over time, it will reach the softer soils of the banks, causing greater damage. Depending on elevation, the headcut could pose a threat to the stability of West Saanich Road if it is allowed to advance that far.

Garbage and other debris were found littered on the upslope of the creek in this location.

The water is extremely turbid from the addition of excess sediments to the system.

Hagan Creek Reach 2 - Concrete dam to West Saanich Road: B channel, FAR

Floodplain areas are present in this reach along both banks including new ones being created by the sediment caught upstream of the concrete dam. Outcrops of rock are not visible and soil sediment seems to dominate the bank material. However, this reach should be visited during periods of lower flow to determine the geological substrate at the base of the channel. There is no evidence of any unstable areas likely as a result of the vegetation being so well rooted in this area.

The vegetation forming the canopy is dominated by a Western red cedar (*Thuja plicata*) along with Douglas-fir (*Pseudotsuga menziesii*), red alder (*Alnus rubra*), big leaf maple (*Acer macrophyllum*), and black cottonwood (*Populus balsamifera* ssp. *trichocarpa*). Sword fern (*Polystichum munitum*), dull Oregon grape (*Mahonia nervosa*), and snowberry (*Symporicarpos albus*) complete the understorey. On the banks in the upstream portion of the reach near West Saanich Road, English ivy (*Hedera helix*) covers the banks. As an invasive species, it poses a threat to the health of the surrounding native vegetation that function in stabilizing Hagan Creek's banks. As such, it would be beneficial to remove the ivy in conjunction with planting native riparian species such as willow and red alder. Additionally, it may be beneficial to plant more conifers as this reach is lacking in numbers.

At the upstream side of the concrete dam sediment has been accumulated creating a sediment extension to the right bank which is being colonized by watercress and other aquatic vegetation. As the right bank is being extended by sediment bars, the left bank is being exposed to the act of channel widening. This is resulting in the skirting of the concrete dam and the forming of a headcut as mentioned in the previous paragraphs. Due to the softer substrate found at the banks in this portion of the creek, erosion could occur much faster thereby threatening the physical stability and function of this reach.

Other items to note include the presence of trash on the upslope areas, a storm drain on the south side of the channel directing flow into the creek, and the large capacity of the box culvert under West Saanich Road.

Hagan Creek Reach 3 - West Saanich Road to 1563 West Saanich Road: Ditch, NF

Just upstream of West Saanich Road, Hagan Creek is contained within a ditch. The creek has been straightened throughout this reach to accommodate flow and reduce flooding in the adjacent agricultural fields. In most areas, the banks are oversteepened but appear to be stable likely due to the clay substrate. In some locations, however, the banks have been lined with rock possibly indicating instability in the past.

The vegetation throughout this reach consists of mostly reed canary grass with patches of red osier dogwood (*Cornus stolonifera*), hawthorn (*Crataegus* spp.), Nootka rose (*Rosa nutkana*), snowberry (*Symphoricarpos albus*), and red alder (*Alnus rubra*). Himalayan blackberry (*Rubus discolor*) can also be found near West Saanich Road.

In these agricultural areas, large irrigation ponds are present. The banks could be planted to reduce sediment movement from on-line ponds to the creek. Additionally, these ponds could potentially be utilized as storage areas for stormwater depending on the use of the water agriculturally and property owner permission.

The water continues to be turbid in this reach although the velocity at which the water is moving is less than that compared to the previous reaches due to little or no slope. At the eastern edge of 1563 West Saanich Road, Hagan Creek and Graham Creek become separate channels with Hagan to the north and Graham to the east.

Hagan Creek Reach 4 - 1563 West Saanich Road to Graham Creek confluence: C channel, FAR

This reach consists of the portion of Hagan Creek between the beginning of the large extensive ditch traveling to West Saanich Road, and the confluence with Graham Creek. This channel is sinuous and has a good cover of riparian vegetation. Accessible floodplain is present in areas and there are gravel areas suitable for fish habitat. Large woody debris further enhances this habitat creating cover as well as forming small pools. This reach is bordered on either side by agricultural fields used by cattle and for hay.

Areas of active erosion are evident especially in the outside bends. In one section, the landowner has repeatedly installed large rocks in an attempt to prevent further erosion into the adjacent field. While erosion is a natural occurrence in stream systems it has been augmented by high flows and sediment loads in this watershed. Additionally, while the riparian vegetation is capable of withstanding high flow events in most areas, it is at risk of trampling by cattle. If the vegetation were to be damaged, higher rates of erosion are likely to occur. Furthermore, removal of vegetation could lead to increased flooding in the area as the storage and uptake potential of the soils and plants would be reduced. Flooding is already an issue in this area and ditching is perceived to be the only method of remedying the flooding.

The vegetation community in this reach consists of a variety of age classes which is important for succession of habitats over time. Red alder (*Alnus rubra*), bigleaf maple (*Acer macrophyllum*), and Western redcedar (*Thuja plicata*) dominate the canopy with Douglas fir (*Pseudotsuga menziesii*) and grand fir (*Abies grandis*) present in much lower quantities. The understorey is composed of sword fern (*Polystichum munitum*), Indian plum (*Oemleria cerasiformis*), snowberry (*Symphicarpos alba*), salmonberry (*Rubus spectabilis*), trailing blackberry (*Rubus ursinus*), bracken fern (*Pteridium aquilinum*), fringecup (*Tellima grandiflora*), licorice fern (*Polypodium glycyrrhiza*), red huckleberry (*Vaccinium parvifolium*), and Himalayan blackberry (*Rubus discolor*).

Overall, this reach has been determined to be Functional-at-Risk with a downward trend as a result of erosion issues, trampling, and ditching threats.

Hagan Creek Reach 5 - 1791 Malcolm Road to Mount Newton Crossroad: C channel, FAR

This reach flows through agricultural fields from Mount Newton Crossroad to Malcolm Road. The lower portion of the reach has been worked on previously by Peninsula Streams to improve flow and capture sediment. During this time rock was added to line and stabilize the banks, choking vegetation was removed from the channel, stumps were installed, and riffles and small pools were created to improve fish habitat and capture sediment. At the eastern edge of 7791 Malcolm Road, a structure (perhaps intended to be a weir) is being avoided by Hagan Creek. Water is now flowing around the structure and is cutting into the southern bank. A large artificial gravel bar also exists on the north bank but is incapable of growing vegetation due to lack of soil material. Additionally, its elevation is too high to be used by the creek as a floodplain.

Further upstream, into 1720 Cultra Avenue, the channel becomes narrower and somewhat sinuous. This section has also had restoration activity including the planting of shrubs along the banks. The banks are oversteepened and trampling activity is evident. The land immediately adjacent to Hagan Creek has been plowed and seeded and a large culvert, big enough to hold equipment, extends across the channel.

The vegetation in this reach consists of red alder (*Alnus rubra*), cattails (*Typha latifolia*), and grass in the lower portion and willow (*Salix* spp.), red alder (*Alnus rubra*), and some other young planted shrubs. North of 7791 Malcolm Road, the vegetation is thicker and more established along Hagan Creek up until it crosses Mount Newton Crossroad.

Hagan Creek in this area is reminiscent of a Rosgen C channel although it is constrained by the agricultural land use around it. As a result of this, along with the sparse vegetation, this reach is functional at risk with no apparent trend. This reach would benefit from continued planting of native riparian vegetation in order to further stabilize the banks. Using cuttings from the willows already planted would be one way to continue this process to increase the vegetation abundance.

The area downstream of Malcolm Road was inaccessible due to private property restraints but observing from the road it was noted that the channel has some sinuosity and is vegetated quite heavily. The vegetation observed includes: red alder (*Alnus rubra*), willow (*Salix* spp.), hawthorn (*Crataegus* spp.), Himalayan blackberry (*Rubus discolor*), and reed canary grass (*Phalaris arundinacea*).

Note: Just upstream of the Mount Newton Crossroad culvert the banks of Hagan Creek are trampled and are starting to undercut. Additionally, according to the landowner, flooding of the property has increased over the last five years. Vegetation in this section includes western red cedar (*Thuja plicata*), daphne (*Daphne laureola*), English ivy (*Hedera helix*), Himalayan blackberry (*Rubus discolor*), and periwinkle (*Vinca* spp.).

On the adjacent property to the north two large ponds exist with a bridged driveway between them. The vegetation surrounding the ponds is sparse and consists of primarily reed canary grass (*Phalaris arundinacea*) and some cattails (*Typha latifolia*).

Hagan Creek Reach 6 - West of Larkvale Road (8000 Larkvale Road) to 1814 Jefferee Road: Cb channel, low PFC

This reach of Hagan Creek shows characteristics of a remnant piece of this subwatershed. The channel is sinuous with large bends, floodplains, and a substrate dominated by gravel/clay. The bottom of the channel exhibits the presence of more gravel than anywhere else in Hagan Creek that was assessed. Deposition activity is evident and scouring of the outside banks is occurring but is not in exceedance of normal creek activity. There is some trampling activity throughout but is not severe. However, a cowpat does exist in the upper portion of the reach which may lead to riparian vegetation degradation in the future if not already.

Cattle pasture is in existence in the upper portion of this reach. At this point in time, the upslope has not been grazed to the edge of the bank despite the cowpat being present. This observation may be a seasonal one however, as the cattle were penned upslope at the time of assessment. The banks in this area are steeper than downstream and do show more erosion and evidence of past slumping.

Douglas fir (*Pseudotsuga menziesii*), western redcedar (*Thuja plicata*), red alder (*Alnus rubra*), bigleaf maple (*Acer macrophyllum*), and red osier dogwood (*Cornus stolonifera*) dominate the canopy throughout this reach. In the understorey, sword fern (*Polystichum munitum*) is the most abundant species interspersed with snowberry (*Symphoricarpos albus*), salmonberry (*Rubus spectabilis*), Indian plum (*Oemleria cerasiformis*), trailing blackberry (*Rubus ursinus*), and Himalayan blackberry (*Rubus discolor*). In the lower section of this reach, the banks are vegetated with sufficient riparian vegetation for function and the surrounding upslopes are forested. In the upper section, riparian vegetation is present as well but is not as vigorous and in places, western redcedars (*Thuja plicata*) are dead or dying. Additionally, the upslopes are no longer forested but consist of agricultural fields with both crop and cattle activity.

Throughout the reach, there are very few young shrubs which may pose a problem in terms of vegetation replacement overtime and consequently, bank stability concerns.

Also of important note in this reach is the amount of turbidity in the water creating a light brown coloured flow. Sources of this excess turbidity may include bare, tilled fields in the area.

Overall, this reach is considered to be a Cb channel in proper functioning condition although on a lower scale due to the absence of young shrubs.

Hagan Creek Reach 7 - Haldon Road area: C channel, FAR

Limited access prevented a full assessment of this area. As such, only the areas just downstream and just upstream of Haldon Road were examined.

On both sides of Haldon Road, Hagan Creek is found within a moderately sinuous channel that has accessible floodplains. Road drainage runs off both sides of the road into the creek via open halved culverts. At the downstream side, a fenceline crosses the creek and has created a large debris jam that is diverting water around its sides. It is possible a headcut may be present but further investigation is required on this front. Upstream of Haldon Road, the creek runs alongside a large open area with old buildings that seem to be rarely used. Machinery and other materials are stored near the banks. North of the yard, a pond or wetland area is located behind some red alder (*Alnus rubra*) trees. This area was not examined further at the time due to access limitations.

The vegetation in this reach consists of Douglas fir (*Pseudotsuga menziesii*), western red cedar (*Thuja plicata*), red alder (*Alnus rubra*), bigleaf maple (*Acer macrophyllum*), Indian plum (*Oemleria cerasiformis*), salmonberry (*Rubus spectabilis*), sword fern (*Polystichum munitum*), English ivy (*Hedera helix*), English laurel (*Prunus laurocerasus*), reed canary grass (*Phalaris arundinacea*), and some sedges (*Carex* spp.).

This reach is in relatively good shape, however, the potential headcut and the heavily invasive ivy crowding out the other vegetation put this reach at risk. With ivy overcrowding the riparian vegetation the appropriate root structure is no longer present to stabilize the banks.

Note: At the uppermost end of the Hagan Creek headwaters, a large subdivision exists that injects stormwater into the watershed. This subdivision is composed of large lots, big houses, manicured lawns, wide streets, and traditional stormwater management such as roadside ditches and catchbasins.

Reaches of Graham Creek

Graham Creek Reach 1 - Western end of Cultra Avenue thru George May Park: Bc channel, PFC

This portion of the Graham Creek consists of numerous floodplain areas and a moderately sinuous channel. The banks are well vegetated with both moss and native riparian species. Riffle areas were noted as well as a small ponding area north of the channel between the CRD pump station and the driveway for 1695 Cultra Avenue. A log weir is located behind the pump station creating a small cascade and aerating the creek channel. Other small and large woody debris is evident throughout this reach of

Graham Creek and are active in creating floodplain and reducing the speed at which the water flows protecting the creek channel from erosion.

The vegetation community in this reach consists of a variety of age classes which is important for succession of habitats over time. Red alder (*Alnus rubra*), bigleaf maple (*Acer macrophyllum*), and Western redcedar (*Thuja plicata*) dominate the canopy with Douglas fir (*Pseudotsuga menziesii*) and grand fir (*Abies grandis*) present in much lower quantities. The understorey is composed of sword fern (*Polystichum munitum*), Indian plum (*Oemleria cerasiformis*), snowberry (*Symphicarpos alba*), salmonberry (*Rubus spectabilis*), trailing blackberry (*Rubus ursinus*), bracken fern (*Pteridium aquilinum*), fringecup (*Tellima grandiflora*), licorice fern (*Polypodium glycyrrhiza*), red huckleberry (*Vaccinium parvifolium*), and some holly (*Ilex aquifolium*). Within the stream channel itself skunk cabbage (*Lysichiton americamum*), Pacific water parsley (*Oenanthe sarmentosa*), and Siberian miner's lettuce (*Claytonia sibirica*) were also noted. Along the upper slopes adjacent to residents on Blackgloma Place, a higher density of invasive species were observed as well as piles of compost which could eventually make their way into Graham Creek increasing its nutrient content.

This reach is a remnant area of Graham Creek that provides insight into what the Graham Creek system may have looked like historically.

Graham Creek Reach 2 - Centennial Park from Prosser Road to Hovey Road: Bc channel, PFC

Graham Creek is found in the bottom of a ravine-like area between Prosser and Hovey Roads. It is moderately sinuous throughout this reach and has access to floodplains along its length. Remnant cement abutments from an old dam were observed as well as a series of cement structures that may have been involved with the drinking water supply historically. There is some erosion occurring at the left side of the dam but is not likely to get any worse. The right bank in this area is steep but the roots from the surrounding vegetation seem to be strong enough to maintain its stability. Large woody debris is present in this reach performing its function of reducing flow velocity and creating floodplain areas.

The vegetation is dominated by a canopy of Western red cedar (*Thuja plicata*), red alder (*Alnus rubra*), bigleaf maple (*Acer macrophyllum*) with Douglas fir (*Pseudotsuga menziesii*) and grand fir (*Abies grandis*) on the upslopes. Sword fern (*Polystichum munitum*), salmonberry (*Rubus spectabilis*), and Indian plum (*Oemleria ceraformis*) create the majority of the understorey. English ivy (*Hedera helix*) is present in patches as well which should be prevented from spreading by removal and subsequent planting of fast-growing native species.

Erosion is occurring in the upslope areas of this reach especially along the left bank where the existing trail is located. A small channel has been created in the upslope by water draining from a white PVC pipe at the top of the ravine. The source of this pipe could be the lawn bowling club building or green. The erosion is active and the channel needs stabilizing as it could end up affecting Graham Creek in a negative way.

Graham Creek Reach 3 - Hovey Road to beginning of bedrock dominated channel: B channel, low scale PFC

This moderately sinuous channel consists of small cobble substrate with little accessible floodplain except for the downstream end by the trail crossing. There is evidence of trampling and soil compaction likely as a result of the trail being too close to the channel in the past.

The canopy consists of primarily mature Western red cedar trees (*Thuja plicata*) with a few red alder (*Alnus rubra*) and bigleaf maple (*Acer macrophyllum*) scattered throughout. Douglas-fir trees (*Pseudotsuga menziesii*) make up the majority of the upslope areas. The understorey is very sparse consisting of almost exclusively sword fern (*Polystichum munitum*). This may be as a result of the abundance of Western redcedar trees in the area and the amount of shade created by the canopy.

A small amount of erosion was also observed at the time of assessment likely due to the volume of water that is conducted through Graham Creek combined with the lack of vegetation acting as bank stabilization structures. This reach would benefit from the addition of large wood to slow down the velocity of the water and create floodplain areas ultimately protecting the banks from more erosion.

Graham Creek Reach 4 - Beginning of the bedrock dominated channel to the pipeline crossing in Centennial Park: B, PFC

The reach boasts a series of small bedrock intrusions that create weirs slowing the flow of water and ultimately holding the creek together. This reach is in good condition despite the trail being so close to it. The bedrock intrusions prevent erosion of the banks and aerate the water.

The vegetation in this area is similar to that of downstream with Western red cedars (*Thuja plicata*), some red alder (*Alnus rubra*), bigleaf maple (*Acer macrophyllum*), and Douglas-fir (*Pseudotsuga menziesii*). The understorey is mostly composed of sword fern with some areas of dull Oregon grape (*Mahonia nervosa*).

This reach provides a very good example of the function of natural weirs within a stream setting.

Graham Creek Reach 5 - Pipeline crossing to the southern end of Centennial Park. Ditch-like cross-section, FAR

This portion of Centennial Park is in the roughest shape. Active erosion is evident in this moderately sinuous channel, especially on the outside bends where the banks are undercutting. The channel shows indication of down-cutting activity either historically or occurring presently at a slow rate.

The vegetation in this reach consists of western red cedar (*Thuja plicata*), red alder (*Alnus rubra*), bigleaf maple (*Acer macrophyllum*), and Douglas-fir (*Pseudotsuga menziesii*). In the understorey, sword fern (*Polystichum munitum*), snowberry (*Symphoricarpos albus*), Indian plum (*Oemleria ceraformis*), salmonberry (*Rubus spectabilis*), English holly (*Ilex aquifolium*), and young cedars can be observed. Vegetation is especially important in this reach for stabilizing the banks that are being eroded. This vegetation community is less mature as compared to the reaches downstream suggesting it is more recently disturbed.

Where the trail crosses Graham Creek at the southern end of Centennial Park extensive scour is occurring at the downstream bank. The culvert under the trail seems to be the main cause of this erosion as there is about a 1 1/2 foot drop from the upstream end to the downstream end which increases the speed of the water at the downstream end. This may be occurring as a result of an incorrect sized culvert. This problem could be fixed by creating a pond on either side of the culvert to slow the water movement down and maintain the same elevation across the culvert.

Of special note, there is a tree located on an outside bend downstream of the culvert where the trail crosses that may take out a good sized piece of the bank if it falls over. It may be prudent to cut down this tree and leave the rootball in place to maintain its stabilizing function and protect the bank.

Graham Creek Reach 6 - Southern end Centennial Park to Keating Crossroad: Ditch, NF

This reach consists primarily of an artificially straightened and deepened channel from the southern end of Centennial Park to Keating Crossroad. Throughout this reach until the uppermost section, the banks are oversteepened and lack appropriate riparian vegetation. In some sections such as the area downstream of Stelly's Crossroad, the banks have slumped in past years. Additionally, garbage is commonly present and is often caught up in other debris in the channel in this downstream portion of the reach.

Upstream of Wallace Drive, Graham Creek makes its way along the western edge of Maber Flats. Here, agricultural fields line both sides of the ditch. Seasonal flooding occurs in this area not due to Graham Creek escaping its banks but because of a heightened water table in the winter months and poorly drained soils. At the time of assessment, two sediment plumes were noted entering Graham Creek. One was occurring from drainage off of a bare agricultural field and the other was flowing out of Stephens Creek (Stinky Ditch). Stephens Creek is the ditch that carries runoff from the Keating Industrial Park east of Maber Flats. Upstream of the confluence with Stephens Creek, the banks of Graham Creek become a little more sloped and the channel depth is much shallower as it crosses through private property near Kersey Road.

The vegetation in this reach consists of primarily reed canary grass (*Phalaris arundinacea*) interspersed with small numbers of red alder (*Alnus rubra*), willow (*Salix* spp.), red osier dogwood (*Cornus stolonifera*), Pacific ninebark (*Physocarpsus capitatus*), English hawthorn (*Crataegus monogyna*), Nootka rose (*Rosa nutkana*), *Rosa* sp., snowberry (*Symphicarpos albus*), English ivy (*Hedera helix*), Himalayan blackberry (*Rubus discolor*), hardhack (*Spirea douglasii*), and some cattail (*Typhus latifolia*). Downstream of Stelly's Crossroad the vegetation is slightly different and is present at higher density. Although the species present are the same, there is more riparian vegetation than upstream due to the landowners preventing clearing of the stream.

According to landowners, this portion of Graham Creek used to be a much smaller channel until the late 1970's when it was straightened and dredged in order to drain the agricultural land upstream.

Note: The reach between Keating Crossroad to West Saanich Road was not assessed due to private land ownership and lack of permission to access. However, looking upstream from Keating Crossroad two ditches were noted coming from the east and west to meet with Graham Creek before flowing through the culvert under the road. The part of the channel that was visible was ditch-like in nature with the following vegetation: red alder (*Alnus rubra*), hawthorn (*Crataegus* spp.), Himalayan blackberry (*Rubus discolor*), rose (*Rosa* spp.), reed canary grass (*Phalaris arundinacea*), bulrush and/or iris.

Graham Creek Reach 7 - Upstream of West Saanich Road (6666 West Saanich Road): B channel, PFC

This reach begins at West Saanich Road and extends upstream to near the property line between 6666 and 6630 West Saanich Road. A decommissioned dam lined with concrete and rocky fill remains in the channel creating a pool upstream of it which is inconsistent with most B channel streams. The dam was used to pool water that was drawn for irrigation until the owner could tap into the CRD water supply. The channel proper is dominantly a silt/clay channel with areas of gravel and sand. Floodplain areas are present but they may be an artifact of the old dam as B channels do not typically have floodplains.

A well is located on the southern side of this channel upstream of the dam and is used by the neighbouring property as a water supply. There is some trampling evident on this bank as well likely from sheep that used to inhabit the area. The bank on the north side however, is well vegetated and there is no evidence of erosion except in one area where drainage initiated by a spring has cut down through the bank. In this location planting would be beneficial to improve the bank stability.

This reach is in good condition and is well vegetated with the following plants: Douglas fir (*Pseudotsuga menziesii*), red alder (*Alnus rubra*), apple trees, willow (*Salix* spp.), Indian plum (*Oemleria cerasiformis*), English hawthorn (*Crataegus monogyna*), snowberry (*Symphicarpos alba*), creeping buttercup (*Ranunculus repens*), some rush (*Juncus* spp.), and grass.

Graham Creek Reach 8 - 6630 West Saanich Road: Cb, NF

This moderately sinuous channel that flows year-long has experienced heavy trampling activity from sheep up until approximately one year ago. As a result, there is a very sparse understorey. Erosion is evident along the channel banks and is likely compounded by the lack of vegetation and high flows during heavy rains. In fact, during heavy rains, the roar of the creek can be heard from the landowners home.

There are some floodplain areas present that are vegetated with rushes and grass and in at least one location a second channel is being created around the floodplain.

A dam and small footbridge are located at the south end of this reach. In this location two ditches enter the main channel, one from the west and one from the east. The eastern ditch collects drainage from field while the western drainage carries run-off from a winery parking lot.

The vegetation in this reach consists of Douglas fir (*Pseudotsuga menziesii*), grand fir (*Abies grandis*), big leaf maple (*Acer macrophyllum*), Pacific willow (*Salix lassiandra*), Pacific ninebark (*Physocarpsus capitatus*), English hawthorn (*Crataegus monogyna*), and oceanspray (*Holodiscus discolor*). At the time of the assessment, no regenerating vegetation was noted which implies that this reach may also have successional vegetation issues. The understorey is extremely sparse and should be revegetated using shade tolerant plants in order to ensure their survival and improve bank stability.

Due to the lack of vegetation as well as active erosion, this reach is characterized as non-functional. Additionally, this reach has been used as a dumpsite in the past including car parts and a frame.

Graham Creek Reach 9 - 6536 West Saanich Road: B channel, FAR

This reach consists of a moderately sinuous channel with a small cobble substrate, a few riffles, and present but minimal floodplain area. The banks are sloping and are heavily trampled by sheep in the area. A small falls made of rock and other material is located at the south end of this reach with a large pond upstream of it. At the time of assessment it was undeterminable whether this structure is stable or not. Another cement structure is located at the downstream end of this reach causing pooling of the channel. Some active erosion is occurring in the channel and is primarily concentrated where a ditch in the west bank meets Graham Creek.

The vegetation in this reach consists primarily of Douglas fir (*Pseudotsuga menziesii*), some western redcedar (*Thuja plicata*). The understorey is very sparse with hardhack (*Spirea douglasii*) and some rush (*Juncus* spp.). A sufficient vegetative community is not present and as such, the creek is not functioning as it should in this reach. Additionally, young vegetation is prevented from growing to correct this due to the trampling and grazing activities of the sheep.

The large pond upstream of the channel portion of Graham Creek is likely used to irrigation purposes. It has little riparian vegetation and has fields on the west bank and a residence on the east bank. The vegetation that is present consists of: willow (*Salix* spp.), Nootka rose (*Rosa nutkana*), Himalayan blackberry (*Rubus discolor*), iris (*Iris* spp.), and milfoil (*Myriophyllum* spp.).

Graham Creek Reach 10 - 6095 West Saanich Road: Cb channel, PFC

The channel in this reach is moderately sinuous and is surrounded by accessible floodplain area. A large concrete pad is located on the west bank but riparian vegetation buffers the creek. On the east bank, deciduous and coniferous forest make up the upslope.

The vegetation in Reach 9 is dominated by western red cedar (*Thuja plicata*), Douglas fir (*Pseudotsuga menziesii*), dull Oregon grape (*Mahonia nervosa*), and sword fern (*Polystichum munitum*). Other species include: bigleaf maple (*Acer macrophyllum*), red alder (*Alnus rubra*), Indian plum (*Oemleria ceraformis*), salmonberry (*Rubus spectabilis*), red huckleberry (*Vaccinium parvifolium*), bracken fern (*Pteridium aquilinum*), salal (*Gaultheria shallon*), Himalayan blackberry (*Rubus discolor*), and English ivy (*Hedera helix*).

Upstream of 6095, at the llama farm, the channel takes on more B-like characteristics as it narrows, increases in slope, and loses the floodplain areas as seen down stream. The understorey is much sparser as compared to downstream, but coniferous trees, especially western red cedar and Douglas fir, are in abundance. Upstream of the llama farm Graham Creek is a ditch.

Graham Creek Reach 11 - wetlands near Kildeer Road

The headwaters of Graham Creek can be found just north of Kildeer Road where 3 big ponds exist in series. They were likely part of a larger wetland prior to agricultural influence.

7.1.2 Hydrologic / Hydraulic Evaluation

Maber Flats Flooding – Graham Creek Reach 6

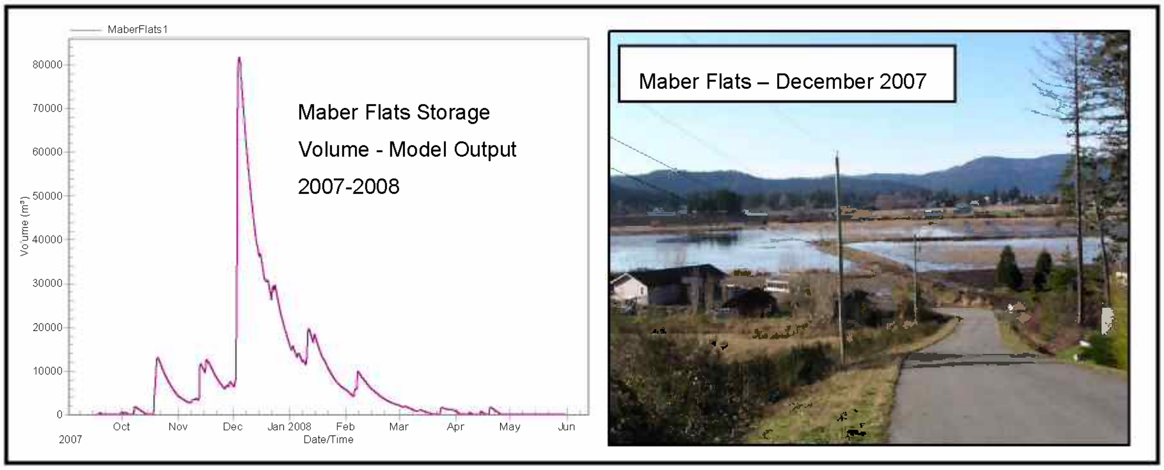
Located in the Graham Creek watershed, Maber Flats floods for extended periods during the winter months. The main causes of this flooding are the poorly draining soils, the low gradient in the Flats and hydraulic restrictions downstream of the Flats including the Wallace Drive and Stelly's Cross Road Culverts and the capacity of the creek channel immediately downstream of Stelly's Cross Road. An hydraulic profile of Maber Flats is presented in Figure R below.

Figure R Graham Creek Hydraulic Profile – Maber Flats through Centennial Park

The combination of poorly draining soil which increases runoff and low gradient and hydraulic restrictions significantly reducing flow out of the Flats causes extensive flooding. The flooding attenuates peak flows in Graham Creek through Centennial Park and to a lesser degree through the lower reaches of Hagan Creek

The computer model results show an approximate 50% attenuation of peak flows through Centennial Park during the 25 year 24 hour storm event with flooding in the Flats typically lasting for 4 -6 months each year. The model results for the 2007-2008 period shows flooding occurring between late October and early May (see Figure S below). Options for reducing the duration of flooding in the Flats were reviewed during the modeling of the watershed.

Figure S Maber Flats Flooding 2007-2008



Erosion issues in the watershed are compounded by high peak flows that are in part the result of increased runoff from residential areas and Keating Industrial Park. The primary areas of concern for erosion in the Hagan Graham watershed are Graham Creek through Centennial Park (Reach 5), Hagan Creek upstream of the confluence with Graham Creek (Reach 5) and Hagan Creek between West Saanich Road and the confluence of Graham and Hagan Creeks (Reach 4). Computer modeling of the 'As-Is' base case of the catchment produced the following results.

- Peak flows into Centennial Park range from 0.92 m^3/s (1.4 L/s/hectare) for the 2 yr 24 hr storm to 2.0 m^3/s (3.1 L/s/hectare) for the 100yr+ 24 hr storm.
- Peak flows at the confluence of Hagan Creek and Graham Creek range from 2.5 m^3/s (2.1 L/s/hectare) for the 2 yr 24 hr storm to 4.6 m^3/s (3.9 L/s/hectare) for the 100yr+ 24 hr storm.

Opportunities to reduce peak flows, and erosion potential, at these key locations were examined as part of the hydrological/hydraulic modeling of the watershed.

Water Quantity and Quality - Keating Industrial Park

Approximately 40 hectares of the Keating Industrial Park drains to the Graham Creek watershed via a piped system. The outlet of the piped system is a 1200 concrete pipe that ties into Stephens Creek (Stinky Ditch) which drains to Graham Creek'. Data collected by others indicates surface water contamination, primarily fecal coliform, above the average expected in a stormwater system. The impact of Keating Industrial Park on the overall hydrology of the watershed is not considered significant as it represents only a small portion of the catchment, however, the increased peak flows have a local impact with increased erosion observed along Stephens Creek.

7.1.3 Watershed Issues

- Flooding in the spring and fall in Maber Flats area reduces agricultural values.
- Maber Flats provides overwintering habitat for numerous bird species. Concerned citizens wish to ensure that this habitat remains as there is little of this type still located within the Capital Regional District.
- High sediment load in the creeks especially during the winter seasons.
- High temperatures and poor water quality especially in Stephens Creek (Stinky Ditch) which transports stormwater from Keating Industrial Park to Graham Creek.
- Creeks are ditched reducing their ability to manage high flow events as a result erosion and flooding is occurring.
- Conflict between ecological function and farming practices *i.e.* flooding leads to idea that digging channel deeper and making it straighter will solve the flooding however, this will remove ecological function from the creek.

7.1.4 Watershed Opportunities

Various opportunities for hydrological/hydraulic modifications in the watershed were examined using the computer model. These options included channel modifications, rainfall capture and detention ponds. The results of the modeling are discussed in detail below and presented in Table S below.

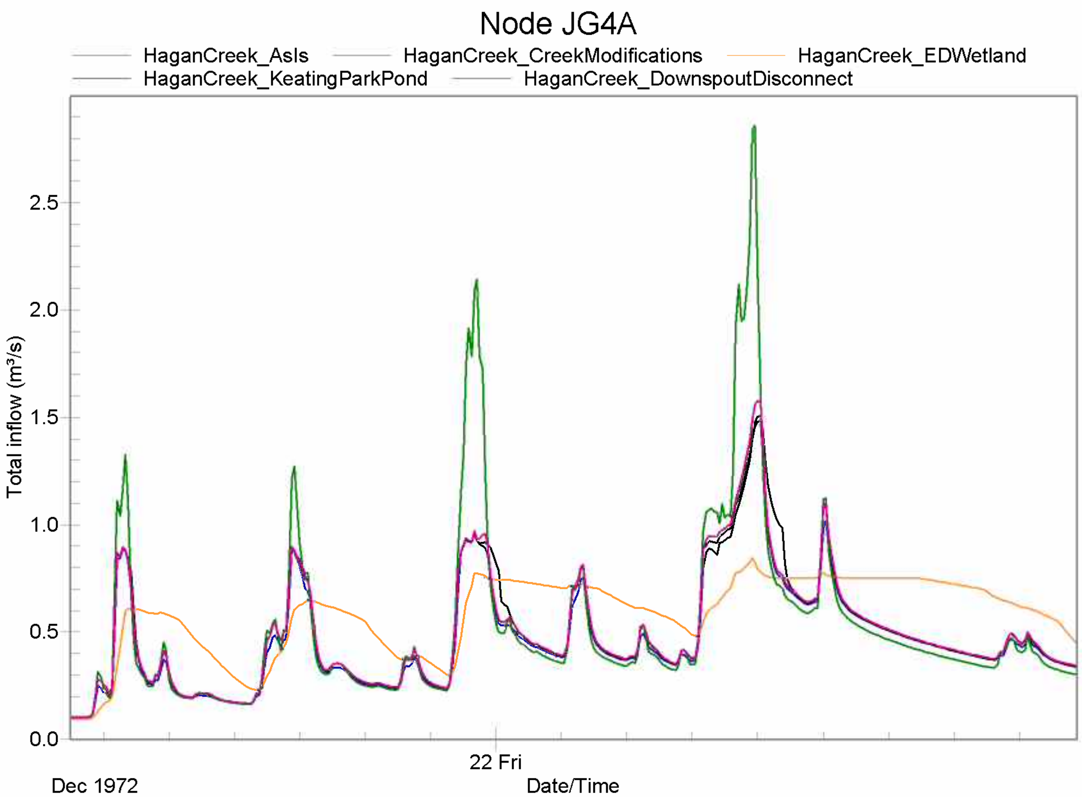
Table S Summary Table of Hagan Graham Opportunities

		Rainfall Event											
		2yr - 50.7 mm			10 yr - 71.2 mm			25 yr - 87.1 mm			100 yr+ - 134.7 mm		
Location	Modification Option	m3/s	l/s/ha	% change	m3/s	l/s/ha	% change	m3/s	l/s/ha	% change	m3/s	l/s/ha	% change
Keating Industrial Park[(4)]	As Is	0.42	10.77	--	0.55	14.10	--	0.72	18.46	--	0.80	20.51	--
	Rainfall Capture[(1)]	0.31	7.95	-26	0.42	10.77	-24	0.55	14.10	-24	0.60	15.38	-25
	Graham Creek Hydraulic Modification [(2)]	0.42	10.77	0	0.55	14.10	0	0.72	18.46	0	0.80	20.51	0
	Keating Industrial Park Detention Pond	0.25	6.41	-40	0.25	6.41	-55	0.27	6.92	-63	0.80	20.51	0
	Maber Flats Wetland[(5)]	0.42	10.77	0	0.55	14.10	0	0.72	18.46	0	0.80	20.51	0
Stelly's Cross Road (flows into Centennial Park)	As Is	0.92	1.42	--	1.02	1.57	--	1.58	2.43	--	2.01	3.10	--
	Rainfall Capture[(1)]	0.92	1.42	0	0.96	1.48	-6	1.48	2.28	-6	1.75	2.70	-13
	Graham Creek Hydraulic Modification [(2)]	1.74	2.68	89	2.33	3.59	128	2.86	4.41	81	3.18	4.90	58
	Keating Industrial Park Detention Pond	0.92	1.42	0	1.02	1.57	0	1.58	2.43	0	2.01	3.10	0
	Maber Flats Wetland[(5)]	0.76	1.17	-17	0.80	1.23	-22	0.85	1.31	-46	3.34	5.15	66
Hagan Graham Confluence	As Is	2.51	2.10	--	2.90	2.43	--	4.59	3.84	--	4.66	3.90	--
	Rainfall Capture[(1)]	2.41	2.02	-4	2.73	2.29	-6	4.29	3.59	-7	4.57	3.83	-2
	Graham Creek Hydraulic Modification [(2)]	3.32	2.78	32	4.20	3.52	45	4.94	4.14	8	5.01	4.20	8
	Keating Industrial Park Detention Pond	2.51	2.10	0	2.89	2.42	0	4.59	3.84	0	4.66	3.90	0
	Maber Flats Wetland[(5)]	2.36	1.98	-6	2.77	2.32	-4	3.92	3.28	-15	4.99	4.18	7
Hagan Bight	As Is	4.98	2.80	--	6.20	3.49	--	8.00	4.50	--	8.47	4.76	--
	Rainfall Capture[(1)]	4.86	2.73	-2	6.03	3.39	-3	8.00	4.50	N/A[(3)]	8.47	4.76	N/A[(3)]
	Graham Creek Hydraulic Modification [(2)]	5.79	3.26	16	7.42	4.17	20	8.00	4.50	N/A[(3)]	8.47	4.76	N/A[(3)]
	Keating Industrial Park Detention Pond	4.98	2.80	0	6.20	3.49	0	8.00	4.50	N/A[(3)]	8.47	4.76	N/A[(3)]
	Maber Flats Wetland[(5)]	4.81	2.71	-3	6.04	3.40	-3	8.00	4.50	N/A[(3)]	8.47	4.76	N/A[(3)]

Notes:
(1) Rainfall capture modeled as a 25% reduction in DCIA where impermeabiliy >10%.
(2) Creek modification reduces duration of Maber Flats flooding but increases downstream peak flows
(3) Peak flows at Hagan Bight in excess of the 25 yr event are limited by capacity of Lower Hagan
(4) Keating Industrial Park flows modelled at Stinky Ditch
(5) Maber Flats Wetland includes hydraulic modifications to Graham Creek

Figure T below presents the 25 year storm event hydrographs for each option modeled.

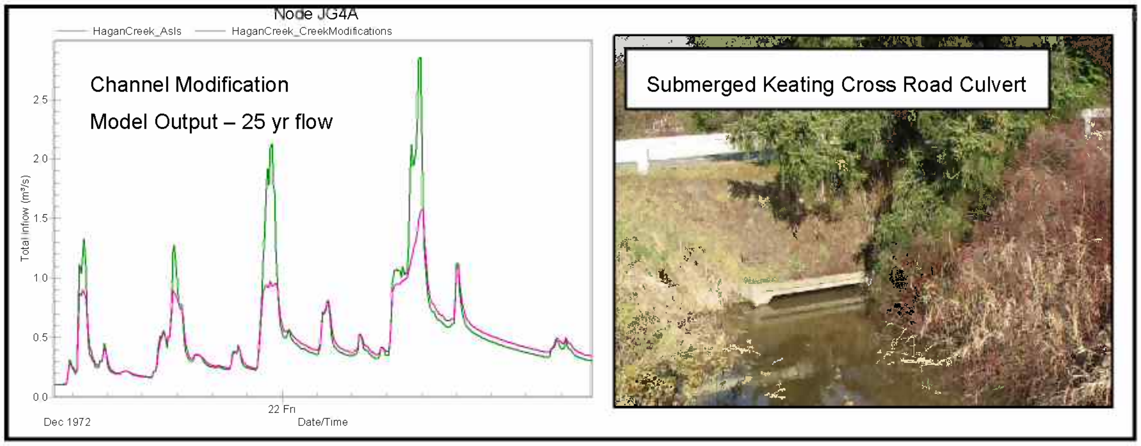
Figure T Model Output Hydrographs for 25 yr Storm Event



Graham Creek Channel Modification

Graham Creek channel modification included the lowering of Wallace Drive and Stelly's Crossroad culverts; and a combination of widening and increasing the gradient of Graham Creek north from Wallace Drive to White Road. The model results show the duration and frequency of flooding in Maber Flats would be significantly reduced by these channel modifications. However, channel modification would also result in increased peak flow rates through Centennial Park by as much as 81% during the 1 in 25 yr storm (see Figure U below).

Figure U Graham Creek Channel Modification Hydrograph



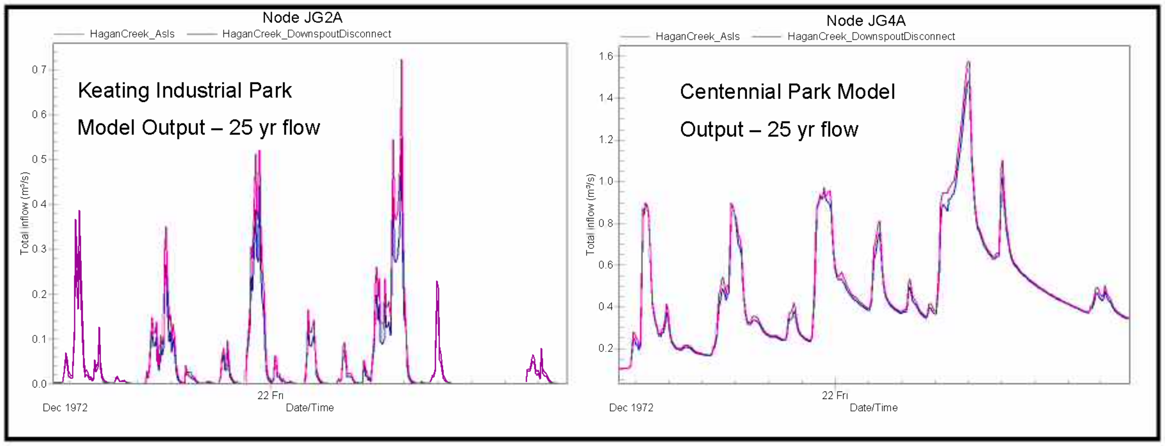
Rainfall Capture

The watershed includes approximately 140 hectares of residential areas with an estimated DCIA of 40 percent. These developed areas produce substantially more runoff than undeveloped areas. In the Graham Creek sub-catchment the residential areas increase peak runoff flows and exacerbate the flooding issues in Maber Flats and also cause erosion issues downstream in Centennial Park (Graham Creek Reach 5). Dean Park, a 90 hectare residential area, drains to the upper reaches of Hagan Creek resulting in increasing peak flows and causing increased erosion notably in Reach 4 of Hagan Creek.

There are several methods of increasing rainfall capture through utilizing rain water source control methods (*i.e.* infiltration and retention) such as disconnecting roof leaders, constructing rain gardens, and building bioswales. The assumption used to model improvements in rainfall capture throughout the watershed was to reduce DCIA in sub-catchments that had greater than or equal to 25% DCIA by 25%. For example, if a sub-catchment had 40% DCIA, the revised DCIA was reduced to 30%. A conservative value of 25% reduction in DCIA was selected as this accounts for areas where capture may not be possible due to adverse soil conditions and areas where residents cannot feasibly participate or elect not to do so.

Rainfall capture in both residential/Industrial areas effectively reduced overall watershed imperviousness by approximately 2.0% (11.5% to 9.5%DCIA). With rainfall capture the simulated peak flows from Keating Industrial Park discharging to Stephens Creek (Stinky Ditch) were reduced by approximately 25% for all storm events up to the 100 yr+ 24 hr rainfall (see Figure V below). Simulated peak flows were reduced by up to 13% at Stelly's Cross Road by downspout disconnection. However no significant attenuation of peak flow was observed in the lower reaches of Hagan Creek despite the reduction of DCIA in Dean Park.

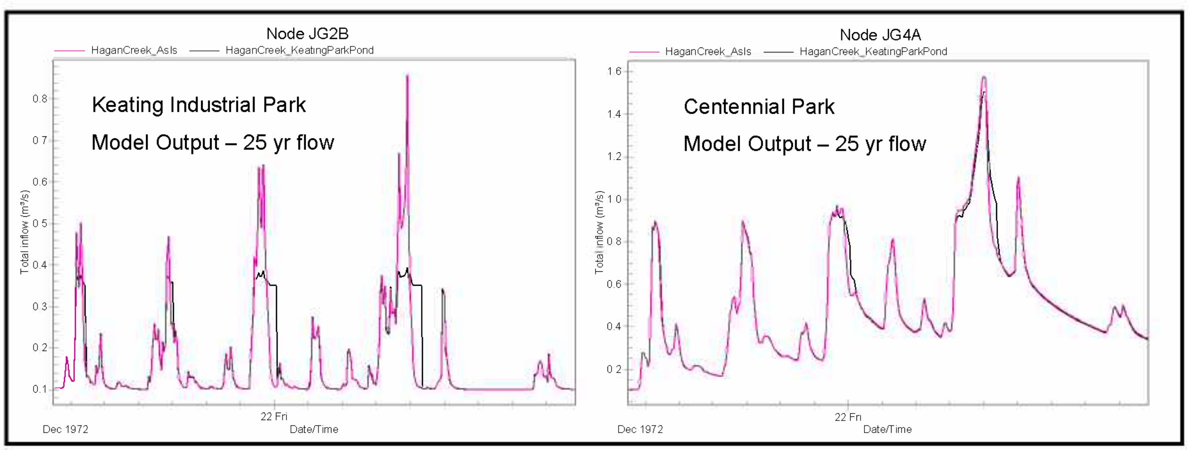
Figure V Rainfall Capture Hydrographs



Keating Industrial Park Detention Pond

A half hectare detention pond/wetland located immediately downstream of Keating Industrial Park would provide significant (40 – 60%) reduction in peak flows for 2 yr, 10 yr and 25 yr storms in Stephens Creek (see Figure W below). No flow attenuation was observed for the 100 year+ storm. This local flow attenuation would reduce the erosion potential along Stephens Creek. Limited flow attenuation was observed downstream in Graham Creek or Hagan Creek and detention pond would not significantly reduce the flooding in Maber Flats. A detention pond/wetland would also improve the water quality of runoff from the industrial park.

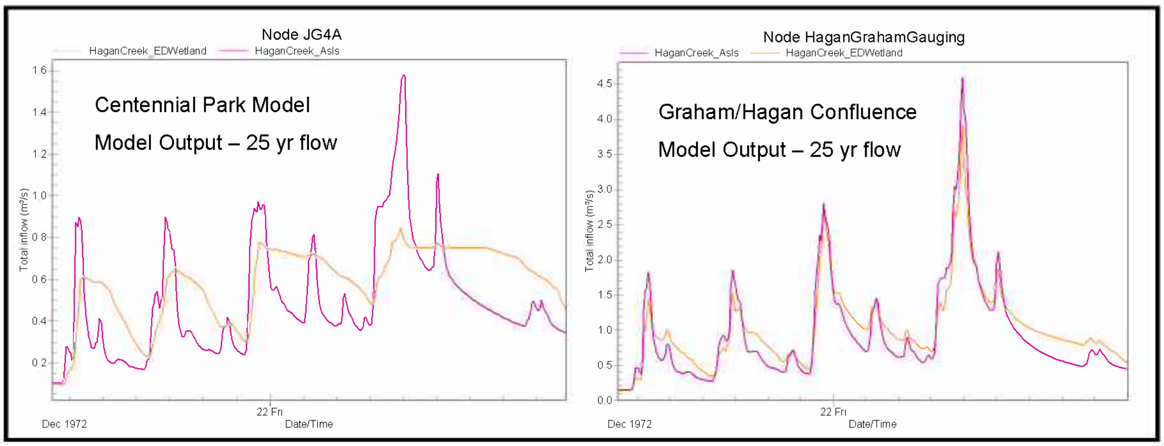
Figure W Keating Industrial Park Detention Pond - 25Yr Hydrographs



Extended Detention Wetland

A ten hectare extended detention stormwater wetland constructed in Maber Flats in conjunction with the downstream channel modification option to improve hydraulics is considered. 10 hectares is equal to approximately 1.5 % of drainage area and is within the recommended size of detention pond (1 to 2% of). This option provides both peak flow attenuation and water quality enhancement. Peak flows into Centennial Park could potentially be reduced by up to 45% for the 25 yr rainfall event (Figure X). No peak flow attenuation is achieved for the 100 yr+ event, and only limited (<16%) peak flow attenuation was simulated in Hagan Creek from this option.

Figure X Extended Detention Wetland Hydrographs



Flooding in Maber Flats would be confined to within the constructed wetland area. Surrounding farmland, outside of the designated wetland, would be useable for most of the year and could potentially meet the ARDSA guidelines for drainage.

Hydraulic modification, as detailed above, to Graham Creek downstream of Maber Flats would be required in conjunction with extended detention / wetland construction. Hydraulic modifications could precede the construction of the wetland, however, the need to control peak flows downstream of Maber Flats would limit the drainage benefits of the hydraulic improvements until the detention facility is in place.

There are many considerations that would affect the size and design of the wetland (and associated variable level control device). Excessive drainage of organic soils will accelerate the decomposition of the soil. Birds require seasonally flooded areas for habitat therefore it would not be advisable to significantly alter flooding conditions during the winter season. A wetland facility of 5 ha or more could alleviate the spring and fall flooding that causes the major impacts to agricultural values. These considerations are discussed in more detail in the recommendations section.

7.2 Tetayut (Sandhill)

This section will summarize the biophysical and hydrologic evaluation of the Tetayut watershed and identify the significant issues and opportunities in the watershed.

7.2.1 Biophysical Evaluation

Reaches of Tetayut Creek

Tetayut Creek Reach 1 - Tetayut Road Crossing: C channel, PFC

This highly sinuous channel has accessible floodplains and a sand/gravel substrate. Downstream of the road the banks are vegetated and active erosion was not obviously occurring. Upstream of the road however, an oversteepened bank was eroded away between the months of October and December 2007. In this location, a large log has fallen in the creek and may have concentrated the waters flow and energy enough on one point of the oversteepened bank to carve it out. A large debris jam, acting as a weir in this instance, is located just upstream of Tetayut road and is aiding in controlling the velocity and volume of water moving through the culvert.

The vegetation in this reach is well established although vegetation is sparse on the oversteepened bank. The canopy is dominated by red alder (*Alnus rubra*) and bigleaf maple (*Acer macrophyllum*) with some western red cedar (*Thuja plicata*), grand fir (*Abies grandis*), black cottonwood (*Populus balsamifera* spp. *trichocarpa*), and Douglas fir (*Pseudotsuga menziesii*).

The oversteepened, eroded bank seems to be the only major erosional activity occurring in this area but further examination of Sandhill Creek is needed.

Tetayut Creek Reach 2 - Tributary at Qwuc Chus Lane: Cb channel, PFC

Sinuous and well vegetated, this portion of the tributary is in good shape. Some erosion is evident on outside bends but does not seem to be occurring in exceedance of normal creek function. The channel has a substrate of primarily clay although there is some gravel present that may have been placed there or washed through from the Patricia Bay Highway located upstream.

The vegetation in this reach consists of the following: western red cedar (*Thuja plicata*), red alder (*Alnus rubra*), bigleaf maple (*Acer macrophyllum*), red osier dogwood (*Cornus stolonifera*), Indian plum (*Oemleria cerasiformis*), snowberry (*Symphoricarpos albus*), salmonberry (*Rubus spectabilis*), sword fern (*Polystichum munitum*), rushes (*Juncus* spp.), and some reed canary grass (*Phalaris arundinacea*).

Tetayut Creek Reach 3 - Heritage Acres 7321 Lochside Drive: F channel, FAR

This reach makes its way from the Patricia Bay Highway through the Heritage Acres property on Lochside Drive. It is a sinuous channel with a sandy substrate that is molded in places into small mounds and valleys beneath the surface of the water. Small floodplain areas are existent in places and a weir creates a pooled area near the Water Survey of Canada hydrometric station.

The vegetation in this reach includes the following: western red cedar (*Thuja plicata*), Douglas fir (*Pseudotsuga menziesii*), bigleaf maple (*Acer macrophyllum*), cascara (*Rhamnus purshiana*), English holly (*Ilex aquifolium*), sword fern (*Polystichum munitum*), English ivy (*Hedera helix*), fringe cup (*Tellima grandiflora*), and a few sedges (*Carex* spp.). The English ivy (*Hedera helix*) is extremely vigorous and is crowding out the native riparian and other vegetation present here. This invasive species needs to be controlled in order to maintain the health of the native vegetation that inhabits the banks.

Further pressure has been added to the riparian vegetation community due to a serious trampling problem initiated by the placement of public trails too close to the edges of the creek. Overtime, this trampling has worn away the majority of the shrubby and herbaceous vegetation and preventing the growth of young trees to successionally replace the older canopy above. With the lack of vegetation, the stability of the banks is at risk. In places, the banks have already slumped into the creek resulting in the loss of a public trail. Peninsula Streams was involved in restoring that specific section of the creek in an emergency repair. Small cobble and rock was installed on an outside bend and the trail was realigned. Not only is the trampling preventing the growth of new vegetation but it is also putting the large trees at risk by negatively impacting and exposing their root systems. If trails are not moved back and an appropriate vegetation community reinstated this reach is at risk of losing all its ecological function. As such, this reach is characterized as functional at risk with a downward trend.

Tetayut Creek Reach 4 - Central Saanich Road: B channel, PFC

This reach encompasses the creek upstream and downstream of Central Saanich Road. Due to private property restraints, and lack of permission to access, the team was unable to assess the majority of this reach. Observation from the road, however, suggest that this reach is in Proper Functioning Condition. The road itself has a grassy shoulder and no curbs which is beneficial from a stormwater point of view as it can filter road runoff. Presently, the shoulder has exposed dirt which may be as a result of mowing practices. In order to maintain a stormwater function, the grass should not be mowed too low (maintaining a height of 4-5 inches is suggested).

Tetayut Creek in this location is found within a gully which is likely the main cause for its heavily vegetated and relatively natural condition. This reach is difficult to access and is not experiencing the trampling issues that other streams throughout Central Saanich and the Peninsula.

Within the gully, Tetayut Creek shows meander and sinuosity with good access to floodplains both upstream and downstream of the road. On the downstream side a large pool is present which may have been used for irrigation historically. Signs of erosion and deposition such as sandbars are present but not in an amount to cause concern. The channel is dominated by a cobble and gravel substrate suitable for fish habitat.

The vegetation in this reach is vigorous with lots of diversity and is not dominated by invasive species. The vegetation observed includes: western red cedar (*Thuja plicata*), bigleaf maple (*Acer macrophyllum*), red alder (*Alnus rubra*), Indian plum (*Oemleria cerasiformis*), salmonberry (*Rubus spectabilis*), red elderberry (*Sambucus racemosa* ssp. *pubens*), Himalayan blackberry (*Rubus discolor*), deer fern (*Blechnum spicant*), sword fern (*Polystichum munitum*), stinging nettle (*Urtica dioica*), and skunk cabbage (*Lysichiton americanum*).

As is, Tetayut Creek is in good condition in this location. In order to maintain this, invasive species management would be beneficial to retain and improve the vigour of the plant community and consequently, the stability of that creek.

Tetayut Creek Reach 5 - East Saanich Road: B channel, PFC

Upstream and downstream of East Saanich Road, Tetayut Creek is found in a gully similar to the reach at Central Saanich Road. Again, due to private property and access difficulties, observations were made from the road crossing.

The channel in this reach is sinuous with meander bends and access to floodplains both upstream and downstream of East Saanich Road. The substrate is a mixture of gravel and cobble of different sizes. This channel receives good flows which are not overly energetic as indicated by the lack of movement of large material. Some erosion is present although this is concentrated on the outside bends especially in the downstream section. A mid-channel bar is present in the downstream section suggesting a high sediment load.

The vegetation in this reach is vigorous although there are some invasive species issues especially upstream of East Saanich Road. The vegetation observed includes the following: western red cedar (*Thuja plicata*), bigleaf maple (*Acer macrophyllum*), red alder (*Alnus rubra*), Indian plum (*Oemleria cerasiformis*), ocean spray (*Holodiscus discolor*), snowberry (*Symphoricarpos albus*), salmonberry (*Rubus spectabilis*), red elderberry (*Sambucus racemosa* ssp. *pubens*), Himalayan blackberry (*Rubus discolor*), thimbleberry (*Rubus parviflorus*), sword fern (*Polystichum munitum*), lady fern (*Athyrium filix-femina*), horsetail (*Equisetum arvense*), English ivy (*Hedera helix*), stink currant (*Ribes bracteosum*), skunk cabbage (*Lysichiton americanum*). The English ivy is extensive especially upstream of East Saanich Road where it is covering the ground and climbing most of the large trees. Overtime, this could become hazardous for the road and power lines if the trees were to fall as a result of the ivy burden. To improve this, invasive species management and control should be conducted.

A culvert on the upstream side of the road is causing erosion of the steep bank exposing bare soil. This erosion may be the cause of the mid-channel bar downstream. A storm drain located north of Shady Creek Church seems to be collecting all the stormwater runoff from the road and nearby areas and conveying it through the culvert. In order to prevent further erosion of this bank it is necessary to instigate upslope management practices. For example, small rain gardens in the upper catchment could reduce the amount of runoff moving into this storm drain and culvert system thereby protecting the bank from further erosion.

Tetayut Creek Reach 6 - Cooperidge Park: C channel, PFC

This reach extends from approximately East Saanich Road to Sandhill Park just north of Keating Crossroad. Tetayut Creek in this location is in very good condition. It is found at the base of a gully which limits trampling and other detrimental activities in and around the stream. Thick vegetation creates a green canopy under which the stream meanders and has access to vegetated floodplains. The substrate is composed of cobble and gravel with some fines suitable for fish habitat. Large pieces of wood in and around the channel serve as weirs which reduce the velocity of flow and create a micro-habitat.

The vegetation in this reach is abundant, diverse, and vigorous. Observed species include the following: western red cedar (*Thuja plicata*), Douglas fir (*Pseudotsuga menziesii*), grand fir (*Abies grandis*), big leaf maple (*Acer macrophyllum*), red alder (*Alnus rubra*), snowberry (*Symphoricarpos albus*), red elderberry (*Sambucus racemosa* ssp. *pubens*), lady fern (*Athyrium filix-femina*), sword fern (*Polystichum munitum*), dull Oregon grape (*Mahonia nervosa*), laurel-leafed daphne (*Daphne laureola*), English holly (*Ilex aquifolium*), English ivy (*Hedera helix*), creeping buttercup (*Ranunculus repens*), herb-robert (*Geranium robertianum*), willow herb (*Epilobium* sp.), English laurel (*Prunus laurocerasus*), gallium (*Galium* sp.), skunk cabbage (*Lysichiton americanum*), and sedges (*Carex* sp.).

Some erosion in the upslope area was noticed near the back of 6929 Veyaness Avenue. It may be possible to prevent this by improving irrigation at the farm at the top of the slope. Planting of the bank may also aid in this issue. Additionally, while there is no designated trail in the park there are small unofficial trails that are in use. Currently, these trails are at the top of the slope and are not commonly used. However, if the linear park is expanded and pressure for a true path occurs, it should be kept upslope from the stream. Yard waste was also noted on the tops of the slopes. This practice should be stopped as yard waste increases the nutrient load of the stream if it happens to migrate down the slope.

Tetayut Creek Reach 7 - Sandhill Park: C channel, PFC

Downstream of Keating Crossroad, Tetayut Creek has more of a lentic (wetland) character although it is still in channel form. A pump was installed here by the Haig-Brown Fly Fishing Association to maintain flows in Tetayut Creek for fish bearing purposes.

The vegetation in Sandhill Park is less diverse as compared to Adam Kerr Park but also has issues with invasive species management. Observed vegetation includes: Douglas fir (*Pseudotsuga menziesii*), big leaf maple (*Acer macrophyllum*), pacific willow (*Salix lassiandra*), cherry trees, snowberry (*Symphoricarpos albus*), Himalayan blackberry (*Rubus discolor*), Nootka rose (*Rosa nutkana*), Scotch broom (*Cystisus scoparius*), cattail (*Typhus latifolia*), grass.

Tetayut Creek Reach 8 - Adam Kerr Park: pond and ditch

This reach encompasses Adam Kerr Park upstream of Keating Crossroad.

Adam Kerr Park has experienced stream restoration activities by Peninsula Streams within the past year (2007). A pond area upstream of the footbridge was enhanced and weir structures were incorporated downstream of the footbridge. Planting of native riparian vegetation also occurred. Of special note in this reach is the section of land north-east of the pond which features a natural dip. This area would be an excellent place for retention/detention of rain- and stormwater as the only design necessary would include adding water and planting. The pond is in Proper Functioning Condition while the channel is ditch-like and therefore, non-functional.

Vegetation in Adam Kerr Park includes the following: western red cedar (*Thuja plicata*), Douglas fir (*Pseudotsuga menziesii*), black cottonwood (*Populus balsamifera* ssp. *trichocarpa*), big leaf maple (*Acer macrophyllum*), red alder (*Alnus rubra*), red osier dogwood (*Cornus stolonifera*), Pacific willow (*Salix lassiandra*), Scouler's willow (*Salix scouleriana*), black hawthorn (*Crataegus menziesii*), Nootka rose (*Rosa nutkana*), Himalayan blackberry (*Rubus discolor*), Scotch broom (*Cystisus scoparius*), common horsetail (*Equisetum arvense*), reed canary grass (*Phalaris arundinacea*), yellow flag iris (*Iris pseudacorus*), lady's thumb (*Polygonum persocaria*), yellow pond lily (*Nuphar polysepalum*), pacific water parsley (*Oenanthe sarmentosa*), water plantain (*Alisma plantago-aquatica*), pondweed (*Potamogeton* sp.), and rushes (*Juncus* sp.). While it has been newly planted, Adam Kerr Park is inundated with invasive species. Management for invasives is extremely important especially as they are capable of migrating quickly. The yellow flag iris especially needs to be removed before it has the chance to move downstream. Mallard ducks and bull frogs were observed during the site visit.

Tetayut Creek Reach 9 - 6516 Central Saanich Road Ponds, low PFC

This reach consists of two large ponds that interrupt Tetayut Creek's channel character. Both of these ponds are fenced off from surrounding fields although upslope areas do have sheep on them. Chickens and horses are also inhabitants of this location. Riparian vegetation does exist in a ring around both ponds although the upstream pond has a much larger setback that the downstream pond. If there is the option of working with the landowner, planting of the ponds with more riparian vegetation could help in filtering runoff that may come from the fields.

The vegetation is vigorous around the ponds and includes the following: black cottonwood (*Populus balsamifera* ssp. *trichocarpa*), red alder (*Alnus rubra*), red osier dogwood (*Cornus stolonifera*) willow (*Salix* sp.), English hawthorn (*Crataegus monogyna*), willow herb (*Epilobium* sp.), reed canary grass (*Phalaris arundinacea*), cattails (*Typha latifolia*), rushes (*Juncus* sp.), duckweed (*Lemna* sp.), water plantain (*Alisma plantago-aquatica*).

Tetayut Creek Reach 10 - 6052 Bearhill Road; ditch, NF

This property marks the northern boundary of the District of Saanich as well as the headwaters of Tetayut Creek. A pond is located on the upstream portion of the property which is nicely lined with a native riparian buffer. A deep ditch drains the pond which flows under Bear Hill Road to a series of agricultural ditches and ponds downstream. Upstream of this location, in a neighbouring property, Tetayut Creek is confined within an artificially straightened channel that has been armoured with rock walls. Further upstream of the rock-lined channel cattails indicated the probable presence of a moister landscape, possibly of wetland character. Unfortunately, due to private property restrictions a closer examination was not permitted.

The vegetation observed in this area includes: red alder (*Alnus rubra*), big leaf maple (*Acer macrophyllum*), red osier dogwood (*Cornus stolonifera*), willow (*Salix* sp.), weeping willow (*Salix babylonica*), reed canary grass (*Phalaris arundinacea*), willow herb (*Epilobium* sp), Pacific water parsley (*Oenanthe sarmentosa*), water plantain (*Alisma plantago-aquatica*), small flowering bulrush (*Scirpus microcarpus*), yellow pond lily (*Nuphar polysepalum*), bureed (*Sparganium* sp.), and duckweed (*Lemna* sp.). Around the pond the vegetation is vigorous and diverse although both characteristics decrease moving downstream. In the fields downstream of Bear Hill Road the pond areas seem to have riparian vegetation while the channel portions would benefit from a riparian fringe.

7.2.2 Hydrologic / Hydraulic Evaluation

Flooding

One of the major issues within the Tetayut watershed is the periodic flooding that occurs along Central Saanich Road beginning just south of the intersection with Ridgedown Place and extending northward up to the intersection with Hovey Road.

There are several contributing factors that cause the flooding along Central Saanich Road and they are as follows:

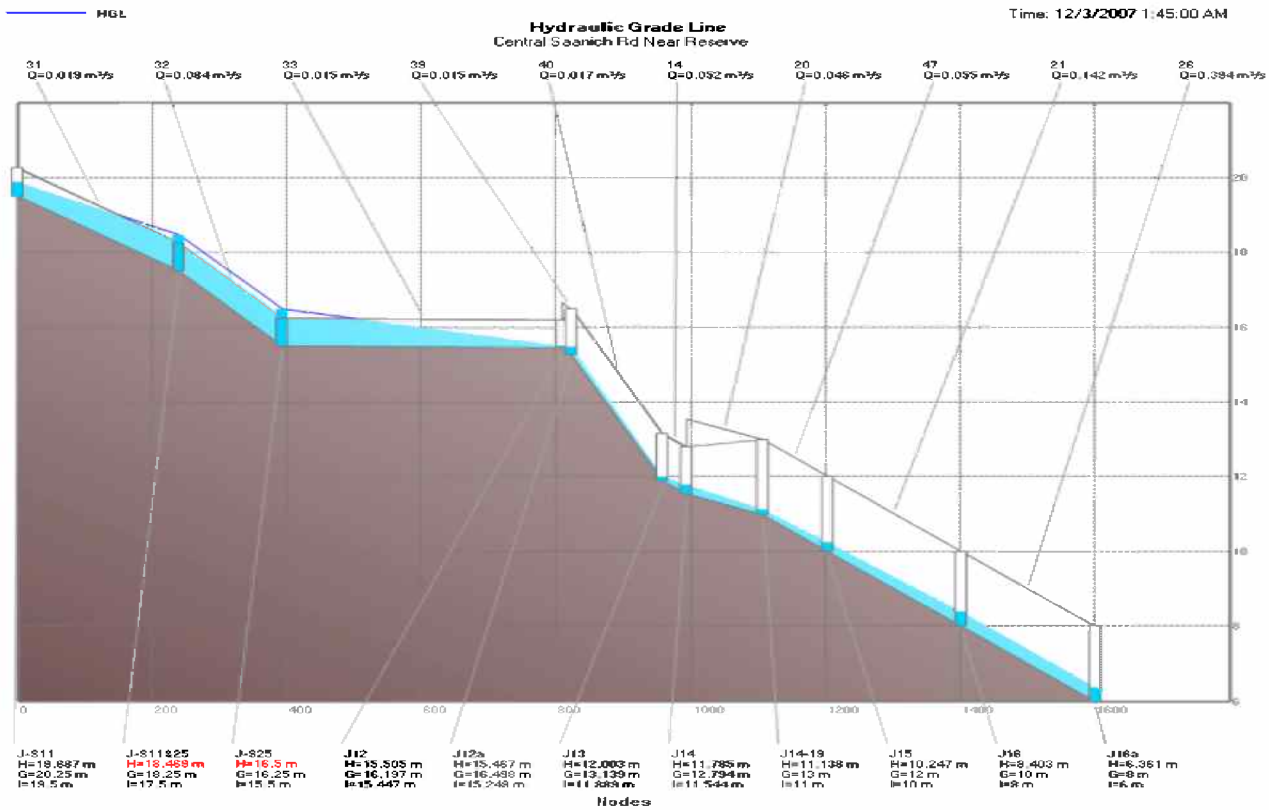
- The affected part of Central Saanich Rd is relatively flat with a minimal gradient, which causes water to pool and flow inefficiently, see Photo F below.
- Ditching along Central Saanich Road is not very uniform, meaning the depths and widths of the ditches continuously change.
- Stormwater runoff from relatively impervious, neighbouring residential areas near East Saanich Road is routed into the ditching along Central Saanich Rd. The high flows and volumes of this runoff during rain events exacerbate the flooding.
- There is a flow restriction in a culvert beneath Central Saanich Road, see Photo G. This culvert is important because it carries flows from Central Saanich Road into Tetayut Creek, and the obstruction prevents efficient flow.
- There is a lack of stormwater best management practices utilized in impervious areas to help capture and infiltrate stormwater which would help reduce flow volumes into the ditches along Central Saanich Road.

Photo F Inundated Ditch Along West Side of Central Saanich Road

Photo G Flow Restriction Beneath Central Saanich Rd

Figure Y depicts the profile along Central Saanich Road during the December 3, 2007 rain event, which was equivalent to the 5yr-24hr storm.

Figure Y Hydraulic Profile Along Central Saanich Road under Current Conditions



The dark blue lines show the areas where stormwater overflows the banks of the ditches along Central Saanich Road subsequently causing flooding.

Water Quality / Erosion

The other major issues in the Tetayut watershed are poor water quality and erosion in Tetayut Creek. The causes are as follows:

- Stormwater runoff from agricultural areas can carry contaminants such as nitrates, phosphates, herbicides, pesticides, and animal wastes into Tetayut Creek.
- Stormwater runoff from Keating Industrial Park can contribute contaminants such as hydrocarbons and heavy metals into Tetayut Creek.
- High peak flows scour creek banks, causing erosion and the transport of heavy sediment loads, see Photo H.
- There are very few detention facilities in the Tetayut watershed to help control stormwater runoff and reduce flow velocities in Tetayut Creek.

Photo H Scour and Erosion on Lower Tetayut Creek

The watershed model was used to assess the accumulated impact of changes in the watershed since its original forested condition. Table T below compares current peak flows and volumes for several 24 hr return periods at the outfall near Saanichton Bay to naturally forested pre-development flows and volumes.

Table T Saanichton Bay Outfall Peak Flows and Volumes

	2yr		10yr		25yr		100+yr	
Scenario	Pk Flow m^3/s	24-hr Volume m^3	Pk Flow m^3/s	24-hr Volume m^3	Pk Flow m^3/s	24-hr Volume m^3	Pk Flow m^3/s	24-hr Volume m^3
Current Conditions	1.01	38,700	1.10	57,400	1.16	64,000	1.67	88,200
Naturally Forested	0.08	6,950	0.10	8,720	0.10	8,720	0.08	6,950

Peak flows and volumes progressively increase as the return intervals increase. As impervious surfaces increase, so do peak flows and volumes. Under naturally forested conditions, the model indicates that Tetayut Creek was supplied primarily by baseflows. There was very little surface runoff due to factors such as tree canopy interception and infiltration.

The model is unable to supply proper baseflow information and volume under naturally forested conditions. This would entail developing a groundwater model which was outside the scope of this project. It can be interpreted that the peak flows would be moderately higher than those stated in the table under naturally forested conditions in the watershed due to a presumed increase in base flows. However, the peak flows would still be substantially less than what the peak flows are currently.

7.2.3 Watershed Issues

The common issues within the Tetayut Watershed are summarized below:

- Industrial and agricultural runoff and creek erosion has deteriorated water quality in Tetayut Creek;
- First Nations cultural practices within Tetayut Creek have been impacted due to poor water quality and a steady decline in fish population;
- Recent sewage spills into Tetayut Creek resulted in the death of many fish;
- Low base flows in all reaches of Tetayut Creek due to agricultural land management practices that involve ditching of the creek in the upper reaches as well as large irrigation ponds that detain water during summer months;
- Invasive species such as English Ivy near East Saanich Road and throughout the Historical Artifacts Society property crowd out native riparian species which are integral to the ecological function of the creeks since the roots help stabilize soils and banks and protect against severe erosion;
- Foot traffic along trails built too close to Tetayut Creek, especially in the Saanich Historical Artifacts Society has caused severe erosion and trampling and as a result several parts of the trail have fallen into the creek; and,
- Minimal gradients and hydraulic restrictions cause flooding along periodic flooding on Central Saanich Road between Ridgedown Place and Hovey Road.

7.2.4 Watershed Opportunities

Rainfall Capture

There are several ways to enhance rainfall capture by utilizing rain water source control methods (i.e. infiltration and retention) such as disconnecting roof leaders, constructing rain gardens, and building bioswales.

The assumption used to model improvements in rainfall capture throughout the watershed was to reduce impervious areas in subcatchments that were greater than or equal to 25% impervious by 25%. For example, if a subcatchment was 40% impervious, the new impervious area would be reduced to 30%.

A conservative 25% impervious reduction was decided upon because it would take into consideration situations in which capture was not possible due to adverse soil conditions or if residents would not want to participate.

There are several subcatchments within the Tetayut watershed where there are opportunities for rainfall capture. Figure AA shows the modeled scenario for rainfall capture.

Runoff Control

The key opportunity to mitigate peak flows, volumes, and poor water quality in the Tetayut watershed is through the construction of two wetlands that would act as detention basins. These wetlands would range in size from 2 – 4 ha in area, have a depth of approximately 2m, and include outflow control structures to regulate the flow of water.

Strategic locations for these wetlands would be in undeveloped areas just north of the Saanich Historical Artifacts Society and to the east of Saanich Peninsula Hospital. Coincidentally, the hospital is looking at options in regards to the functionality of its existing ponds.

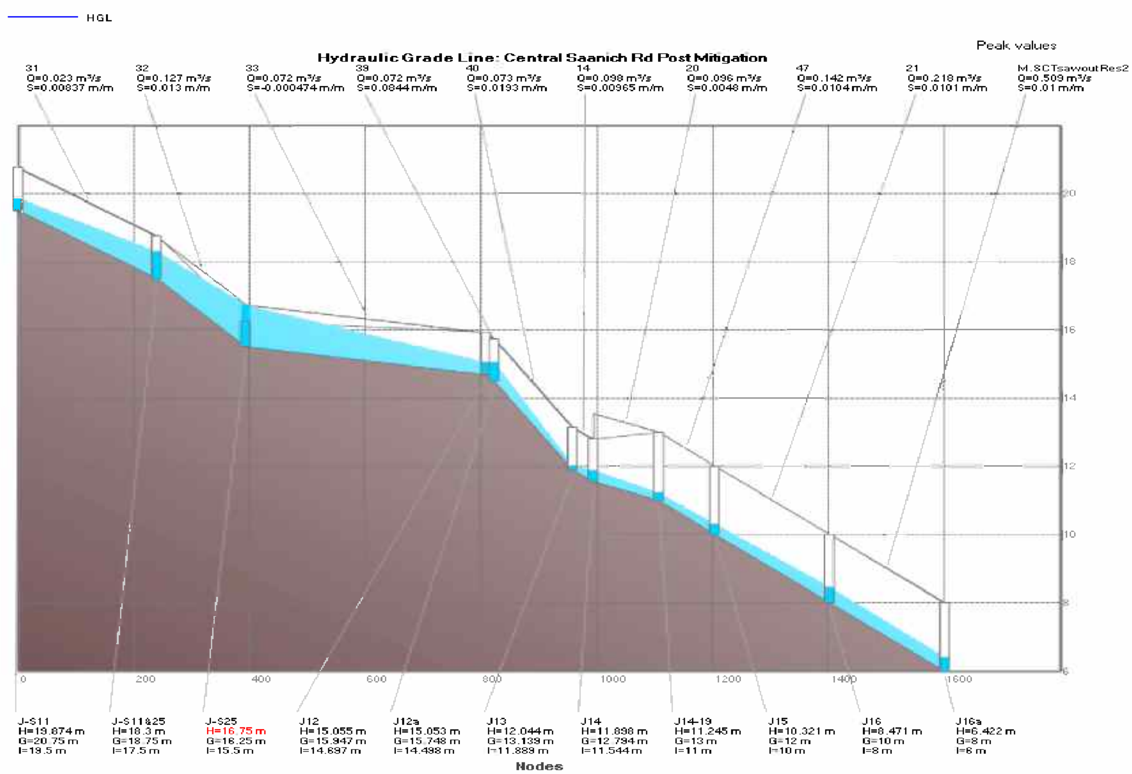
Refer to Figure AA for a depiction on the effect constructed wetlands would have on peak flows.

Hydraulic Improvements

In order to prevent flooding along Central Saanich Road some hydraulic improvements are necessary to culverts and ditches that periodically overflow their banks and flood Central Saanich Road. To simulate this scenario in the model, the depths of the effected ditches were increased, the invert elevations of several culverts were lowered, and the slope of the ditches were increased. These strategies were necessary in order to increase capacity and gravitational flow. Figure Z below shows the new modeled hydraulic profile of Central Saanich Road during the December 3, 2007 rain event.

In this scenario with hydraulic improvements, flooding conditions are prevented from occurring along Central Saanich Road. The hydraulic improvements were tested against the 10, 25, and 100+ year events and again there was no flooding. However, this scenario would not necessarily improve the health of the overall watershed as discussed later.

Figure Z Hydraulic Profile Along Central Saanich Road after Hydraulic Improvements



Combined Opportunities

This section describes the resulting peak flows and volumes at the outfall of Tetayut creek if all of the stormwater management opportunities previously discussed are combined and simultaneously applied to the watershed.

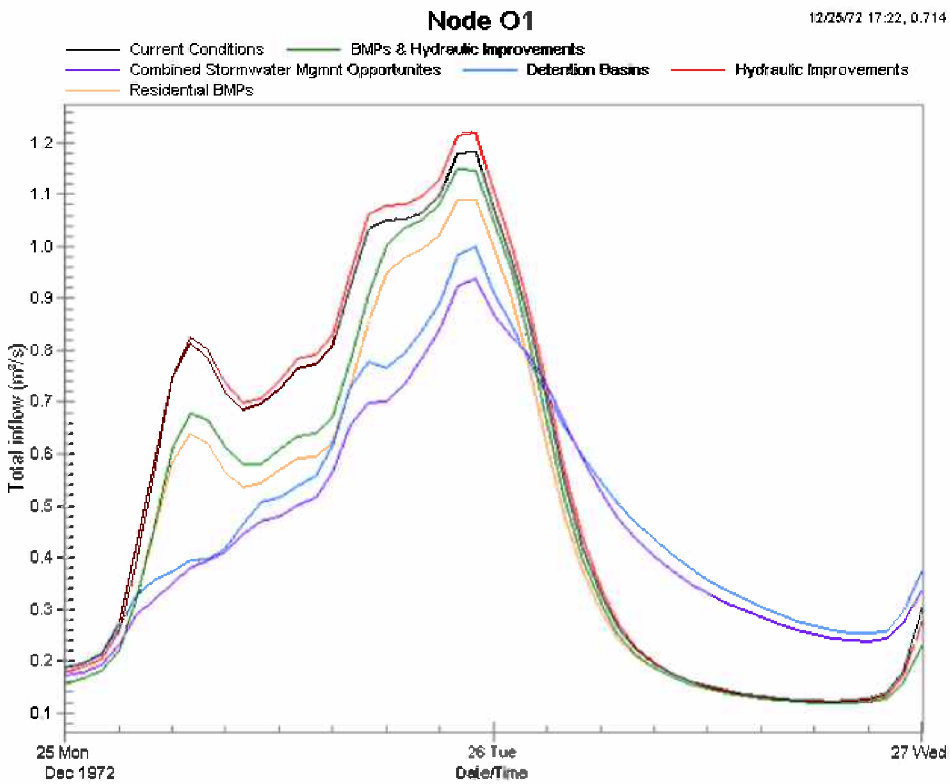
Table U below shows the peak flows, volumes, and percent change for each opportunity described above as well as the results when all of opportunities for stormwater management are combined.

Table U Hydrologic Values for Simulated Opportunities

		2yr					10yr					25yr					100+yr				
Node	Scenario	Pk Flow m^3/s	Peak l/s/ha	24-hr Volume m^3	l/s/ha % change	Volume % Change	Pk Flow m^3/s	Peak l/s/ha	24-hr Volume m^3	l/s/ha % change	Volume % Change	Pk Flow m^3/s	Peak l/s/ha	24-hr Volume m^3	l/s/ha % change	Volume % Change	Pk Flow m^3/s	Peak l/s/ha	24-hr Volume m^3	l/s/ha % change	Volume % Change
Outfall	Current Conditions	1.036	5.450	38,660			1.127	5.928	57,430			1.16	6.102	63,950			1.672	8.795	88,240		
	Residential BMPs	0.961	5.055	34,400	-7%	-11%	1.044	5.492	52,970	-7%	-8%	1.091	5.739	55,810	-6%	-13%	1.489	7.832	78,660	-11%	-11%
	Hydraulic Improvements	1.061	5.581	39,390	2%	2%	1.157	6.086	60,360	3%	5%	1.219	6.412	67,640	5%	6%	1.631	8.579	91,900	-2%	4%
	Residential BMPs & Hydraulic Improvements	1.015	5.339	35,900	-2%	-7%	1.102	5.797	55,770	-2%	-3%	1.149	6.044	59,060	-1%	-8%	1.556	8.185	83,130	-7%	-6%
	Detention Basins	0.858	4.513	29,000	-17%	-25%	0.759	3.990	41,700	-33%	-27%	0.999	5.254	48,280	-14%	-25%	1.48	7.785	64,320	-11%	-27%
	Combined Mitigation Strategies	0.781	4.107	26,800	-25%	-31%	0.747	3.931	41,300	-34%	-28%	0.938	4.934	45,150	-19%	-29%	1.342	7.059	59,720	-20%	-32%

Figure AA graphically represents the peak flows at the Tetayut Creek outfall for each stormwater management scenario for the 25yr-24hr storm event.

Figure AA Peak Flows Based Upon Stormwater Management Opportunities



Based on the values for hydraulic improvements alone, there would be higher peak flows and volumes because the water does not have a chance to flood and be detained along Central Saanich Road. The storm water moves through the system more swiftly, causing the higher peak flows and volumes which destabilizes creek banks and causes severe erosion. These improvements may prevent flooding and alleviate a nuisance to vehicular and pedestrian traffic, but it does not improve the overall health of the watershed.

Figure AA and Table U also show that if all of the stormwater management opportunities are combined together, there would be substantial reduction in peak flows and volumes leaving the watershed. For example, the flows and volumes for the 25yr-24hr storm event would be reduced 19% and 29%, respectively.

The hypothetical detention facilities allow the volume of rainwater to slowly dissipate through the system instead of incurring a steep rise and a precipitous drop. This dissipation is an important feature to watersheds since it guards against bank erosion. It also supports base flows and riparian zones.

Additional Opportunities

There are several additional opportunities within the watershed to prevent flooding and improve the overall health of Tetayut Creek.

- The farming community could use their existing irrigation ponds as a form of stormwater management. The best use of the ponds from a stormwater management and ecological perspective would be to capture and control the release of stormwater during the winter to reduce peak flows and augment base flows in the summer and early fall. As discussed in the previous section, the use of detention basins significantly reduces peak flows. Therefore, the use of additional in-line and off-line ponds would further benefit Tetayut watershed.
- A depression in Adam Kerr Park located upstream of Keating Cross Road, adjacent to the stream, could be used as a detention facility in the winter months to help reduce peak flows.
- Riparian planting could be conducted throughout the Historical Artifacts Society property to reduce the erosion occurring there.
- The ditch maintenance program could be modified. For example, maintenance crews can clean out a segment of the ditch and leave the next segment vegetated based on engineering and ecological assessments. This type of maintenance would provide several benefits including filtration of stormwater pollutants, velocity reduction to decrease erosions and improved hydraulic efficiency to help prevent flooding. Ditch maintenance BMP’s are addressed in Appendix 2.

7.3 McHugh-Noble

This section will summarize the biophysical and hydrologic evaluation of the McHugh-Noble watershed and identify the significant issues and opportunities in the watershed.

It should be noted that as a result of a meeting between Martindale Valley property owners, representatives of the District, the Ministry of Agriculture and Lands, and the Ministry of Transportation and infrastructure held on May 4, 2009, the District commissioned supplementary work to process additional data collected from the Pat Bay Highway / Martindale flow monitoring station and refine the hydraulic assessment of this watershed based on this additional data. This will compensate for the relative lack of significant storm data during the monitoring period for this report. Consequently, a letter report will be issued in the coming months that will provide an update to this Section of the report.

7.3.1 Biophysical

McHugh Ditch/Noble Creek

McHugh Ditch Reach 1 - Martindale Flats area: Ditch, NF

This reach consists of a large ditch that runs south from Martindale Flats to Noble Road where it begins to take on a more characteristic creek channel shape. This ditch was dug in order to drain Martindale Flats for agricultural purposes. The water in this ditch is turbid and is barely moving due to the virtually flat slope. Because this channel is a ditch in nature it has no ecological function and is, therefore, nonfunctional.

The vegetation lining McHugh ditch consists of primarily reed canary grass (*Phalaris arundinacea*) with a few willow (*Salix* spp.), red alder (*Alnus rubra*), and black cottonwood (*Populus balsamifera* spp. *tricharpo*), and Himalayan blackberry (*Rubus discolor*) scattered throughout.

Noble Creek Reach 2 - Noble Road: C channel, PFC

Due to limited accessibility, this reach was examined in brief looking upstream and downstream from the Noble Road crossing.

There was a good flow in this creek at the time of assessment although the water was quite turbid. The channel is slightly sinuous in this area and seems to be fairly moist for a distance upstream due to the observed presence of red alder (*Alnus rubra*) and willow (*Salix* spp.).

Near the creek channel upstream and downstream of Noble Road the vegetation consists of the following: grand fir (*Abies grandis*), willow (*Salix* spp.), red osier dogwood (*Cornus stolonifera*), a few English holly (*Ilex aquifolium*), snowberry (*Symphiocarpos albus*), Nootka rose (*Rosa nutkana*), salmonberry (*Rubus spectabilis*), sword fern (*Polystichum munitum*), and sedges (*Carex* spp.).

Noble Creek Reach 3 - outlet near Parker Park: intertidal

The outlet of Noble Creek is found north of Parker Park in the area of Mattick's Farm. It is tidally influenced and has soft, silty/sandy banks. There is a large log jam at the moth of the creek as it accesses the beach but this does not seem to impede flows at all.

The vegetation in this reach includes: grand fir (*Abies grandis*), shore pine (*Pinus contorta var. contorta*), red alder (*Alnus rubra*), oceanspray (*Holodiscus discolor*), salmonberry (*Rubus spectabilis*), snowberry (*Symphoricarpos albus*), horsetail (*Equisetum* sp.), and reed canary grass (*Phalaris arundinacea*).

Upstream of the beach fish parts, excrement, shellfish, and small tracks were noted indicating the presence of some sort of small animal (likely otter).

Note: because this reach is intertidal, the PFC assessment does not apply.

7.3.2 Hydrologic / Hydraulic Evaluation

Flooding

The issue of primary concern within the McHugh-Noble watershed is flooding within the Martindale Valley as shown in Photo I below. In order to improve drainage in this naturally low lying area, McHugh Ditch was dug and connected to Noble Creek to the southeast in the late 1800's. Based on topographical maps, the flooded valley would likely have originally drained through both Noble Creek in the southeast and Tetayut Creek to the northwest once the flood level reached an elevation sufficient to connect to the creeks.

Photo I Flooding of McHugh Ditch north of Martindale Road on February 26, 2008

The Metchosin soils located within the Martindale Valley are also indicative of this historical flooding. Metchosin soils are "generally saturated with free water present at or near the surface for most of the year," (Jungen, 1985). Additionally, Metchosin soils are very poorly drained, therefore drainage of inundated areas by infiltration would be relatively slow.

Anecdotal evidence from the farmers of the Martindale Valley indicates that flooding occurs from the fall (roughly late October) through to the spring (roughly late April). Flooding during the shoulder seasons limits the agriculturally productive season in the Martindale Valley and limits the types of crops the land may produce. During the winter, the duration of flooding is also of concern to farmers.

Agricultural drainage guidelines are set out in the Agricultural and Rural Development Subsidiary Agreement (ARDSA) Agricultural Drainage Criteria (BC MOAFF, 2002). According to the criteria, the time in which flooding on farmlands should subside and for channels return to baseflow elevations after a 10 year, 5 day storm event in the winter is 5 days. In the productive seasons, including fall and spring, a 10 year, 2 day storm must subside within 2 days. A number of under drain systems exist on farmland within the Martindale Valley, however there is insufficient anecdotal evidence to confirm or refute that the ARDSA guidelines are being met currently. The ARDSA criteria also dictate that 1.2 m is required between the elevation of farmland and the elevation of the drainage ditch/creek under baseflow conditions, although a lesser separation of 0.9 m is deemed acceptable in some circumstances. Based on cross-sections measured during the field survey of McHugh Ditch, the maximum depth of the ditch (top of bank to base) is approximately 1.1 m. Even without accounting for baseflow elevations and berming around the channels, the depth of the ditches do not meet the primary ARDSA criteria.

The existing hydraulic profile of McHugh Ditch was the result of changes implemented in 1981 by the BC Department of Agriculture. According to ditch profile drawings, the depth of the McHugh Ditch between Island View Road and Martindale Road was roughly doubled at that time (BC DOA, 1981). The grading also eliminated negative ditch grades around Dooley Road, but maintained very shallow slopes between Martindale Road and Dooley Road (BC DOA, 1981). This shallow slope is a likely cause of flooding in the Martindale Valley. The drawings also indicate the presence of a “manual control structure” at Dooley Road however Central Saanich staff have no recollection of it, nor did the survey staff identify any evidence of it in the field. Field survey staff did note, however, that the culvert at Dooley Road had a negative grade and was positioned at least 1 m above the bottom of the sediment filled ditch. The positioning of the Dooley Road culvert in relation to McHugh Ditch creates a hydraulic control point, and likely compounds the flooding problem.

Model Results

An assessment of the stormwater model for the McHugh-Noble watershed indicates that the flooding does occur within the Martindale Valley (see Figure BB below). In 2007/2008, flooding occurred in the model from mid October to early February. This flooding is due primarily to the hydraulic restrictions imposed by shallow slopes in the McHugh ditch and the culvert elevation at Dooley Road.

Figure CC below shows the profile and slopes of McHugh Ditch and Noble Creek between Island View Road and the marine outlet. The slopes within the system are generally between 0.1% to 0.4% except downstream of Noble Road, where the creek slopes steeply at 2% towards the ocean, and between Martindale Road and Dooley Road, where the ditch slope is very shallow at only 0.03%. In the model, the shallow slope causes a backflow up McHugh Ditch, flooding areas around Martindale Road. This correlates well with the accounts provided by Martindale Valley farmers, who have occasionally observed flows moving upstream through McHugh Ditch and flooding lower lying areas of the Martindale Valley north of Martindale Road.

Figure BB Modelled depth of flooding at Martindale Road during 2007/2008

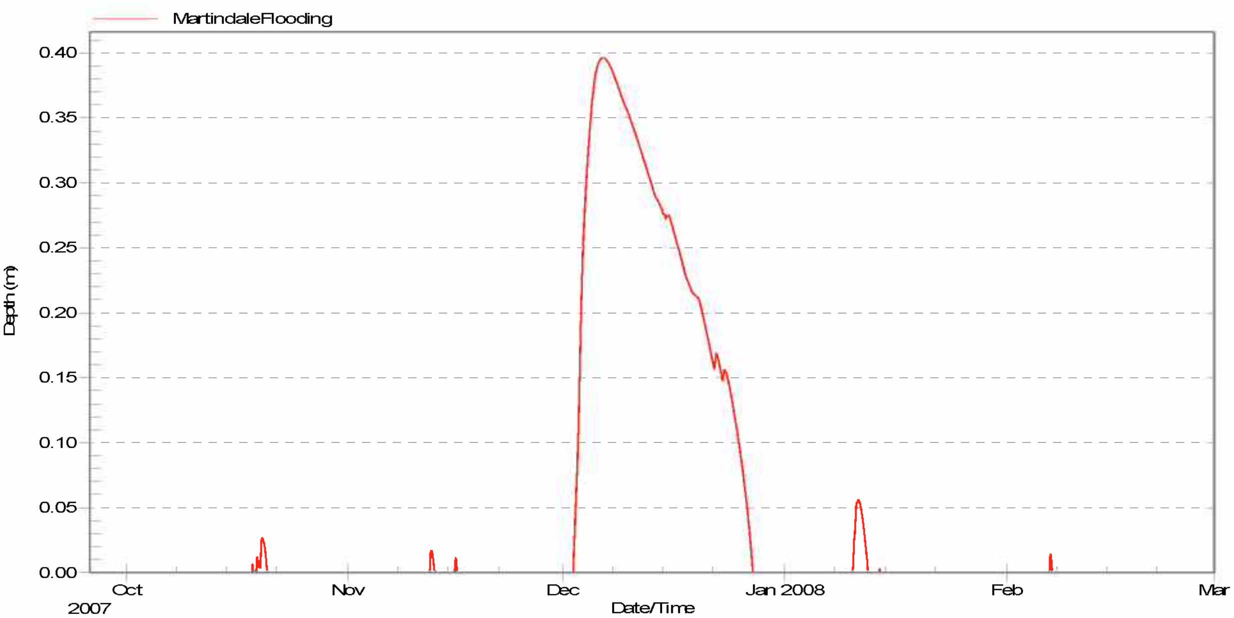
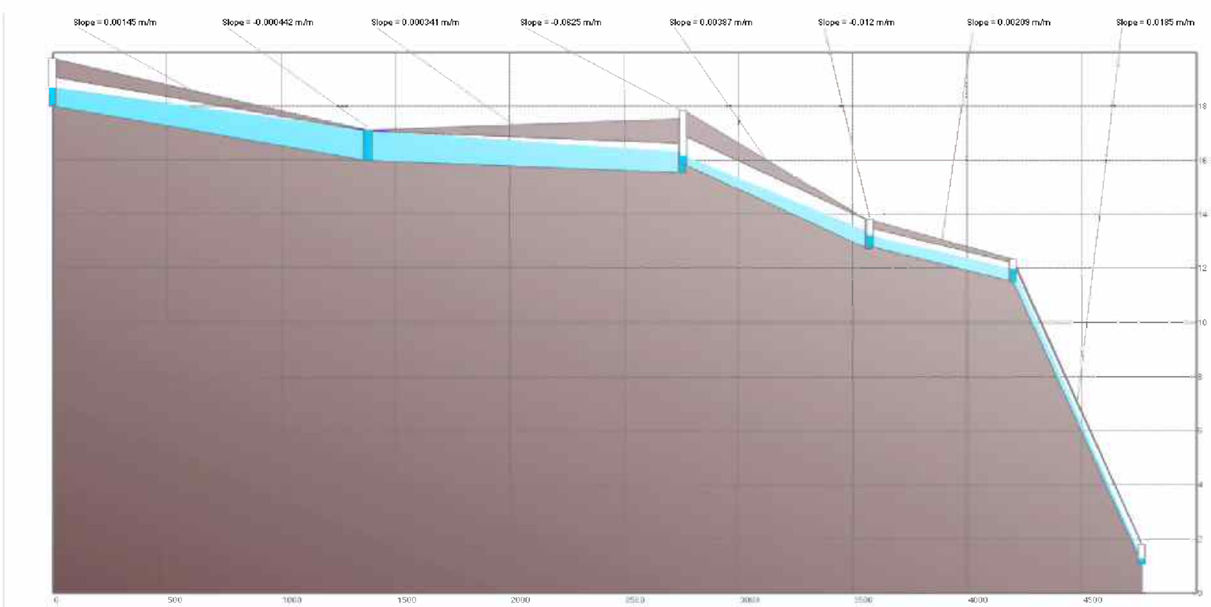


Figure CC McHugh Ditch/Noble Creek Profile from Island View Road to Marine Outlet



The depth and duration of flooding during both continuous and design storms of varying intensities are presented in Table V below. Continuous modelling tends to exaggerate flood since storms before and after the event of interest, as well as the storm intensity, affect the model output. Thus it is difficult to isolate the amount of flooding due specifically to the storm event of interest. Conversely, event modelling ignores antecedent soil moisture conditions, therefore the design storm values are likely conservative.

The duration and depth of flooding for continuous storms presented in Table V vary with no discernable pattern – a 2 year storm produces 52 cm of flooding while a 100+ year storm only produces 38 cm. This is because the storm return intervals are based on total rainfall over a 24 hour period, regardless of the rainfall distribution. Therefore two storm events with the same amount of rainfall but differing intensities may produce drastically different results. Further differences can result from differing antecedent moisture conditions, which are accounted for in continuous storms but not in design storms.

Table V Flooding During Storms of Varying Return Intervals

Storm Return Interval	Storm Type	Duration of Flooding	Maximum Depth of Flooding
2 year, 24 hour	Design	67 hours – 2.8 days	9 cm
	Continuous	900 hours – 90 days	52 cm
10 year, 24 hour	Design	138 hours – 5.75 days	17 cm
	Continuous	305 hours – 12.7 days	28 cm
25 year, 24 hour	Design	200 hours – 8.3 days	22 cm
	Continuous	870 hours – 36 days	67 cm
100+ year, 24 hour	Design	430 hours – 18 days	41 cm
	Continuous	530 hours – 22 days	38 cm

ARDSA Agricultural Drainage Guidelines

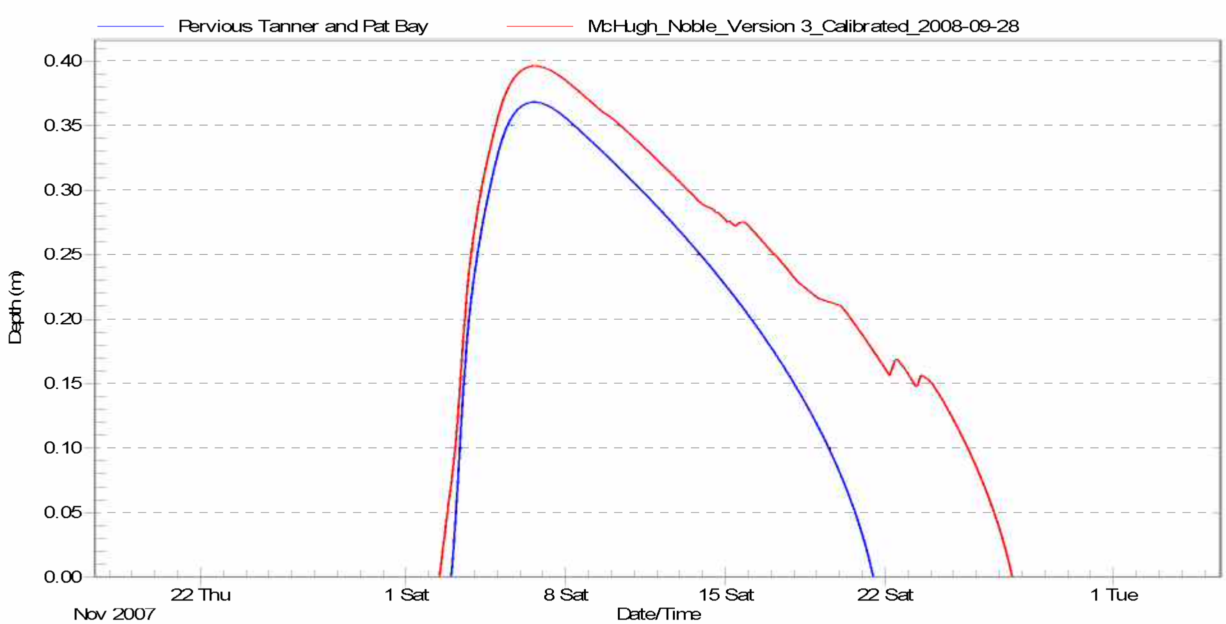
Agricultural drainage guidelines are set out in the Agricultural and Rural Development Subsidiary Agreement (ARDSA) Agricultural Drainage Criteria (ARDSA, 2002) (Appendix 2). According to the criteria, the time in which flooding on farmlands should subside and for channels return to baseflow elevations after a 10 year, 5 day storm event in the winter is 5 days. In the productive seasons, including fall and spring, a 10 year, 2 day storm must subside within 2 days. A number of under drain systems exist on farmland within the Martindale Valley, however there is insufficient anecdotal evidence to confirm or refute that the ARDSA guidelines are being met currently.

Based on the data presented above in Table V, the drainage system in the Martindale Valley does not meet the ARDSA Agricultural Drainage Criteria. Flooding from the 10 year, 24 hour storm took 5.75 days (design storm) to 12.7 days (continuous model) to subside, exceeding the 2 and 5 day requirements for the summer and winter, respectively. The ARDSA criteria were for 10 year 5 day (winter) and 2 day (summer) storms, both of which would have had lower intensities than a 24 hour storm, but would be of longer duration. Comparing the ARDSA criteria to the 10 day, 24 hour storm is considered to be conservative because hydraulic restrictions are the main cause of flooding in the Martindale Valley and are directly related to rainfall intensity.

A number of farmers within the Martindale Valley assert that the flooding on their fields is exacerbated by runoff from impervious areas on Tanner/Keating Ridge and the Patricia Bay Highway. While runoff from Tanner/Keating Ridge and the Patricia Bay Highway does exacerbate flooding slightly due to increase in runoff volumes, it is not the primary cause of flooding in the Martindale Valley.

Figure DD below shows the simulated flooding during the December 2007 storms both with and without impervious areas at Tanner/Keating Ridge and Patricia Bay Highway. Assuming that Tanner/Keating Ridge and the Pat Bay Highway were 100% pervious, flooding would still occur, however both the maximum flooded depth and duration of flooding would be reduced by approximately 7% and 26%, respectively.

Figure DD Flooding at Martindale Road with and without impervious areas for December 2007 storm event



Water Quality and Runoff Volumes

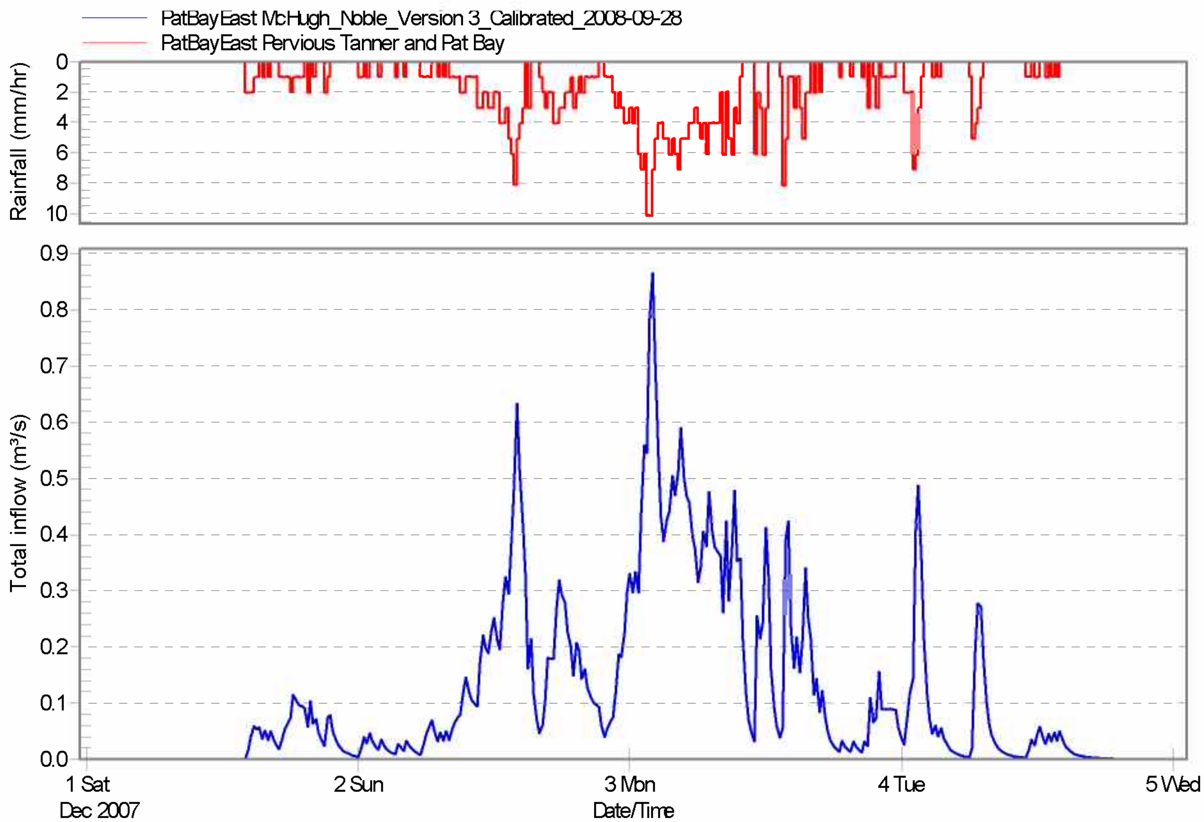
In the late 1800's, McHugh Ditch was excavated in order to drain the Martindale Valley. While the connection of McHugh Ditch to Noble Creek increased the catchment area of Noble Creek considerably, the biophysical survey of Noble Creek did not identify any ecological impacts of concern. Observations made during field visits to the McHugh-Noble watershed however, noted evidence of erosion on minor ditches extending from the Patricia Bay Highway towards McHugh as shown below.

Photo J Erosion south of Martindale Road between Pat Bay Highway and Lochside Drive

The observed erosion may be one contributing factor to the water quality concerns noted in McHugh Ditch. Rainfall falling on impervious areas such as Tanner/Keating Ridge is quickly conveyed away through storm sewers before discharging into side channels that connect to McHugh ditch. The scour caused by the increase in velocity from this rapid discharge of runoff can lead to erosion. The eroded soil then becomes suspended within the channel flow, deteriorating water quality.

Figure EE below shows the runoff flows from Tanner/Keating Ridge following the December 2007 storm event both with existing conditions and pre-development conditions (*i.e.* if Tanner/Keating Ridge and the Pat Bay Highway were 100% pervious). In the modelled pre-development condition, there is no runoff from Tanner/Keating Ridge and the Pat Bay Highway. This is due to the very well drained soils found in the area – rainfall infiltrates into the ground, producing no runoff. Figure EE also shows a near immediate discharge response to rainfall, demonstrating that there is very little rainfall retention within Tanner/Keating Ridge.

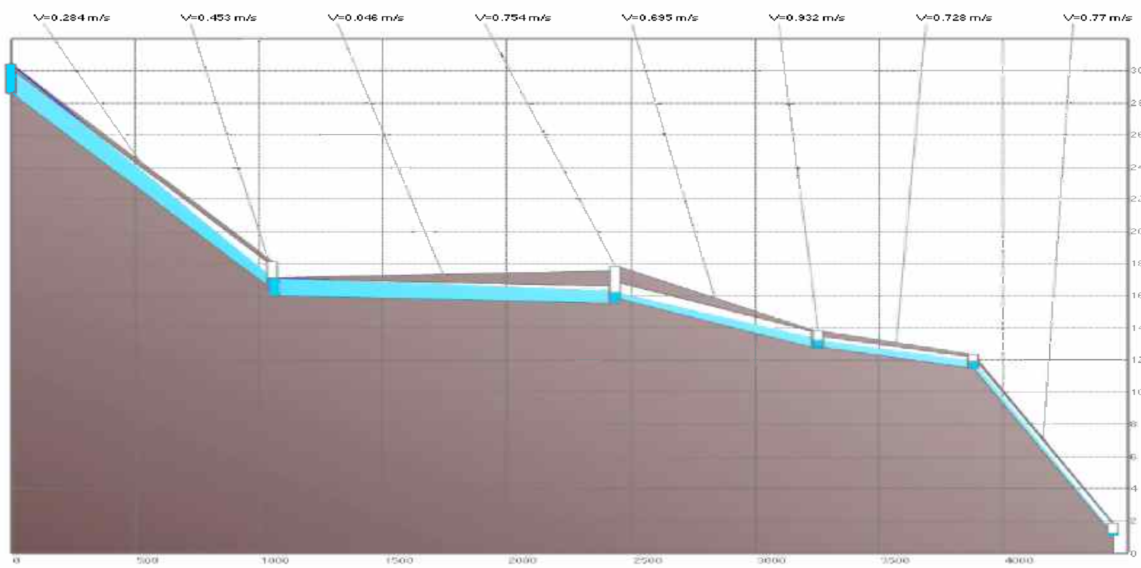
Figure EE Flow from Tanner/Keating Ridge and part of Patricia Bay Highway with and without impervious areas for December 2007 storm event



Another concern regarding runoff from Tanner/Keating Ridge and the Pat Bay Highway is the presence of contaminants in the drainage system. Farmers in the area have expressed concerns regarding the discharge of brake dust, engine oil drips, minor and major fuel spills, and salts in runoff from the Patricia Bay Highway, as well as construction runoff from Tanner/Keating Ridge. Additionally, runoff from agricultural operations such as the dairy and composting operation on the western flank of the Martindale Valley may deposit sediment, organic matter and fecal coliforms into McHugh Ditch, further deteriorating water quality. Without retention, accumulated sediment and other contaminants are carried away by runoff directly into the drainage system. As velocities decrease through the shallow portion of the McHugh Ditch between Martindale Road and Dooley Road, portions of the sediment loads are deposited into the ditch, compounding the hydraulic restrictions described previously. Figure

FF below shows the hydraulic profile and velocities from Tanner/Keating Ridge to McHugh Ditch at Martindale Road to the marine outfall during the December 2007 storm. The channel velocity leaving Tanner/Keating Ridge is 0.284 m/s but drops to 0.046 m/s once it joins the McHugh Ditch.

Figure FF Profile from Tanner/Keating Ridge to McHugh Ditch at Martindale Road and of McHugh Ditch and Noble Creek from Martindale Road to Marine Outlet



7.3.3 Watershed Issues

In summary, the major issues around the McHugh Noble watershed are:

- McHugh Ditch is a deep ditch with little ecological value;
- Flooding of agricultural fields for extended periods into the shoulder seasons impacts crop productivity;
- Drainage within the Martindale Valley does not meet the ARSDA agricultural drainage criteria;
- Runoff from the Pat Bay Highway, Tanner/Keating Ridge, and agricultural operations create water quality concerns, especially where stormwater is used for agricultural production.

7.3.4 Watershed Opportunities

Rainfall Capture

Capturing rainfall at or near the source in impervious areas can mitigate some of the issues currently centred around runoff from Tanner/Keating Ridge and, to a lesser degree, the Patricia Bay Highway.

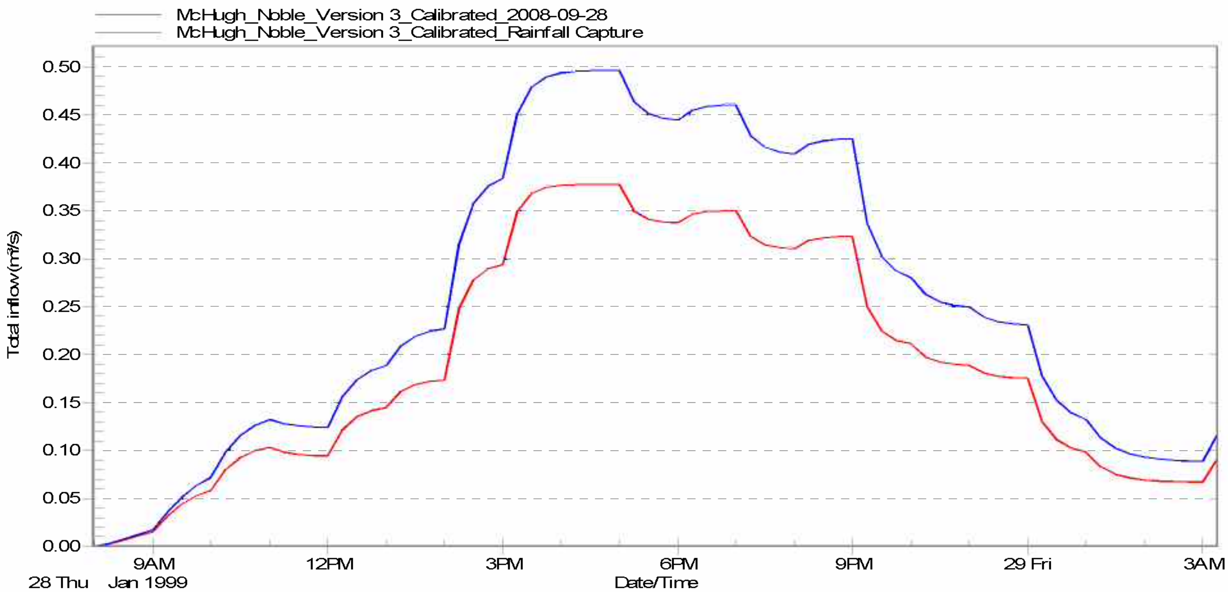
Runoff peak flow rates are reduced, as runoff from impervious areas is diverted away from the drainage system into a detention tank (rain barrel), landscaping (rain garden) or to the ground (infiltration swales). Lower runoff peak flow rates result in lower velocities through side ditches, McHugh Ditch, and Noble Creek, leading to less erosion and thus, improved water quality. Additional water quality improvement is obtained as sediment settles out in a detention tank or is filtered out through infiltration. Diverting stormwater into the ground also serves to replenish baseflow, assisting to restore the natural water balance of the watershed.

Given that the soils in the near fully developed Tanner/Keating Ridge area are comprised of very well drained gravelly sandy loam, stormwater best management practices (BMPs) such as infiltration swales and downspout disconnections can be implemented to capture rainfall. These BMPs are ideal in post-development areas. In new development areas, a variety of BMPs such as absorbent landscaping, pervious paving, rain gardens, detention systems, green roofs, and infiltration swales are possible. The suitability of rainfall capture methods is site specific and are highly dependent on topography, soil conditions, and land available.

Generally, the intent of rainfall capture is to collect runoff from 90% of the storms that occur within a year, storms between 0% to 50% of a 2 year, 24 hour return storm, also known as the mean annual rainfall (MAR) (BC MLWAP, 2002) and divert it away from the drainage system.

As Tanner/Keating Ridge is already a developed area, the implementation of rainfall capture is dependent on the willingness of private land owners and the land available. Assuming conservatively that the implementation of rainfall capture through Tanner/Keating Ridge resulted in a 25% reduction of impervious areas, MAR peak flows and volumes were both reduced by 24% as shown in Figure GG below. Greater reductions in runoff peak flows and volumes are possible with increased implementation.

Figure GG Flow from Tanner/Keating Ridge and part of Patricia Bay Highway with and without rainfall capture for a 2 year 24 hour (MAR) storm event



A summary of the reductions in peak flow achieved by rainfall capture for various storm events is presented in Table W below. While the peak flow rates from Tanner/Keating Ridge were reduced considerably with the implementation of rainfall capture, the effect on peak flow rate within the McHugh Ditch is marginal. This is because the flows in McHugh Ditch at Martindale Road are controlled by flooding. For even the two year return storm, flooding occurs which limits the flow through McHugh Ditch.

Table W Peak Flowrates for Various Storm Events with Rainfall Capture

Location	Scenario	2 Year		10 Year		25 Year		100+ Year	
		m3/s	Change	m3/s	Change	m3/s	Change	m3/s	Change
Martindale North	Base	0.576		0.8385		1.462		2.072	
	Rainfall Capture	0.5701	-1%	0.8296	-1%	1.447	-1%	2.048	-1%
Martindale West	Base	0.277		0.277		0.277		0.277	
	Rainfall Capture	0.277	0%	0.277	0%	0.277	0%	0.277	0%
Dooley South	Base	0.6851		0.8403		1.481		2.175	
	Rainfall Capture	0.6851	0%	0.8403	0%	1.481	0%	2.175	0%
Outfall	Base	1.615		2.311		3.497		4.813	
	Rainfall Capture	1.615	0%	2.311	0%	3.497	0%	4.813	0%

As demonstrated previously in Figure DD, reducing the runoff from Tanner/Keating Ridge marginally decreases the depth and duration of flooding in the Martindale Valley.

In terms of a 2 year 24 hour design storm event (see Figure HH below), by assuming a 25% reduction in impervious areas through rainfall capture, flooding in the Martindale Valley is reduced in duration by 1% and in depth by 7%.

In terms of the 2007/2008 rainfall events, had rainfall capture been in place, flooding would still have occurred, even in the shoulder season (Figure II). However, the depth and duration of flooding is decreased marginally.

Figure HH Flooding in Martindale Valley with and without rainfall capture for a 2 year 24 hour (MAR) storm event

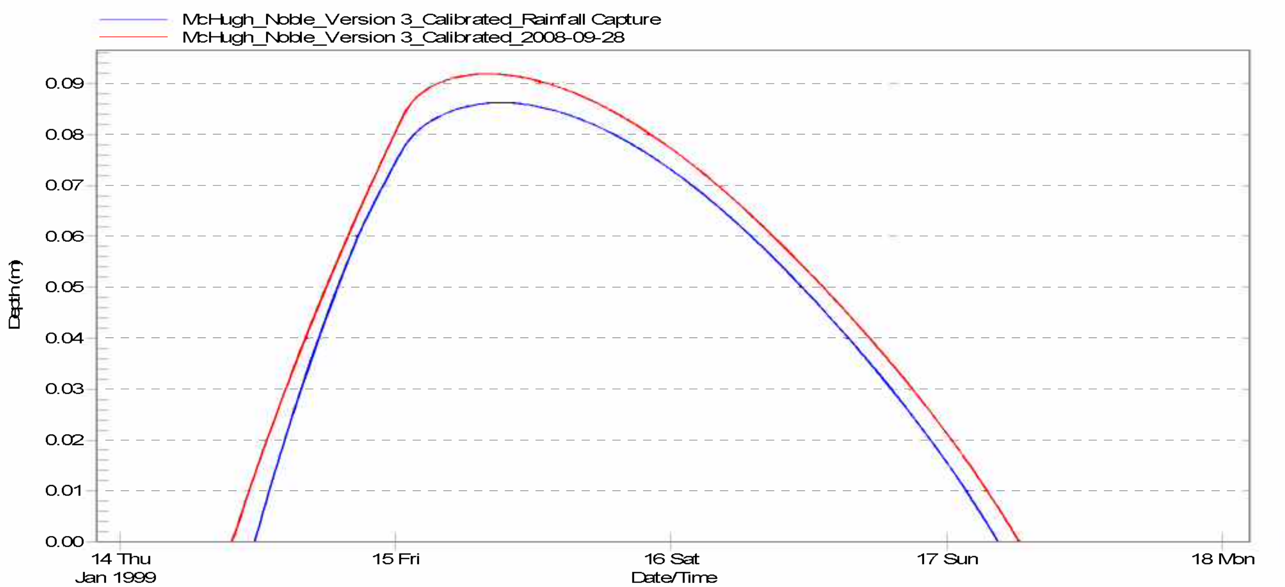
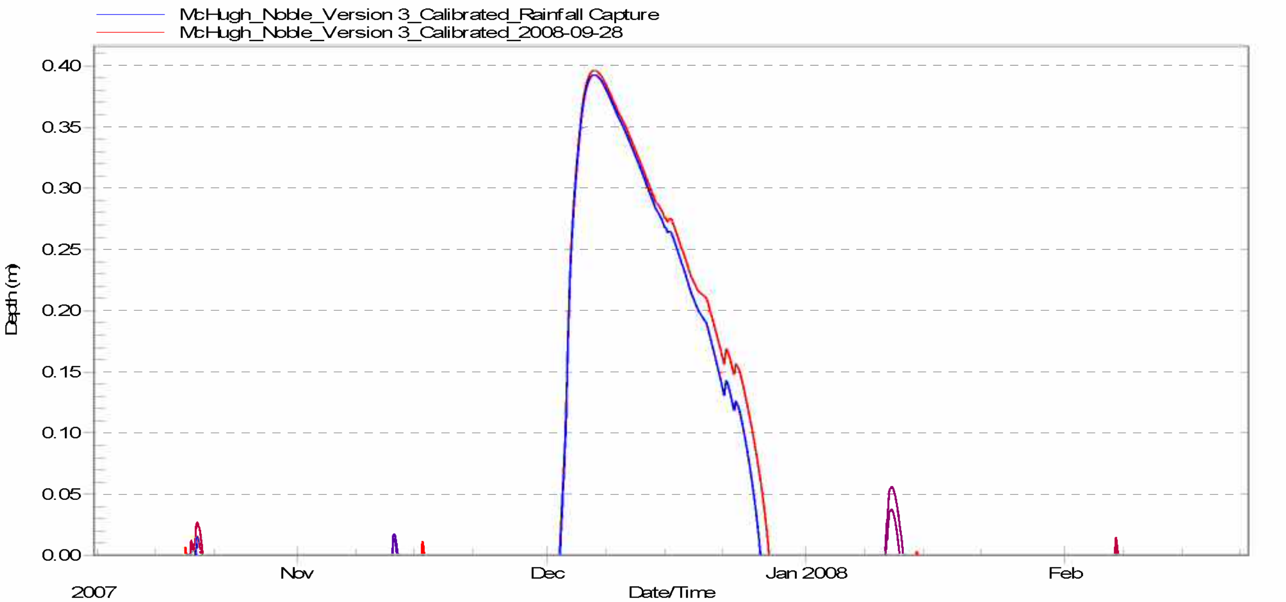


Figure II Modelled depth of flooding at Martindale Road during 2007/2008



Runoff Control

Runoff Control is a measure used to detain runoff from storm events greater than that which can be handled by rainfall capture, generally storms between 50% to 100% of a MAR, or 10% of the storms in a year. For the McHugh-Noble Watershed, a runoff control facility is envisioned for Martindale Road, on the western flank of the Martindale Valley. By diverting runoff into either detention ponds or constructed wetlands, flashy runoff from the impervious areas of Tanner/Keating Ridge and the Patricia Bay Highway is attenuated and discharged at a flow rate similar to baseflow rates. This reduces peak flow rates thereby minimizing erosion. Constructed wetlands also act as large settling ponds to remove and treat solids suspended in runoff, improving water quality. Runoff control facilities cannot replenish baseflow or restore the natural water balance, however. Therefore runoff control should be implemented with rainfall capture strategies as part of an integrated stormwater management approach.

The proposed constructed wetland will provide detention, treatment, and reduction of runoff peak flow rates from Tanner/Keating Ridge and a small portion of the Patricia Bay Highway. Generally, a detention facility is sized to be 2% of the drainage area it serves, however the actual size of the facility will be dependent on the land available, site topography, and reduction objectives. Assuming that the Martindale Road constructed wetland is 1.4 hectares in size, modelled peak runoff flows for the MAR storm were reduced by 38%, as shown in Figure JJ below.

Figure JJ Flow from Tanner/Keating Ridge and part of Patricia Bay Highway at McHugh Ditch with and without detention for a 2 year 24 hour (MAR) storm event

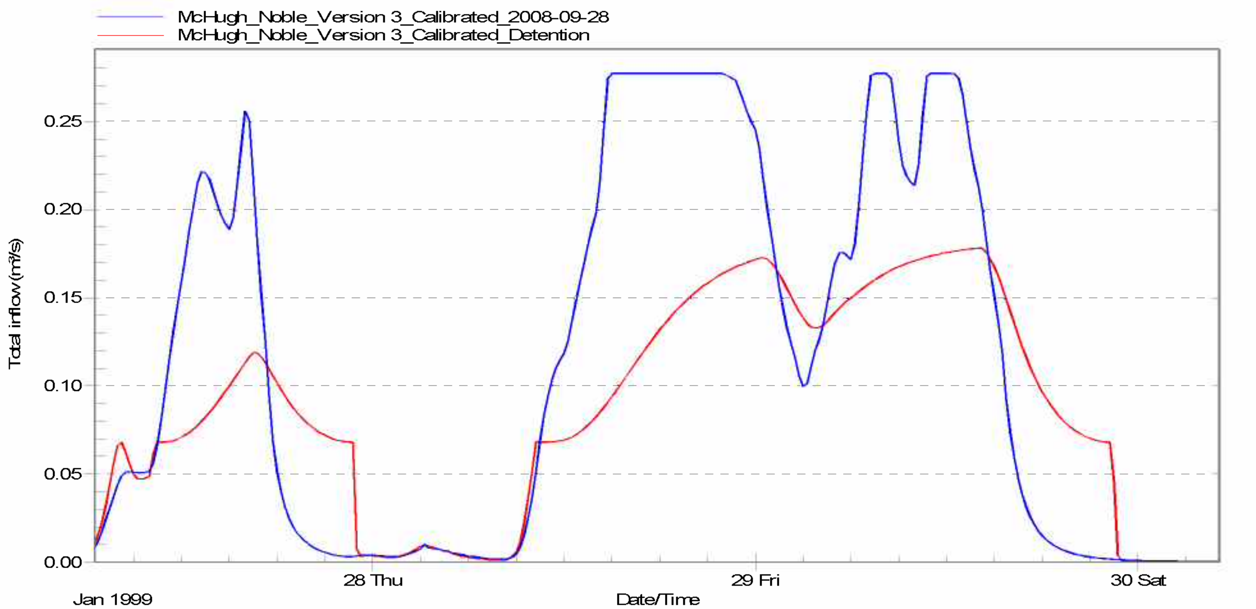


Table X below summarizes the peak flows rates throughout the drainage system for various storm events if runoff control was implemented in the McHugh-Noble Watershed. Unlike rainfall capture measures, runoff control significantly alters the shape of the hydrograph for McHugh Ditch at Martindale Road. Rainfall capture decreases the runoff volume and therefore the peak flow rates, whereas runoff control slows the release of runoff. The constructed wetland attenuates peak flow through detention, therefore reducing flows to McHugh Ditch.

Table X Peak Flowrates for Various Storm Events with Runoff Control

Location	Scenario	2 Year		10 Year		25 Year		100+ Year	
		m3/s	Change	m3/s	Change	m3/s	Change	m3/s	Change
Martindale North	Base	0.576		0.8385		1.462		2.072	
	Runoff Control	0.576	0%	0.8385	0%	1.462	0%	2.072	0%
Martindale West	Base	0.277		0.277		0.277		0.277	
	Runoff Control	0.1726	-38%	0.1745	-37%	0.1803	-35%	0.1806	-35%
Dooley South	Base	0.6851		0.8403		1.481		2.175	
	Runoff Control	0.6851	0%	0.8403	0%	1.481	0%	2.175	0%
Outfall	Base	1.615		2.311		3.497		4.813	
	Runoff Control	1.615	0%	2.311	0%	3.497	0%	4.813	0%

Similar to rainfall capture, detaining runoff from Tanner/Keating Ridge has a marginal impact on flooding in the Martindale Valley, as shown in Figure KK below. In terms of a design MAR rainfall event, by assuming a constructed wetland facility of 1.4 ha, flooding in the Martindale Valley is reduced and delayed slightly, while the depth of flooding increased slightly. The marginal increase in flood depth is attributed to the controlled discharge from the wetland facility. As shown in Figure JJ above, without detention storage, flow rates surge to a peak and dissipate quickly. With detention storage, peak flows are reduced and the runoff volume is distributed over a longer period of time. Therefore the flow at which flooding occurs may exist for a slightly longer period of time, resulting in a slight increase in flooding depth.

In terms of the 2007/2008 rainfall events, the effect of runoff control on flooding was insignificant, even during the shoulder seasons (Figure LL). The 1.4 ha detention facility was unable to attenuate flows enough to overcome the hydraulic restrictions within the McHugh Ditch.

Smaller detention facilities are also recommended to address water quality issues around Patricia Bay Highway runoff. As the Patricia Bay Highway is drained by a series of disjointed ditches, treatment of the highway runoff may be completed through a series of decentralized infiltration / detention facilities such as at Island View Road. WorleyParsons recommends that a co-operative approach between the District of Central Saanich and the Ministry of Transportation be taken to address highway runoff quality issues.

Figure KK Depth of flooding in Martindale Valley with and without detention for a design 2 year 24 hour (MAR) storm event

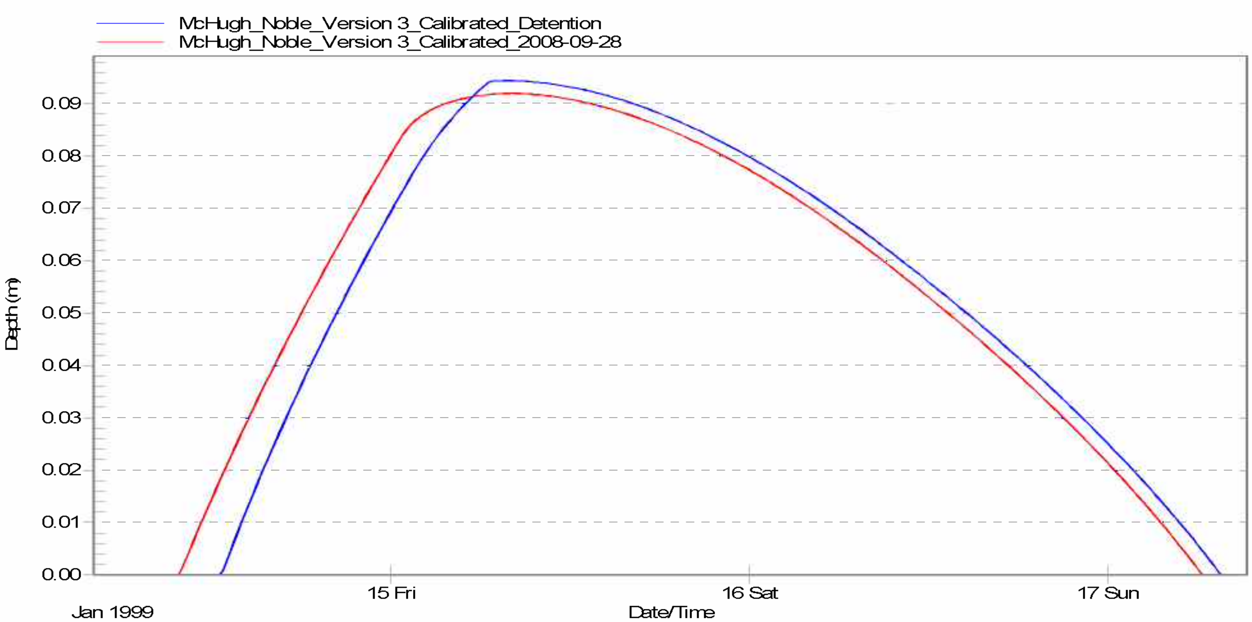
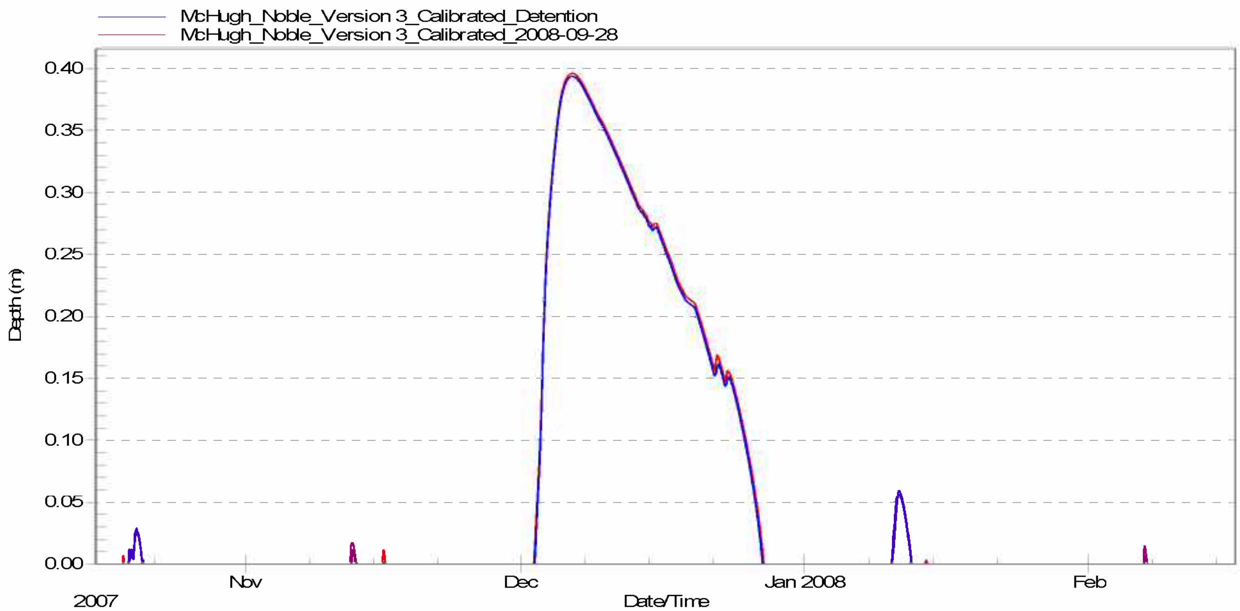


Figure LL Modelled depth of flooding at Martindale Road during 2007/2008 with a 1.4 ha constructed wetland

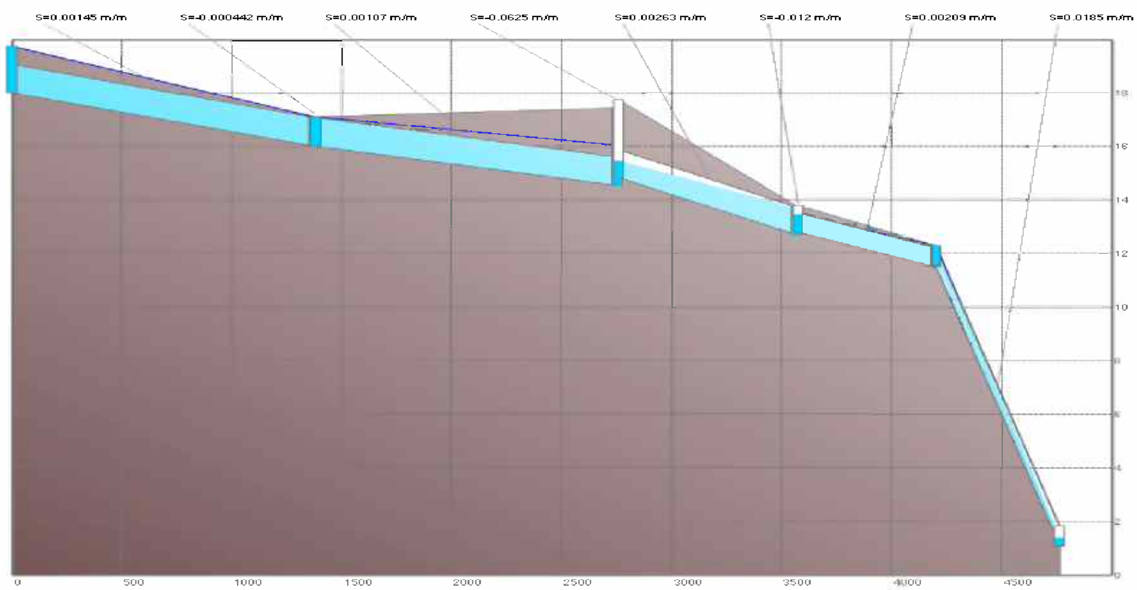


Hydraulic Improvements

As discussed previously, the flooding in the Martindale Valley is due largely to the hydraulic restrictions imposed by the Dooley Road culvert and the shallow slope in McHugh Ditch between Martindale Road and Dooley Road. Assuming the following hydraulic improvements were completed, the slope between Martindale Road and Dooley Road would be increased from 0.03% to 0.1% (Figure MM):

- McHugh Ditch to be cleaned out (assumed to lower channel between Martindale Road and Dooley Road by 1 m) and,
- The Dooley Road culvert to be lowered 0.5 m; and,
- The Dooley Road culvert to be increased in size from a 2.4 m x 2.0 m box culvert to a 3.05 m x 2.4 m box culvert.

Figure MM McHugh Ditch-Noble Creek Profile from Island View Road to Marine Outlet with hydraulic improvements



The impacts of the hydraulic improvements detailed above are significant, as shown in Figure NN below. The depth and duration of flooding in the Martindale Valley decreased by 66% and 60%, respectively.

In terms of shoulder season flooding, the modelled hydraulic improvements were sufficient to eliminate flooding events in October 2007 and January and February 2008, as shown in Figure OO below. The depth and duration of flooding in December 2008 was also minimized. These results confirm that flooding in the Martindale Valley is due to the hydraulic restrictions in McHugh Ditch

Figure NN Depth of flooding in Martindale Valley with and without detention for 2 year 24 hour (MAR) design storm event

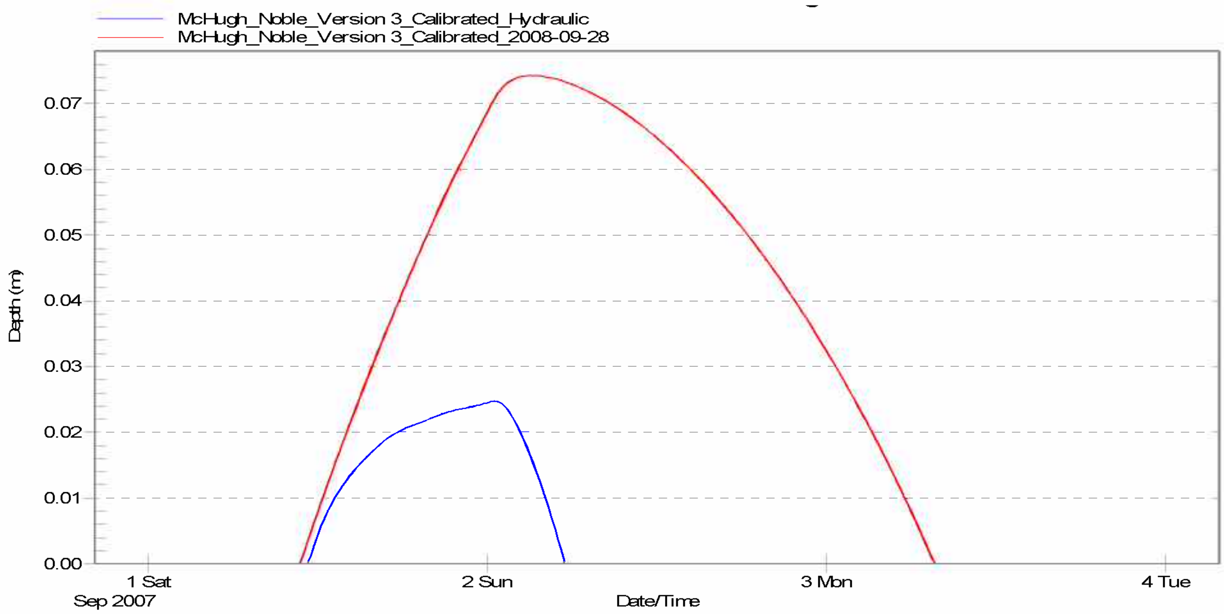
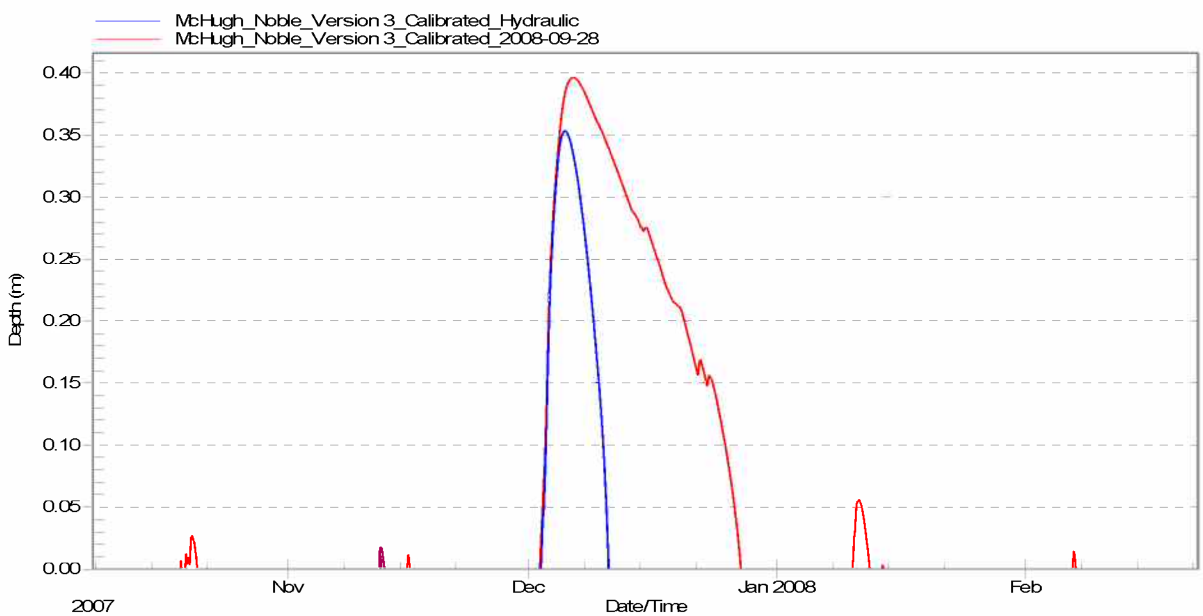


Figure OO Depth of flooding in Martindale Valley with and without hydraulic improvements for 2007 & 2008 rain events



By reducing the hydraulic restrictions, runoff is able to flow through McHugh Ditch with greater ease. The resulting outcome, as shown in Table Y below, is that the runoff peak flow rate at Dooley Road increased by 15% during the MAR event. For storms of larger return intervals, the impact of the hydraulic improvements declines due to higher runoff flow rates, increasing the hydraulic restrictions through the drainage system. Implementing hydraulic improvements, alone is therefore potentially detrimental to the goals of reducing peak flows, minimizing erosion, and improving water quality. To counter this, the installation of a manual flow control structure such as an adjustable weir is proposed together with the hydraulic improvements. The weir level can be adjusted to control flows into the District of Saanich south of Dooley Road, minimize flooding in the Martindale Valley during the shoulder season, and retain baseflows in the summer. The weir adjustments levels should be designed in consultation with farmers, ecologists, and both the District of Central Saanich and Saanich to protect the interests of the affected parties.

Table Y Peak Flowrates for Various Storm Events with Hydraulic Improvements

Location	Scenario	2 Year		10 Year		25 Year		100+ Year	
		m3/s	Change	m3/s	Change	m3/s	Change	m3/s	Change
Martindale North	Base	0.576		0.8385		1.462		2.072	
	Hydraulic	0.576	0%	0.8385	0%	1.462	0%	2.072	0%
Martindale West	Base	0.277		0.277		0.277		0.277	
	Hydraulic	0.277	0%	0.277	0%	0.277	0%	0.277	0%
Dooley South	Base	0.6851		0.8403		1.481		2.175	
	Hydraulic	0.7862	15%	0.9368	11%	1.557	5%	2.235	3%
Outfall	Base	1.615		2.311		3.497		4.813	
	Hydraulic	1.712	6%	2.409	4%	3.57	2%	4.824	0%

ARSDA Assessment

The proposed hydraulic improvements also bring the drainage of the Martindale Valley more in line with the ARDSA agricultural drainage guidelines. As shown in Figure PP below, flooding in the Martindale Valley during a 10 year, 24 hour storm is reduced from 13 days to just under 5 days. Thus the Martindale Valley could potentially meet the ARDSA guidelines for flooding during the non-productive season.

To assess for ARDSA criteria during the productive season, a 10 year, 24 hour design storm event was modelled. As the modelling of design storm events cannot account for antecedent soil moisture conditions, the model better reflects soil conditions experienced during the productive season characterized by drier weather.

Figure QQ below indicates that flooding is reduced from approximately 3.5 days to 2 days, thus the Martindale Valley could potentially meet the ARDSA guidelines for flooding during the productive season as well.

Figure PP Depth of flooding in Martindale Valley with and without hydraulic improvements for a 10 year, 24 hour return storm (continuous)

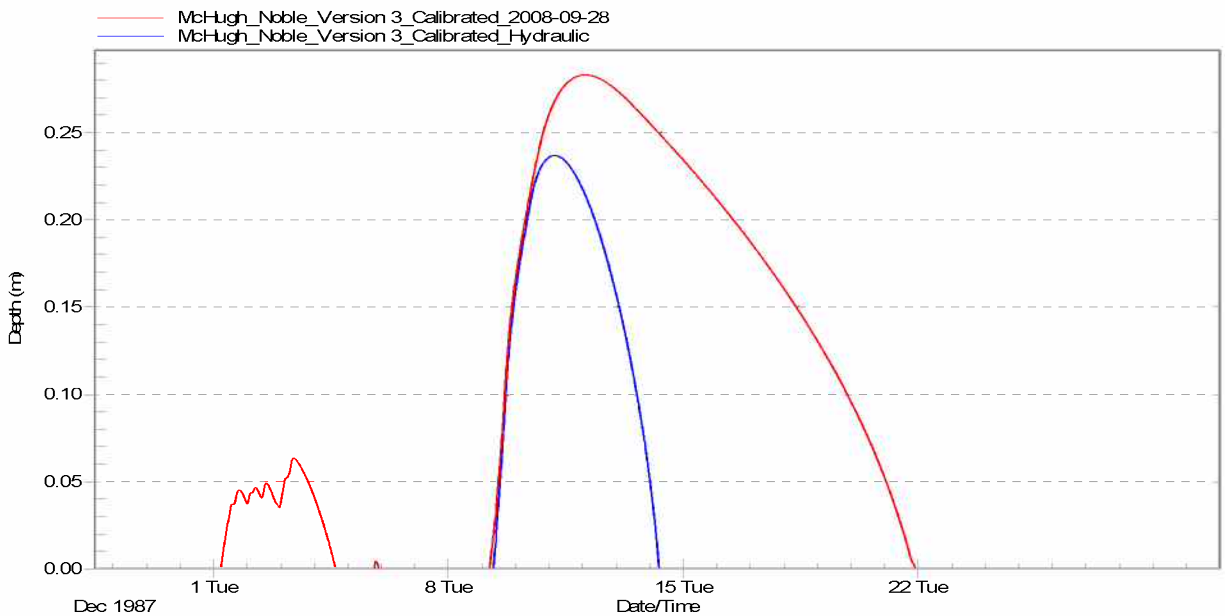
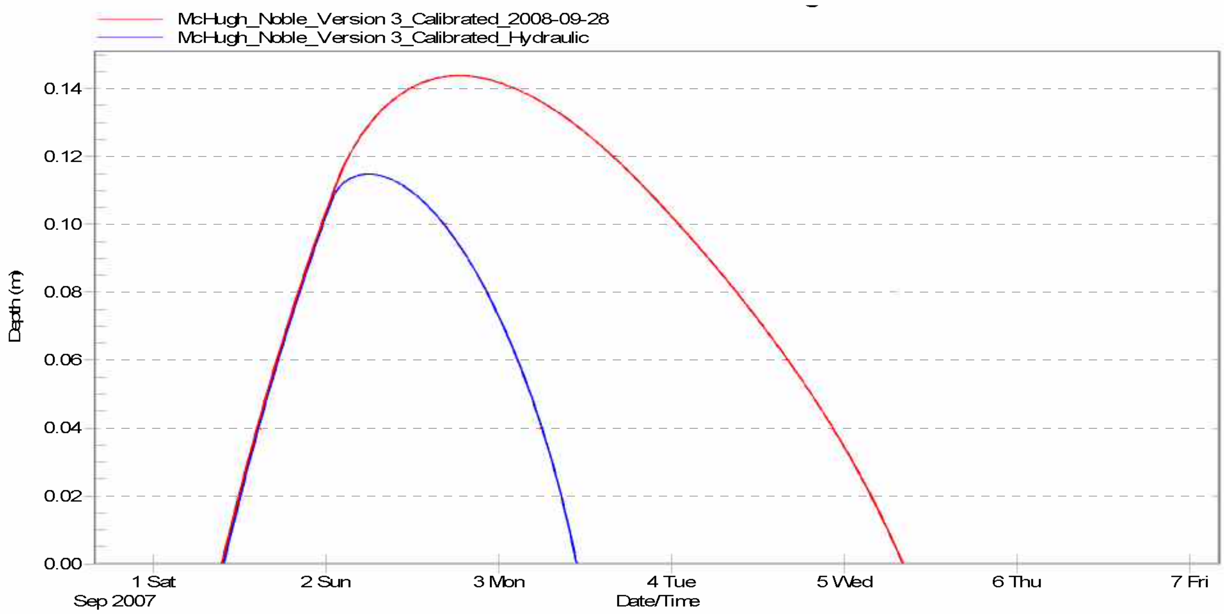


Figure QQ Depth of flooding in Martindale Valley with and without hydraulic improvements for a 10 year, 24 hour return storm (design)



Combined Opportunities

As the watershed improvements suggested above mitigate different issues experienced by the watershed, it is likely that a number of the watershed improvements will be implemented together. If rainfall capture alone was completed to replenish baseflow and reduce peak flows, the improvement to MAR peak flows at Martindale Road are significant, but are marginal at Dooley Road. Hydraulic improvements alone will mitigate flooding but will also result in the increase of runoff flows and volumes at Dooley Road . The impact of the two improvements combined, as shown below in Figure RR and Table Z, is that the MAR peak flow rate at Dooley Road will increase by 9%, but to a lesser degree than if the hydraulic improvements were completed alone (increase in peak flow of 15%). The addition of runoff control produces no additional reduction in overall peak flows at Dooley Road, although the reduction at Martindale Road is significant (38%).

Figure RR Flow south of Dooley Road as-is and with hydraulic improvements, rainfall capture, both hydraulic improvements and rainfall capture for a 2 year 24 hour (MAR) storm event (continuous)

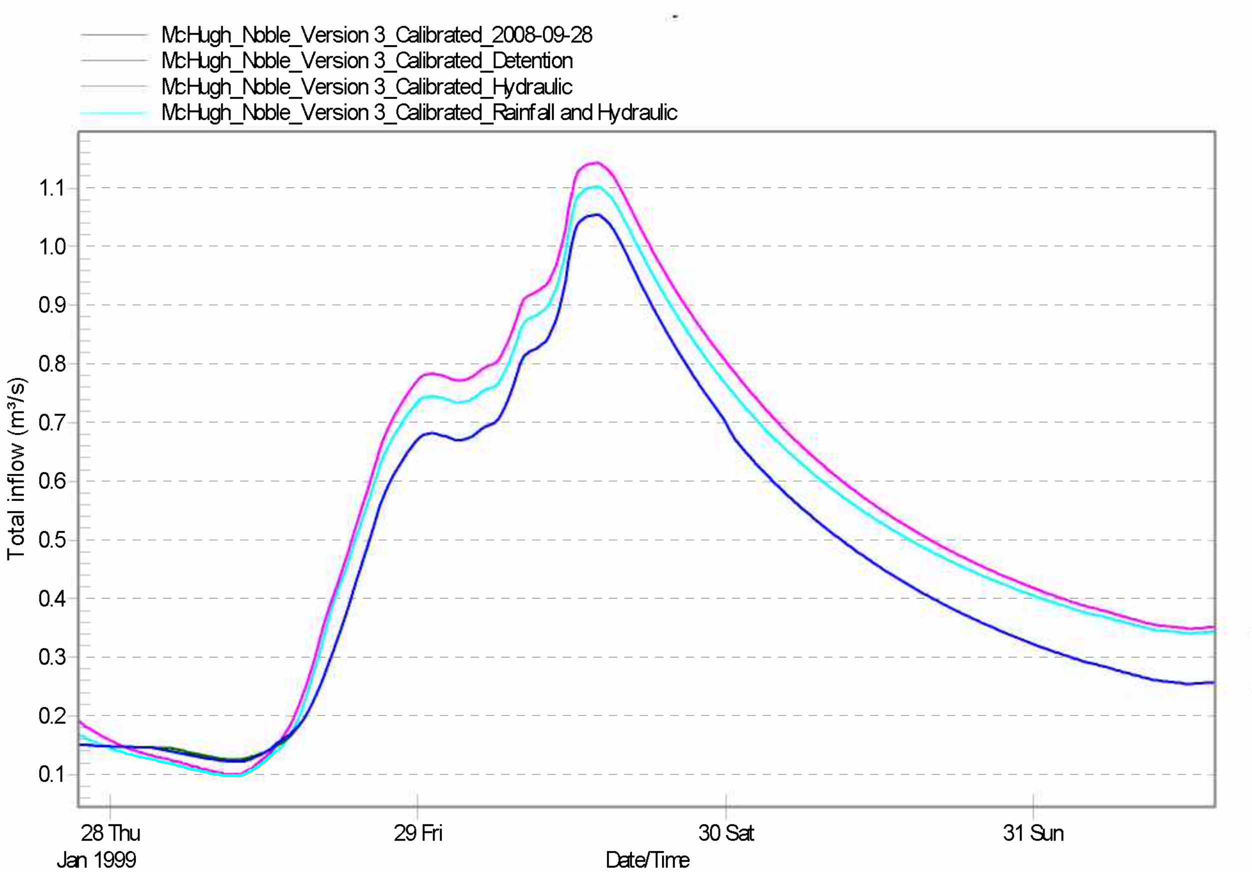


Table Z Peak Flowrates for Various Storm Events with Hydraulic Improvements

Location	Scenario	2 Year		10 Year		25 Year		100+ Year	
		m3/s	Change	m3/s	Change	m3/s	Change	m3/s	Change
Martindale North	Base	0.576		0.8385		1.462		2.072	
	Rainfall & Hydraulic	0.5701	-1%	0.8296	-1%	1.447	-1%	2.048	-1%
	All	0.5701	-1%	0.8296	-1%	1.447	-1%	2.048	-1%
Martindale West	Base	0.277		0.277		0.277		0.277	
	Rainfall & Hydraulic	0.277	0%	0.277	0%	0.277	0%	0.277	0%
	All	0.1688	-39%	0.1737	-37%	0.1783	-36%	0.1805	-35%
Dooley South	Base	0.6851		0.8403		1.481		2.175	
	Rainfall & Hydraulic	0.7482	9%	0.8972	7%	1.513	2%	2.187	1%
	All	0.7482	9%	0.8972	7%	1.513	2%	2.187	1%
Outfall	Base	1.615		2.311		3.497		4.813	
	Rainfall & Hydraulic	1.682	4%	2.371	3%	3.527	1%	4.814	0%
	All	1.682	4%	2.371	3%	3.527	1%	4.814	0%

Summary of Opportunities

The opportunities available to improve stormwater management within the McHugh-Noble watershed are:

- Capture rainfall near the source to divert runoff into the ground in impervious areas such as Tanner/Keating Ridge. Best management practices (BMPs) which can be implemented in developed areas include downspout disconnections, rain gardens, and infiltration swales;
- Creation of a detention pond / constructed wetland on the western flank of the Martindale Valley to minimize peak flows, provide waterfowl habitat, and treat water via vegetation and settling;
- Use of in-line and/or off-line ponds within the watershed for the purposes of detention to reduce the impact of peak flow rates and first flushes; and,
- Improve the hydraulic condition through McHugh Ditch by cleaning out ditches regularly and expanding and lowering the culvert at Dooley Road to minimize flooding, especially in the agricultural shoulder seasons.

7.4 Riparian Zone Integrity

The word riparian stems from the Latin riparius meaning “of or relating to a river bank” (Webster’s Encyclopedic Dictionary of the English Language, 1988). In other words, the riparian zone is found at, and creates, the interface between a stream or wetland and the terrestrial land adjacent to the aquatic ecosystem. Naiman and Décamps (1997) describe it as a zone “encompass(ing) the stream channel between the low and high water marks and that portion of the terrestrial landscape from the high water mark toward the uplands where vegetation may be influenced by elevated water tables or flooding and by the ability of soils to hold water.”

Due to the ability of the soils and other biota in the riparian zone to capture and store water, the vegetation in these areas are very different than what would be found in a typical coniferous/deciduous forest. Vegetation in riparian zones perform an essential function in creating a interlacing network of roots that hold and stabilize the soils along the banks of a stream or wetland. In large flow events or in areas of consistently increased flows (*i.e.* urban areas with lots of impervious surfaces conduct more sheet flow to streams than would be expected in a forested area) these stabilizing root structures aid in preventing heavy erosion of the banks. Additionally, as the vegetation grows and the root systems expand they act to maintain the elevation of the stream bottom by adding a strong structural network under and, adjacent to, the stream channel. Consequently, riparian vegetation provides the infrastructure required to maintain the integrity of the stream and/or wetland.

Throughout the District of Central Saanich, there are examples of both healthy and functional riparian zones and areas where the riparian zone is virtually non-existent. In the areas of essentially no riparian zone such as Graham Creek along Willow Way and further upstream of West Saanich Road creek function has been negatively affected. Not only is there less integrity in the system in terms of bank stability but the water table is also lowered without roots maintaining the soil water storage capacity.

Riparian zones also play a role in stormwater management processes. Vegetation and soils in these areas are capable of filtering pollutants from stormwater as well as binding heavy metals through means of adsorption. As such, the pollutant load into the streams themselves is reduced. Additionally, by acting as a buffer, vegetation in riparian zones can reduced the velocity and volume of sheet flow into streams by allowing infiltration into the soils. This decreases the amount of erosion occurring along stream banks and within stream channels. As such, the sediment load will be reduced by preventing excess erosion and by causing some sediment to settle out when the velocity of flow slows down when it reaches a vegetated, permeable area instead of impervious surfaces.

It is recommended that wherever possible riparian zones are enhanced via planting and subsequently maintained to ensure their continued function in the elements stated above. Not only will this protect the integrity of the streams both functionally and physically, but it will also lead to a natural filtration of pollutants, improve water quality and reduce sediment loading.

7.5 Wildlife

Little wildlife was observed during the field assessments conducted along the streams throughout the municipality. In most areas, wildlife corridors are broken up by street crossings, agriculture, and residential properties.

Mallard ducks were noted in some areas such as the pond in Adam Kerr Park as well as other pond areas. Evidence of a small carnivore in the form of fish parts, excrement, shellfish, and tracks was noted at the outlet of Noble Creek on February 15, 2008. Additionally, a barred owl (*Strix varia*) was observed in Centennial Park during the third Creeks and Communities workshop on June 16, 2008. While no fish were noted during the assessments, Graham Creek, Hagan Creek, and Tetayut Creek are all known to have fish populations. Cutthroat trout (*Onchorhynchus clarki*) are present in all three streams while salmon species such as Chum (*Onchorhynchus keta*) and Coho (*Onchorhynchus* *kisutch*) do inhabit the lower reaches of Tetayut Creek. An electroshocking of Hagan Creek near Hagan Bight in 1997 by the Hagan-Kennes Watershed group also revealed the presence of threespine stickleback (*Gaterosteus aculeatus*) and pumpkinseed sunfish (*Lepomis gibbosus*) in this area (Hagan-Kennes Watershed Project, 1997). Anecdotal information suggests that the fish populations in all three streams are much smaller than they were historically.

In order to determine the type of bird activity occurring in Central Saanich, the study team met with a group of birders from the Victoria Natural History Society who do bird counts within the District of Central Saanich on May 29, 2008. With a general interest in birds throughout the Municipality and Southern Vancouver Island, the particular focus of the meeting was bird use in the Maber Flats area which provides habitat for many wintering fowl. Their main concern is a loss of overwintering habitat for the bird species as there is a lack of this specific form of habitat on Southern Vancouver Island. From November to early May, the Flats act as a lay over for migratory bird species (Pers. comm. VNHS). Dabbling ducks are the most common users of the Flats with some use by diving ducks and swans when the water is deeper. As the water level begins to drop off shorebirds make use of the shallow water and mud flats. Shorebirds have long migratory paths and are often overlooked in terms of places available for them to use on Southern Vancouver Island. Once the water has disappeared, other birds such as sparrows and warblers can be found in the riparian area. Over the years, occasional muskrats have also been noted in Graham Creek at Maber Flats during bird counts.

A total of 34 different species were recorded at the Christmas count on December 15, 2007. A count in the mid-30's has been relatively consistent since 1991 with the highest number of species observed to be 43 in December of 1997. Some of the most common species consistently migrating to Maber Flats include the following: Canada Goose (*Branta canadensis*), Great Blue Heron (*Ardea herodias*), Mallard (*Anas platyrhynchos*), Northern Pintail (*Anas acuta*), American Wigeon (*Anas Americana*), Green-winged Teal (*Anas crecca*), and Europeon Starling (*Sturnus vulgaris*). While there seems to be little use by rare or endangered species, uncommon bird species such as Peregrine falcons (*Falco peregrinus*), Northern shrike (*Lanius excubitor*), Trumpeter swans (*Cygnus buccinator*), and white-throated sparrow (*Zonotrichia albicollis*) have been observed (Pers. Corres. VNHS). For the complete bird count[7] refer to Appendix 11.

[7] Victoria Natural History Society

7.6 Water Quality

7.6.1 2007-2008 Sample Areas and Results

Hagan Creek flows from agricultural, industrial, institutional, recreational and residential land, discharging into Hagan Bight as indicated in Figure SS below.

Figure SS Upper and Lower Hagan Creek Sample Locations

The Hagan-Graham watershed is approximately 1780 hectares in size. Hagan Creek was sampled in two separate locations throughout the sample period. The most upstream location was on Gordon Godfrey's property near Mount Newton Crossroad and Malcolm Road. This location was chosen as the confluence with Graham and Hagan creek occurs not far upstream from the sample location. The upper Hagan sample location is located within a forested portion of the creek, which then flows through a series of widened reed canary grass ditches into a box culvert running beneath West Saanich Road. The lower Hagan sample location is immediately downstream of the West Saanich Road box culvert. After the creek flows through the box culvert, it flows into a more natural creek setting, past a historical aboriginal bathing pool and down through some large bedrock outcrops (not fish passable due to the height and extent of the rocks) prior to discharging into the ocean. Both sample locations were relatively similar and measured parameters appeared to be stable for most part of the year.

With respect to temperature, the lower Hagan sample location was consistently warmer than the Graham Creek and Upper Hagan sample locations. Graham Creek is well-vegetated and therefore may not warm to the same degree as less-vegetated areas. Vegetation plays a key role in temperature regulation by preventing water in creeks from warming up. The increase in stream temperature is expected to occur downstream of the upper Hagan creek sample location as the riparian canopy has been removed and the creek has been ditched and widened (Appendix 7). It also receives drainage from numerous tributaries, some of which drain urbanized areas.

pH shows an upward trend from the Graham Creek sample location to the lower Hagan location (Appendix 7). This upward trend may be the result of the increased precipitation from September 2007 to May 2008 on local soils, and/or farming activities as June and August pH levels begin to decrease. From October through January, turbid waters were evident at the lower Hagan location (likely due to upstream dredging activities). Fish have been observed in this area. During the September 2008 sampling run, samplers noted cows accessing the upper portion of Hagan Creek as the area had not been fenced off. Cows and other livestock animals can quickly trample the stream banks and degrade water quality (*i.e.,* defecating within or near the creek can increase fecal coliform levels) if proper management techniques are not implemented. The minimum, maximum, median and average values for each parameter for the two sample locations in Hagan Creek are in Table AA and Table BB below.

Table AA Minimum, maximum, median and average values for each water quality parameter sampled at the upper Hagan location

Parameter	Min	Max	Median	Average
Conductance (uS/cm)	139.00	230.00	190.00	190.11
Specific Conductance (uS/cm °25C)	225.00	312.00	286.00	281.00
Temperature (°C)	2.88	12.76	7.89	7.99
Total Dissolved Solids (mg/L)	0.15	0.20	0.19	0.18
pH	7.03	7.75	7.64	7.54

Table BB Minimum, maximum, median and average values for each water quality parameter sampled at the lower Hagan location

Parameter	Min	Max	Median	Average
Conductance (uS/cm)	132.00	255.00	196.00	189.00
Specific Conductance (uS/cm °25C)	213.00	309.00	263.00	264.73
Temperature (°C)	3.20	17.26	9.25	9.81
Total Dissolved Solids (mg/L)	0.14	0.20	0.17	0.17
pH	7.08	8.00	7.58	7.60

Graham Creek is situated within the Hagan Creek watershed. Graham Creek originates at approximately 125 m elevation between West Saanich Road and Old Saanich Road in the District of Saanich, drains both agricultural and residential areas and eventually discharges into Hagan Creek (see Figure TT below).

Figure TT Graham Creek Sample Location

Graham Creek was sampled at the south end of the culvert just before the creek turns North through a box culvert underneath Stelly's X-Road. The area south of the road is continuously dredged (therefore having little riparian vegetation) in order to efficiently drain adjacent agricultural lands. As a result, the water is turbid and is expected to have high levels of total suspended solids. The area north of the road is notably covered in riparian vegetation and is less channelized thereby allowing for some sediment deposition. The DO levels were noted as erratic and only remained above the aquatic life guidelines for a small portion of the year (likely due to high temperatures, large areas of duckweed and filamentous algae); notably, only during the winter season. Graham Creek has been noted to be quite turbid throughout the year; specifically in October 2007 as the channel had recently been dredged (turbid waters were noted downstream even with the placement of hay bales in front of the box culvert). Like the other sample locations, this portion of the creek experiences high temperatures (15.59°C) in the summer due to the lack of shading and over-widened channel. These high temperatures, low DO levels and consistently turbid waters are anticipated to create unsuitable habitat conditions for most aquatic life. Interestingly enough, (unidentified) minnows have recently been spotted within the area; however, these minnows are expected to be a pollution tolerant species such as stickleback. pH, conductivity and TDS were surprisingly consistent throughout the sampling period (see table below). During the September 2008 sampling, hay bales and silt fence had been recently installed (incorrectly) upstream of the culvert in preparation for dredging activities to commence by the municipality. Ditching or dredging fish bearing streams prior to the onset of the autumn/winter rains is expected to increase sedimentation and turbidity within the stream; creating unfavourable/harmful conditions for aquatic life known to exist in this system. The minimum, maximum, median and average values for each parameter for Graham Creek are in Table CC below.

Table CC Minimum, maximum, median and average values for each water quality parameter sampled at the Graham Creek location

Parameter	Min	Max	Median	Average
Conductance (uS/cm)	97.00	249.00	188.00	191.00
Specific Conductance (uS/cm °25C)	135.00	322.00	302.00	275.82
Temperature (°C)	3.08	15.59	8.73	9.02
Total Dissolved Solids (mg/L)	0.09	0.21	0.20	0.18
pH	6.75	7.56	7.29	7.18

Tetayut Creek flows through agricultural, industrial, recreational and residential lands and discharges into Saanichton Bay (see Figure UU below).

Figure UU Tetayut Creek Sample Location

The portion of Tetayut Creek that was sampled is adjacent to a pump station, prior to entering into a culvert that runs beneath Tetayut Road. As Tetayut Creek receives a large amount of stormwater during the winter months, specific areas of stream bank have eroded. During the summer, the creek has considerably lower flows and is subject to higher temperatures, but continues to have reasonable dissolved oxygen levels throughout the year. pH and conductance levels appear to be stable throughout the sampling period as well (Appendix 7). During the sampling period, the water did not appear to have much turbidity in the stream even though upstream bank erosion has and continues to occur. Some unidentifiable minnows (perhaps three-spine stickleback) have recently been spotted within the area. These minnows may be the result of recent fish stocking or may be sea-run cutthroat trout as they are the only known fish populations still in this creek. The minimum, maximum, median and average values for each parameter for Tetatyut Creek are in Table DD below.

Table DD Minimum, maximum, median, and average values for each water quality parameter sampled at the Tetayut Creek location

Parameter	Min	Max	Median	Average
Conductance (uS/cm)	157.00	258.00	200.00	202.91
Specific Conductance (uS/cm °25C)	256.00	329.00	313.00	301.27
Temperature (°C)	2.09	14.12	8.05	7.86
Total Dissolved Solids (mg/L)	0.17	0.21	0.20	0.20
pH	6.89	7.99	7.61	7.57

McHugh Ditch, situated within the Noble Creek watershed, drains a collection of surface runoff and spring flows though agricultural areas and a small, forested area prior to discharging into the ocean. McHugh Ditch was sampled south of the box culvert that runs below Dooley Road (see Figure VV below).

Figure VV McHugh Ditch Sample Location

The area is largely agricultural/hobby farms. North of the culvert, the channel resembles a down cut ditch with some riparian/upland species (this may suggest a very low water table). Due to ditching and dredging activities south of the culvert, the stream banks are covered in reed canary grass, resulting in an even less diverse habitat. The overly widened channel and lack of riparian vegetation has resulted in fluctuating temperatures (ranging from a low of 1.56 deg C to a high of 13.91 deg C) and exceptionally low dissolved oxygen levels well below aquatic life standards of 6.5mg/L. This is a critical point to note, as the combination of high temperature, low summer flows and low dissolved oxygen levels are negatively impacting aquatic life. During the summer period, a large amount of duckweed was noted to be within the channel, likely contributing to the reduction in dissolved oxygen levels when it decomposes. Interestingly enough, the pH value falls below the aquatic life guidelines during the December sampling period (low of 6.43). A drop in pH levels is expected to have occurred due to increased precipitation as the pH level of rainwater is lower than what may be the current background levels (from the data the trend seems to sit above a pH of 7 for the majority of the year). pH can also be effected by soils and non-point/point source pollution inputs. Finally, there was a considerable amount of fine sediment covering the channel bottom. The sediment is likely due to upstream agricultural and municipal activities (*i.e.,* ditching, dredging). This ditch does not receive high enough flows to move the fine sediments to downstream nor can it deposit these sediments (as a natural system would) in the naturally occurring floodplain as the channel has been ditched and entrenched. During the September 2008 sampling, hay bales and silt fence had been recently installed (incorrectly) upstream of the culvert in preparation for dredging activities to commence by the municipality. Ditching or dredging fish bearing streams prior to the onset of the autumn/winter rains is expected to increase sedimentation and turbidity within the stream; creating unfavourable/harmful conditions for aquatic life. The minimum, maximum, median and average values for each parameter for McHugh Ditch are presented in Table EE below.

Table EE Minimum, maximum, median and average values for each water quality parameter sampled at the McHugh Ditch location

Parameter	Min	Max	Median	Average
Conductance (uS/cm)	245.00	543.00	402.00	376.00
Specific Conductance (uS/cm °25C)	337.00	906.00	518.00	566.55
Temperature (°C)	1.56	13.91	9.60	8.39
Total Dissolved Solids (mg/L)	0.22	0.59	0.34	0.37
pH	6.43	7.53	7.02	7.04

7.7 Implications for Agriculture

One of the recommendations emerging from this plan is to consider the creation of stormwater detention facilities in low-lying areas, specifically Maber and Martindale Flats. Despite the potential advantages of such facilities in the management of stormwater in Central Saanich, these proposals have important agricultural ramifications that should be considered.

The land in which these facilities are proposed are active farm lands and lie within the Agricultural Land Reserve. Land use is on such lands is governed by the Agricultural Land Reserve Act (2002). Non-farm use is restricted, and stormwater detention is considered a non-farm use. Section 25 of the Act states that the Agricultural Land Commission (ALC) may refuse or grant permission, or it may grant permission with terms. Under law, any proposal for a stormwater detention facility cannot proceed without the blessing of the ALC. In recent years, such permission has not been granted without due and careful deliberation, and many applications have not been successful. Recent developments in

Panama Flats, in the District of Saanich, have focused attention on the issue of land use on land in the Agricultural Land Reserve and on the right to farm on areas of interest to water managers.

The creation of these facilities would clearly have implications to the practice of agriculture. Any such facility, including a pond and access roads, would remove land from agricultural production. Furthermore, the pond and associated access roads could interfere with farm access or decrease the efficiency of cultivation and harvesting operations.

A stormwater detention facility may have the secondary effect of attracting more waterfowl. Most farmers in the Maber Flats area are already resigned to winter flooding; however if the detention pond provided additional waterfowl habitat outside of the existing flood periods (*e.g.,* spring and fall) then it may very well attract more birds. Although such a development would be welcomed by certain sections of the public, including birdwatchers, an increased bird population would not be well received by farmers.

Birds create a number of problems for farmers. Some, particularly geese, graze crops, including forages, thereby reducing production. This is not a problem in the winter now, when most fields are bare, but the stormwater pond would extend habitat into spring and summer, when crops have been established. Nearby fruit and berry farmers will also suffer increased losses due to bird feeding if the bird population is increased.

Birds create contamination problems by spreading fecal matter on soils, on standing water and on crops themselves. This raises health issues and for certain crops such as leafy lettuce, in which washing does not effectively remove fecal matter there is the potential for crop loss.

A further impact may result from increased use by birdwatchers and other visitors. Roads and trails allowing access for these visitors may affect farm operations.

Normal farm operations include the use of bird control. Control methods include hunting (with special permits), egg addling, noisemakers such as guns, bear bangers, screechers and cannons. This is a controversial issue that has been brought before the courts in the Saanich Peninsula.

Any plan to create stormwater detention facilities would require consideration of compensation to adjacent farmers, both for the land taken up as well as for potential impacts on farm practice. The compensation could take the form of funds, mitigation of impacts, measures to increase soil productivity or some combination of these.

The most powerful form of compensation would be to improve drainage in the agricultural land in Maber and Martindale flats outside of the proposed pond. Improved drainage – particularly in Maber – would result in increased productivity. It would extend the cropping season by allowing earlier entry to fields in spring and later operations in the fall. It would increase the range of crops and varieties suitable to the land. It would allow perhaps more cuts of hay, more flexibility in multiple cropping systems or in crop rotation. It may allow some farmers to add pumpkins to their cropping system. Most farmers would welcome such improvements.

However the problem of maintaining a year-long detention pond (even with variable water levels) on the one hand, and achieving the necessary invert elevation to allow drainage to ARDSA criteria. Two of the criteria will make it difficult to have both perennial pond and drainage:

a) the 1.2 m (or 0.9m) freeboard between base flow and field elevation, and

b) the requirement to drain the 10 year, 5 day storm, within 5 days in the dormant period.

The modelling work for Maber Flats (Section 7.1.2) indicated that a combination of hydraulic improvements and a detention facility could improve conformance with ARDSA but not meet the standard. To achieve ARDSA drainage criteria it may be necessary to isolate the detention pond from the local water table, possibly through dyking, or locating it away from the lowest point in the Flats. Unfortunately, this type of facility would involve extensive civil works and would be relatively unattractive from an aesthetic and ecological perspective.

7.8 Water Balance Model

A comparison of the BC Water Balance Model (WBM) and PCSWMM shows that both models generate comparable values of runoff rate versus hours of exceedance, however, as both models were setup with the same input parameters and are based on the same hydrological processes this result is to be expected. There are however several differences in the two models not identified by comparing the runoff generated from an individual site. The WBM has been developed as a tool to simulate and compare runoff from pre-development, base cases and multiple BMP scenarios with hourly time step weather data; the WBM is not a complete hydrological/hydraulic model. The engine of the WBM is QUALHYMO, a comprehensive hydrologic simulation model, however, the front-end of the WBM provides only limit access to the capabilities of the model engine. The WBM has been designed so that it is a relatively simple to use and has been developed with the non-engineer user in mind. The WBM model does not provide hydraulic modeling capability and therefore should not be compared to PCSWMM. The WBM is a useful tool for a quick assessment of the effectiveness of BMPs proposed for a development, however, it should not be considered a suitable model for modeling flooding or for the detailed design or assessment of the hydraulic structures. The WBM is not considered a suitable model for the development of a watershed scale ISMP.

7.9 Climate Change

Climate change within the context of British Columbia and the CRD has been the subject of considerable research and modelling. The predicted impacts of climate change in BC are summarized Chapter 8 of the report, “From Impacts to Adaptation: Canada in a Changing Climate” (Walker and Sydneysmith, 2008). In summary, there will be:

- More wet days;
- Less consecutive dry days; and,
- More rain and less snow during winter.

The main body of research on climate change in BC has been initiated under the Pacific Climate Impacts Consortium (PCIC) (pacificclimate.org), a collaboration between the MOE, BC Hydro, and the Canadian Institute for Climate Studies at the University of Victoria's Centre for Global Studies. The PCIC models predict the following to occur by 2050 (PCIC, 2008):

- Overall yearly precipitation will increase by approximately 3% in the Capital Regional District;
- Summer precipitation will decrease by between 12 to 27%;
- Winter precipitation will increase by between 3 and 9%; and
- Mean temperatures will increase by approximately 2 degrees Celsius.
- Increased frequency of 24-hr precipitation events greater than 80mm
- Summers will be hotter and drier and the winters will be wetter
- 20% – 100% reduction in spring snow pack, causing a decline in spring snow water levels
- Changes to timing of river flows:
  - Flows will shift away from being snow driven to being rain driven
  - Low flow conditions will last considerably longer

Based on the PCIC models, Table FF below presents the forecasted impacts of climate change on precipitation and evaporation in Central Saanich. The current precipitation values were obtained from monthly Canadian Climate Normals for the Victoria International Airport for data collected between 1971 and 2000.

Table FF Forecasted Climate Change Data in Year 2050

Component	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Current Precipitation (mm)	137	108	78	45	37	32	20	24	30	76	147	151	883
% Change Prediction	3	-1	3	5	5	-12	-27	-24	-7	9	9	8	3
2050 Precipitation (mm)	140	107	81	47	38	28	14	18	28	82	160	163	907
Current Evaporation (mm)	12	18	28	46	72	62	27	28	39	40	22	15	409
2050 Evaporation (mm)	14	22	34	54	44	32	16	21	32	48	26	18	362

The PCIC states that a model predicting evapotranspiration rates will be released near the end of 2008 (Murdock, 2008). Without published models to predict evaporation, current evaporation values were obtained from Environment Canada for Saanichton and increased by 20% to obtain an estimate of what future evaporation values may be in 2050. In months where evaporation significantly exceeds precipitation, the values were limited to 115% of monthly precipitation.

7.9.1 Implications

As shown in Table FF above, the forecasted change in precipitation due to climate change varies from month to month. In the months with the most precipitation, November and December, monthly average precipitation is forecasted to increase by 8% to 9%.

In order to simulate the impacts of climate change on the watersheds of Central Saanich, the increase in precipitation was conservatively estimated to be 10%. This increase was applied on rainfall events of various recurrence intervals obtained from the Victoria International Airport climate station IDF curve. The resulting rainfall depths are shown in Table GG below. Design rainfall hydrographs were then created in PCSWMM using the SCS Type IA design storm and applied to the base watershed models

Table GG Climate Change Recurrence Interval Depths

	24 Hr Recurrence Interval Period					
Rainfall Depth	**2yr**	**5yr**	**10yr**	**25yr**	**50yr**	**100yr**
Current (mm)	50.7	65.8	71.2	87.1	96.0	103.1
Central Saanich (mm)	-	-	76.8	91.2	-	-
Climate Change (mm)	55.8	72.4	78.3	95.8	105.6	113.4

In terms of rainfall depth for 24 hour storms, it can be interpreted that the current 10 year storm will become the new 5 year storm, the 50 year storm will become the 25 year, and the 100 year storm will become the new 50 year storm. This is consistent with the PCIC prediction that the 20 year storm in 1990 will become the 7 to 10 year storm in 2050 (PCIC, 2007)

According to Central Saanich's Engineering Specifications and Standard Drawings (Central Saanich, 1999) storm water drains less than 900 mm are to be designed for a 10 year storm and those greater than 900 mm, a 25 year storm. If the rainfall depths increase due to climate change as predicted, culverts may be undersized to handle the increased runoff. However, as shown in Table GG above, the rainfall depths from IDF curve used by Central Saanich (based on data collected at the Victoria International Airport between 1965 and 1979) are slightly higher than the current IDF curve for Victoria International Airport.

Table HH below shows the changes in rainfall parameters due to climate change in all three watersheds.

Table HH Runoff Peak Flows and Volumes with Climate Change

Recurrence Interval (24 hour storm)	Watershed	Peak Flows			Runoff volume		
		Before	After	% change	Before	After	% change
2	Hagan Graham	3.1	3.5	13%	192,000	221,000	15%
	Tetayut	1.0	1.0	4%	44,000	47,100	7%
	McHugh Noble	0.2	0.3	19%	61,900	68,950	11%
5	Hagan Graham	4.1	4.7	15%	280,000	323,000	15%
	Tetayut	1.1	1.2	6%	52,500	55,800	6%
	McHugh Noble	0.4	0.5	19%	87,510	100,500	15%
10	Hagan Graham	4.6	5.1	11%	315,000	362,000	15%
	Tetayut	1.1	1.2	6%	55,200	58,500	6%
	McHugh Noble	0.4	0.5	20%	95,100	109,400	15%
25	Hagan Graham	5.8	6.5	12%	421,000	482,000	15%
	Tetayut	1.3	1.4	5%	62,200	65,400	5%
	McHugh Noble	0.6	0.8	19%	125,800	139,200	11%
100	Hagan Graham	7	7.8	11%	535,000	613,000	15%
	Tetayut	1.4	1.5	5%	67,900	71,300	5%
	McHugh Noble	1.4	1.6	19%	209,500	236,800	13%

Based on the modeled results, the average increase in peak flows and volumes for recurrence interval periods varies from watershed to watershed due to differences in infiltrative capacities and impervious areas. However the increase in peak flows ranged from 4% to 20% and the increase in volume ranged from 5% to 15%.

8. CONCLUSIONS AND RECOMMENDATIONS

The following are the key findings from this Integrated Stormwater Management Plan (ISMP) study of the Hagan-Graham, Tetayut and McHugh-Noble watersheds:

8.1 Conclusions

a) The three major watersheds addressed in this report (Hagan/Graham, Tetayut (formerly Sandhill) and McHugh-Noble) cover an area of approximately 3900 ha (39 km^2), contain 32 km of creek and receive approximately 858 mm of precipitation (33 million m^3) in a typical year. This represents one of the most important District assets by any measure, with implications for everything from agriculture to recreation to biodiversity.

b) The ecological condition of creeks in Central Saanich varies from non-functional to near-pristine with approximately half of the total creek length in the non-functional classification, according to the Proper Functioning Condition (PFC) method of assessment (Appendix 8).

c) Ecologically significant areas showing remnant creek character, good spawning areas, large trees, and good waterfowl habitat amongst other things were noted during the creek assessments and other field visits. Key areas include: George May Park, Centennial Park, Cooperidge Park, and Tsawout First Nation. Such areas should be maintained and/or improved where possible.

d) The trend in ecological condition of the creeks is downward.

e) The adverse ecological conditions observed in the creeks can be principally attributed to:

    i) Modifications to the morphology of creeks and drainage works that have rendered them less ecologically stable and much less capable of supporting biologically diverse communities;

    ii) Increased runoff rates and volumes due to increases in impervious surface and fast conveyance structures;

    iii) Destruction of Riparian Plant Communities through encroachment by humans and pets and invasive species; and,

    iv) Climate change, which is increasing the frequency and severity of storm events.

f) The decline in ecological condition has been gradual, reflecting an accumulation of impacts from a large number of incremental changes over many decades.

g) The hydraulic and hydrologic condition of the three major watersheds was assessed through the creation of a stormwater model for each watershed on PCSWMM.net modelling software which is provided to the District upon completion of this project.

h) Seasonal inundation occurring in Maber Flats and Martindale Valley is due to a combination of low-permeability soils, low hydraulic gradients and discharge flow restrictions, exacerbated by increased runoff volumes. This flooding depresses agricultural values in these areas by severely limiting the productive season. Both of these areas were historically wetlands and have been drained for agricultural purposes. Both areas continue to provide rare and valuable habitat for migratory water fowl.

i) Increasing rainfall capture throughout the District, through a variety of means, can reduce runoff volumes and flows, replenish groundwater and base flows in creeks, and improve water quality, thereby helping to counter many of the adverse cumulative impacts on the watersheds.

j) Additional rainwater detention in the watersheds is desirable to attenuate peak flows and increase base flows and can be achieved through enhanced riparian zones, construction of new ponds and wetlands and (where feasible) voluntary modification of existing farm ponds to better meet stormwater management objectives.

k) There are significant water quality issues in the watersheds associated with direct runoff of "first flush" rainwater from roads, parking lots and industrial facilities. Insufficiently maintained oil-grit traps and the lack of bioinfiltration facilities are major factors. The most critical issue of this nature is concern expressed by Martindale farmers about the potential impact of Highway 17 (Pat Bay Highway) runoff on agricultural activities.

l) The combination of measures identified to attenuate flooding conditions in Martindale Valley (see below) has the potential to meet most ARDSA criteria for drainage of agricultural lands, those proposed for Maber Flats would significantly improve conformance to ARDSA but not fully meet the standards.

m) Climate change, based on the most recent projections for this area of BC, will put more stress on the watersheds by increasing the frequency of large storm events, thereby increasing peak flows and erosion processes, and concentrating the precipitation seasonally thereby reducing base flows. The magnitude of the change is represented by the fact that the storm which currently occurs once every 5 years will occur once every 2 years, by 2050. The same measures proposed in this ISMP to counter observed issues in the watersheds will help adapt to these effects.

8.2 Recommendations

8.2.1 Advocacy, Coordination and Education

- Establish a "Healthy Watersheds" (or similar) Committee with involvement of the District, the CRD, NGO's and interested residents to aid and encourage the implementation of ISMP recommendations.

- Proclaim the District's intention to further develop the cooperative relationship with Tsartlip and Tsawout First Nations, local NGO's, farmers and other local landowners as partners in improving watershed conditions.
- Develop a community stormwater education program around implementing BMPs, protecting streams and discouraging discharge into creeks along the lines of the Yellow Fish Road program.
- Support the involvement of non-governmental organizations such as Peninsula Streams in programs to continue collection of water flow and quality information.

8.2.2 Best Management Practices[8]

- Implement and encourage measures to enhance rainfall capture throughout the three watersheds (including riparian storage) to reduce peak flows, reduce runoff volumes, increase base flow and reduce the demand for municipal water.
- Support a voluntary "downspout disconnection" program whereby residents / property owners in appropriate areas of the District are encouraged to implement rain barrels, rain gardens and onsite infiltration as a way of increasing rainfall capture in the community.
- Encourage the adoption of BMPs at agricultural operations such as managing the storage and application of manure, fertilizer, pesticides, and herbicides.
- Provide a summary of BMPs for agriculture, residences and commercial property on the District website and include links to relevant sources of information.
- Improve water quality by encouraging the implementation of BMPs which provide biofiltration treatment of contaminated runoff from parking lots, roads and industrial areas.
- Encourage the use of filter strips along the edges of agricultural fields where possible (depends on steepness of slope).
- Encourage an increased the depth of permeable soil (absorbent landscaping) throughout the District where possible, particularly in areas designated for new development or renewal.[9]

8.2.3 Specific Rainwater Management Projects

- Initiate projects to improve control of spring/fall inundation of agricultural lands in the Maber Flats and Martindale Valley areas, thus improving agricultural values in these areas. Each of these

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[8] Appendix 1 contains information on Best Management Practices and their implementation.

[9] Generally, the absorbent soil layer should be deep enough to store the 50.4 mm 2 year storm (the Mean Annual Rainfall). Assuming that the soil used for the absorbent surface soil layer can hold about 20% of its volume, a soil depth of at least 255 mm is recommended.

projects is complicated and requires investigations specific to the application and which go beyond the scope of this report.

- The Maber Flats project should contemplate channel modifications in conjunction with a constructed wetland of approximately 5 - 10 ha in size for flood attenuation, peak flow reduction, increases in base flow, enhanced habitat (principally birds), reduced channel erosion in Centennial Park and First Nations cultural uses. Costs for this project are estimated at $2 to 5 million, depending on the final scope.
- The Martindale Valley project should contemplate a community rainfall capture program in the Tanner / Keating Ridge area (downspout disconnection, infiltration swales, etc.), hydraulic improvements in the vicinity of the Dooley Rd. crossing (culvert replacement and control structure) and one or more retention ponds (totalling 0.75 – 1.4 ha in area) on the west valley flank to attenuate flows from the Martindale west subcatchment. Care must be exercised to restrict peak flows within Saanich to acceptable values. Costs for this project are estimated at $0.5 - 2 million, depending on the final scope.
- A combination bio-infiltration – retention facility to process runoff from the western portion of the Keating Industrial area should be implemented in the Hydro right of way just west of the main culvert to address water quality issues and attenuate peak flows so as to reduce observed channel erosion issues. The size of the facility would be approx 0.5 ha, with costs ranging from $0.25 to 0.75 million, depending on specific site circumstances.
- Encourage the development of multi-purpose farm ponds that meet agricultural, stormwater management and ecological needs by providing design guidance and encouraging community support for these initiatives. Make modern pond design and construction guidelines available on the District website, similar to the USDA guidelines (USDA, 1997). Consider an incentive program for modification of existing ponds to better meet stormwater management objectives while also meeting irrigation needs. Where possible retrofit to create detention during winter months and water release during summer months (if possible).
- Encourage the development of other pond / wetland / detention facilities in the watersheds, as described in Section 9.3.3.
- Work collaboratively with the Ministry of Transportation and Infrastructure, the Ministry of Agriculture and Lands and local property owners to improve control and treatment of runoff from the Pat Bay Highway in the Martindale Valley.

8.2.4 Hydraulic/Hydrologic Knowledge and Modelling

Upon the completion of this project, the District of Central Saanich will be provided with the stormwater models for the Hagan/Graham, Tetayut, and McHugh-Noble watersheds. The District may use the models to assist in the design of recommended hydraulic improvements, account for future land development, and maintain an inventory on stormwater infrastructure, amongst others. As noted previously, the amount of rainfall between September 2007 and September 2008 was uncharacteristically low for the region, therefore continued monitoring and model verification and, if necessary, refinement is recommended in order to capture watershed response during winters with high rainfall. To ensure the long term viability of the models, we recommend that the District:

- Gain a general understanding on the use and manipulation of the PCSWMM software and the model by attending course provided by Computational Hydraulics or though a staff training session.
- Retain the services of an engineering consultant to provide guidance on the use, manipulation, and interpretation of model results as required.
- Continue the collection of stream flow data, possibly with volunteers, at the 7 existing monitoring stations.
- Continue gathering staff level gauge measurements in Maber Flats and Martindale Valley following wet weather events to gauge flood levels.
- Continue periodic in-stream measurements, possibly with volunteers, to refine the stage-discharge curves, especially following wet weather events.
- Partner with the Victoria School Weather Network to access up to date rainfall records or alternatively, establish a weather station complete with a tipping bucket rain gauge for measuring rainfall.
- In due course, commission a hydrogeological study on groundwater resources in the district including an inventory of groundwater use, assessment of recharge / withdrawal balance and characterization of groundwater discharge locations and characteristics for inclusion in the stormwater models.

8.2.5 Ecological Restoration

- Develop a multi-decade plan of restoring PFC to creeks, including ditch to creek restoration. This plan would be prioritized by reaches with relatively low effort/high gain addressed first, as described in Section 9.5.
- Planting of riparian vegetation along creeks and ditches along with general planting throughout the municipality will aid in stabilization of creek banks as well as interception and uptake of water.

8.2.6 District Policy

- Make changes to the OCP that reflect the recommendations of the District's ISMP. Section 8.3.1 contains details of additional suggested OCP updates.
- Make ISMP recommendation changes to the District of Central Saanich Council Policy Manual. These recommendations are to be included in the OCP and are outlined in Section 8.3.1.

- Adopt surface water runoff Bylaw #1606.
- Consolidate all stormwater management Bylaws into one comprehensive Integrated Stormwater Bylaw.
- Make amendments to the Zoning Bylaw as outlined in Section 8.3.1.
- Refer to Section 8.3 for details on all policy recommendations.

8.2.7 District Resources and Practices

- Increase resources allocated to rainwater management activities by staff, including direct District responsibilities as well as coordination of what is expected to be a significant increase in activity by NGEO's and other groups.
- Nominate a Stormwater Coordinator from Engineering Staff to champion ISMP implementation, be a permanent member of the Healthy Watersheds Committee and help coordinate stormwater activities between Departments.
- In cooperation with CRD, develop a program of spot checks of oil / grease traps in the District (especially Keating Industrial Area).
- Implement modern BMP's into District methods of maintaining and replacing drainage infrastructure, with an emphasis on biofiltration to enhance runoff water quality and infiltration / detention to moderate the flows and volumes of runoff from impervious surfaces.
- Develop a long-term plan for upgrading / conversion of conveyance structures and other District stormwater management facilities to better meet modern BMPs; this would include a prioritized list of infrastructure segments requiring improvement.
- Develop a municipal ditch maintenance program in line with DFO's best practices to prevent sediment loading to streams. The timing and method of ditch maintenance should be re-examined. For example, during clearing, vegetation and other organic materials should not be allowed to fall into the creeks as this often leads to deoxygenation of the water during decomposition processes and can lead to fish kills and other damage to aquatic life. Alternate segment cleaning should be considered.
- Develop an education and training program for staff that focuses on the change from traditional stormwater management to integrated stormwater management. Resources that could be accessed include:
  - Visits by staff to sites that illustrate the practical implementation of Best Management Practices, such as University of Victoria (varied BMPs), Crown Street in Vancouver (illustrating street edge alternatives) and North Vancouver (Mr. Richard Boase).
  - Training on Proper Functioning Condition (PFC) for Parks staff in particular.

- Various stormwater management workshops (mainly for engineers and engineering techs) sponsored by APEGBC in Victoria.
- Various technical and non-technical rainwater management seminars hosted by CRD. (A new program is currently being developed).
- Other local seminars sponsored by CAVI (contact Kim Stephens outreach@waterbalance.ca).

8.3 Policy and Legislation

Central Saanich has a well-developed hierarchy of policy, objectives, implementation strategies operational guidelines and regulations to enable and guide its decisions and actions. The purpose of this section is to recommend policy, regulation and implementation strategies that extend this same enablement and guidance to the District's Integrated Stormwater Management objective.

The policy recommendations of this plan are structured to include:

- new Integrated Stormwater Management policy for inclusion in the OCP and/or Council policy documents;
- a discussion of policy and the planning concepts of density bonus, density transfer and lot averaging in response to the suggestion that such planning methods might be used in for the acquisition of land, design, construction or maintenance of the recommended rainwater management projects (e.g. constructed wetlands in Maber Flats and the Martindale Valley) found at Subsection 10.2.3 of this report. It being noted that the Official Community Plan adopted November 3, 2008 established no enabling policy for the use of density bonus, density transfer or lot averaging concepts;
- strategies for implementation and evaluation;
- proposed amendment of OCP Guidelines for Development Permit Areas; and
- proposed regulatory amendments.

8.3.1 Policy Recommendations

The supporting policies for the District's objective to protect surface water resources are structured as follows:

- Source Control Initiatives
- Watershed Planning and System Improvements
- Agency Advocacy and Cooperation
- Outreach and Education
- District Leadership
- Community Participation
- Resources and Priorities

- Evaluation and Continuance / Measuring Success

The OCP policy section is followed by additional policies and implementation strategies that supplement and expand upon the proposed OCP policies. The level of detail in these additional policies and implementation strategies is considered inappropriate for inclusion in the OCP and they are accordingly recommended for inclusion as Council adopted policy in Council's Policy Manual. Reference to this Council Policy is noted in the proposed OCP policy.

Official Community Plan – Policy Recommendation

7.2 Guiding the Future – Environment and Shorelines

Policy 3

Implement the following recommendations of the District's Integrated Stormwater Management Plan.

Source Control

- Introduce "source control" stormwater management initiatives to emulate the pre-development natural watershed by reducing and controlling stormwater quantity, and improving the stormwater quality discharge from individual properties

Watershed Planning and System Improvements

- Develop integrated and community-based Watershed Management Plans for each of the District's watersheds and identify at-risk watersheds for priority action.
- Consider integrated drainage and watercourse improvement projects (E.g., constructed and managed wetlands) that demonstrate multiple benefits such as protection of agricultural lands from flooding, improved flow hydraulics, water quality, wildlife habitat, fish enhancement and First Nations cultural practices.

Agency Advocacy and Coordination

- Advocate and cooperate with other agencies and levels of government to safeguard and restore healthy watersheds.

Outreach and Education

- Conduct outreach and education programs to engage the entire community and all ages.

Community Participation

- Establish a terms of reference for, and foster community involvement in, a "Healthy Watersheds" Advisory Group that is empowered to act both as an advisory committee to Council and coordinator of volunteer activities.

District Leadership

- Establish the District of Central Saanich and its staff and administration as leaders and champions of innovation, education and action for practical, affordable stormwater solutions.

Resources and Priorities

- Develop funding strategies, set timelines and establish priorities for healthy watershed projects and initiatives.

Evaluation and Continuance / Measuring Success

- Monitor and evaluate all stormwater management initiatives and develop a regular reporting structure for measuring the District's success in protecting its surface water resources.

Note: Further implementation policy and strategies for integrated storm water management are contained in the District's Integrated Stormwater Management Policy

Council Policy Manual Recommendations

The Corporation of the District of Central Saanich

Integrated Stormwater Management Policy

Scope:

This policy is intended to be comprehensive and applicable to all lands and all activity relating to the protection of surface water resources and the implementation of the District's Integrated Stormwater Management Plan.

Purpose:

To provide enablement and clear guidance to the decisions and actions of District Council and all District administration and staff as it pertains to the objective of the District to protect its surface water resources and implement the attached Integrated Stormwater Management Plan.

Policy:

The decisions of Council and actions of District administration and staff shall be consistent with the following policy and implementation strategies.

1. Source Control

Introduce "source control" storm water management initiatives to emulate the pre- development natural watershed by reducing and controlling stormwater quantity, and improving the stormwater quality discharge from individual properties.

- Where ground conditions permit, preference should be given to promote the natural infiltration of rain water into the ground.
- When stormwater is discharged into the District's system, require a "zero net increase" in post development flows relative to the pre-development, naturally vegetated condition of the land.
- Regulate the discharge of waste into storm sewers and watercourses.
- Adopt and promote Best Management Practices in stormwater management for existing and new residential, agricultural, commercial, industrial and institutional lands.
- Adopt a comprehensive Stormwater Management Bylaw to regulate stormwater quantity, quality, erosion and sediment control measures during construction and the on-going maintenance of stormwater management facilities, incorporating components of the Capital Regional District Model Bylaw. Further consider adoption of Codes of Practice to regulate existing stormwater contributors.

Note: To maintain the existing momentum of the proposed Surface Run-off Bylaw No. 1606 it may be appropriate to consolidate existing bylaws after its adoption.

2. Watershed Planning and System Improvements

Develop integrated and community-based Watershed Management Plans for each of the District's watersheds and identify at-risk watersheds for priority action.

- Restore watercourses and ditches to their proper functioning condition including their potential re-alignment, re-establishment of floodplain benches and revegetation to emulate natural conditions.

Consider integrated drainage and watercourse improvement projects (e.g. constructed and managed wetlands) that demonstrate multiple benefits such as improved flow hydraulics, protection of agricultural lands from flooding, improved water quality, wildlife habitat, fish enhancement and First Nations cultural practises.

3. Agency Advocacy and Coordination

Advocate and cooperate with other agencies and levels of government to safeguard and restore healthy watersheds.

- Confirm the District's commitment to further develop the cooperative relationship with Tsartlip and Tsawout First Nations as partners in shared watersheds.
- Advocate with the Ministry of Agriculture to complete Best Management Practices for farming next to watercourses.
- Coordinate efforts and approvals as required from the Agricultural Land Commission to construct integrated stormwater management facilities in the Agricultural Land Reserve.
- Negotiate with the Ministry of Transportation to eliminate salt contamination from road runoff.
- Work with, and seek assistance from, Capital Regional District and Ministry of Environment technical staff to monitor and enforce water quality regulations.
- Liaise with the Ministry of Environment to ensure that water license applications and renewals are consistent with this policy.
- Establish agreement with the Ministry of Agriculture and Lands and the Agricultural Land Commission respecting the conditions, if any, under which applications for berming or dyking of watercourses / ditches might be considered.

4. Outreach and Education

Conduct outreach and education programs to engage the entire community and all ages in safeguarding and restoring healthy watersheds, for example:

- A yellow fish road program.
- A school ground rain garden demonstration project.
- A topographic display map of watersheds for display at the Municipal Hall and regular referencing of the District watersheds.
- Distribution of watercourse and stormwater management promotional and information material through brochures, website and telephone information line.
- Liaise regularly and provide information and support to groups such as Contractor and Industry Associations, Chamber of Commerce, Vancouver Island Health Authority and the School Board.

5. Community Participation

Establish a terms of reference for, and foster community involvement in, a "Healthy Watersheds" Advisory Group that is empowered to act both as an advisory committee to Council and coordinator of volunteer activities to:

- Advise Council on stormwater management matters that Council refers to the group.
- Oversee and direct on-going flow monitoring stations.
- Present annual Protection of Water Resource awards to recognize deserving stormwater management projects and contributors.
- Coordinate watercourse re-vegetation projects.

Note: Community groups that advise Council and undertake volunteer projects demand the dedication of substantial staff resources to serve their information, oversight, administrative and coordination needs. The involvement of volunteers in construction related projects is particularly onerous for staff where issues of liability, insurance, expertise, safety and project planning/scheduling arise. Volunteer groups are encouraged to be well managed and funded with a dedicated and experienced coordinator for liaison with District staff

6. District Leadership

Establish the District of Central Saanich and its staff and administration as leaders and champions of innovation, education and action for practical, affordable stormwater solutions such as:

- The retrofitting of a District facility (E.g., Municipal and Fire Hall complex) as an example of "zero net runoff."
- Train staff in stormwater Best Management Practices, set the example in best practices in ditch maintenance and erosion control measures during construction and train staff to assist home owners in small scale infiltration systems.
- Encourage all staff to be proactive educators and champions of integrated stormwater management by removing municipal barriers and promoting best management practices.
- Support a proactive bylaw compliance strategy that includes education, outreach, proactive inspection and incentives in addition to traditional enforcement based on complaint.

7. Resources and Priorities

Develop funding strategies, set timelines and establish priorities for healthy watercourse projects and initiatives to:

- Encourage and support community non-profit organizations to access funding programs.
- Ensure that the District's maintenance, repair and replacement programs incorporate modifications for water resource protection.

8. Evaluation and Continuance / Measuring Success

Monitor and evaluate all stormwater management initiatives and develop a regular reporting structure for measuring the District's success in protecting its water resources.

Density Bonus, Density Transfer and Lot Averaging Discussion

This report recommends a number of drainage and watercourses improvement projects, including the “re-construction” and management of wetlands in Maber Flats and the Martindale Valley. The constructed wetlands are considered to provide multiple benefits such as protection of agricultural lands from flooding (resulting in a net benefit to agricultural production) together with improved flow hydraulics, water quality, wildlife habitat, fish enhancement and First Nations cultural use. These projects are recommended in response to a growing issue of seasonal flooding of agricultural lands. Spring and fall flooding has been increasing in scale, frequency and duration over time with associated negative agricultural impacts, loss of farm income, growing frustration levels and more recently, reference to potential legal action involving the District. This is not the first time this issue has been addressed. Its resolution has evaded previous recommendations (Dayton and Knight - 1994 and Delcan - 2003). At this time there is a growing sense of urgency and mounting expectation that a solution be reached and implemented.

This ISMP has looked for and evaluated potential alternative solutions for this issue. It has conducted thorough analysis of the problem and consulted with all potential contributors including government and agency representatives, farmers, stream-keepers, community members and drainage experts. In the end, there are no recommended alternative solutions nor a series of other actions or source control methods that can resolve the problem. The need for the proposed managed wetlands is consistent with the findings of previous studies.

There appears to be general consensus amongst all stakeholders that the proposed wetlands are a viable solution.

The challenges for this proposal relate to implementation. The following key implementation items include:

- ALC Approval – requires the support of the local farming community, together with District support and a demonstrated net benefit to farming,
- Land Acquisition – the proposed wetlands are on privately held farmland (the locations are determined by existing topography) and although there may be some benefits to the individual land owner, there is a loss of farmland on the individual property that provides benefit to other farmland and the District in general.
- Project Funding – The Maber Flats project cost estimate is $2 - 5 million and the Martindale Valley project cost estimate is $0.5 – 2 million. Although there is potential for other sources of funding, it is anticipated that the bulk of funding will fall to the District.

There is also consensus that the funding challenges of these projects may prevent them from moving forward. Discussions with farm owners, farming representatives and District Engineering staff about the constructed wetland projects have led to speculation and proposals concerning ways to acquire land and help fund the projects thorough some form of planning and land use approvals. These discussions range from concepts of lot size averaging and density transfer to density bonuses. The purpose of this section of the report is to review the potential to employ innovative planning tools to assist in land acquisition and project funding.

The following is a brief description and summary of the characteristics of these planning tools.

Density Bonus: The density bonus provisions of the Local Government Act (often referenced as amenity zoning) allow local governments to establish base density regulations for a zone and to further establish a greater density that is authorized if the land owner conserves or provides an amenity to the municipality. An amenity is broadly defined and it may, in this instance, include land, physical improvements to land or cash payment to a reserve fund to be spent on the designated amenity. Amenity zoning is typically employed on a site specific zoning basis; for example a property owner might apply for rezoning of their lands offering to provide an amenity to the District in exchange for increased development rights on their property. Amenity zoning:

- helps finance community amenities (needs);
- is increasingly used by many local governments to help finance their services;
- can have a negative connotation of buying development rights; and
- the financial value of the amenity and the increased land value resulting from the rezoning must be deemed transparent and objective – by third party professionals.

Where further subdivision of agricultural lands is not supported, amenity zoning in agricultural lands is not feasible without introducing a means to transfer the increased density to an acceptable location.

Density Transfer: Density transfer schemes move development potential (usually a potential residential unit) from one property to another property located in the same jurisdiction. These schemes are generally designed to encourage the movement of density from an area where additional development is not preferred (a donor area) to areas where additional density is more acceptable (a receiver area). A donor area might be an environmentally sensitive, agriculture or unserviced area whereas a donor area might be a serviced or village area. Density transfer schemes:

- support “smart growth” principles;
- are voluntary programs that may not be taken up; and
- are density neutral;

Receiving areas must be designated in appropriate areas with additional density developed in a manner sensitive to intensification concerns.

Lot Averaging: Lot averaging is a further planning method that has been referenced in this discussion but is only mentioned briefly due to its lack of application in agricultural areas in Central Saanich. Lot averaging specifies a minimum average lot size for subdivision calculation and allows a smaller size for individual lots thereby allowing the clustering of smaller residential lots leaving a large remaining lot. It is effective in protecting environmental features where there is potential for land subdivision. In the Central Saanich agricultural context where further subdivision is not supported it would appear to have no application. It is understood that there are some subdivided parcels without frontage on a constructed road in some agricultural areas of Central Saanich however it is the understood position of the District and the Agricultural Land Commission that road construction in the ALR, boundary adjustments or re-subdivision of these lots is not supported.

Finally, consideration of the use of these planning tools must be within the context of the District’s Official Community Plan. The existing land use and policy context in Central Saanich appears to include a number of challenges to the conventional use of these methods. The key policies related to these planning tools include:

- a gradual and paced growth rate (70 residential units per year);
- no further subdivision of agricultural lands – increase minimum lot size to 20 Ha.; and
- all additional housing to be located within the urban containment boundary – residential/ commercial mix encouraged in village areas.

Central Saanich has the authority to use the planning tools described above at their discretion. The brief review presented here suggests that these tools are not readily or easily applied in the current planning context of Central Saanich. Their use to assist in the implementation of constructed wetlands in agricultural areas would appear to involve a potentially complex combination of density bonus and density transfer or amenity zoning cash contributions. An evaluation of such schemes is beyond the scope of this project. In any case, the use of these tools requires approval by Council and incorporation into the District's Official Community Plan. The OCP would also need to include policy and detailed guidance as to how these tools would be employed within the local context of Central Saanich. The District has just completed a review of the OCP and these planning tools are not identified in the new OCP as appropriate tools for implementation of the plan.

Appendix 18 provides some local examples of "Green Stormwater Infrastructure" projects, where policy tools such as the above have been used to simultaneously meet high ecological standards and enhance project economics.

Regulatory Bylaws

Source control regulation is a key implementation tool to achieve the District's integrated stormwater management objectives. The purpose of this section is to review the legislative tools and opportunities available to the District and recommend methods to introduce new source control regulations.

Examples of stormwater management bylaws from trend-setting municipal jurisdictions in British Columbia are included in Appendix 16.

Legislative Options for Source Control Regulation

The District has several alternative legislative tools that may be used to implement the ISMP recommendations.

1. Development Permit Area Requirements and Guidelines (Sec. 919 of the Local Government Act)
   - Applies only to new development that is located in a development permit area.
   - Included in the revised OCP (Residential Multi-family and Commercial Mixed-use DPA).
   - Development Permits may include maintenance requirements and notice of a Development Permit may be registered on title.
   - Potential impact may be limited given the development densities conferred in the Land Use Bylaw.

2. Land Use Bylaw - Runoff Control Requirements (Section 907 of the LGA)
   - Not currently used.
   - Applies only to new impervious materials.
   - Likely to create legal non-conforming properties.
   - Provides limited discretion (E.g., development variance permits required to vary regulations).
3. Subdivision Servicing Requirements – (Section 938 of the LGA)
   - For new land subdivision only.
   - Most effective in stormwater quantity regulation, less for water quality.
4. Municipal services, including storm drainage, (Section 8(3)(a) of the Community Charter)
   - Potential for broad application of stormwater quantity regulation both during and after construction.
5. Protection of the Natural Environment, (Section 8(3)(j) of the Community Charter)
   - Existing Bylaw No. 1237 – Protection of Watercourses, Ditches and Drains.
   - Potential for broad application for stormwater quality during and after construction.
   - May apply to new and existing development.
6. Business Regulation, manufacturers and processors to dispose of the waste from their plants, (Section 59(1)(c) of the Community Charter)
   - Existing Bylaw No. 1237 – Protection of Watercourses, Ditches and Drains.
   - May regulate existing businesses.
   - May not enable regulation of stormwater.

The current regulatory structure in Central Saanich divides stormwater regulation amongst three existing bylaws and a fourth bylaw; Surface Water Runoff Bylaw, is proposed. It is possible that stormwater regulation for erosion and sediment control measures during construction may be separately regulated in the future.

Single Comprehensive Bylaw

The District has the option of adopting a series of bylaws, each distinguished by its enabling legislation, or a single bylaw that recites the various enabling legislation. The advantages of a single bylaw are:

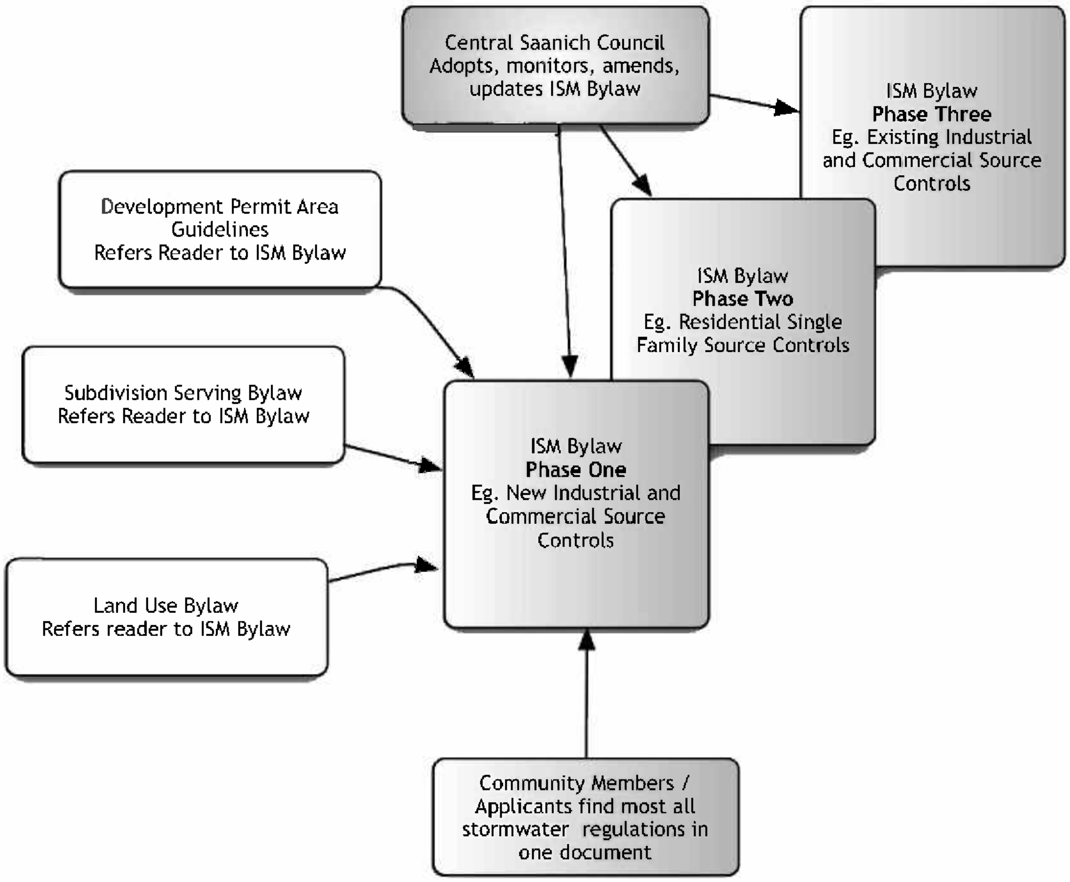
- more convenient, user-friendly and efficient for readers;
- more easily referenced;
- easier for staff to administer;
- facilitates amendments to a single, rather than multiple bylaws;
- avoids duplication of items such as definitions and standard bylaw provisions; and
- reduces potential confusion or oversight through reference to the incorrect bylaw.

Consideration should be given to a single comprehensive bylaw (perhaps titled an Integrated Stormwater Management / ISM Bylaw) containing all regulations and guidelines pertaining to storm water management – stormwater quantity, stormwater quality, erosion and sediment control measures during construction and the maintenance of stormwater management facilities. Related bylaws such as the Development Permit Areas Guidelines and the Subdivision Servicing Regulations would set out their general requirements and make reference to required compliance with the ISM Bylaw. The design, construction and maintenance requirements of the ISM Bylaw may be inserted into development permits and servicing agreements.

An Incremental Approach to New Regulation

The introduction of new regulatory requirements is most successful when managed as a change process. Community members and property owners need to gain an understanding of why change is required, build consensus around the nature of the change, establish a common vision of the new regulatory environment, abandon old methods and adopt new ones. Successful compliance with new regulation is largely dependent upon community outreach, communication and education programs. The District may wish to consider an incremental approach to the implementation of ISMP objectives. An incremental approach (see Figure WW below) builds on successes, allows time for community outreach and education and is sensitive to the limited resources of the District. For example, the first phase of an ISM Bylaw might focus on known problem areas and land uses such as the Keating Industrial Park. This first phase might focus on developing staff expertise and experience in administering new regulations. A later phase might introduce regulation for single and two-family residential properties and a final phase might introduce codes of practice for various existing businesses.

Figure WW Incremental Regulatory Approach



Regulatory Amendment Recommendations

Development Permit Areas – OCP Bylaw No. 1600

1. Incorporate the new stormwater management guidelines from the Residential Multi-family and Commercial Mixed-use Development Permit Areas, Subsections 11.5.15 (g), (n) and (o) into the following Development Permit Areas,

- Light Industrial / Arterial Commercial
- Brentwood Bay and Moodyville Commercial Mixed Use
- Tourist Commercial

- Consider re-ordering the subsections in a sequential manner to be followed by the recommended guideline below

2. Add the following guideline to the Development Permit Area guidelines listed above;

a) Stormwater discharge from the development shall be designed, constructed and maintained in accordance with the requirements of the District's Integrated Stormwater Management (ISM) Bylaw including provisions for quantity and quality control, erosion and sediment control measures during construction and the on-going maintenance of stormwater management facilities. The property owner's professional engineer shall be required to certify to the District that all requirements of the ISM Bylaw have been met.

The following are sample clauses for insertion in Development and Subdivision Agreements.

Stormwater Management: Prior to and as a condition precedent to the issuance of a building permit, the Owner's professional engineer shall submit to, and have accepted by the District, a stormwater management study, including drawings, specifications and recommendations for stormwater management facilities that are in accordance with the District's ISM Bylaw. The study shall maximize stormwater retention, natural infiltration and ensure that the post-development stormwater discharge from the development does not exceed the discharge occurring in the pre-development natural vegetated condition of the lands. The Owner's consulting professional engineer shall conduct field review services during construction and, upon completion of the works, shall certify to the District that all stormwater management works and facilities have been constructed in accordance with the accepted study, specifications, drawings and recommendations. The Owner shall maintain the stormwater management facilities so that they are functional as designed.

Erosion and Sediment Control Measures During Construction: Prior to, and as a condition precedent to the issuance of a building permit, the Owner's professional engineer shall submit to, and have accepted by the District, an erosion and sediment control plan, including drawings, specifications and recommendations for the management of erosion and sediment before, during and after construction in accordance with the District's ISM Bylaw and including measures to be put in place prior to the commencement of any construction. Prior to the earlier of; any land disturbance, the commencement of construction, or the issuance of a building permit, the Owner's professional engineer shall certify to the District that the recommended erosion and sediment control measures have been installed in accordance with the recommendations of the accepted report. The Owner's professional engineer shall provide continued field review services during construction and, upon completion of the works, shall certify to the District that all erosion and sediment control works and measures have been constructed and maintained in accordance the accepted study, specifications, drawings and recommendations. Throughout the construction period, the Owner shall maintain all erosion and sediment control measures so that they are functional as designed.

(Note: the final wording of clauses for insertion in development permits and subdivision agreements should be reviewed by District legal counsel for compatibility with Central Saanich documents)

Land Use Bylaw No. 1309

3. Consider introducing a land use regulation to set a maximum percentage lot coverage by impervious materials in the single and two family residential zones. The maximum percentage of impervious materials may vary by zone and by area within the District. Initially this regulation might be introduced in areas where soil infiltration conditions are most favourable and peak flow reduction /natural infiltration is most needed. It is recognized that the introduction of such a regulation will likely result in a legal non-conforming status of some existing properties that may exceed the new standard. This situation may be partially overcome by including a "deemed to conform" clause in the bylaw. For example; *Where any land now subject to the following regulation was in compliance with the applicable regulations in force and effect on (date of bylaw adoption), but would not be in compliance with the following impervious materials regulation, that land, building or structure is hereby deemed to be in compliance with the following regulation, so long as the area of impervious materials on the land does is not increased from that which existed on (date of bylaw adoption).*

Compliance with this regulation will be assisted through plan review at building permit stage, however enforcement of paving installation will rely more on voluntary compliance as permits are not required for paving.

A component of an impervious materials regulation is the definition of those paving materials considered pervious and impervious. Paving systems that are generally described as being porous include inter-locking paving stones, concrete grid pavers, perforated concrete grids, porous concrete and compacted gravel. These surfaces however, are prone to clogging by suspended solids and will lose their porosity in areas that receive significant amounts of sediment, including mud tracked onto the surfaces during wet weather and sand or cinders used in snow conditions. Long-term performance of pervious paving is difficult to achieve and for the purpose of this proposed regulation the District may wish to define all paved areas and paving systems for vehicular use as impervious.

Table II below indicates the recommended maximum impervious materials for residential zoning.

Table II Recommended Maximum Impervious Materials – Residential Zones

	Single and Two Family Residential Lot Size	Recommended Maximum Percent Coverage by Impervious Materials	Comparison to Existing Zoning		
			Zone	Minimum Lot Sizes Regulations	Maximum Lot Coverage Regulations
1.	Less than 1,000 sq.m.	50%	R-1Z	400 m^2	40%
			R-1S	480 sq.m.	30%
			R-1M	660 sq.m.	30%
			R-2	660 sq.m.	30%
			R-1A	780 sq.m.	30%
			R-1	780 sq.m.	30%
2.	1,000 - 4,000 sq.m.	30%	RE-5	0.14 Ha. (1,400 sq.m.)	20%
			RE-4	0.4 Ha. (4,000 sq.m.)	5%
3.	4,001 – 8,000 sq.m.	15%	RE-2	0.8 Ha. (8,000 sq.m.	5%
4.	Greater than 8,000 sq.m.	10%	RE-1	4 Ha. (40,000 sq. m.)	2%
			RE-3	2 Ha. (20,000 sq.m.)	5%

The District may consider a supplementary regulation to exempt from the above proposed regulations, any impervious materials that do not direct stormwater to the District's drainage system. In this respect the proposed regulations might apply only to "connected" impervious materials. This regulatory approach suggests a possible reduction in the maximum impervious material percentages listed above as a means to encourage property owners to adopt stormwater infiltration facilities such as rain gardens, bio-swales and rock pits. On the other hand, this supplementary regulation would likely add complexity to the administration of the bylaw as staff would have to verify the direction of stormwater surface flows, the construction of stormwater infiltration facilities and the stormwater connection. Given the potential ease of stormwater redirection/overflow, on-going compliance may be difficult to confirm. In addition, the District may wish to seek legal counsel respecting a bylaw advisory to property owners respecting liability for private infiltration systems and indemnification of the District.

4. Consider introducing a land use regulation to set a maximum percentage lot coverage by impervious materials in the multi-family, commercial, industrial and institutional zones (see Table JJ below). The discussion above applies to this recommendation.

Table JJ Recommended Maximum Impervious Materials – All Other Zones

	Zoning	Recommended Maximum Percent Coverage by Impervious Materials	Comparison to Existing Zoning Maximum Lot Coverage
Multi-family	RM-1G	75%	33%
	RM-2		35%
	RP-1		40%
	RM-1	65%	25%
Commercial	C-1	85%	50%
	C-2		40%
	C-3		40%
	C-5		40%
	C-6		40%
	C-6A		40%
	C-4	75%	15%
	CR-1		40%
	C-8	25%	n/a
Industrial	I-1	85%	60%
	CD-1		60%
	I-2		60%
Institutional	P-1	75%	40%
	P-1A		40%
	P-2		
	P-3		40%

5. Amend Section 42(5) of the bylaw to recognize that off-street parking areas should be graded and drained to direct surface flows to storm water infiltration and management facilities. The intent of this recommendation is to preclude any potential interpretation of the existing regulation that storm water is to be immediately disposed to the District's drainage system.

For example;

(5) Off-street parking areas for more than 4 vehicles shall be surfaced with asphalt, concrete or similar pavement or gravel or similar water permeable material so as to provide a durable surface and shall be graded to eliminate sheet flow of water onto sidewalks, public rights-of-way or abutting properties.

6. Schedule 4 of the Land Use Bylaw contains the Works and Services General Provisions, Engineering Specifications and Standard Drawings. Section 3 deals with the design and installation of storm drains and subsection 3.02 provides discretion to the Municipal Engineer to require that “zero increase in run-off” to be incorporated into the design of storm drains. The District should consider replacing this discretionary requirement with a non-discretionary regulation.

Other sections of this document deal with standards for roadway, curb and gutter and landscaped areas in a conventional engineered manner permitting no departure from the specifications except with written approval of the District. The Municipal Service Standards should be amended to modify those standards that discourage natural infiltration of storm water.

Examples of current standards considered potential barriers to innovation in storm water management are included in Table KK below.

Table KK Examples of Potential Barriers to Innovation in Storm Water Management

Example: Existing Municipal Service Standards	Potential Alternatives
• curb and gutter requirements for water control on local urban and collector roads	• allow road drainage to flow into roadside infiltration swales
• asphalt paved roads and concrete sidewalks	• allow alternative porous materials and narrower road widths
• cul-de-sac islands sloped for drainage with 6 mil black plastic under plant material	• allow cul-de-sac islands to be depressions that receive road drainage and maximize infiltration without plastic covers in landscaped areas
• maximum swale depth of .45 metre	• reduce swale gradients for optimum infiltration and allow greater depths before requiring culverts

7. Consider adding an “absorbent landscaping” policy where a minimum depth of 300mm topsoil or amended organic soil is to be provided in grassed areas, with a depth of 450mm for shrubs. Generally, the absorbent soil layer should be deep enough to store the 50.4 mm 2 year storm (the Mean Annual Rainfall). Assuming that the soil used for the absorbent surface soil layer can hold about 20% of its volume, a soil depth of at least 255 mm is indicated. More information on Absorbent Landscaping in contained in Appendix 1.

Other District Bylaws

1. **Protection of Natural Watercourses Bylaw No. 1237**
   - To be replaced with an ISM Bylaw

2. **Erosion Control and Tree Cutting Bylaw No. 993**

   This existing bylaw is complimentary to SWM objectives as it requires the retention of tree cover in designated areas considered subject to flooding, erosion and land slip which in turn contributes to healthy watercourses.
   - No change recommended

3. **Soil Removal and Deposit Bylaw No. 1544**

   The regulations of this existing bylaw compliment SWM objectives by prohibiting works that would foul, pollute, obstruct, damage of destroy any watercourse, requiring that all watercourses be kept free of silt, clay, sand, rubble, debris or any other thing arising from the work; and not allowing watercourses to be altered or diverted without permission.
   - No change recommended

4. **Tree Protection Bylaw No. 1595**
   - Regulations compliment SWM objectives
   - No change recommended

5. **Watercourses and the Sea Bylaw No. 1187**
   - No change recommended

6. **CRD Model Bylaw to Regulate the Discharge of Waste into Storm Sewers and Watercourses**
   - Incorporate into new ISM Bylaw.
   - Phase in codes of practice to regulate existing properties.

7. **Proposed Surface Water Runoff Bylaw No. 1606, 2008**
   - Incorporate stormwater quantity source controls into the ISM Bylaw.

9. ISMP IMPLEMENTATION

9.1 Policy

Strategies for Implementation and Evaluation

The following flow chart illustrates the range of implementation strategies and proposed process for implementation. The listed strategies range from “soft,” voluntary methods on the left side of the flow chart to the “harder,” regulatory methods shown on the right.

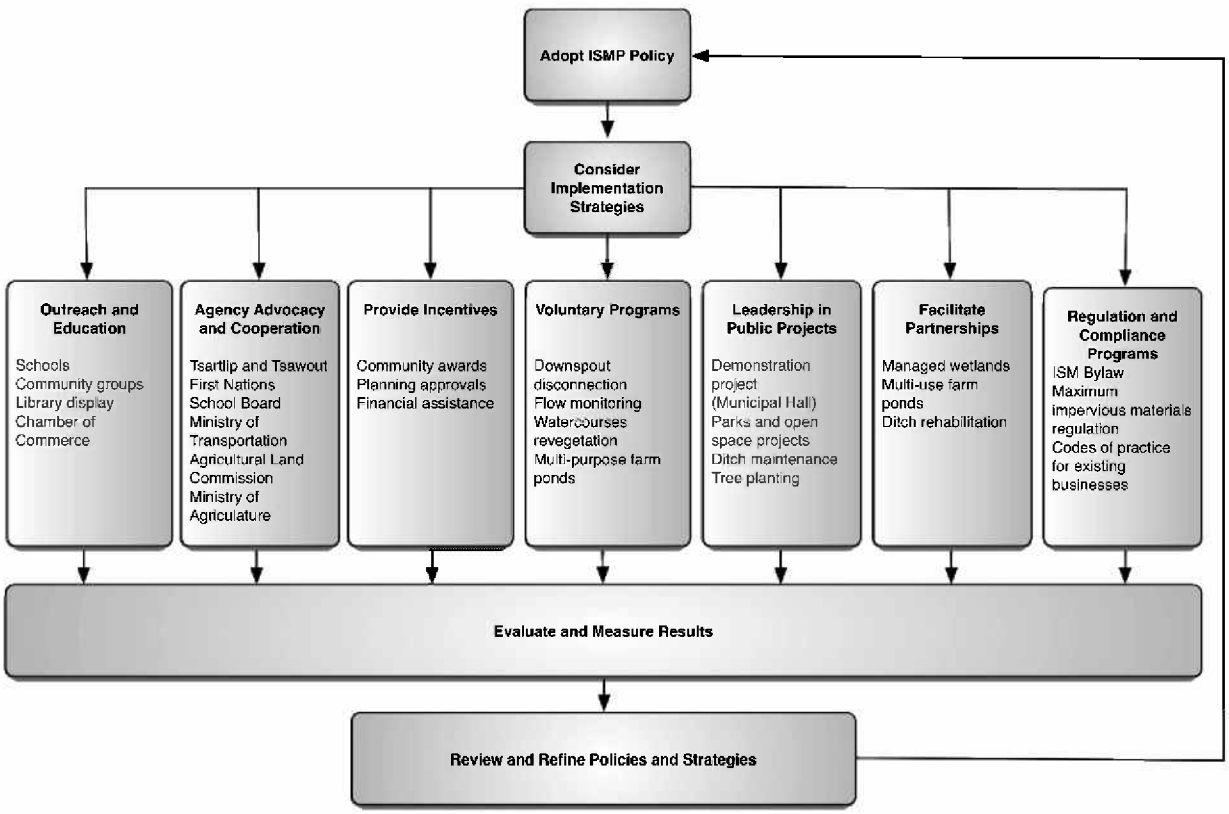


Figure XX Strategies and Proposed Process for Implementation

9.2 Implementation Priorities and Plan

The Implementation Plan on the next several pages has been prepared to summarize how the recommendations of this report could be implemented on a prioritized basis. The table includes both Programs and Projects and the associated timelines range from 1 year to 10+ years.

This Table contains substantial detail on programs and projects, however, it must be regarded as a guideline and roadmap that will need to be regularly updated and amended as the District gains experience with the ISMP process. The first substantial revision will likely occur once the HWC is constituted and underway.

Here is a guide to the Plan:

Category: The category of Recommendation per Section 8.2

Recommendation: The specific recommendation of program, policy or project

Details: Specifics of the recommendation and what is to be implemented

Benefits: How the recommendation achieves ISMP objectives

Timing: An approximate indication of the time interval within which major portions of the recommendation could be implemented. Some recommendations are readily implemented, others will take substantial periods of time for preparation. Where possible, projects have been broken into phases and timing has been assigned to each phase. The categories are as follows:

a. Immediate – Within the first year (2010)

b. Short Term – Within Years 2 – 4

c. Medium Term - Within Years 5 – 10

d. Long Term - Beyond Year 10

The Plan attempts to strike a reasonable balance between the urgency to implement ISMP objectives and the reality that resources are limited. Considering that the rainwater management issues in Central Saanich developed over many decades, they cannot be expected to be resolved quickly. Some of the more complex projects and programs are naturally suited to an incremental, collaborative approach which will take some time to fully implement correctly. A hasty program of major physical works is likely to be suboptimal and have unintended consequences. Fortunately, some of the complex issues (such as drainage in Maber Flats and Martindale Valley) can be approached incrementally, and the Plan breaks these projects into more manageable pieces, with partial benefits accruing in the short term.

The timing of individual projects and programs is indicative only. Funding availability, District resource levels, technical findings from further investigations, levels of community interest and concern and benefits from development activity are all variables that can affect the timing.

Priority: A qualitative indication of the impact of the recommendation, principally the magnitude of the benefits to achieving ISMP objectives. Also considers the resources required and how readily the recommendation can be implemented.

Resources and Funding Required: Funding, in-kind contributions, permissions, compensations and other resources required to accomplish the task.

Staff Required: Approximate indication of the scale of effort required from staff to accomplish the recommendations. It is assumed that major projects will require comprehensive support from consulting engineers, with staff providing oversight. It is estimated that in the short term the District can make reasonable progress by dedicating 1/2 full time equivalent experienced engineering tech or junior engineer as Rainwater Management (or Stormwater) Coordinator and initiating a continuous rotation (one full time equivalent) of Co-op students (Camosun Civil Engineering, Camosun Environmental Management or UVic Sciences). These two staff would provide direction, structure and support to HWC activities and provide services in support of a wide variety of ISMP initiatives. They would be supervised by senior staff in the Engineering Department but liaise closely with other Departments. The annual incremental cost of the staff addition, associated training and incidental expenses is expected to be approximately $85,000/yr.

Funding Opportunities: Identification of funding programs that are *prima facie* the best fit with the given projects. It should be noted that funding programs are constantly changing and budgets appear and disappear without notice. The Rainwater Management coordinator will need to coordinate with other Staff to stay current with the changing funding landscape and maintain regular contact with key funding contacts. For many of the identified projects, funding could be provided by private sector developers in return for the types of planning incentives described in Section 8.3, however these are not identified here since they are highly case specific.

9.2.1 Progress in Implementation

The District has already taken some significant steps to implement the recommendations of the ISMP, including:

a) Implemented new ditch maintenance procedures according to Best Management Practices
b) Initiated work in collaboration with the District of Sannich to improve drainage conditions in the vicinity of the Dooley Road crossing
c) Removed obstructions and debris in Graham Creek from Stelly's Cross Road to Centennial Park
d) Drafted a Surface Water Runoff Bylaw

Table LL Implementation Plan

Implementation Category:	**Page**
Advocacy Coordination and Education	193
Best Management Practices	194
Specific Rainwater Management Projects	195
Ecological Restoration	199
District Resources and Practices	200
Knowledge Devepopment and Monitoring	201

Implementation Plan - Advocacy Coordination and Education

Item	Recommendations	Details	Benefits	Timing	Priority	Resources Required / Cost	Staff Required	Funding Opportunities
1	Establish a "Healthy Watersheds" Committee (HWC)	- Create committee with members from first nations, government, local ngos, farmers, stakeholders - 12-16 members ideal - Tracks progress on rainwater initiatives - Assist with funding applications - Champion progressive rainwater management in the district - Assist with public outreach and field work	- Ensures stakeholders have a key role in ISMP implementation - Provide leverage for a variety of Initiatives	Immediate	Very High - Tremendous potential benefit for minimal cost	- Advertising cost (if required to find members) - Use of District Meeting Facilities	- Setup by stormwater management group (SMG) - SMG representative time for meetings - Time to book and arrange for meeting facility - Staff time to coordinate and oversee cmmittee activities - Staff time for HWC related activities: - 0.25 fte stormwater coordinator - 0.5 fte co-op student * see District Resources and Practices #1 (DRP1) for aggregate staff requirements	- EcoAction community funding program
2	Proclaim District intention to develop cooperative relationships in rainwater management	- Place statement of intention on District Website - Continued Public education and outreach program will emphasize intentions	- Sends message that District: - recognizes importance of rainwater management and flooding issues - is committed to resolve issues through collaboration	Immediate	High - Readily accomplished - Sets the context for implementation	- Virtually no cost - District website	- Staff time to develop and post intention statement on website - Staff hours minor	
3	Develop Community Stormwater Education Program	- Development of a comprehensive outreach program - Website Development - HWC participation at events - HWC sponsored events (ie stream cleanup) - Yellow Fish Road Stormwater marking program - May be dovetailed with CRD efforts	- Demonstrates importance of stormwater management to District - Informs public about: - rainwater management in general - the connection between certain activities and creek health - builds public support for ISMP recommendations - Demonstrates creek health is everyone's responsibility	Immediate	Moderate to High - Long term effort required before results likely - Can be implemented gradually	- HWC to help identify outreach goals and schedule - HWC to help organize outreach programs - staff time to collaborate with CRD stormwater outreach programs/material - staff time to organize and attend events - Creation of a stormwater Page on district Website	- Facilitate Yellow Fish Road Project (setup, process applications, provide equipment) - Programming of Stormwater Page on District Website - Staff and program hours included in HWC	- EcoAction Community Funding Program - British Columbia Transmission Corporation

Note: Quoted costs are order of magnitude only

Implementation Plan - Best Management Practices

Item	Recommendations	Details	Benefits	Timing	Priority	Resources Required / Cost	Staff Required	Funding Opportunities
1	Provide a BMP summary and relevant links on the District website	- Makes Information on BMPs readily available to residents	- Passive public outreach and education - Low cost - Emphasizes District's intention to address stormwater issues - Sets the context for implementation	Short Term	High - Readily accomplished	- Low cost - Information is provided digitally as part of this ISMP - Staff time to organize and code the webpage	- Staff time to organize Stormwater Page on District website (minor)	
2	Support a voluntary "downspout disconnection" program	- Voluntary adoption at residential, commerical, institutional, and industrial sites - Disconnection of downspouts from storm sewer system - discharge to ground, rock pit, rainbarrel - Development of guidelines with consulting engineer - District and HWC to provide guidance material - District subsidy or incentive (optional) - Could be HWC initiative supervised and directed by Staff	- Can have a significant positive impact on peak flows and groundwater recharge - Reductions in peak flow and runoff volume are nearly proportional to the rate of adoption	Short Term	High	- Assistance of geotechnical engineer to write suitability guidelines (~$15,000) - HWC to develop guidelines and outreach materials - HWC to implement Public outreach program and hold workshops - Advertising costs (optional)	- Engineering staff to retain professional services - Development of downspout disconnection website - Facility space for workshops (optional) - Co-op students to assist in public outreach - Staff time: See DRP #1	- Building Canada Fund - EcoAction Community Funding Program - British Columbia Transmission Corporation
3	Encourage implementation of biofiltration treatment BMPs (Private Land)	- Treat runoff from parking lots, private roads and industrial areas - Infiltrate through raingardens and bioretention areas - Public property BMPs detailed below - Could be HWC inititative supervised and directed by staff - Demonstration projects are key	- Provides bioinfiltration treatment - Can dramatically improve quality of runoff entering creeks - Provides some flow attenuation	Short Term	Moderate - Implementation by HWC - Improved response expected after demonstration projects in place	- Minimal direct costs - HWC to provide educational materials and promotion - HWC to provide guidance and advice	- Staff time: See DRP #1	- Building Canada Fund - EcoAction community funding program - British Columbia Transmission Corporation
4	Encourage adoption of agricultural BMPs	- HWC outreach to farming interests to develop strategies - Publish agricultural BMPs on website - Identify potential for farm pond demonstration projects	- District is about 70% agricultural - Farmers actively interested in stormwater management issues - Issues with erosion and sediment load due to lack of BMP adoption - Results in improved Creek health and water quality	Short Term	Moderate	- HWC meeting time to consult with farmers - HWC/District time to produce outreach materials - Possibly HWC time to knock on doors (optional) - HWC outreach at fairs incl. materials and space (optional)	- Staff time to add agricultural BMP to District website (minor)	- Agriculture Environmental Initiatives Funds - Greencover Canada - EcoAction Community Funding Program - British Columbia Transmission Corporation
4a	Encourage the use of filter strips along the edges of agricultural fields	- Encourage farmers to add a buffer zone to areas around Creeks and ditches - May create a loss of productive land - Compensation may be required - To be implemented by farmers on an individual basis	- Same as agricultural BMPs above - Creates an "expanded riparian area" - Increased water retention - Enhanced habitat and bio-diversity	Medium Term	Moderate -Implementation will be gradual due to voluntary participation - Requires education on the benefits	- District/HWC might supply vegetation - HWC to assist with planning and field work	- Staff HWC time - Possible staff consultation with ALC	- Agriculture Environmental Initiatives Funds - Ducks Unlimited - National farm Stewardship program - Greencover Canada
5	Implement rainfall capture program (in concert with Demonstration Projects)	- Encourage implementation of rainfall capture throughout District - A primary focus of the HWC - Requires policy changes for greatest implementation - Includes encouraging absorbent landscaping	- Increasing Rainfall capture can be implemented on a) District property including roads and right of ways b) residential properties c) commercial and industrial properties d) agricultural properties. - Provides "at source" reduction in peak flows and runoff volumes - Increases groundwater recharge and stream baseflow	Short Term	High - Reductions in peak flow and runoff volume are nearly proportional to the rate of adoption	- Principal costs would be for demonstration projects (detailed below)	- Staff time to support HWC	- Building Canada Fund
6	Encourage Tree Planting and Tree Retention	- Develop program to increase urban tree canopy - Tree planting program on public property - Develop/enforce policies protecting existing trees	- Tree canopy interception can significantly reduce runoff - Reduces urban heat island effect - Increased aesthetic value in neighborhoods	Long Term	Moderate to low - Increase in urban forest has multiple benefits - May be long time before full impact seen	- Costs to subsidize/purchase trees (optional) - Staff time to develop and administer program - HWC to do community tree planting	- Staff time to support HWC	- Greencover Canada - EcoAction Community Funding Program - British Columbia Transmission Corporation

Note Quoted costs are order of magnitude only

Implementation Plan - Specific Rainwater Management Projects

Item	Recommendations		Details	Benefits	Timing	Priority	Resources Required / Cost	Staff Required	Funding Opportunities
1	Keating industrial Area: Source Control	Demonstration Project Infiltration Swale	- Potential Parking Lot candidates (private property): - School District offices - Corner of Butler Crescent and Keating - Northwest corner of Oldfield and Keating - Parking lot at 2220 Keating - Retrofit conventional curb and gutter with an infiltration swale or raingarden	- Provide a practical example of a retrofit within district - Demonstrate the swale/garden's aesthetic appeal - Demonstrate the swale/garden's performance during storms - Reduce volume of runoff - Improve runoff water quality	Short Term	Moderate -Important to establish a catalyst for changes in the industrial areas	- Approx $2,500 - $15,000 depending on the scope - Property owner(s) may contribute portion of the cost - Possible landscape architect/ecologist and geotechnical fees - Contractor and material fees - HWC time to assist with plantings and promotion/tours - Staff time & resources to assist with plantings and construction - May require incentive from District to find volunteer property	- Staff time to coordinate design and construction (1 week)	- Building Canada Fund
2	Keating Industrial Area West: Infiltration Retention BMP	Feasibility and Preliminary Design	- Identify location, configuration, design, and cost - Likely in or near the Hydro ROW adjacent to Kirkpatrick Crescent - Approximately 0.5 ha - Combination infiltration and detention facility - Stream restoration should be considered with the BMP to control erosion	- Provides flow attenuation - Allows for infiltration of smaller storms - Water quality improvement upstream of Maber Flats - Possible mitigation of erosion and sediment load problems at Stephens Brook	Short Term	High - Priority would be reduced by high uptake of source BMP's in the Keating area - protects Maber Flats from water quality impacts	- Approx $30,000 - $50,000 in professional fees, depending on the scope.	- Staff time to retain consultants/contractors	- Building Canada Fund - Infrastructure Planning Grant Program - Green Municipal Fund
		Implementation					-Approx $250,000 - 750,000 depending on specific site circumstances - Excludes the cost of land	- Staff time to supervise (1 week)	- Building Canada Fund
3	Community Demonstration Projects: Rain gardens and Infiltration Swales	Feasibility and Preliminary Design	- Stelly's School and Municipal Precinct ideal locations - Identify location, configuration, design, and cost	- Provides working demonstration of techniques that can work in the District; works through typical challenges and issues - Reduces heat island effect - Replaces heavily paved and bare areas with vegetation - Educational value - Creates socially inviting areas	Short Term	Moderate - Important to establish visible examples in the community	- Could be accomplished by the HWC largely with volunteer support and a small amount of professional assistance	- Staff time on HWC - Staff time to retain consultants/contractors	- Building Canada Fund - Evergreen Foundation - Green Municipal Fund
		Implementation					- Physical costs will vary with each application - Costs may be largely covered by in-kind contributions - Rain Garden Project at Municipal Building could cost $15,000	- Staff time to supervise (1 week)	- Building Canada Fund - Evergreen Foundation - Green Municipal Fund

Implementation Plan - Specific Rainwater Management Projects continued

4	Maber Flats: Integrated Drainage and Watercourse Improvement	Graham Ck at Stelly's - Channel Improvements - Hydraulic and Ecological Design	Defines: - appropriate depth and profile of channel - culvert modifications - control structure - streambed/revegetation design and implementation plan - estimate of costs	- Significantly improves drainage capability for Maber Flats area - Provides potential to meet modified ARDSA criteria - Full benefit constrained until detention facility constructed - Demonstrates District is taking physical action to address drainage concerns of Maber Flats	Immediate	Very High - Maber Flats is a critical agricultural area - An important, concrete step to resolving the complex set of issues related to seasonal indundation	- Approx $65,000 in engineering services - Sufficient survey and hydrology work must be done in the Graham Creek / Maber Flats area to ensure that the channel improvements will be compatible with the extended detention facility (to be built later)	- Staff time to retain consultants/contractors	- Building Canada Fund - Green Municipal Fund
		Graham Ck at Stelly's - Channel Improvements - Implementation			Short Term		- Cost depends on findings of design study (above) - Very roughly $200,000 in excavation services and materials - Very roughly $40,000 in structures - Very roughly $15,000 for plantings - Assume volunteer labour available for planting, monitoring and hand labour	- Staff time to supervise (6 weeks)	- Building Canada Fund - Green Municipal Fund
		Constructed Wetland / Extended detention facility - Feasibility assessment and conceptual design	- 5 ha or more ideal - Consultation in ALC to select appropriate location - Consultation with affected landowner - Survey of elevation, soils, and drainage systems - Determine consolidated calendar of operation - Design of wetland size, general configuration, and costs - Determine financial feasibility	- Fully alleviates spring and fall inundation of Maber Flats farm land - reduces peak flows on Graham / Hagan Creek - provides ecological and recreational benefits - surrounding farmland could come closer to meeting ARDSA drainage guidelines	Short Term	High - exploits the full benefits of the hydraulic improvements (elimination of shoulder season flooding) without adversely impacting Graham Creek through excessive peak flows	- Workplan defined in Section 9.4.2. - Approx $135,000 in professional services	- Staff time to enter into discussion with ALC - Staff/HWC time to find volunteer land owner - Staff time to enter into discussion on concessions with volunteer land owner - Staff time to retain engineering consultant - Approximately 8 weeks staff time	- Agriculture Environmental Initiatives Funds - Greencover Canada - Building Canada Fund - Infrastructure Planning Grant Program - Green Municipal Fund
		Constructed Wetland / Extended detention facility - Preliminary and Detailed Design	- Completion of hydraulic modelling - Detailed layout and cross-sections - Refined cost estimate - Detailed civil, mechanical, and hydraulic design - Preparation of bid package		Medium Term		- Approx $300,000 in professional services	- Approximately 8 weeks staff time	- Agriculture Environmental Initiatives Funds -Greencover Canada - Building Canada Fund - Green Municipal Fund
		Constructed Wetland / Extended detention facility - Implementation	- Construction by selected contractor		Medium Term		- Approx $2 - 5 million for 5 - 10 ha wetland, excluding the cost of land and construction supervision - HWC time to plan public event to celebrate completion	- Staff time to retain contractor (12 weeks)	- Agriculture Environmental Initiatives Funds - Ducks Unlimited - Greencover Canada - Building Canada Fund - Green Municipal Fund

Note Quoted costs are order of magnitude only

Implementation Plan - Specific Rainwater Management Projects continued

Item	Recommendations		Details	Benefits	Timing	Priority	Resources Required / Cost	Staff Required	Funding Opportunities
5	Martindale Valley: Integrated Drainage and Watercourse Improvement	Community Rainfall Capture Program	- Tanner and Keating Ridge Areas - Encourage use of rainbarrels and downspout disconnection - Potential subsidy of rainbarrels - Groundwork completed in conjunction with public education program (see above)	- Provides "at source" reduction in peak flows and runoff volumes - Lower cost/impact means of rainwater management in built up areas - Increases groundwater recharge and stream baseflow - Reductions in peak flow and runoff volume are nearly proportional to the rate of adoption - Most soils in area are highly pervious	Short Term	High - May be implemented gradually - HWC would be a main vehicle for implementation	- Costs largely borne by participants in this voluntary program - Some direct costs would be borne by the District to retrofit existing catch basins as infiltration swales. District costs approx $7000 per instance and 10 - 20 instances.	- Staff time to porivde consultation and support to HWC (see DRP #1)	- Building Canada Fund
		Hydraulic Improvements - Dooley Road area	- Clean out section of McHugh Ditch between Martindale Road and Dooley Road - Modest stream restoration - Deepen and widen culvert at Dooley Road - Consultation with Saanich necessary - Install control structure to regulate flows	- Significantly improves drainage capability for Low-lying porions of Martindale Valley - Provides potential to meet modified ARDSA criteria - Full benefit May be constrained until extended detention facility (below) is operational due to downstream erosion concerns - Demonstrates that the District is taking physical action to address concerns of Martindale property owners	Immediate	Very High - Martindale Valley is a critical agricultural area - this would be an important, concrete step to resolving the complex set of issues related to seasonal indundation	- Estimated cost of $80,000 to replace culvert with an arched CMP one - Additional excavation / stream restoration work north of Dooley and south (in Saanich) will be required	- Staff time to organize and retain contractors - Staff time to enter into discussions with Saanich - Staff time to manage traffic rerouting during construction - Approximately 4 weeks of staff time	- Green Municipal Fund
		Detention Pond / Constructed Wetland: Feasibility and Design	- Consultation in ALC to select appropriate location - Consultation with affected landowner - Survey of elevation, soils, and drainage systems - Determine consolidated calendar of operation - Design of wetland size, general configuration, and costs - Determine financial feasibility	- Reduces peak flow from Tanner / Keating Ridge to Martindale ditch by approx 35% - Combined with hydraulic improvements (see above) will largely eliminate spring and fall inundation of farm land - Reduces peak flows in McHugh ditch and Noble Creek - Improve water quality - Provide ecological and recreational benefits	Medium Term	Moderate - Benefits from the hydraulic improvements will be available without the pond(s), however, pond is required to extract the full benefit - High uptake of rainfall capture will reduce required size of pond	- Approx $100,000 in professional services	- Staff time to enter into discussion with ALC - Staff/HWC time to find volunteer land owner - Staff time to enter into discussion on concessions with volunteer land owner - Staff time to retain engineering consultant - Approximately 2 weeks of staff time	- Agriculture Environmental Initiatives Funds - Greencover Canada - Builidng Canada Fund - Infrastructure Planning Grant Program - Green Municipal Fund
		Detention Pond/ Constructed Wetland: Implementation	- Construction by selected contractor		Long Term		- $0.5 - 2.0 million (0.75 to 1.4 ha facility) - cost depends on the site and scope - Excludes cost of land	- Staff time to retain contractor - Staff time for supervision - Approximately 4 weeks of staff time	- Agriculture Environmental Initiatives Funds - Ducks Unlimited - Greencover Canada - Building Canada Fund - Green Municipal Fund

Note: Quoted costs are order of magnitude only

Implementation Plan - Specific Rainwater Management Projects continued

6	Encourage the development of multi-purpose ponds	Provide guidelines	- Gather modern pond design and construction guidelines - Post information on the District Stormwater Website	- Provides readily usable guidelines and information - Most existing pond capacity is not exploited for rainwater management due to the "fill and overflow" design. - Increases the likelihood of well designed ponds being constructed - Low cost for implementation - Enables stormwater management through use of exisiting ponds with slight change in management - Allows property owners interested in establishing a pond to design one to aid in rainwater management and ecological objectives while maintaining aesthetics	Immediate	High. - District needs more retention - Pond design is critical to maximize rainwater management, agricultural and ecological benefits	- Minimal cost - provide links on the website - material provided in the ISMP report	- Staff time to post materials on website	
		Develop Incentive Program for Farm Ponds	- For new and existing farm ponds - Change of discharge practice to allow for detention in the early winter months - Requires education and incentives				- Develop program, possibly with Ministry of Agriculture - Promote program - Verify and award incentives	- Staff time to consult with Ministry of Agriculture for assistance - May require staff time to provide one-on-one design and funding application assistance - Staff time to develop incentive plan - Staff time to administer incentive plan	- Agriculture Environmental Initiatives Funds - National Farm Stewardship Program
		Develop a program to encourage the establishment of new facilities	- Encourage new ponds, wetlands, detention facilties		Long term	Moderate. - Ponds on agricultural land more significant	- Develop and implement program	- HWC to plan and promote program	- Agriculture Environmental Initiatives Funds - National Farm Stewardship Program
7	Manage water quality Impacts from Pat Bay Highway runoff with MOT	Highway Runoff Quality Improvements	- Valuable farm land in Martindale Valley affected by Pat Bay Highway runoff at and south of Island View Road - Salt for ice control a particular concern - Met with the MOT to discuss on May 4, 2009 - Reconfigure drainage to avoiding inundation of farmland (such as Mitchell Farms) with highway runoff	- Improved control of runoff quality will protect farm yields and crop quality - Improves Creek health	Immediate	High - Serious concern for agriculture in Martindale Valley	- Solutions are complicated - Working with MOTI to establish costs	- Staff time to meet with MOTI - Staff time to implement solutions (unclear at the moment)	- Ministry of Transportation and Infrastructure

Note Quoted costs are order of magnitude only

Implementation Plan - Ecological Restoration

Item	Recommendations		Details	Benefits	Timing	Priority	Resources Required / Cost	Staff Required	Funding Opportunities
1	Develop Creek Restoration Plan		- Develop multi-decade plan for restoring PFC to Creeks	See Section 9.5 in ISMP report for details	Immediate	These reaches are ranked in order of priority. See Section 9.5 in ISMP report for details. The top listed ones would be in the "very high" category.	Costs for stream restoration range from approximately $100/m to $700/m depending on the scope of work required (less with volunteer labour from HWC).	- Staff to supervise	- Building Canada Fund - Green Municipal Fund
2	Implementation of PFC restoration plan (in order of priority)	Hagan Creek Reach 1	- See Section 9.5 in ISMP report for details	Stop headcutting	Short Term		Reach length ~ 131 m, see above		- Building Canada Fund - EcoAction Community Funding Program - British Columbia Transmission Corporation - Green Municipal Fund
		Tetayut Creek Reach 2		route trail away from creek - repair degradation from trail - remove invasive ivy	Short Term		Reach length ~ 100 m, see above		
		Graham Creek Reach 5		Stop erosion due to blocked culvert	Short Term		Reach length ~ 220 m, see above		
		Graham Creek Reach 9		Stop trampling and erosion	Short Term		Reach length ~ 150 m, see above		
		Graham Creek Reach 8		Stop trampling, restore creek profile and flora	Short Term		Reach length ~ 115 m, see above		
		Hagan Creek Reach 5		Halt bank erosion, protect young riparian plants	Short Term		Reach length ~ 600 m, see above		
		Hagan Creek Reach 4		Stop trampling and erosion	Short Term		Reach length ~ 450 m, see above		
		Hagan Creek Reach 7		Halt scour from debris jam, restore flora	Short Term		Reach length ~ 150 m, see above		
		Tetayut Creek Reach 5*		Halt bank erosion and invasive species	Medium Term		Reach length ~ 100 m, see above		
		Tetayut Creek Reach 4*		Halt invasive species	Medium Term		Reach length ~ 100 m, see above		
		Graham Creek Reach 2*		Halt upslope erosion	Medium Term		Reach length ~ 290 m, see above		
		Graham Creek Reach 3*		Correct excessive scout due to velocity	Medium Term		Reach length ~ 280 m, see above		
		Graham Creek Reach 1*		Stop compost leaching, creek contaminantion	Medium Term		Reach length ~ 895 m, see above		
		Tetayut Creek Reach 6*		Control upslope erosion, reduce sediment load	Long Term		Reach length ~ 800 m, see above		
		Graham Creek Reach 7*		Correct channelization in high flow, sediment suspension	Long Term		Reach length ~ 70 m, see above		
		Tetayut Creek Reach 1*		Reduce erosion and sediment transfer	Long Term		Reach length ~ 130 m, see above		
		Tetayut Creek Reach 8*		Halt invasive species	Long Term		Reach length ~ 200 m, see above		
3	Plant riparian vegetation		- Plant riparian vegetation - Creeks, ditches, throughout municipality	- Reduces erosion - Counters invasive species - Improves water quality - Potential significant impact over 10 year period	Short Term	Moderate - more general program than reach restorations	- A seasonal program of $10,000/yr would be significant - Cost mostly associated with plantings - Use of volunteer labour. - HWC and District may wish to look at aquatic plant nursery options	- See HWC details	- Building Canada Fund - EcoAction Community Funding Program - British Columbia Transmission Corporation - Green Municipal Fund

Note: Quoted costs are order of magnitude only

Implementation Plan - District Resources and Practices

Item	Recommendations		Details	Benefits	Timing	Priority	Resources Required / Cost	Staff Required	Funding Opportunities
1	Establish a District Stormwater Management Group		- Comprised of District Staff from various departments - Oversees District responsibilities for stormwater management - Ensures viability and relevance of ISMP - Champions implementation of the ISMP - representative Oversees the Healthy Watersheds committee - Maintains stormwater Pages on the District website - Applies for funding Grants - Includes professional Development training for group	- Ensures viability and relevance of ISMP - Ensures representation of District staff from various departments	Immediate	Very High - formalizes District intention to implement recommendations - should be among the first implementation steps	- Weekly to monthly group meetings - Staff representatives from Planning, Public Works, Engineering - Additional staff from Co-op students - Membership could also be subset of HWC - $2500/yr training costs	- Setup of Healthy Watershed Committee - Representative to Healthy Watershed Committee - One full time equivalent co-op student - Staff time for stormwater management/ISMP activities (including HWC support): - Stormwater Management Coordinator (0.5 fte) - Co-op student (1 fte) - Total Incremental District Cost (2010) for added manpower, training, software and incidentals of $85,000	
2	Train District staff on ISMP recommendations		- Educates staff on: - Direction District is taking - Why stormwater management is important - Relevance to their departments/jobs	Support by District Staff essential to accomplishing most of the recommendations - allows for exchange of ideas	Immediate	High - ensures staff co-operation with stormwater initiatives	- Use of District meeting facilities	- Staff time to attend training - Staff time to arrange for training - Approximately 1 week staff time per year	
3	Revise Ditch Maintenance Practice		- Re-examine timing and method of ditch maintenance - Provide staff education - Refer to Appendix 2 of ISMP - Review existing program in the context of the new BMP's - Develop prioritized implementation plan - This program has already commenced	- Prevents fish kills - Reduces sediment loads Current ditch maintenance practices a factor in affecting: - sediment load - fish kills due to oxygen depletion - fish kills due to high temperature from sun exposure	Immediate	High	- Current annual budget for ditch maintenance ~ $70,000 - BMP will increase cost in short term, but moderate in long term as ditches are modified	- Staff time to learn new ditch maintenance practices - Staff time to review existing program - Staff time to develop prioritized implementation program	
4	Implement BMP's during infrastructure renewal	Develop Prioritized Plan	- Identifies for viable retrofits and installations: - Location - Configuration - Design - Cost	- District has responsibility for a large proportion of the impervious surface - Includes most of the (contaminated) trafficed surface - District is in a powerful position to improve rainfall capture and water quality. - Benefits are detailed in Appendix 3, Table 1 of the ISMP report	Short Term	Moderate - High - Implementation will be gradual	- Approx. $45,000 of professional services - Staff time for coordination	- Staff time for coordination and information transfer (see DRP #1)	- Infrastructure Planning Grant Program
		Implementation	- Retrofit District drainage systems - Convert ditches and catch basins to infiltration swales		Medium Term		- Average cost of ~ $5000 - $15,000 per instance - About 30 conversions providing a majority of benefits	- Staff time to implement changes	
5	Retain services of consulting engineering firm for periodic consultation on SWM issues as required		- Professional advice on an as needed basis - Compliment to Staff resources	- Rainwater management practices are in a state of rapid evolution and the subject is often a contentious issue with respect to development and land use.	Immediate	Moderate - Very High - very high in cases where these are legal issues at stake	- $35,000/yr may be adequate - Excludes work related to specific projects or developments - Costs can be minimized by increasing staff resources and training and resorting to professional services only for complex issues	- Staff resources to retain consultant	

Note: Quoted costs are order of magnitude only

Implementation Plan - Knowledge Development and Monitoring

Item	Recommendations	Details	Benefits	Timing	Priority	Resources Required / Cost	Staff Required	Funding Opportunities
1	Continue water information collection	- Support continued measurement of streamflow and level by non governmental organizations - Ensure data is collected on schedule and archived	- Ensures continued rainwater management data collection - Minimal direct cost to the District - Improves accuracy of the stormwater model - Provides baseline data - Allows assessment of the impacts of climate change, development, and changes in rainwater management	Immediate	High - loggers in place have finite capacity - implementation already in progress - training provided previously - data gathering is critical to any rainwater management program	- District staff to ensure scheduling, data processing, and archiving - Volunteer time to complete monitoring - Rental/purchase of flow measurement device - Minor field supplies (weatherproof note book, first aid kit, etc)	-Coordinate monitoring schedule and data archiving -Coordinate use and maintenance of equipment	
2	Expand water quality monitoring program	- Coordinate with CRD - Support continued and enhanced measurement of stream water quality by NGEO's - Measure temperature, pH, conductance, TDS, specific conductance - Minimum of 4 samples a year - Ensure data is collected on schedule and archived	- Significant water quality issues identified - Help delineate water quality issues - Aid in determining success of improvement initivatives/activities	Immediate	High - Data gathering is critical to any rainwater management program	- District staff to ensure scheduling, data processing, and archiving - Volunteer time to complete monitoring - rental/purchase of Water quality measurement devices - Minor field supplies (weatherproof note book, first aid kit, etc)	-Coordinate monitoring scheduling and data entry - Coordinate use and maintenance of equipment (rental or owned)	
3	Continue incremental development of stormwater base maps and models	- Implement GIS system at the district (optional) - District staff education to pass along knowledge of changes to stormwater system - District staff training on PCSWMM.net - Continued collection of stormwater rainfall data - Modification of Model based on changes in impervious area, or record of changes since model completion	- Makes maps and models more relevant - useful for local area and single Development area planning	Immediate	Moderate - Incremental changes to a current model simpler than making changes to an outdated model - Eliminates need to recall historical changes during model update	-Staff will need to have means for regularly entering all new data - Best accomplished through implementation of GIS system at the district - Staff training on PCSWMM.net - Stormwater Model liscensing costs (~$2500)	- Staff time to learn to use stormwater model - Staff time to implement GIS - Staff time to make minor changes to stormwater model	
4	Commission a hydrogeological study of aquifers and ground water use in Central Saanich	- Groundwork laid by recent CRD aquifer study (Kenny, 2008) - Determine usage patterns and recharge relationshios - Identify how to achieve long term sustainability wrt groundwater supplies	- Protection of groundwater critical to agriculture - Identify ways to reverse declining groundwater levels	Medium Term	Moderate	- Hydrogeologist fees - approx $75,000 - $125,000 in professional services.	- Staff time to develop terms of reference and retain Hydrogeologist	

Note Quoted costs are order of magnitude only

9.3 Community Programs

9.3.1 Healthy Watersheds Committee

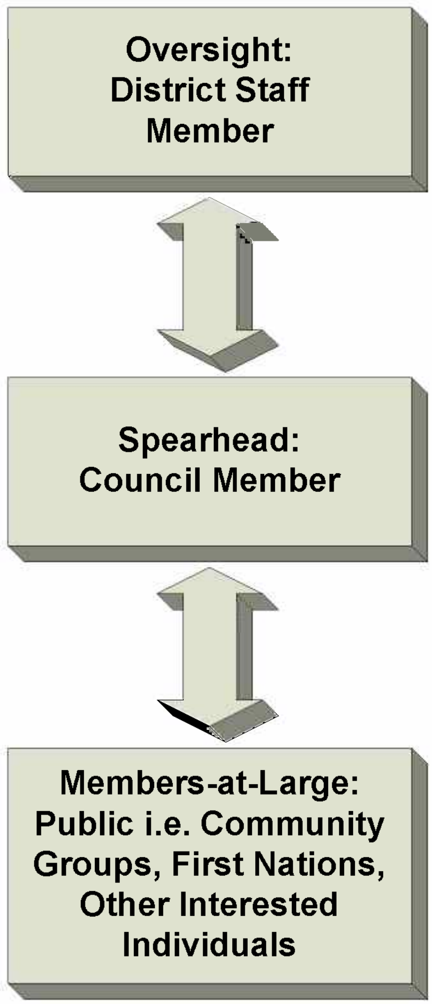
A Healthy Watersheds Committee (HWC) can assist Central Saanich in implementing the recommendations of the ISMP. The HWC would help to track progress on rainwater initiatives, help guide monitoring decisions, assist in developing funding applications and act as a champion for progressive rainwater management in the municipality. This committee would function on a consensus-based model, rather than one in which decisions are made through votes. This alleviates the need for quorum and promotes a collaborative approach, rather than an adversarial model. The committee could make suggestions and recommendations which would always be referred to Council for decision. The committee should have the representation from the appropriate government agencies, First Nations and community groups, without being overly large. Between 12 and 16 members is ideal; more than that number becomes unwieldy and unproductive, fewer members increases the burden to each individual. The committee should always have technical experts present to ensure that the suggestions are viable and to provide advice and comment. Ideas arising at the Council table should be referred to the HWC for comment (but not for decision- that rests with Council). This model ensures that there is good communication between the committee and council, and that accountability continues to rest with Council, without altering the City's liability.

A suggested structure for the Healthy Watersheds committee outlined in Figure YY below is:

- Oversight Staff Member - involved in committee meetings and discussions, reports back to staff and Council committees with status of projects and actions taken. This individual would preferably be the Rainwater Management (or Stormwater) Coordinator described in Section 8.2.7
- Council Member - involved in committee meetings, the spearhead of the organization, relays discussions to Council from the councillor's perspective and fields questions or ideas from the public at large.
- The committee should include many of the same agencies as the SAC: Peninsula Agriculture Commission, Ministry of Agriculture, Ministry of the Environment, Ministry of Highways, business community, Tsawout and Tsartlip representatives (from lands committee?), CRD, Peninsula Streams, and possibly Central Saanich Parks, Public Works and Planning representatives in addition to the engineering staff member. Alternatively, these other Departments can be on the email list and the Rainwater Management Coordinator can keep them informed and invite their attendance whenever important relevant issues will be discussed. Volunteers (public) from Central Saanich and other municipalities who share watersheds *i.e.* Saanich and North Saanich should be invited in order to balance the committee and provide much of the energy and outreach that such a committee requires. The volunteer complement should include members from existing NGEO's (for example, Peninsula Streams) to ensure strong communication with these important organizations.

- In addition to the members present, the District of Saanich and District of North Saanich should receive meeting minutes and be kept informed of activities.

Figure YY Suggested Healthy Watersheds Committee Structure



9.3.2 Downspout Disconnection

Downspout disconnection is a rainfall capture BMP that, if implemented correctly, will reduce the load on stormwater systems. A simplified example (splash block) of a downspout disconnection is shown in Photo K below.

Photo K Downspout disconnection example

Rainfall capture aims to, during light showers, keep the rainfall on site, for heavy rainfall, delay runoff and for extreme storms, reduce flooding. The roof areas of most buildings in the Central Saanich District have downspouts that collect rainwater from the roof and direct it to the stormwater system (which traditionally was engineered to remove water as fast as possible). Rain runoff from the roof is generally relatively clean. By disconnecting the roof downspout, roof runoff does not add unnecessary load to the stormwater system and can be kept on site, supporting re-establishment of the natural hydrology of the area. This runoff can be redirected to infiltration galleries where it can soak into the ground and recharge groundwater. Runoff can also be directed for use in gardens, swales, stormwater planters reducing irrigation needs and / or to a rain barrel or cistern for storage.

Downspouts carrying roof runoff can be disconnected on residential, commercial and industrial properties and systems used can range from rather simple to complex depending on goals and what the site constraints allow. Maintenance is minimal, most materials are easily replaceable and cost is relatively low. Please see the downspout disconnection synopsis in Appendix 3 for more detail and Photo L for an example.

Downspout disconnection should not be applied to sites without firstly considering site specific factors. Adequate investigation of site soil and groundwater characteristics is necessary to ensure that infiltration areas are dimensioned to receive and infiltrate all incoming flows. Directing runoff to low-permeability soils, particularly clays, will not be suitable as there are likely to be problems with soil saturation.

Photo L Downspout Disconnection Example

Opportunities can be investigated by firstly identifying suitable areas through assessment of site grading/topography and soil conditions as well as land available for infiltration. Published soils maps give a good indication of regional soil types, while topography maps give a general indication as to the site's suitability for gravity to aid drainage from a higher to lower point. Soils dominated by clay are less likely to drain water than sand and gravel dominated soils. Sites with at least a 1 in 100 slope (for every 100 m the ground level drops by 1 m) allow for better movement of water away from the point where rainfall has been directed. A site that is too steep (steeper than 1 in 10) will not allow time for the water to infiltrate the soils. However, slope and soil types should not be considered in isolation from the larger geographic context. For instance, a number of houses may be built on a slope directing rainfall to a low point, and even though the slope is suitable and the soils have a good infiltration capacity, the cumulative effect on this low point if all houses disconnected their downspouts could be detrimental.

Risks from downspout disconnection can be reduced by providing an "overflow" connection to the storm drain system when the capacity of the infiltration system is exceeded. This will often involve a weir (or pipe) that becomes active when water reaches a predetermined level.

Another related opportunity is the provision of rain barrels/tanks to store water drained by the roof areas. This will increase the volume of water that can be retained on site as well as allow water use at a later date suitable to the property occupant(s). These rain barrels/tanks could be provided at a subsidised price as an incentive to attract a wider range of the community. In addition, rain barrels/tanks could also be utilised on sites that have soils which have been considered unsuitable for infiltration. Used in combination, rain barrels/tanks and infiltration of water collected by downspouts has many benefits when compared to traditional management of stormwater.

Downspout disconnection programs have been implemented in a variety of locations throughout the world and the success at the City of Portland, Oregon, is discussed below.

In City of Portland (City of Portland, 2008), rooftops account for about 20% of the surface area and downspouts that drain rain runoff from the roof connect directly to their collection system.

City of Portland residents qualify for a discount on the stormwater portion of their city utility bill if they contain rainwater on their property. Furthermore, residents living in the Downspout Disconnection Program area can have downspouts disconnected for free or alternatively earn US$53 for each downspout disconnected. Note that these disconnections need to meet the municipal standards. Within the defined Downspout Disconnection Program area, no City permit is required to disconnect a residential downspout. They also require a plumbing permit if the flow from the downspout is directed to an on site stormwater management facility (such as a rain barrel).

Portland's Stormwater Management Manual (SWMM), most recently updated August 2008, is a useful reference for all aspects of stormwater management. It includes the City Code and policies that direct implementation and revision of the SWMM as well as design guidelines. Recently updated submittal guidance (and associated forms) presents information on how to navigate the source control permitting, land use, building and public works processes. Detailed information on sizing, placement and design for downspout disconnections are included and simplified information sheets have been developed for this BMP as well as many others.

Among the guidance given, these general standards have been outlined and may be useful to the District:

- Slope: do not disconnect downspouts on slopes over 10% (1 in 10)
- Drainage: ensure area is adequate
- Extensions: ensure structures are not undermined; disconnected downspouts must be extended to discharge water at least 6 feet from a structure's basement and 2 feet from a structure's crawl space or slab foundation.
- Property lines: The end of the downspout extension must be at least 5 feet from the neighbour's property and 3 feet from the public sidewalk
- Access: don't create tripping hazards, such as adding extensions across a walkway
- Other hazards: don't disconnect within 10 feet of a retaining wall or directly over a septic system

A downspout disconnection handout included in Appendix 3 has been prepared outlining the problem, solutions, timeframe and benefits of this BMP.

It is recommended as part of the ISMP implementation that the District consider development of a Downspout Disconnection Program. The program could be developed in a phased approach and implemented on a priority basis in areas we have identified within the District. The Healthy Watersheds Committee could assist in implementation of this program which could be trialed initially in Tanner / Keating Ridge area. Depending upon the success of the program and with any revisions required, it could then be implemented in selected areas of Saanichton and over the longer term in the remainder of the community where soils are suitable.

One of the principal issues that would have to be resolved is the role and responsibilities of the District in this program. This could be as limited as providing generic information on the website or as extensive as providing professional advice, permitting and inspection services for disconnection facilities. Potential liability will no doubt be a concern of legal services. The Healthy Watersheds Committee may be interested in playing a role in this program help to resolve these questions.

Recommended aspects of the program would include:

- Placing guidance information on this BMP (for residential, commercial and industrial applications) on the District Website
- Define Downspout Disconnection Areas (DDAs) wherein residents may disconnect without the need for a permit, provided that they observe basic design standards
- Find a way of making adequate technical advice available at low or no cost to interested residents, possibly through an NGEO, from District staff, or qualified persons retained by District staff.
- Implement a demonstration project in one of these areas (such as Keating / Tanner Ridge) and establish several disconnects with monitoring over a winter season.
- Try to establish economically advantageous group discounts for equipment (such as rain barrels and diverters) and installations through local contractors or manufacturer's representatives
- Adjust the program and standards as necessary and then more widely promulgate the program in the DDA's
- For areas outside the DDA's, require permitting with qualified technical or professional approval of design.

9.3.3 Ponds and Wetlands

There are opportunities for restoration or creation of ponds, wetlands and riparian zones throughout the watersheds. Small facilities upstream attenuate flows and address water quality issues close to the source.

Examples of logical locations for ponds and wetlands include the following:

- Near the eastern portion of the Saanich Peninsula Hospital property.
- Near the boundary of the Saanich Historical Artifacts Society and the Tsawout First Nations properties (to reduce erosion occurring there).
- Upstream of Mount Newton Crossroad or potential wetland areas further upstream in Hagan Creek.

- In the depression within Adam Kerr Park.
- In the western quadrant of the Graham Creek watershed, bordering the developed areas of Brentwood Bay

Each of these is site-specific, however, the following general guidelines apply:

- they will preferably be designed to create detention during winter months and water release during summer months, reconciling this, where required, with farm irrigation needs
- they will follow modern pond design guidelines, such as those of the USDA where ponds are used for farm irrigation purposes (USDA, 1997)
- they will incorporate appropriate ecological design so as to create habitat values

9.4 Specific Projects

9.4.1 Demonstration Projects

There would be considerable value in establishing projects in the District that implement and provide physical demonstration of modern BMP's. Examples of prime sites include:

a) Stelly's School – establish a rain garden, infiltration swales and associated canopy in an area that is heavily paved and bare. A school group may be eager to assist in such a project. A similar project has been executed at Victoria West Elementary School and would serve as a useful example.

b) Keating Industrial Park – several parking areas are prime candidates for relatively easy retrofit of catch basins to infiltration swales. There are also numerous opportunities for rain gardens. The School District property is a possible candidate.

c) Municipal Complex – Prime candidate for rain garden and infiltration swales

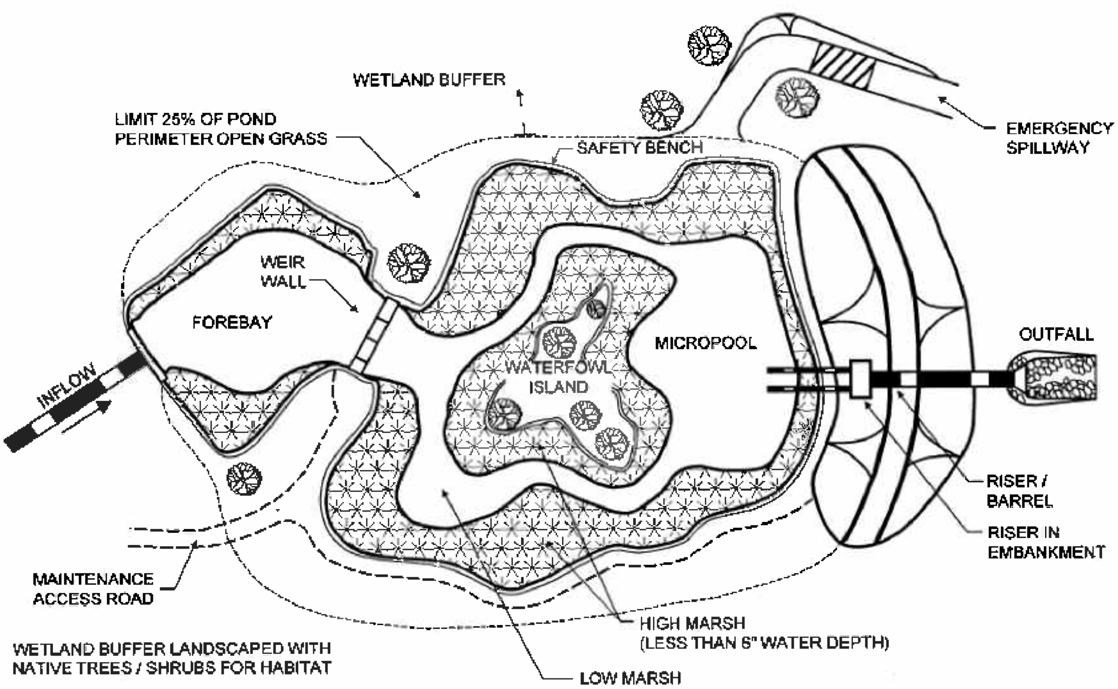
Photos of sites for these and other possible demonstration projects are contained in Appendix 3.

9.4.2 Maber Flats

As described in Section 7.1.4, the improvements recommended for the Hagan-Graham watershed include a 5 – 10 ha. extended detention stormwater wetland constructed in Maber Flats in conjunction with a variable control structure and downstream channel hydraulic improvements. A conceptual design is shown in Figure ZZ. This facility would demonstrate multiple benefits such as protection of agricultural lands from flooding, peak flow reduction, increases in base flow, enhanced habitat (principally birds and fish), reduced channel erosion in Centennial Park and First Nations cultural uses.

There are many considerations that would affect the size and design of the wetland (and associated variable level control device). Excessive drainage of organic soils will accelerate the decomposition of the soil. Birds require seasonally flooded areas for habitat therefore it would not be advisable to significantly alter flooding conditions during the winter season. Other agricultural considerations are described in Section 7.7. A wetland facility of 5 ha or more could alleviate the spring and fall flooding that causes the major impacts to agricultural values. Surrounding farmland, outside of the designated wetland, would be useable for most of the year and could come much closer to meeting ARDSA guidelines for drainage. Costs for this project are estimated at $2 - 5 million, (excluding the cost of land) depending on the final scope.

Figure ZZ Conceptual Design of an Extended Detention / Wetland Facility



This project would need to proceed in four phases as follows:

Phase 1: Feasibility and Conceptual Design

There are important political considerations to address including determination of whether this type of facility, constructed in ALR land, would be deemed an acceptable use by ALC. It is hoped that a support from First Nations, the District, affected farmers and various NGEO's for the project combined with convincing evidence that there would be a significant net positive increase in agricultural values in the Maber area would allow the ALC to deem it an acceptable agricultural use.

The other major political hurdle would be coming to an appropriate arrangement with the owner of the land affected. In the absence of substantial external funding for the project, the landowner will likely seek a land use concession such as those described in Section 9.2.6, with the associated policy and political issues.

A detailed survey of elevation, soils and agricultural drainage systems in the Flats would be required. A preliminary hydraulic model would be developed based on the existing PC-SWMM model and a conceptual design (including sizing) would be prepared to achieve certain month-by-month water level targets.

Consultations would take place with property owners, NGEO's and First Nations to establish parallel calendars for stormwater management, agriculture, habitat (primarily bird and fish) and cultural practices. An agrologist would be present to facilitate discussions with the farmers. Any conflicts in requirements would be identified and mitigated if possible, and a consolidated calendar of operation would be prepared. In addition, an approach to control of the new variable control structure would be recommended.

Based on the operational calendar and discussions with farmers, the economic impact on agriculture would be quantified and backed up with specific examples. A report on this subject would be prepared for transmission to the Ministry of Agriculture and the ALC. A parallel "green capital" assessment could also be prepared to help solicit co-funding by benefiting parties.

A preliminary cost estimate would be prepared and discussions with potential funding agencies (and the property owner) could progress to the point that financial feasibility could be determined.

Phase 2: Preliminary Design

With the technical, political and financial feasibility established, the preliminary design would be completed. This would complete the hydraulic modelling work and the process design, detail the layout and representative cross-sections of the facility and the hydraulic profile, quantify the excavations required and the management of spoil materials. A refined cost estimate would be produced. This work would need to be done by a hydrological engineer in collaboration with an aquatic ecologist. Ecological input will be key to a successful design.

Phase 3: Detailed Design and Tendering

Detailed design will complete detailed civil, mechanical, and hydraulic design and drawings for all components. The retained consultant will provide complete process control and logic design and selection of instrumentation, produce construction drawings and schedules for all aspects of the project, and provide a tender package ready for bid by contractors.

Phase 4: Construction, Commissioning and Operation

During the construction phase, the engineering and ecological consultants should be on-site regularly to perform inspections and assist in commissioning. Following the completion of the project, the consultants will provide an operation and maintenance manual and training, if required.

It should be noted that the hydraulic improvements portion of this project could precede the wetland construction and provide partial benefits earlier, provided that the former is carefully designed for compatibility with the latter. The Implementation Schedule in Section 9.2 makes this assumption.

9.4.3 Martindale Valley

As described in Section 7.3.4, the improvements recommended for the McHugh-Noble watershed are rainfall capture in Tanner/Keating Ridge area, hydraulic improvements to McHugh Ditch and the Dooley Road culvert, and the construction of a detention pond on the western flank of the Martindale Valley. Simultaneous implementation of these improvements may not be practical due to the differences in capital cost, required political consultation and approvals, and construction / implementation time. In terms of alleviating the immediate concern within McHugh-Noble, that of seasonal flooding within the Martindale Valley, hydraulic improvements will directly address the issue and is therefore considered to have the highest priority.

The first portion of the hydraulic improvements, which can be done by the District in the short term, is to clean out the section of McHugh Ditch between Martindale Road and Dooley Road. The adjacent land owners should be consulted prior to this and ditch maintenance BMPs (Appendix 2) should be adhered to. The clean out will restore the pre-existing hydraulic condition of the ditch and is not expected to significantly impact hydraulic conditions downstream due to the elevation and size of the culvert at Dooley Road. However, the extra ditch volume and gradient should reduce shoulder season flood depths, and possibly frequency. Some consideration could be given to a modest amount of stream restoration as part of the project, for example for a segment upstream of Dooley Road. The methods described in Section 9.5 would apply.

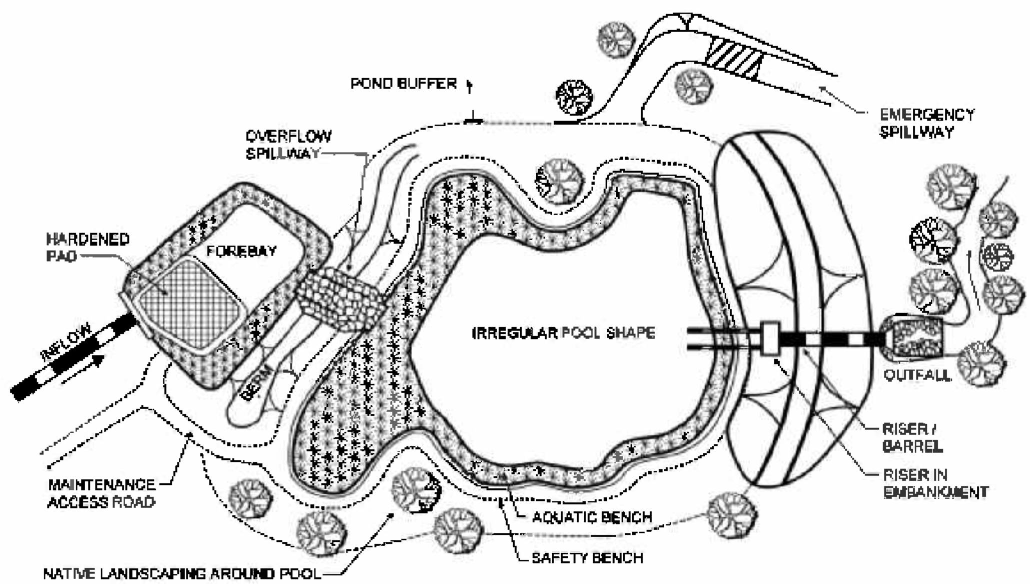
The deepening and widening of the Dooley Road culvert would be instrumental in alleviating shoulder season flooding in the Martindale Valley. As Dooley Road lies on the southern extent of the District of Central Saanich, consultation with the District of Saanich on the proposed upgrades is important. Some hydraulic improvements in the drainage course south of Dooley may be required as well. Since the upgrades will reduce the hydraulic restriction currently imposed by the Dooley Road culvert, runoff peak flows and volumes are expected to increase, all else being equal. As this is detrimental to the goals of stormwater management, the impact of this increase may be addressed as follows:

- As the PFC assessment did not identify erosion within the Saanich section of McHugh Ditch and Noble Creek, it will be necessary to complete a tractive force calculation to determine flows at which channel erosion may occur (herein referred to as “critical flow”) and compare to expected peak flows for mean annual rainfall storm (2 year storm);
- If the expected flows are less than the critical flow, design a control structure (i.e. adjustable weir) to limit flows when desired, such as to maintain summer baseflow levels. Consult with adjacent land owners who use McHugh ditch to determine weir level set points;
- If the expected flows are greater than the critical flow, determine if a control structure is capable of reducing flows to below the critical flow. The control structure conceptually may have level sensors at Martindale Road and upgradient and downgradient of the weir in order to calculate in channel flow rates. During heavy rainfall events, the weir position will initially be low, so as to allow runoff to flow freely, however, as the flows increase to the critical flow, the weir will rise, throttling the flow. As the storm subsides, the weir would recede.

- If the control structure is not capable of lowering runoff flow rates to below the critical flow, then runoff peak flow rates must be dampened with the construction of a detention pond on the western flank of the Martindale Valley.

The benefits of proposed detention pond are twofold. Firstly, the detention pond serves to lower peak flow rates, minimizing the potential of downstream erosion. Secondly, water quality improvement is often realized due to settling within the pond and biological activity. Seasonal flooding can also be reduced, albeit marginally. Even if a control structure was capable of maintaining flows below the critical flow, the detention pond (see Figure AAA below) is still recommended for water quality enhancement.

Figure AAA Rough Conceptual Design of a Detention Pond



In terms of project phasing and implementation, many of the same considerations described above for Maber Flats apply. Key steps required to implement a detention pond are as follows:

- Determine if the siting of the detention pond is acceptable under the District's Official Community Plan and policies
- Determine possible recreational values through consultation with the District's Parks and Recreation department
- Consult with interested parties to determine a potential site. Parties that should be consulted include the ALR, ALC, First Nations, community groups, landowners, and provincial agencies
- Retain an engineering firm to complete the preliminary design and cost estimate of the facility
- Determine economic feasibility of the project and means of funding the project within the District

- Determine eligibility and apply for grants under various funding programs (see Section 9.7 on funding options)

Following the securing of funding and support of affected parties, an engineering firm should be retained to complete the detailed design of the facility, in consultation with project ecologists. Key steps in the detailed design include:

- Further data collection (flow, flooding extent, water depth) and analysis of historical data
- Modelling of the natural channel morphology based on volume, gradient and runoff curve
- Determination of “natural” bankfull elevation and comparison with existing condition
- Calculation of volume of “excess” water that needs to be accommodated in the pond/wetland
- Detailed soil and elevation survey and mapping of adjacent farm drainage systems
- Consideration of impacts, if any, on surrounding agricultural activity including drainage systems, soils, cropping and tillage. Determine if additional benefits to agriculture are possible and practical, if so, refine design to suit
- Consideration of impacts on bird habitat, recreational values, and surrounding property values. If additional benefits are available, adjust design where practical
- Create a detailed stormwater model for the facility based on the pre-existing stormwater models
- Determine pond sizing
- Create an Integrated Calendar through consultation with interested parties to determine water levels in the pond and ditch that suit agricultural, habitat, and stormwater management values
- Design local channel hydraulic modifications to integrate the pond into the stormwater system
- Design pond outlet control structure to maintain water levels outlined in the Integrated Calendar;
- Complete detailed civil, mechanical, and hydraulic design and drawings for all components
- Complete process control and logic design and selection of instrumentation
- Presentation of detailed design to the District
- Prepare and submit tender package, review tenders, and assist in selection of a contractor
- Prepare an operation and maintenance manual and provide training if needed

During the construction phase, the engineering and ecological consultants should be on-site regularly to perform inspections and assist in commissioning. Following the completion of the project, the consultants will provide an operation and maintenance manual and training, if required.

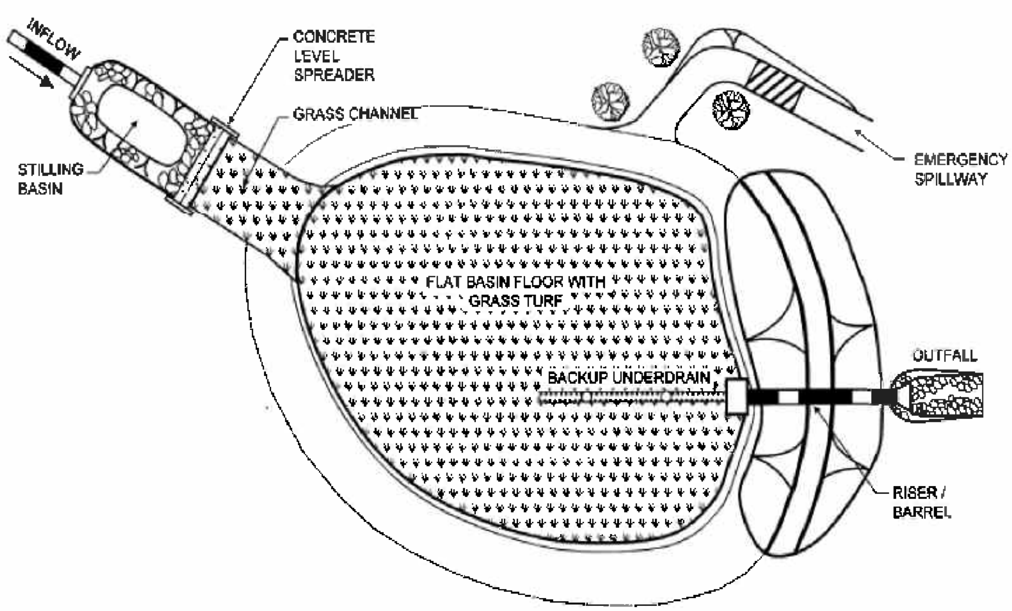
It should be noted that the hydraulic improvements portion of this project could precede the detention pond construction and provide partial benefits earlier, provided that the former is carefully designed for compatibility with the latter and the system is operated so as not to exceed peak flow limits. The Implementation Schedule in Section 9.2 makes this assumption.

9.4.4 Keating West Bioinfiltration Project

Historically, there have been water quality issues associated with runoff from the Keating industrial areas. The western portion, which drains to Graham Creek, collects in a 1.2m culvert that discharges to Stephen's Brook (Stinky Ditch), providing a good opportunity for implementing a stormwater management facility or "BMP" in or near the Hydro ROW adjacent to Kirkpatrick Crescent. This would mostly be oriented toward water quality improvement, however it would provide some attenuation of flow for Stephens Brook, thereby mitigating erosion and sediment loading problems. (Note that the eastern portion of Keating industrial area drains to Tetayut and there is less opportunity to implement a common BMP, so that controls at source will likely need to be relied upon exclusively).

A combination bioinfiltration / detention facility of approx 0.5 ha. is recommended. The general design (see Figure BBB below) would be that of a pond with an infiltration floor. Early runoff from storms ("first flush") which is the most contaminated, would infiltrate through the vegetated bottom of the pond, where natural biological and adsorptive processes provide effective treatment. Further runoff would be partially detained in the pond, thereby attenuating the peak flows.

Figure BBB Rough Conceptual Design of a Bio-infiltration / Detention Facility



Just west of the main culvert from the industrial area, Stephens Creek is joined by a flow of clean water from the Brentwood Springs area before proceeding west to the confluence with Graham Creek (ditch) at the power pylons. Some stream restoration should be considered in conjunction with the BMP, or afterward in order to further control erosion. If the proposed Maber detention facility is in place, a new revised creek alignment from the Brentwood Springs / Stephens Creek confluence to the Maber wetland, along the valley flank could be considered. This would divert a substantial flow around the Graham Creek ditch.

9.5 Restoration – Prioritization and Methodology

The following list of reaches was selected for their status of “Functional at Risk,” and in the case of Graham Creek Reach 8, for cooperative land owners. Non-Functional reaches should be monitored in terms of erosion prevention and vegetation cover to prevent damage to reaches downstream that are still in functional condition. Where channel rehabilitation is an option, terracing, meander bends, and channel profile enhancements would be beneficial in ditched and straightened sections. This should be done based on Rosgen and PFC criteria and requires hydrological modelling in close consultation with aquatic ecologists in order to optimize minimize flood risk while still ensuring restoration of ecological function.

1. Reach 2 of Tetayut Creek: Saanich Historical Artifacts Society.

- Trails are too close to the stream channel significantly reducing the riparian vegetation in these areas. This leads to erosion and in one location the bank has slumped and the trail was lost.
- English ivy is threatening the health of the riparian vegetation. In particular, it is threatening several large trees whose roots are critical to maintaining bank integrity and stability.
- Riparian planting is needed to bolster the understorey and aid in erosion prevention.
- Invasive species control is needed to protect riparian vegetation.
- Trails presently too close to the creek need to be realigned to protect the banks from trampling.
- There is a potential opportunity to create clear span bridges if the driveway is rebuilt.

2. Reach 5 of Graham Creek: The south end of Centennial Park

- Ditch-like cross section.
- Erosion issues are present as a result of channel shape and high flows experienced in this reach.
- The culvert under the trail is blocked at the upstream end creating a hydrological drop which is increasing the velocity of flows and likely augmenting scour on the downstream bank.
- The culvert should be unblocked and the bank stabilized with large wood. Some rock may be needed, but this area should not be rip-rapped.
- The channel could be terraced to create floodplain within the channel. This will require review by a vegetation ecologist and a hydrologist.
- Garbage is consistently present between Centennial Park and Stelly’s X-Road. This should be removed and an education program implemented for the local high school.

3. Reach 9 of Graham Creek: 6536 West Saanich Road
- Banks are heavily trampled by sheep.
- Trampling is preventing understorey vegetation from growing.
- Active erosion is occurring primarily on the west bank where a ditch meets the main channel.
- Fencing would control livestock access; a watering area could be created with hardened materials to prevent bank trampling and reduce sediment movement into the channel.

4. Reach 8 of Graham Creek: 6630 West Saanich Road
- Property owners have been in contact with Peninsula Streams and are willing to cooperate with works.
- Riparian planting should be conducted.
- Garbage removal is necessary.
- Terracing to create more accessible floodplain in the channel would reduce stream velocity and erosive force (this will require review by an aquatic ecologist and a hydrologist).
- A BMP should be installed upstream of the intersecting ditch to treat first flush as well as detain flow for slower release to protect Graham Creek from erosion.

5. Reach 1 of Hagan Greek: Hagan Bight
- Need to determine strength of the dam structure and whether it is designed for the stream to flow around its western edge. If not, the diversion needs to be managed to prevent a headcut.
- Garbage removal from the channel is needed.

6. Reach 5 of Hagan Creek: Malcolm Road
- Riparian planting has occurred along the creek here, however agricultural activity is present on either side of the banks and is limiting plant success.
- Water is skirting the southern edge of a weir structure and eroding the southern bank. The weir structure should be reinforced.
- Riparian plantings need to be protected from agricultural activity and the bank stabilized with plantings (e.g. willow wattles) and large wood.

7. Reach 4 of Hagan Creek: 1563 Mount Newton Crossroad:
- Areas of erosion are present.
- Agricultural activity occurs directly adjacent to the channel.
- Trampling by livestock is occurring in sections.
- Fencing could be utilized to prevent uncontrolled access to the creek by livestock; a watering area could be constructed with hardened materials to prevent hooves from damaging the banks and adding sediment to the stream.
- Bioengineering, such as willow wattles could be implemented to stabilize areas of erosion.
- This reach is a remnant reach but is in danger of becoming Non-Functional.

8. Reach 7 of Hagan Creek: Haldon Road area

- A fence is crossing the creek causing a debris jam and diverting flows around the outer edges. This can increase erosion of banks and increase the sediment load to the stream. If possible, the fence should be removed, or altered such that it can be raised (or the bottom wires removed) during high flows.
- Presence of invasive English ivy threatens riparian species. Invasive species should be removed and native riparian planting undertaken.

Next Steps:

a. All Reaches in PFC:

- These reaches need to be protected and managed for invasive species such as English ivy and Himalayan blackberry.

b. All Reaches that are Non-Functional:

- These areas should be managed so as to ensure that they are not causing damage to downstream reaches that are in PFC or FAR.

Table MM below shows all the reaches assessed as Functional at Risk and Proper Functioning Condition.

Table MM PFC Prioritization

Priority	Reach	Issues	Options
1	Hagan Creek Reach 1	• Potential headcut • Garbage	• Assess dam stability • Garbage removal
2	Tetayut Creek Reach 2	• Trails close to channel. • English ivy threatening riparian plants.	• Riparian planting • Trail realignment
3	Graham Creek Reach 5	• Blocked culvert • Erosion	• Unblock culvert • Terrace channel
4	Graham Creek Reach 9	• Trampling • Erosion	• Fencing and controlled access • Riparian planting
5	Graham Creek Reach 8	• Trampling • Garbage • Little understorey	• Riparian planting • Garbage removal • Terracing
6	Hagan Creek Reach 5	• Erosion • Young riparian plants	• Protect plants, plant more • Stabilize eroding bank
7	Hagan Creek Reach 4	• Erosion • Trampling	• Bioengineering • Fencing, controlled access
8	Hagan Creek Reach 7	• Debris jam • Invasive species	• Assess jam, clear if causing heavy scour. • Riparian planting, invasive species control
9	Tetayut Creek Reach 5	• Invasive species • North bank erosion from road culvert	• Invasive species removal and control • BMPs along road
10	Tetayut Creek Reach 4	• Invasive species	• Invasive species removal

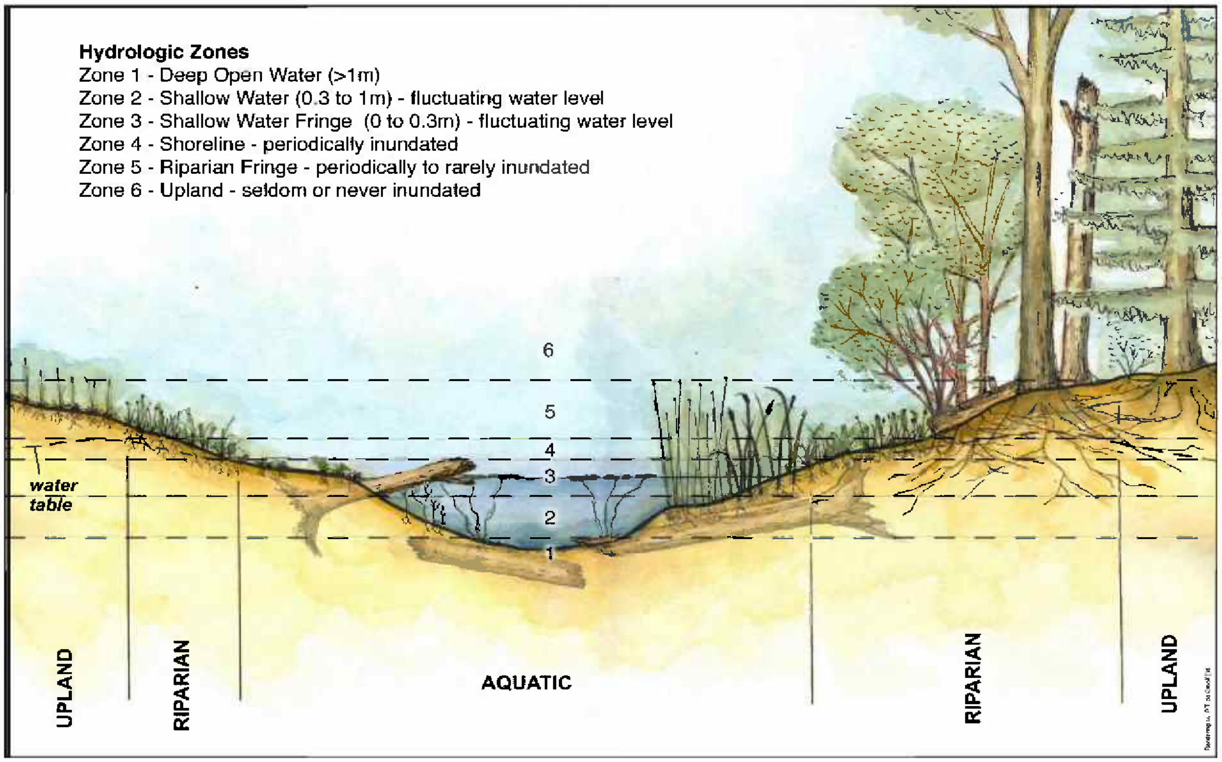
Priority	Reach	Issues	Options
11	Graham Creek Reach 2	• Upslope erosion	• Dispersion of flow from PVC pipe. Use a diffuse pipe to disperse flow.
12	Graham Creek Reach 3	• High velocity flow	• Addition of more large wood
13	Graham Creek Reach 1	• Compost piles	• Homeowner education on creeks and compost • Remove compost
14	Tetayut Creek Reach 6	• Upslope erosion	• Improve farm irrigation • Plant slope • BMP
15	Graham Creek Reach 7	• Channelized spring flow	• Planting to stabilize channel
16	Tetayut Creek Reach 1	• Erosion	• Bioengineering • Upstream BMP
17	Tetayut Creek Reach 8	• Invasive species	• Invasive species removal • More riparian planting

In all of the non-functional areas, riparian planting would be beneficial to stabilize the banks and reduce water temperature fluctuations thereby decreasing impact to downstream reaches and protecting sections characterized as FAR and PFC. A list of appropriate vegetation species and planting areas is included below.

Vegetation Restoration

The following section outlines planting zones and native plant species associated with each zone that are suggested for use in restoration and stormwater management facilities throughout Central Saanich.

Figure CCC Typical Hydrologic and Native Vegetation Planting Zones



The following planting lists were considered with the zones delineated in Figure CCC above. These zones describe the level of water inundation typically experienced by vegetation in these areas, and the planting lists therefore identify species ranging from obligate and facultative riparian species to upland dry species. The species list here is not comprehensive. It contains native species that are commercially available and therefore most useful for implementation of stormwater management projects.

These plant lists will be useful for the creation of planting designs for wetland and stream restoration, construction of stormwater management facilities (*e.g.* constructed ponds and wetlands) and bioswales, as well as for use in landscaping.

Zone 1 - Deep Open Water (>1 m)

No rooted vegetation

Zone 2 - Shallow water (0.30m to 1 m) - fluctuating water level

Sagittaria latifolia	wapato, arrowhead
Scirpus acutus	hard-stemmed bulrush
Scirpus microcarpus	small-flowered bulrush
Typha latifolia	cattail

Zone 3 - Shallow water fringe (0-0.30 m) - fluctuating water, regularly inundated

Cornus stolonifera	red-osier dogwood
Salix hookeriana	Hooker's willow
Salix lucida (lasiandra)	Pacific willow
Salix scouleriana	Scouler's willow
Salix sitchensis	Sitka willow
Spirea douglasii	hardhack
Carex mertensii	Merten's sedge
Carex obnupta	slough sedge
Carex rostrata	beaked Sedge
Carex sitchensis	Sitka Sedge
Carex stipata	sawbeak Sedge
Juncus effusus	common Rush
Juncus ensifolius	dagger-leaf Rush
Lysichiton americanum	skunk cabbage
Oenanthe sarmentosa	Pacific water-parsley
Typha latifolia	cattail

Zone 4 - Shoreline - periodically inundated

Populus trichocarpa	black cottonwood
Cornus stolonifera	red-osier dogwood
Crataegus douglasii	black hawthorn
Lonicera involucrata	black twinberry
Rhamnus purshiana	cascara
Rubus spectablis	salmonberry
Salix hookeriana	Hooker's willow
Salix lucida (lasiandra)	Pacific willow
Salix scouleriana	Scouler's willow
Salix sitchensis	Sitka willow
Sambucus racemosa	red elderberry
Spirea douglasii	hardhack
Carex mertensii	Merten's sedge
Carex obnupta	slough sedge
Carex rostrata	beaked Sedge
Carex sitchensis	Sitka Sedge
Carex stipata	sawbeak Sedge
Juncus effusus	common Rush
Juncus ensifolius	dagger-leaf Rush
Lysichiton americanum	skunk cabbage

Zone 5 - Riparian Fringe - rarely inundated

Alnus rubra	red alder
Populus trichocarpa	black cottonwood
Thuja plicata	western red cedar
Cornus stolonifera	red-osier dogwood
Crataegus douglasii	black hawthorn
Lonicera involucrata	black twinberry
Physocarpus capitus	Pacific ninebark
Populus tremuloides	trembling aspen
Rhamnus purshiana	cascara
Rubus parviflorus	thimbleberry
Rubus spectablis	salmonberry
Salix hookeriana	Hooker's willow
Salix lucida (lasiandra)	Pacific willow
Salix scouleriana	Scouler's willow
Salix sitchensis	Sitka willow
Sambucus racemosa	red elderberry
Spirea douglasii	hardhack
Athyrium felix-femina	lady fern
Aruncus sylvester	goat's beard
Blechnum spicant	deer fern
Polystichum munitum	sword fern
Pteridium aquilinum	bracken fern

Zone 6 - Upland - seldom or never inundated

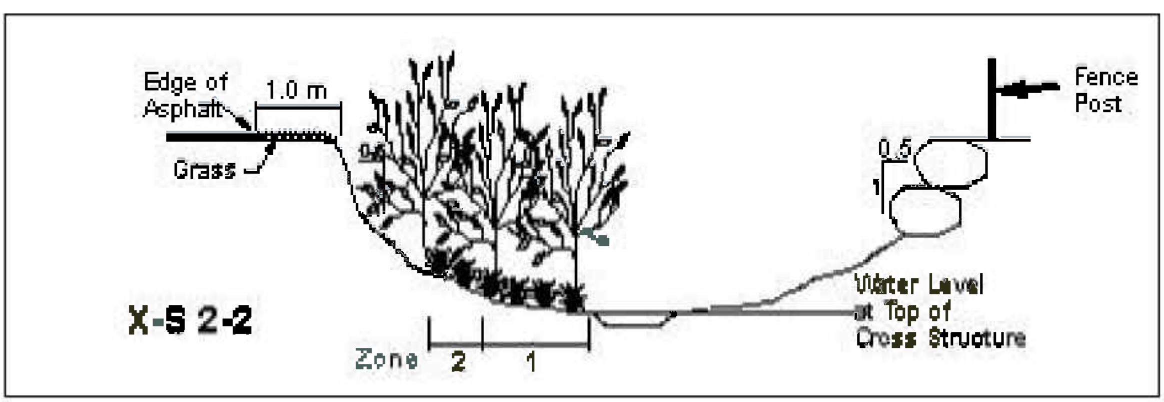
Acer macrophyllum	bigleaf maple
Malus fusca (Pyrus fusca)	Pacific crab apple
Prunus emerginata	bitter cherry
Quercus garryana	Garry oak
Thuja plicata	western red cedar
Amelanchier alnifolia	saskatoon
Arctostphylos uva-ursi	kinnickinick
Holodiscus discolor	oceanspray
Mahonia nervosa	dull Oregon grape
Oemleria cerasiformis	Indian plum
Philadelphus lewisii 'Gordianus'	mock orange (Coastal)
Ribes sanguineum	red flowering currant
Rosa gymnocarpa	baldhip rose
Rosa nutkana	Nootka rose
Rosa pisocarpa	clustered wild rose
Rubus parviflourus	thimbleberry
Rubus spectablis	salmonberry
Sorbus sitchensis	Sitka mountain ash
Symphoricarpos albus	common snowberry
Vaccinium membranaceum	black huckleberry
Polystichum munitum	sword fern
Pteridium aquilinum	bracken fern

The following figure (see Figure DDD below) is an example of reconfiguring a roadside ditch (Photo M below indicates existing condition) for effective stormwater management. Figure DDD depicts vegetation on one bank of the swale to illustrate the the planting zones and show subsurface structures. During implementation planting would occur on both banks.

Photo M Existing Condition X section 2-2

(Aqua-Tex Photo)

Figure DDD Proposed X section 2-2



X-section 2-2 Plant List:

Zone 1

hardhack	*Spirea douglasii*
willow (Sitka, Pacific, Scouler's)	*Salix sp.*
slough sedge	*Carex obnupta*
beaked sedge	*Carex rostrata*
Sitka sedge	*Carex sitchensis*
common rush	*Juncus effusus*
dagger-leaved rush	*Juncus ensifolius*
small-flowered bulrush	*Scirpus microcarpus*

Zone 2

red alder	*Alnus rubra*
black hawthorn	*Crataegus douglasii*
red osier dogwood	*Cornus sericea*
slough sedge	*Carex obnupta*
beaked sedge	*Carex rostrata*
Sitka sedge	*Carex sitchensis*
common rush	*Juncus effusus*
dagger-leaved rush	*Juncus ensifolius*
small-flowered bulrush	*Scirpus microcarpus*

Saanich #2 Grass mix from Integrity Sales should be used on the upslope areas.

9.6 Long-Term Monitoring Program

A long-term monitoring program will be necessary for ongoing collection of data and to help assess whether new stormwater management strategies are working to reduce peak flows and volumes and to improve water quality. Eight continuously recording flow monitoring stations are in place and should be visited every two months to download data, record staff gauge levels and check the installation. In addition, three standalone staff gauges should be visited.

The Peninsula Streams Society has volunteered to continue taking data from the flow monitoring stations. This will include gathering monthly flow monitoring data using a flow measurement device and downloading the pressure transducer. The data needs to be organized, tracked and interpreted by the District of Central Saanich or by a contracted engineering firm. The District should also consider installing several thermistors in each stream to document and monitor stream temperature and document recovery.

A program such as Microsoft Excel should be used for logging and engineering interpretation of the data (*i.e.*, creating flow discharge curves). The flow discharge curves can be monitored on a semi-annual basis to verify that desired reductions in peak flows and volumes are being realized.

These data will be invaluable in continuously improving the District's hydrological database and models and identifying and measuring any significant trends such as climate change or the positive impacts of implementing BMPs.

It is also recommended that water quality monitoring be expanded, using as a model the work done by the Hagan-Kennes Group in the Graham Creek area. As CRD resources develop, increased coordination with CRD monitoring efforts will be beneficial. One of the challenges with water quality monitoring is that the most significant events are transitory and it is difficult to time sampling so as to catch the "first flush" events. This requires volunteers to do sampling on demand or "intelligent" automatic sampling equipment.

Water Quality issues are more thoroughly addressed in Section 7.6.

9.7 Funding Sources

There are several potential sources of funding to implement the recommendations put forth by this ISMP. They are summarized below:

- Federation of Canadian Municipalities (FCM)
- Ministry of Environment
- Ministry of Agriculture
- Ducks Unlimited
- Tsawout and Tsartlip First Nations in coordination with Indian and Northern Affairs Canada (INAC)
- Canada Strategic Infrastructure Fund (CSIF)
- Municipal-Rural Infrastructure Fund (MRIF)
- Collaborate with Non-Governmental Organizations (NGOs) such as Peninsula Streams Society to obtain grants
- Urban Salmon Habitat Program

- Enact a stormwater utility

9.7.1 Agricultural Areas

Agriculture Environmental Initiatives Funds

The Agriculture Environment Partnership Initiative (AEPI) and the Agriculture Environment Stewardship Initiative (AESI) funds were created in 2001 to aid in the resolution of environmental issues and wildlife agriculture conflicts (B.C.A.C., 2008). Applications are expected to be submitted by a farm organization or groups with strong ties to the agricultural community. Other groups may apply if they can demonstrate support from a farm organization.

Funding is provided to projects coming under the following general headings of:

b) Area Plans and Implementation- cost share up to 100% of costs to a maximum of $5000 for each planning initiative and cost share up to 10% of a project cost to a maximum of $100,000 for implementation.

c) Education and Awareness- up to $10,000 per group.

d) Research- cost share of up to 90% to a maximum of $50,000;

e) Stewardship-cost share up to 80% of project cost to a maximum of $50,000 or for an On-Farm project cost share up to 25% of cost to a maximum of $20,000.

f) Wildlife-for prevention of wildlife damages cost share 33-100% depending on objective up to a maximum of $25,000. For wildlife damage compensation $500-$5000.

g) Monitoring- cost share up to 25% to a maximum of $10,000.

For more detailed information see: http://www.bcac.bc.ca/agriculture_enviro_programs.htm.

Ducks Unlimited

Riparian Area Management-will fund 10% of project up to $4000.

- Buffer Establishment: forage, shrubs, trees, planting, weed control.
- Fencing: grazing management and improved riparian function.
- Erosion control structures: bank stabilization, terraces etc.

Enhancing Wildlife and Biodiversity-will fund 10% of project up to $2000.

- Buffer strips with native vegetation.
- Improved stream crossings.
- Wetland restoration: will fund 40% up to $8000.

For further information see: http://www.bcac.bc.ca/documents/DUC_BMP_list_2006_v2.pdf.

Funding through the National Farm Stewardship Program

Riparian Area Management-will fund 50% of project up to $20,000.

Erosion Control Structures (Riparian)-will fund 50% of project up to $20,000.

Enhancing Wildlife and Biodiversity-will fund 50% of project up to $10,000.

Funds up to $2000 are also provided for consultative services as per the BMP brochure.

For further information and other acceptable initiatives see:

http://www.bcac.bc.ca/documents/BMPBrochure.pdf.

Application steps:

h) Complete an Environmental Farm Plan (EFP) for your farm and obtain a “Statement of Completion” from a Planning Advisor recognized by the B.C. Agriculture Council (B.C.A.C).

i) Fill out an application form. These can be downloaded from the B.C.A.C. website, http://www.bcac.bc.ca/efp_documents.htm, and are called “Draft BMP application form”.

j) Have the Planning Advisor sign the application form.

k) Submit the application form to the B.C.A.C.

Note: funding is not provided for projects started prior to authorization from the B.C.A.C.

Table NN Contact Information for EFP Delivery Groups

EFP Delivery Group	Primary Contact	Telephone
B.C. Cattlemen’s Assoc.	Peter Spencer	250-764-0376
B.C. Fruit Growers Assoc.	Don Magnusson	250-762-5226
B.C. Grain Producers Assoc.	Julie Robinson	250-782-4501
B.C. Greenhouse Growers Assoc.	Amandeep Bal	604-591-5349
B.C. Landscape and Nursery Assoc.	Hedy Dyck	604-574-7772
B.C. Milk Producers’ Assoc.	Dave Melnychuk	604-534-2639
B.C. Pork Producers Assoc.	Jack Reams	604-858-1715
B.C. Potato and Vegetable Growers Assoc.	Henry Wiens	604-864-0565
B.C. Poultry Administration	Allen James	604-795-7656

EFP Delivery Group	Primary Contact	Telephone
B.C. Raspberry Industry Development Council	Mike Wallis	604-858-8010
Certified Organic Assoc. of BC	Kristen Kane	250-260-4429
Comox Valley Farmers' Institute	Mary-Jane Douglas	250-337-1834
Creston Valley Agricultural Soc.	Val Miller	250-229-5313
District 'C' Farmers Institute	Warren Wilson	250-967-4645
Horse Council of BC	Vicki Pauze	604-856-4304
Island Farmers' Alliance	Peter Versteege	250-743-2243
Peace River Forage Assoc. of BC	Julie Robinson	250-782-4501
United Flower Growers Cooperative Association	Susan McLeod	604-290-1185

*Information based on B.C.A.C. BMP brochure. http://www.bcac.bc.ca/documents/BMPBrochure.pdf.

Greencover Canada

Funded by Agriculture and Agri-Food Canada this program aims to improve grassland-management practices, protect water quality, reduce greenhouse-gas emissions, and enhance biodiversity and wildlife habitat. Eligible projects fall under the following categories: land conversion, critical areas such as land near water, technical assistance to aid in adoption of BMPs, watershed evaluation, and shelterbelts (tree planting) (The Green Source, 2008).

Applicants to this program must be registered landowners or be entitled to become registered landowners. The next deadline for applying is January 31, 2009.

For more information see Greencover Canada (http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1181580137261).

9.7.2 Infrastructure

Building Canada Fund

This fund is supplied through Infrastructure Canada with the vision of creating a stronger Canada with "modern world-class public infrastructure"(Infrastructure Canada, 2008). The Building Canada Fund has two arms, a major infrastructure component and a communities component. One umbrella of funding includes wastewater infrastructure which aims to "reduce the negative impacts of municipal wastewater effluent or storm-water effluent on human health and the environment" among other things (Infrastructure Canada, 2008). A culture category also exists with goals of helping communities "express, preserve, develop and promote their culture and/or heritage within Canada" which may be useful with collaboration with the First Nations communities within the Municipality.

Funding is provided through a GST/HST Rebate program and a Gas Tax fund. See the Building Plan website for more details (http://www.buildingcanada-chantierscanada.gc.ca/plandocs/index-eng.html). Additionally, applications can be found on the B.C. Secretariat website: http://www.bcbuildingcanadafundcommunities.ca/English/Pages/default.aspx. The first intake is underway but there is expected to be other intakes in the future. This information is also accessible through the B.C. Ministry of Community Development website: (http://www.cd.gov.bc.ca/LGD/infra/infrastructure_grants/index.htm).

Infrastructure Planning Grant Program

This program through the B.C. Ministry of Community Development aims to support local governments in projects related to sustainable community infrastructure. Grants of up to $10,000 are provided and can be used for assessing "technical, environmental and/or economic feasibility of municipal infrastructure projects" including stormwater management (B.C. Ministry of Community Development, 2008). While 2008 approvals are complete, the next round of applications are expected to be approved in early 2009. Application packages are available on the Ministry of Community Development website: (http://www.cd.gov.bc.ca/LGD/infra/infrastructure_grants/infrastructure_planning_grant.htm).

9.7.3 General Stewardship Funding

EcoAction Community Funding Program

Funded through Environment Canada, this program funds projects that have "measureable, positive impacts on the environment" (Environment Canada, 2008). Eligible projects are considered to be those that address themes including climate change, clean water, nature, and clean air.

Groups who are eligible to apply are non-profit groups such as environmental or aboriginal groups, First Nations councils, and youth groups. Application deadlines are the 1st of November annually. Funding is provided up to $100,000 per project with 50% of the total value of the project coming from sources other than the federal government (Environment Canada, 2008). Application forms can be found on the Environment Canada website: (http://www.ec.gc.ca/ecoaction/applicants_guide_e.html).

Environment Canada also provides a document called "The Green Source" with information about other sources of funding. This can be accessed through an online database (http://www.ec.gc.ca/ecoaction/grnsrc/index_e.cfm) or picked up in hardcopy from an Environment Canada Regional Office. The closest office for the Municipality of Central Saanich is situated in Vancouver:

401 Burrard Street
Vancouver, British Columbia
V6C 3S5

Telephone: 604-664-9100
Fax: 604-713-9517
Email: greenlane.pyr@ec.gc.ca

Evergreen Foundation

This foundation provides support for securing funding as well as supplying small grants for 'naturalization' projects with schools (Learning Grounds) and community groups (Common Grounds). Applicant schools are eligible for $500-$2000 while community groups can receive a range of funding depending on Evergreen partners.

The application deadline for schools is January 29, 2010 while the community group funding has passed for the 2008 year.

For more details on funding through Evergreen see their website (http://www.evergreen.ca/en/index.html)

9.7.4 Other Funding Opportunities

Federation of Canadian Municipalities - The Green Municipal Fund

This fund supplies up to 50% of eligible costs to a maximum of $350,000 for studies of feasibility and field tests related to brownfield, sites, energy, transportation, waste, and water. Capital project funding, in grants and loans, is also available with funding up to 80% of eligible costs.

Municipal governments, agencies owned entirely by municipal governments, and public non-governmental or private groups applying with a municipality are eligible for funding through this source. Prerequisites include the adoption of a sustainable community plan or sector plan. An "Intent to Apply" can be submitted at any time during the year (FCM, 2008).

Guidelines and application forms, as well as more detailed information, can be accessed on the Federation of Canadian Municipalities website under the heading "The Green Municipal Fund" (http://www.sustainablecommunities.fcm.ca/GMF/).

British Columbia Transmission Corporation (BCTC)

The BCTC provides funding between $500 and $25,000 to projects in education, environment, and community development. Eligible applicants are non-profit organizations and registered charities.

Applications are reviewed quarterly with upcoming deadline of December 4, 2009. For more information see the BCTC website: (http://www.bctc.com/about_bctc/community_investment/supporting_our_communities/)

10. CLOSURE

We trust that this report satisfies your current requirements and provides suitable documentation for your records. If you have any questions or require further details, please contact the undersigned at any time.

Report Prepared by

Original signed and sealed on file October 26th, 2009

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