DISTRICT OF WEST VANCOUVER
INTEGRATED STORMWATER MANAGEMENT PLAN FOR PIPE, WESTMOUNT, CAVE, TURNER AND GODMAN CREEKS

APPENDIX A

ORIGINAL PROPOSED SCOPE AND AMENDMENTS

4.0 PROJECT METHODOLOGY

Figure 4-1 illustrates the tasks and schedule proposed to undertake the study.

The work flowchart and schedule are identified on Figure 4-1. The schedule assumes a May 1, 2008 start, a November 2008 model completion and a March 2009 project completion. Final reviews or revisions may lengthen the process, but the core of the work is anticipated to be completed by the December objective.

The work plan was developed from the tasks that are identified in the Template for Integrated Stormwater Management Planning 2005, Metro Vancouver, and from review of previous ISMPs conducted in the District of West Vancouver.

4.1 Task 1 – Kickoff Meeting and Project Scope

Task 1 is designed to confirm the project scope and the needs and expectations of stakeholders, including BPP, the District of West Vancouver, regulatory agencies, and the community as a whole.

Task 1.1 - Establish Framework

The purpose of Task 1 is to identify the appropriate drainage needs of British Pacific Properties Limited and the District of West Vancouver, and to ensure the validity of Tasks 3 and 4.

Objective: Establish the key issues for the development area and for the watersheds in the District of West Vancouver covering the following five creeks:

- Pipe Creek,
- Westmount Creek,
- Cave Creek,
- Turner Creek, and
- Godman Creek.

Provide a global view in terms of the societal, environmental and financial goals of British Pacific Properties Ltd. (BPP) and

the District of West Vancouver.

Method: Assemble drainage plan mapping, infrastructure inventory, basin confirmation, confirmation of known drainage problems, and assemble governing criteria and agency needs.

Identify goals and objectives of the ISMP for the five creeks in conjunction with BPP, the District of West Vancouver, the stakeholder committee, and environmental agencies in Meeting #1.

Understand watershed issues, establish regulatory requirements, and confirm study approach and scope of the Integrated Stormwater Management Plan (ISMP).

Develop and confirm stakeholder involvement objectives and processes.

Deliverables: Initiation meeting, meeting minutes and action items identified.

Project control manual to confirm goals and constraints of the study, following Meeting #1.

Base plan and relevant overlays showing catchments and subbasins.

Summary of issues to be addressed in the ISMP and work program.

Resources: Dayton & Knight Ltd., BPP, District of West Vancouver

4.2 Task 2 – Inventory, and Data Collection

Task 2 includes a number of work items designed to obtain meaningful and reliable data that can be used to develop and assess stormwater management alternatives later in the project.

Task 2.1 - Existing Stormwater Program Review

The purpose of Task 2 is to assemble the needed inventory of information including physical and financial criteria for baseline use in the plan development.

Objective: To provide the background and information for the development of the Integrated Stormwater Management Plan. To obtain, review and evaluate all available current and historical information.

Method: Review existing stormwater programs, such as the ISMPs for McDonald and Lawson Creeks (Kerr Wood Leidal Associates Ltd. 2002), and for Rodgers Creek (Associated Engineering Ltd. 2006) Dayton & Knight Ltd. reports, etc. Use data and apply relevant approaches as described in these reports.

Gather information about the District's existing practices related

to stormwater, such as bylaws, design standards, operation and maintenance practices, public education, equipment, and staff training.

Deliverables: Deliverables for Tasks 2.1 to 2.6 are described at the end of Section "Task 2".

Resources: Dayton & Knight Ltd.

Task 2.2 – Assemble Hydrometric Data

Objective: To monitor hydrometric data to understand watershed response to rainfall. We understand that appropriate stream gauging stations within the District drainage and currently being installed to secure accurate information for stream flow monitoring and for use in computer model calibration.

Method: Collection of available hydrometric data, such as rainfall and responding stream flow to calibrate the computer runoff model.

Time constraints for this ISMP do not allow for extensive monitoring of rainfall, stream flow and stormwater flows in the five creeks. The available flow data will be used, if possible, to calibrate and verify the hydraulic model. Criteria and data from the existing ISMP will be used for modeling, such as the Rodgers Creek stream flow gauge or Capilano Golf and Country Club rainfall gauge(s).

Resources: Dayton & Knight Ltd., InterCad flow data

Task 2.3 - Drainage System Inventory

Objective: Identify watercourse characteristics, erosion concerns, drainage facilities, flow paths, opportunities and constraints for flood management measures.

Method: Gather information about the existing drainage system, such as drainage maps and GIS data from the District of West Vancouver.

Undertake site reconnaissance and site survey plan, photo interpretation, creek channel survey to estimate probable full bank channel capacity, sediment capture sites, physical barriers to fish passage, past drainage problems, and mapping.

Inventory of the existing drainage facilities and culverts (diameter, slopes). See Appendix A for inventory collection templates.

Develop hydraulic and hydrologic understanding for constraints

	in design approach. Identify existing erosion sites and use rating of low, moderate, or severe. Three days of visual field reconnaissance is included in Task 2.3. An additional 2 days per basin is included for inventory assembly. This information will be field recorded on digital processes for direct tabulation using criteria of Appendix A. Further effort can be undertaken at rates shown in Section 5 if necessary. This task does not include entering data in GIS. Resources: Dayton & Knight Ltd.
Task 2.4 – Hydrogeological and Geotechnical Inventory	Objective: To determine geotechnically significant areas, identify flow regimes, and to identify areas in the watershed where infiltration should be encouraged or prohibited. Method: Identify sub-surface flow regimes, soil types, infiltration opportunities, ravine and streambed instability, and determine the sub-surface catchment area and baseflow potential. Complete a desk-top review of existing geotechnical and hydrogeological information / reports, including available historical air photos. Complete field reconnaissance surveys as required to identify sections of all creek channels that are or will be susceptible to erosion, based on 1-year return and 100-year return conditions. Complete field reconnaissance surveys as required to identify natural hazards and the corresponding potential impacts of the drainage systems, with specific consideration for the geotechnical hazards caused by proposed stormwater management approaches / methods. Prepare comments on the overall feasibility of infiltrating stormwater runoff in proposed development areas within the overall study area. For detailed task description and deliverables see Appendix D by Golder Associates Ltd. Resources: Golder Associates Ltd.
Task 2.5 - Environmental Inventory	Objective: Identify importance of habitat and suggest opportunities for environmental enhancement.

Method: Biophysical Inventory to identify existing stream, floodplain, riparian and wetland resources. (Benthic Community Sampling using B-IBI, calibration).

SLR will complete a desktop synthesis of available biophysical inventory information within the five catchments, including:

- physical stream parameters (e.g., gradient, channel width, substrate composition, cut bank cover, fish-passage barriers to fish movement);
- aquatic and riparian habitat characteristics, and known presence of fish and amphibians;
- terrestrial wildlife habitat, vegetation communities, wildlife inventory;
- environmentally sensitive areas and listed species and communities;
- wetland delineation and classification;
- a map, at an appropriate scale, summarizing information by stream reach;
- a general overview evaluation of watershed health and riparian integrity.

SLR will then identify data gaps and undertake a field survey of the five major creeks to confirm information, and to fill only those data gaps that can be filled through reconnaissance-level observations, and will then make recommendations for additional study, as appropriate.

For detailed task description and deliverables see Appendix E proposal by SLR Consulting Ltd.

Resources: SLR Consulting Ltd.

Task 2.6 – Land Use Planning

Objective: To identify existing and future land use and recreational amenities.

Method: Gather land use information from the District's Official Community Plan and from BPP's development plan. Suggest options for land use together with BPP.

Identify existing practices with respect to drainage and riparian area protection.

Define and incorporate existing and recommended recreational amenities, such as greenway corridors, pedestrian and bike

routes etc.

Resources: Dayton & Knight Ltd., Information provided by the District of West Vancouver

Task 2.1 to 2.6 - Deliverables

Deliverables for Task 2.1 to 2.6: AutoCAD based maps and figures to show the information assembled in Task 2: e.g., overview of existing drainage system, watershed characteristics, results of geotechnical and environmental assessment.

Meeting #2 will be arranged with the Client and the District to review the systems operation in conjunction with this task.

4.3 *Task 3 –Technical Analysis*

Task 3 involves technical analysis and computer modeling to assess the drainage conditions for existing and future development, including erosion and natural hazards, and environmental issues. Task 3 includes initial development or stormwater management solutions.

Task 3.1 - Hydrological Analysis

Objective: To assemble and enter the model criteria for rainfall simulations, hydrologic parameters, and the watershed hydrologic response. Estimate design flows and volumes, which will be used in the hydraulic analysis to evaluate flooding and size upgrades.

Method: Review data assembled in Task 2 and develop hydrologic components of the computer runoff model PCSWMM. Develop rainfall hyetographs for the various return events to be modeled, and identify the run-off for all nodes/manhole entries to the model system.

The analysis will also include a verification procedure to confirm the suitability of the model for the site, and to calibrate the model with the flow monitoring data collected (if available).

Deliverable: Assembly of rainfall analysis, physical and rainfall modules for selected computer model, modeling results.

Resources: Dayton & Knight Ltd.

Task 3.2 - Hydraulic Analysis

The purpose of Task 3 is to complete the drainage system analyses and refine the drainage modeling for final drainage recommendations.

Objective: To assemble and enter the hydraulic model criteria for simulations of flood routing and to determine the conveyance capacity for existing and future conditions. Determine the impact and drainage improvement needs as a result of three different run-off conditions (10-year, 100-year and 200-year return storms) on existing and future land use for selected

drainage improvements. Determine peak flows and volumes for minor frequent events (<<2 years) to determine environmental impacts.

Method: Assemble data for hydraulic model flood routing for analysis of current and future run-off predictions, including potential mitigative strategies. This could include diversions, weir-orifice controls, detention, pumping and surcharge conditions related to flood conditions for various boundary conditions.

Analyze the storm conditions for existing and future land use, and introduce various stormwater management solutions to manage the run-off and mitigate flooding to acceptable levels.

Identify major flood paths as well as minor storm drainage.

Determine peak flow estimates for storm conditions.

Determine conveyance capabilities of channels, drainage ditches and structures and size of upgrades if required.

Determine structural deficiencies.

The Metro Vancouver Template for ISMPs recommends using PCSWMM for hydraulic modeling.

Deliverable: Modeling for current and future run-off conditions. Drawings with minor and major flow paths, problem areas, and capacity deficiencies.

Resources: Dayton & Knight Ltd.

Task 3.3 - Channel Erosion and Natural Hazard Assessment

Objective: To identify mitigative solutions for erosion protection.

Identify and recommend mitigative measures for natural hazard areas (i.e. debris flows, etc.)

Engineering solutions are required for flood and erosion control.

Method: Identify sections of creek channels that are or will be susceptible to erosion for the storm conditions.

Summarize flow velocities at key locations using the modeling results.

Determine channel velocity threshold limits and erosion susceptibility for existing and future conditions.

Suggest mitigative measures to protect against erosion with prioritization.

Identify natural hazard areas (floods, debris flow, etc.), potential impacts on the drainage system, and areas where the stormwater plan may cause geotechnical hazards. A detailed assessment of specific hazards is outside the scope of work of this ISMP and could be investigated in a separate study.

Deliverable: See Golder proposal in Appendix D.

Resources: Golder Associates Ltd., Dayton & Knight Ltd. for flow velocities.

Task 3.4 - Environmental Analysis

Habitat protection and restoration are highly important

Objective: Consider environmental impacts of development in watersheds.

Method: Complete a desktop synthesis of available biophysical inventory information within the five catchments, including:

- Physical stream parameters (e.g., gradient, channel width, substrate composition, cut bank cover, fish-passage barriers to fish movement);
- Aquatic and riparian habitat characteristics, and known presence of fish and amphibians;
- Terrestrial wildlife habitat, vegetation communities, wildlife inventory;
- Environmentally sensitive areas and listed species and communities; and
- Wetland delineation and classification.
- Map summarizing information by stream reach
- General overview of watershed health and riparian integrity.
- Provide recommendations for ongoing water quality and sediment quality monitoring needed to evaluate the health of surface waters within the five catchments as development proceeds.
- Prepare and submit a report summarizing the environmental work.
- As an optional extra, depending on needs of the ISMP, SLR will develop and conduct a program of benthic invertebrate and water quality sampling for the five major creeks.

For detailed task description and deliverables see Appendix E – SLR Consulting Ltd.

Deliverable: See SLR proposal in Appendix E.

Resources: SLR Consulting Ltd.

4.4 *Task 4 – Assess Mitigative Alternatives*

Task 4 involves assessing the stormwater management solutions, developed in Task 3, and selection of the preferred alternative(s).

Objective: To determine the most appropriate solutions for stormwater drainage improvements for current and future land use.

Task 4.1 - Stormwater Management Alternatives

Method: The work includes evaluating and selecting the best improvement options in conjunction with Task 3.

Assess stormwater management alternatives, flood and erosion management alternatives, water quality alternatives, and habitat protection alternatives with consideration of health and safety, environmental impacts, costs, and public acceptance.

SLR will review stormwater management alternatives developed by Dayton & Knight Ltd. for the ISMP in light of information developed earlier in the project, and provide comments and input from an environmental perspective, including potential positive and negative impacts of alternatives.

Golder Associates will identify areas with natural hazards (floods, debris flow, landslide, erosion, etc.), potential impacts on the drainage system, and areas where the stormwater plan may cause geotechnical hazards. They will also provide comments on the feasibility of infiltrating storm runoff in development areas identified within the study area.

Hydraulic modeling and analysis of alternatives, (D&K),review of alternatives on the basis of hydrogeological factors (Golder Associates) and environmental protection (SLR Consulting).

Evaluate benefits, costs and effectiveness of the alternatives considering all aspects described above, and select preferred option(s).

Meeting #3 provides presentation of findings for review and final comment.

Meeting #3 will be arranged with the Client, the District and the stakeholders committee to select options.

Deliverable: Selected improvements that best meet BPP and District requirements confirmed through workshop Meeting #3. Minutes will be provided and action items recorded.

Resources: Dayton & Knight Ltd., SLR Consulting Ltd., Golder Associates Ltd.

4.5 *Task 5 - Integrated Stormwater Management Plan*

Task 5 involves completion of the ISMP and production of the draft and final reports.

Task 5.1 - ISMP

Objective: To summarize the findings of the study and present a final report to BPP, to the stakeholders, and to the District of West Vancouver that will meet the short and long term drainage needs for the drainage works for the District, and that maintains, restores, and enhances the watershed for hydrotechnical and environmental aspects.

The purpose of Task 5 is to assemble the selected study findings and complete the ISMP.

Method: Develop implementation strategy with timeline and cost estimation.

Meeting #4 includes a presentation of the draft report findings to BPP, to the stakeholders (third meeting with stakeholders committee), and to the District of West Vancouver.

Revise report to suit requirements and produce final bound copies including colour illustrations and tables.

Deliverable: Meeting #4 minutes.

6 bound copies of the final report as well as a PDF version of report and record data. A possible outline for the report is shown in Appendix A.

Resources: Dayton & Knight Ltd.

DISTRICT OF WEST VANCOUVER
INTEGRATED STORMWATER MANAGEMENT PLAN FOR PIPE, WESTMOUNT, CAVE, TURNER AND GODMAN CREEKS

APPENDIX B

SLR ECOLOGICAL OVERVIEW REPORT

Integrated Stormwater Management Plan
for Pipe, Westmount, Cave, Turner, and Godman Creeks

Ecological Overview Report

Dayton & Knight Ltd. Project 578.001.200

Prepared for:

Dayton & Knight Ltd.
CONSULTING ENGINEERS

March 2009
SLR Project No. 201.88342

ECOLOGICAL OVERVIEW REPORT

INTEGRATED STORMWATER MANAGEMENT PLAN

FOR PIPE, WESTMOUNT, CAVE, TURNER, AND GODMAN CREEKS

Dayton & Knight Ltd. Project 578.001.200

SLR Project No. 201.88342

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EXECUTIVE SUMMARY

On behalf of Dayton & Knight Ltd., SLR Consulting (Canada) Ltd. has prepared this report on ecological investigations that form part of an Integrated Stormwater Management Plan (ISMP) derivation process. To the extent applicable, component studies follow the template Kerr Wood Leidel Associates Limited (2005) prepared for ISMPs undertaken within Metro Vancouver and member municipalities. The ISMP Study Area comprises the watersheds of five streams that originate on the slopes of Hollyburn Mountain in West Vancouver, BC, and flow generally southward into English Bay. From east to west, the five streams are Pipe Creek, Westmount Creek, Cave Creek, Turner Creek, and Godman Creek.

Land use in upper portions of each of these watersheds consists mainly of undeveloped second-growth forest, while lower portions constitute residential areas of the District of West Vancouver. Developed and undeveloped portions of the watersheds are divided by the lower portion of Cypress Bowl Road or Highway 1. An exception is the watershed of Turner Creek, of which the District Operations Yard occupies the upper portion.

Large undeveloped portions of the Pipe, Westmount, Cave and Godman watersheds are owned by British Pacific Properties Ltd. The Pipe, Westmount and Cave watersheds form the western part of the Rodgers Creek Area Development Plan, while the Godman and Turner watersheds form the eastern part of the future Cypress Creek Area Development Plan. Proposed land use is mainly mixed-form residential housing, with associated parks, institutional use, and business-retail precincts. Owing to servicing practicability, most development is planned below the 1,200 ft (366 m) elevation contour.

Objectives of this report are: to provide ecological information as input to derivation of the ISMP; to help ensure that valued ecosystem components are accounted for during development within the watersheds; and to ensure that ecologically relevant information for purposes of continued monitoring of watershed health is available for a wider portion of West Vancouver than is now the case.

Streams and Riparian Habitat

Much of the information on streams and riparian habitat was derived from recent SLR reports (2008a,b) on the Rodgers Creek and Cypress Creek Neighbourhoods. As Turner Creek lies between these two areas, new assessments of this stream were also undertaken.

Based on fish sampling, database searches, and information from DFO and West Vancouver Streamkeepers, sections of all five study-area streams below Highway 1 are known to support populations of salmonid fish (cutthroat trout and, to a lesser extent, coho salmon). Resident cutthroat trout have been reported in sections of Godman Creek above Highway 1.

The headwaters of Pipe Creek are within Cypress Bowl Provincial Park and several tributaries augment its flows. Upstream of Highway 1, the Pipe Creek mainstem is primarily in a natural state, while sections downstream of the highway have been affected significantly by adjacent residential and infrastructure development. Pipe Creek is approximately 3 km long and flows southward through the Altamont neighbourhood of West Vancouver before discharging into English Bay, near the foot of 31st Street.

Westmount Creek flows from Cypress Bowl Provincial Park, and through the Westmount neighbourhood of West Vancouver, before discharging to English Bay along West Bay. Upstream of Highway 1, Westmount Creek is primarily in a natural state. Downstream of the highway, however, Westmount Creek has been controlled by channelization (flumes) and culverts to its mouth. The stream has become a landscape feature for residential properties along its banks, and little remains of riparian vegetation or in-stream substrate.

Cave Creek is a short, steep watercourse that flows from the lower Cypress Provincial Park area, then through the Westmount neighbourhood of West Vancouver. It discharges into English Bay at the West Bay Park. Sections of Cave Creek above Highway 1 are in a relatively natural state, while, downstream of the highway, owners of adjacent lands have manipulated Cave Creek significantly, and there are numerous perched culverts at road crossings.

Turner Creek originates immediately above the District of West Vancouver Operations Centre property, and is culverted under both those lands and lower Cypress Bowl Road. After flowing from the culvert, Turner Creek waters enter a partially confined channel within a shallow ravine. Below Highway 1, Turner Creek flows generally southeastward through the Westmount neighbourhood, and discharges to English Bay at West Bay Park, a short distance west of the mouth of Cave Creek.

Godman Creek is approximately 4.8 km long, with a total drainage area of approximately 1.8 km^2, and an elevation range of sea level to approximately 800 m. Godman Creek has a mainstem (Main Branch), a major tributary (West Branch), and a minor tributary (East Branch) that appears to have been formed by diversion of a former side channel by the alignment of Eagle Lake Road. Below Highway 1, Godman Creek flows through the Bayridge neighbourhood of West Vancouver, and enters English Bay a short distance west of Sandy Cove Park.

Based on application of the Riparian Areas Regulation, minimum setbacks along study area stream sections within undeveloped areas are all under 17 m, and many are 10 m (the minimum). The major portion of stream riparian assessment fieldwork along Pipe, Westmount, Cave and Godman creeks was undertaken between November 14 and 24, 2005, with periodic follow-up data-gathering through February 2006 (SLR 2008a,b). A riparian assessment was conducted along Turner Creek on August 27, 2008.

The ISMP process also includes a riparian corridor assessment to derive a measure of the Riparian Forest Integrity (RFI). This indicator is determined by examining two main riparian characteristics: the proportion of the stream that has been enclosed in culverts; and the degree to which forested riparian setbacks are narrower than 30 m from HWM along one or both sides of a stream channel. The RFI is 100% if the entire length of a stream has intact 30-metre treed riparian zones along both sides, as measured from HWM.

As study area streams flow through existing residential neighbourhoods below Highway 1, while portions above Highway 1 flow mainly through forested areas, separate RFI percentages were derived for portions of these streams above and below Highway 1, as well as for the total stream length extending from the headwaters to English Bay. As would be expected, RFI values were 0% for sections of all the streams below Highway 1. RFI values for stream portions above Highway 1 were: Pipe Creek 85%; Westmount Creek 84%; Cave Creek 92%; Turner Creek 71%; and Godman Creek (mainstem) 88%.

Water Quality Monitoring

Quality of waters in study area streams has been monitored on several occasions since 1999 (SEACOR 2008a,b), consisting of both *in situ* analyses and sampling for laboratory analyses. SLR undertook *in situ* measurements in August 2008 at two locations along each stream to provide recent baseline data for the ISMP investigations. In addition, SLR collected samples from Godman Creek for laboratory analyses, in conjunction with monitoring of the benthic invertebrate community. Results of all available water quality investigations are presented in Appendices C and D. Physical parameters and chemical constituents, and their seasonal variations, were considered typical of fast-flowing mountain streams of BC coastal areas.

Laboratory analysis of total coliform levels found water sampled from Godman Creek on 29 August 2008 contained unexpectedly high levels of faecal coliforms, at 500 CFU/100 mL (detection limit: 100 CFU/100 mL). As the District sanitary system follows Westridge Avenue and the water samples were taken upstream of Westridge Avenue, the source of faecal coliforms may have been dog faeces not recovered by owners in Westridge Park, where dogs are often allowed to be unleashed. The stream was sampled following three days of rain, and it is possible that saturated conditions in soils adjacent to the stream contributed to ongoing accumulations of coliforms being flushed into the channel.

Benthic Invertebrate Community Investigations, Godman Creek

ISMP investigations included sampling and analyses of the benthic invertebrate community at a representative site. The population density and composition of benthic communities is known to be an indicator of the relative “health” of a watershed, through analyses based on the degree to which community characteristics differ from those expected of communities within a pristine, “natural” stream in a similar Biogeoclimatic zone. A monitoring program can be used to track changes in the benthic community over time, revealing changes in the health trajectory of the surrounding watershed as it undergoes land-use change.

The site chosen for sampling of the benthic invertebrate community, Sampling Site G1, was along Godman Creek within a 52 m reach immediately Westridge Avenue and upstream of Viewridge Place. SLR sampled benthic invertebrates on August 29, 2008, and analyses were conducted in a manner consistent with the Module 4 Stream Invertebrate Survey developed by DFO for Streamkeeper organizations, and with Benthic Index of Biological Integrity (B-IBI) as applied by Metro Vancouver during ISMP investigations.

Although Godman Creek Site G1 exhibited the riffle-pool morphology, gravel and cobble substrates with moderate fines, and moderate flows characteristic of a more natural, undisturbed stream, the benthic invertebrate community was dominated by Pollution-Tolerant Oligochaetes rather than Ephemeroptera-Plecoptera-Trichoptera (EPT) taxa, suggesting that factors other than habitat may be influencing community composition. Of note, two minor and one significant rain event occurred in the days preceding sampling, which may have reduced EPT abundance and taxa. In addition, high faecal coliform levels, as identified by lab analysis of water samples, may also affect EPT composition.

The metric Shannon-Weaver Diversity Index suggested that, according to Wilhm’s classification, the Godman Creek Site fell between a “polluted” and a “clean” stream, whereas the Pielou Evenness Index reflected a community with individuals distributed unevenly among the taxa, likely due to Oligochaete dominance. The Streamkeeper and B-IBI protocols yielded, respectively, an Acceptable Site Assessment Rating, and a B-IBI Good Stream Condition of 38.

Terrestrial Ecosystem and Vegetation Characteristics

This report includes results of reconnaissance-level vegetation surveys and ecosystem mapping of various parts of the ISMP study area to characterize forests of the proposed Rodgers Creek and Cypress Creek neighbourhoods (SLR 2008a,b). As such, areas already developed for urban land uses, primarily below Highway 1, were not included.

The ISMP study area straddles two biogeoclimatic units, subzones of the Coastal Western Hemlock zone (BCMOF 2003): the Very Dry Maritime subzone (CWHxm1) and the Dry Maritime subzone (CWHdm). The CWHxm1 extends from sea level to elevations of approximately 200 m where it grades into the CWHdm, with local variation influenced by aspect, exposure, and topography. The gradation between the upper extent of the CWHxm1 and the lower extent of the CWHdm biogeoclimatic units begins at approximately the elevation lower Cypress Bowl Road. As such, lower portions of study area watersheds, including developed areas, are within the CWHxm1 unit, while the upper portions are within the CWHdm unit.

Undeveloped portions of study area watersheds are dominated by forested ecosystems located primarily on moderately well-drained sites. Sites richer than average are relatively common because the study area comprises a lower macroslope position where many sites receive nutrient-rich soil and moisture from upslope. Occasionally, drier than average sites occur, with thin soil underlain by convex bedrock. Very dry sites occur rarely, only where soil is virtually absent and vegetation grows on humus and bedrock. Streamsides tend to be moist and rich. Wetlands in the study area are associated mainly with Godman Creek.

Young forests that cover most of the upper study area consist of second growth stands that have regenerated following clear-cut logging in the early 20th century. In addition to logging, ecosystems have historically been disturbed by chairlift construction, operation and placement of water reservoir tanks, and other infrastructure, such as powerline rights of way. Recent disturbances include clearing, residential building, and road construction. No old forest or mature structural stages were observed in the ISMP study area.

On the basis of information available, there are no known rare element occurrences of vascular plants or ecological communities in the ISMP study area, and sensitive ecosystems are quite limited in area, consisting mainly of riparian areas, wetlands, and rock outcrops.

Wildlife of the ISMP Study Area

Wildlife occurrence has been investigated in the Rodgers Creek Neighbourhood area (SLR 2008a) and the Cypress Creek Neighbourhood area (SLR 2008b) through ground reconnaissance and from a review of existing information sources. These study areas included large forested portions of the watersheds of Pipe, Westmount, Cave, and Godman creeks. In addition, systematic studies have been undertaken in these study areas in 2007 (SLR 2008a,b) to document presence of breeding birds and species of concern.

Vertebrate wildlife species that could potentially occur in or near the subject area are listed in Appendix G. This list is based on review of several documents describing occurrence and habitat relationships of vertebrate wildlife in the Lower Mainland, known distribution of vertebrates in the area, and on assessment of habitat types available in the study area. Not all species may in fact occur, owing to habitat conditions or present distribution limits.

SLR (2008a,b) analysed potential occurrence of Red- and Blue-listed terrestrial and amphibious vertebrate species to identify species that have some likelihood of occurring within or near the Rodgers Creek and Cypress Creek Neighbourhood areas. This analysis was based on the BCCDC tracking list for the Chilliwack Forest District, which includes many species not found in the study area (based on known range or absence of suitable habitat in the study area, such as marine species). On the basis of habitat availability, this list was reduced to a total of 9 species (2 amphibians, 3 birds, and 4 mammals). Terrestrial and amphibious vertebrate wildlife included were assessed on the basis of known distribution in the region, habitat preferences, and likelihood of occurrence based on habitat available in and near the study area.

Five listed bird species and five listed mammal species have ranges that may include the ISMP study area. None has actually been confirmed as being present.

Two at-risk species of frog, the coastal tailed frog and the red-legged frog, have been found within the ISMP study area. The coastal tailed frog has been found along Tributary N of Pipe Creek and along the mainstem of Godman Creek, above Eagle Lake Road. The red-legged frog has been found near the wetland along Godman Creek, below Eagle Lake Road.

SEACOR (2008a,b) also assessed the Rodgers Creek and Cypress Creek Neighbourhood study areas for occurrence probability, and habitat for, significant species of damselflies, dragonflies and butterflies. The potential for rare butterflies in the study area was rated as low-to-nil, as plants forming the diet of larvae were not present. The only exception would be accidental species and infrequent migrating Monarch butterflies passing through the area. Although habitat in the ISMP study area had limited potential to support listed dragonflies, none were located. The area provides only low-quality habitat for listed dragonfly and butterfly species, and supports a low diversity of common species.

Watershed Health

The watershed health tracking system recommended by Kerr Wood Leidel (2005) in the ISMP template is based on correlation among three quantifiable biophysical characteristics of watersheds: Percent Riparian Forest Integrity (RFI); Effective Impervious Area (EIA); and the Benthic Index of Biotic Integrity (B-IBI). This report includes derivation of the baseline watershed health of the Godman Creek watershed, based on its RFI, B-IBI and EIA values.

Given that it is located a short distance below Highway 1, the benthic invertebrate population at Site G1 is influenced mainly by conditions in the upper, mostly undeveloped, part of the Godman watershed, and very little by conditions below the highway. For the upper portion of the watershed, the RFI is 88%, and the EIA is approximately 5% (very close to the Total Impervious Area, TIA). The overall B-IBI score for Godman Creek, Site G1, was 38 or “Good”.

With reference to Figure 6, the predicted B-IBI score for a watershed with an RFI of 88% and an EIA of 5% would be approximately 34. The actual B-IBI score of 38 for Site G1 exceeds this predicted score, indicating that there are no concerns related to the baseline health level of the Godman Creek Watershed. As development progresses in the upper Godman Creek Watershed, the watershed health tracking system may be used to evaluate the effectiveness of low-impact development (LID) practices and riparian habitat conservation measures as they are implemented.

ABBREVIATIONS, ACRONYMS AND INITIALISMS USED IN THIS REPORT

BCMOE	British Columbia Ministry of Environment
BCMOF	British Columbia Ministry of Forests
BCMSRM	British Columbia Ministry of Sustainable Resource Management
BPPL	British Pacific Properties Limited
CDC	Conservation Data Centre of BCMOE
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
DFO	Department of Fisheries and Oceans or Fisheries and Oceans Canada
EIA	Effective Impervious Area, which is the Total Impervious Area (TIA) minus the amount connected to stormwater infrastructure
GPS	Global Positioning System
HADD	Harmful Alteration, Disruption or Destruction of Fish Habitat (federal *Fisheries Act*)
HWM	High Water Mark (of waterbodies)
ISMP	Integrated Stormwater Management Plan
NDM	Norecol, Dames & Moore, now part of URS
QEP	Qualified Environmental Professional
RAA	Riparian Assessment Area (under the RAR)
RAR	Riparian Areas Regulation
RFI	Riparian Forest Integrity
SPEA	Streamside Protection and Enhancement Area (under the RAR)
TIA	Total Impervious Area
URS	United Research Services (now known only as URS, which includes the former URS Norecol, Dames & Moore, Inc.)
ZOS	Zone of Sensitivity (under the RAR Assessment Methods)

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APPENDICES

1.0 INTRODUCTION

Dayton & Knight Ltd. has been contracted by British Pacific Properties Limited (BPPL) to complete an Integrated Stormwater Management Plan (ISMP) for a study area in West Vancouver, British Columbia. SLR Consulting (Canada) Ltd. (formerly SEACOR Environmental Inc.) has prepared this report on ecological investigations that form part of the ISMP derivation process, on behalf of Dayton & Knight Ltd.

1.1 Study Area

The ISMP Study Area comprises the watersheds of five streams, all of which originate on the slopes of Hollyburn Mountain, and flow generally southward into English Bay. From east to west, the five streams are Pipe Creek, Westmount Creek, Cave Creek, Turner Creek, and Godman Creek. Each stream also has tributaries, the most significant being Godman Creek West Branch. The study area location is depicted in Figure 1, and the stream locations and watershed boundaries in Figure 2.

Land use in upper portions of each of these watersheds consists mainly of undeveloped second-growth forest, while lower portions constitute residential areas of the District of West Vancouver. Developed and undeveloped portions of the watersheds are divided by the lower portion of Cypress Bowl Road or Highway 1. An exception is the watershed of Turner Creek, of which the District Operations Yard occupies the upper portion.

Large undeveloped portions of the Pipe, Westmount, Cave and Godman watersheds are owned by BPPL. The Pipe, Westmount and Cave watersheds form the western part of the Rodgers Creek Area Development Plan, while the Godman and Turner watersheds form the eastern part of the future Cypress Creek Area Development Plan. Proposed land use is mainly mixed-form residential housing, with associated parks, institutional use, and business-retail precincts. Owing to servicing practicability, most development is planned below the 1,200 ft (366 m) elevation contour.

1.2 Scope of Work and Objectives

Metro Vancouver, formerly the Greater Vancouver Regional District (GVRD), has mandated that member municipalities undertake or oversee ISMPs for watersheds within their jurisdictions. As such, the study team worked with staff of the District of West Vancouver to develop the scope of work for these investigations.

To ensure that ISMPs developed throughout Metro Vancouver are comparable, Kerr Wood Leidel Associates Limited (2005) was contracted to prepare a template for the component studies, in consultation with member municipalities. The ISMP to which the current report contributes has followed the template to degree applicable.

The scope of work for ecological investigations was based on the Metro Vancouver ISMP Template (Kerr Wood Leidel 2005), with some modifications to ensure it was practical and had achievable goals and well-defined tasks that could be completed efficiently. Tasks are summarized below.

Task 1: A desktop synthesis of available biophysical inventory information within the five catchments, including:

- o physical stream parameters (e.g., gradient, channel width, substrate composition, cut bank cover, fish-passage barriers to fish movement);
- o aquatic and riparian habitat characteristics, and known presence of fish and amphibians;
- o terrestrial wildlife habitat, vegetation communities, wildlife inventory;
- o environmentally sensitive areas and listed species and communities; and
- o wetland delineation and classification.

Task 2: A field survey to confirm information developed in Task 1, and to fill only those data gaps that could be filled through reconnaissance-level observations.

Task 3: A program of benthic invertebrate and water quality sampling from a representative site along one of the streams

Task 4: In light of information developed in Tasks 1, 2 and 3, comments on, and input to, the ISMP from an environmental perspective, including potential positive and negative impacts of alternatives.

Task 5: Recommendations for ongoing water quality and sediment quality monitoring needed to evaluate the health of surface waters within the five catchments as development proceeds.

Task 6: Completion of this report summarizing the work carried out in Tasks 1 to 5.

The project also entailed meetings with the client, project team, and District staff.

Objectives of this report are:

- To provide ecological information as input to derivation of the ISMP;
- To help ensure that valued ecosystem components are accounted for during development within the watersheds; and
- To ensure that ecologically relevant information for purposes of continued monitoring of watershed health is available for a wider portion of West Vancouver than is now the case.

1.3 Study Team

The ISMP study team consists of:

- British Pacific Properties Limited (BPPL), proponent and owner of the upper portion of the study area;

- The District of West Vancouver (the District), overseeing the technical quality of the ISMP;
- Dayton & Knight Ltd., Prime Consultant and lead on derivation of the ISMP;
- Golder Associates Ltd., Geotechnical Subconsultant;
- InterCAD Services Ltd., Digital Mapping; and
- SLR Consulting (Canada) Ltd., Ecological Subconsultant.

1.4 Information Sources

References are cited throughout this report, and listed in Section 9.0. Much of the information synthesized for Task 1 originated from two recent reports:

SLR Consulting (Canada) Ltd. 2008a (July Draft). Environmental Overview Update, Proposed Rodgers Creek Neighbourhood Development, West Vancouver, BC. Prepared for British Pacific Properties Limited. Vancouver; 99 pp. + app. [an update of SEACOR 2004]

SLR Consulting (Canada) Ltd. 2008b (August Draft). Environmental Overview Update, Proposed Cypress Creek Neighbourhood Development, West Vancouver, BC. Prepared for British Pacific Properties Limited. Vancouver; 71 pp. + app.

Study areas for SLR 2008a and SLR 2008b were neighbourhood-planning areas owned by BPPL.

Rodgers Creek Neighbourhood Study Area

The SLR 2008a Rodgers Creek Neighbourhood study area extended from Marr Creek to a powerline right-of-way east of Cave Creek, and included portions of the watersheds of Pipe, Westmount, and Cave creeks between the lower portion of Cypress Bowl Road and the next higher switchback of Cypress Bowl Road.

Cypress Creek Neighbourhood Study Area

The SLR 2008b Cypress Creek Neighbourhood study area included two land parcels, Lower Cypress on the east and Upper Cypress on the west, and included the portion of the Godman Creek watershed above the Upper Levels Highway (Highway 1).

Turner Creek

Previous SLR reports (prepared on behalf of BPPL) did not include Turner Creek, which flows through a section of non-BPPL lands between the Rodgers Creek and Cypress Creek neighbourhood-planning areas. However, at the request of BPPL, SLR has completed ecosystem mapping for the upper Turner Creek watershed, and this mapping is included in the current report.

Previous ISMP Reports

Two previous ISMPs developed for other watersheds in West Vancouver were reviewed to provide consistency of methods and reporting:

Kerr Wood Leidel Associates Limited. 2002 (December Draft). McDonald and Lawson Creeks, Integrated Stormwater Management Plan. Prepared for the District of West Vancouver. North Vancouver, BC.

Associated Engineering (B.C.) Ltd. and Jacques Whitford AXYS Ltd. 2008 (February Draft). Rodgers and Marr Creeks, Integrated Stormwater Management Plan. Prepared for the District of West Vancouver.

1.5 Health and Safety During Fieldwork

SLR's standard operating procedure is to produce Health and Safety Plans for all fieldwork. Specific safety measures applied during these investigations included:

- fieldwork teams of two or more people, with no one working alone;
- regularly scheduled check-in by cellular phone call to the SLR office, and frequent updates;
- cellular phone contact between teams;
- protective field gear, including WCB-approved footwear, rain suits, cold-weather clothing, gloves, and cruiser vests with reflective tape;
- one first-aid kit per team; and
- parking of vehicles off roadways in safe locations.

Tailgate meetings were held at the beginning of each day to confirm the day's work plan, review potential worksite hazards, and discuss communications.

2.0 STREAMS AND RIPARIAN HABITAT

This section summarizes ecological information for each ISMP study-area stream and related riparian habitat. Much of this information was derived from recent reports on the Rodgers Creek and Cypress Creek Neighbourhoods (SLRa,b). As Turner Creek lies between these two previous study areas, however (Figure 2), new assessments were undertaken along Turner Creek, including a riparian assessment, applying Riparian Areas Regulation methods, and collection of BC Ministry of Environment (BCMOE) site card data.

2.1 Evaluating Habitat Conditions

Initial field investigations of streams on the BPPL lands by fisheries biologists were conducted between November 1999 and October 2003. These investigation included Pipe, Westmount, Cave, and Godman creeks, but not Turner Creek. Streams were located and biophysical data collected for steam mainstems, tributaries, and associated wetlands. The biologist walked the entire length of each creek, and wetland perimeters, and completed Stream Survey Forms to describe and quantify habitat stream features (Appendix A). The habitat survey included measurements and ground estimates of flow and substrate types, channel and wetted widths, riffle and pool depths, riparian vegetation types and coverage, bank height and texture.

Habitat in the section of Turner Creek between lower Cypress Bowl Road and Highway 1 was evaluated on August 27, 2008, concurrent with other investigations in the ISMP study area.

2.2 Evaluating Fish Presence

A limited fish-sampling program was conducted along Godman Creek between May 4 and 13, 2000. Baited minnow traps were placed in nine locations deemed to have greatest likelihood of fish capture.

Additional investigations of fisheries resources in the Cypress Neighbourhood area were carried out in April 2004; assessments included confirmation of stream locations and wetland perimeters with use of a global positioning system (GPS). The GPS data were downloaded and used to construct the base map for the site.

Mainstems and larger tributaries of Rodgers Creek Neighbourhood area streams were surveyed for fish presence on January 24, 2006, concurrently with water-quality investigations. The method used was electroshocking, conducted by a team of two individuals, each fully trained and experienced. Surveys were conducted along sections of streams immediately upstream of road crossings that formed the lower elevation limit of the study area. Choice of electroshock locations was to include those with the greatest likelihood of harbouring fish populations.

2.3 Known Fish Presence in Study Area Streams

Table 1 summarizes salmonid (salmon and trout) species believed present in ISMP study area. This information was obtained from the Provincial on-line Fisheries Information Summary System (FISS), and from a variety of other sources (including personal communications with Fisheries and Oceans Canada – DFO, West Vancouver Streamkeepers, and site visits by SLR, URS-NDM, and Sartori Environmental Services). Appendix B provides FISS information on Westmount and Godman creeks. No FISS data were available for Pipe, Cave, or Turner creeks.

Table 1
Known Salmonid Fish Presence in Study Area Streams

Creek and Section	Presence or Absence of Salmonids	Species
Pipe Creek – above Highway 1	X	
Pipe Creek – downstream of Highway 1		cutthroat trout
Westmount Creek – above Highway 1	X	
Westmount Creek – downstream of Highway 1		cutthroat trout
Cave Creek – above Highway 1	X	
Cave Creek – downstream of Highway 1		anadromous cutthroat trout possibly other salmonids
Turner Creek – above Highway 1[1]	X	cutthroat trout unlikely
Turner Creek – downstream of Highway 1[1]		anadromous cutthroat trout possibly other salmonids
Godman Creek, lower section near the mouth		coho salmon
Godman Creek, below Highway 1[2]		resident cutthroat trout
Godman Creek, between Highway 1 and Eagle Lake Road[3]		resident cutthroat trout
Godman Creek, West Branch[3]		resident cutthroat trout

Note 1: Alex Sartori, Sartori Environmental Services, pers. comm.

Note 2: Presence of cutthroat trout in Godman Creek, between Westridge Avenue and Highway 1, was reported to SLR by a local resident during assessments for this report.

Note 3: It has been thought that resident cutthroat trout populations in Godman Creek and Godman Creek West Branch may not have survived recent hot, dry summers during which flows were extremely low, resulting in elevated temperatures; recent reports, however, suggest populations may have become re-established (Alex Sartori, pers. comm.).

2.4 Stream Summaries

Information on the biophysical environment and fish habitat conditions of study area streams is summarized below. The sequence in which streams are described reflects their locations, approximately from east to west across the mountainside, as depicted in Figure 2. Each summary includes descriptions of the biophysical environment and fisheries information. Descriptions of riparian habitat are provided for mainstems of streams. Known presence of at-risk amphibians associated with study area streams is presented in Section 6.2.4, Table 17.

2.4.1 Pipe Creek and Tributaries

Pipe Creek is approximately 3 km long and flows southward through the Altamont neighbourhood of West Vancouver before discharging into English Bay, near the foot of 31st Street. The headwaters of Pipe Creek are within Cypress Bowl Provincial Park and several tributaries augment its flows.

Biophysical Environment

Pipe Creek is a steep stream, with an average gradient of approximately 25%. Upstream of Highway 1, the Pipe Creek mainstem is primarily in a natural state.

The portion of Pipe Creek above Cypress Bowl Road (within the Rodgers Creek Neighbourhood area) is of moderate size and steep (Photo 1). Channel gradients approach 30% in numerous areas, precluding the presence of resident fish. A mix of boulder-cobble dominates the substrate, with infrequent areas of gravel and fines. Bedrock outcrops are also present.

The channel through this section averages 3.5 m wide, with an average wetted width of 1.3 m. Due to the steep gradient, flow consisted of pool-riffle-chute combinations, with pools being shallow (<15cm deep). Large woody debris is present throughout the stream channel, with most appearing to be stable.

Downstream of the highway, Pipe Creek has been affected significantly by adjacent residential development. Numerous culverts and driveway crossings have eliminated the possibility of fish access into upper reaches. Owners along the banks have also encroached with landscape features, including retaining walls and manicured lawns.

Baseline August 2003 surface flows in mainstem Pipe Creek were approximately 0.3 LPS, and less than 0.01 LPS in Tributary P. SEACOR biologists found large (3 cm) dark brown stonefly nymphs, caddisfly nymphs, and an aquatic earthworm in Pipe Creek at that time.

Fisheries Information

No information is listed in the FISS files for Pipe Creek. Downstream of the Upper Levels Highway, Pipe Creek has been documented to contain cutthroat trout (*Onchorhyncus clarki*) in large pools below culverts (West Vancouver Streamkeepers 2000). No fish have been found in the portion of Pipe Creek above the highway.

Riparian Habitat

The riparian zone along the section of Pipe Creek within the Rodgers Creek Neighbourhood area is intact and consists mainly of maturing western redcedar, red alder, Douglas-fir, ferns, and salmonberry. Crown closure ranges from 50% to 85% along its length.

Tributary N

Tributary N originates above the first switchback of Cypress Bowl Road and enters Pipe Creek at a point a short distance downstream of Highway 1.

Biophysical Environment

Tributary N is a medium-sized creek, with a well incised channel, approximately 1.0 m deep and averaging 3.5 m wide. Its bed consists of cobble and gravel substrate, with boulders scattered throughout. Gradient through the 630 m section of Tributary N within the study area ranged from 19% to 55%. A portion of this watercourse flows adjacent to the Mulgrave School access road and lacks riparian vegetation along the right bank. Observations in summers of 2003 and 2006 indicated that this stream has very low to no flows during periods of drought (Photo 2).

Fisheries Information

No fish were captured within Tributary N.

Tributary M

Tributary M originates below the first switchback of Cypress Bowl Road flows into Tributary N at a point approximately 220 m downstream of the road.

Biophysical Environment

The Tributary M channel width averaged 2.4 m wide, with a substrate dominated by gravel and organic leaf litter. The riparian zone is intact and dominated by conifers with complete overstorey. Gradient averages 25% along its length, with a steeper section near the confluence with Tributary N. The channel narrows significantly near the base of the culvert under Cypress Bowl Road. This watercourse is ephemeral, but it is unclear if it flows for greater than 6 months of the year.

Fisheries Information

No fish have been found within Tributary M.

Tributary L

Tributary L originates below the first switchback of Cypress Bowl Road and flows into Tributary N at a point just above Mulgrave School.

Biophysical Environment

The upper 350 m of Tributary L flows within an unmodified channel and through a moderately wide ravine. The lower 100 m have been modified so that the stream flows in an excavated ditch and then into a culvert to its confluence with Tributary N. The substrate within the study area consists primarily of leaf litter, cobbles and gravel. The average gradient is 31.4%, and the average channel width is 1.82 m.

Fisheries Information

No fish have been found within Tributary L.

Tributary O

Tributary O, identified in the SEACOR (2004) report is actually on historic avulsion of Tributary P along an old logging road alignment.

Tributary P

Tributary P is a major tributary of Pipe Creek. It originates above the first switchback of Cypress Bowl Road and enters Pipe Creek below the Highway 1 culvert crossing. It is over 500 m long through the study area.

Biophysical Environment

The average width of the Tributary P channel is 3.37 m, and the gradient ranges from 15% to 45%. The substrate is dominated by cobbles and boulders. In August 2003, Tributary P contained trace amounts of flowing water, though most of the flow was subsurface. Dissolved oxygen levels in this water were relatively low (<5 mg/L).

Fisheries Information

No fish have been found within Tributary P.

Tributary PP

The channel of Tributary PP begins as a minor depression within a deciduous forest and, and this stream is only 75 m long before entering Tributary P. This minor tributary is not depicted on Figure 2.

Biophysical Environment

The average width of the Tributary PP channel is 1.1 m, and the substrate is dominated by leaf litter and organics. This stream is ephemeral, but it is uncertain whether it flows greater than 6 months of the year. Riparian vegetation is dominated by shrubs and deciduous trees near the headwater depression.

Fisheries Information

No fish have been found within Tributary PP.

Tributary Q

Tributary Q is a 170 m long tributary of Pipe Creek that originates upstream of a culvert under the upper switchback of Cypress Bowl Road.

Biophysical Environment

The average width of the Tributary Q channel is 3.0 m, the gradient ranges from 30% to 50%, and the substrate is dominated by cobbles and gravel. Vegetation in the intact riparian area is dominated by conifers. This stream is likely ephemeral, but it is unknown if it flows for greater than 6 months.

Fisheries Information

No fish have been found within Tributary Q.

Tributary R

Tributary R is a moderate-size watercourse that originates above the first switchback of Cypress Bowl Road and flows into Pipe Creek at a point immediately upstream of lower Cypress Bowl Road.

Biophysical Environment

The average width of the Tributary R channel is 2.46 m and the average gradient is 29%. The substrate is dominated by cobbles and gravel, with areas of exposed bedrock. Mountain bike trails cross the creek at a few locations, and a bridge has been constructed approximately half way through the study area. This stream is likely ephemeral, but it is unknown if it flows for greater than 6 months.

Fisheries Information

No fish have been found within Tributary R.

2.4.2 Westmount Creek

Westmount Creek flows from Cypress Bowl Provincial Park, and through the Westmount neighbourhood of West Vancouver, before discharging to English Bay along West Bay.

Biophysical Environment

Upstream of Highway 1, Westmount Creek is primarily in a natural state. Within the Rodgers Creek neighbourhood area, Westmount Creek flows southward through a channel that averages 4.5 m wide, with an average gradient of approximately 37%. Wetted widths ranged from 1.5 m to 2.3 m, and the morphology is typical of steep stream flow types, including sections of riffles, steps, pools and chutes (depending on local gradient), broken up by downed logs and large boulders (Photo 3).

Substrate is predominately boulders (50%) and cobbles (30%); large patches of gravels and fines were found, however, adjacent to pools and depositional areas, and there are occasional areas of exposed bedrock. Substrate compaction was considered to be at a medium level. A significant amount of in-stream woody debris is present, with most being stable. No fish were observed during fieldwork.

Downstream of the highway, Westmount Creek has been controlled by channelization (flumes) and culverts to its mouth. The stream has become a landscape feature for residential properties along its banks, and little remains of riparian vegetation or in-stream substrate.

During the December 2000 survey, water volume in the creek was high, and flows were estimated to be 0.15 m^3/sec. Baseline August 2003 surface flows were approximately 0.05 LPS. SEACOR biologists observed caddisfly nymphs and water striders in the creek in August 2003.

Fisheries Information

Though no information is listed in the FISS files for Westmount Creek, West Vancouver Streamkeepers have observed cutthroat trout above Marine Drive. There do not appear to be any other data on fish presence, other than minnow trap data collected for BPPL. Minnow traps were set upstream of the Upper Levels Highway near the Deer Ridge area during spring 2000 for an extended period of time, with no success (Norecol, Dames & Moore, Inc. 2000). Similar trapping by DFO in spring 2002 also showed that this reach unlikely contained fish at that time. Fish sampling in January 2006 confirmed that no fish reside in Westmount Creek upstream of Highway 1.

Riparian Habitat

The riparian zone along Westmount Creek above lower Cypress Bowl Road is intact and dominated by maturing western redcedar, red alder, Douglas-fir, ferns and salmonberry. Crown closure ranges from 50% to 90% along its length.

Tributary W

Tributary W is a small tributary of Westmount Creek and, when assessed, appeared to have originated from avulsed flow from Westmount Creek along an old logging roadm, a short distance downstream of the first switchback of upper Cypress Bowl Road. This minor or temporary tributary is not depicted in Figure 2.

Biophysical Environment

Tributary W contains very little habitat and has an average channel width under 1.0 m. Stream flow is intermittent, with subsurface flows in many areas along its length. Substrate is dominated by small gravels and fines.

Fisheries Information

No fish have been found within Tributary W.

Tributary T

“Tributary T”, as identified in the SEACOR (2004) report, is a smoall, unconnected water-collecting are on the forest floor a short distance west of Westmount Creek. As it flows to ground, it does not qualify as a “stream”.

Tributary U

Tributary U is small watercourse that originates within a shallow depression above Cypress Bowl Road and follows a bedrock ridge along its left bank.

Biophysical Environment

Tributary U is approximately 150 m long and flows into a culvert under Cypress Bowl Road. It is unknown where it connects beyond this point. Average channel width is 1.1 m and the substrate is dominated by organic litter and fines. Inspection in August and October 2003 characterized the channel as a dry shallow wash zone, more resembling forest floor than a creek.

Fisheries Information

No fish have been found within Tributary U.

2.4.3 Cave Creek

Cave Creek is a short, steep watercourse that flows from the lower Cypress Provincial Park area, then through the Westmount neighbourhood of West Vancouver. It discharges into English Bay at the West Bay Park.

Biophysical Environment

Immediately above lower Cypress Bowl Road, Cave Creek has a steep channel, with gradients exceeding 30%. Farther upstream, Cave Creek flows through a shallow "U"-shaped valley and becomes braided and unconfined in numerous locations, making the average channel width exceed 3.0 m, but with an average wetted width of approximately 1.8 m. The substrate varies, with boulder-cobble being dominant along most of the channel, though forest litter and debris also become dominant substrates through areas of braiding. Flow morphology consisted of riffle-pool and cascade-pool sections, with pools shallow and infrequent. A significant amount of woody debris was present, with most appearing to be stable.

Downstream of the highway, Cave Creek has been manipulated significantly by owners of adjacent lands, and it is also affected by numerous perched culverts at road crossings. Work has recently been conducted at the mouth of Cave Creek where it enters English Bay to improve fish access into the first culvert at Marine Drive.

Two unnamed tributaries have been observed above lower Cypress Bowl Road, between Cave Creek and the powerline right-of-way to the west. Each contained trace flows on October 6, 2003. The more western tributary had a channel approximately 0.3 m to 0.75 m wide (0.2 m to 0.5 m wetted width), with a substrate of gravel and soil. The tributary immediately west of Cave creek was approximately 1.5 m wide (0.3 m wetted width), and appeared to flow through a small outcrop of mineralization containing pyrite.

SEACOR biologists observed caddisfly nymphs in Cave Creek during fieldwork in August 2003. Baseline surface flows at that time were approximately 0.16 LPS.

Fisheries Information

No information is listed in the FISS files for Cave Creek, though West Vancouver Streamkeepers (pers. comm.) have identified anadromous cutthroat trout as present within the lower reaches. This finding suggests that coho salmon (*Onchorhyncus kisutch*) could also utilize the open channel reach from the mouth to Marine Drive. Historical accounts of steelhead trout caught in Cave Creek in the early 1970s have also been found (West Vancouver Streamkeepers, pers. comm.). No fish have been found within Cave Creek upstream of Highway 1.

Riparian Habitat

The riparian zone along Cave Creek above lower Cypress Bowl Road in the Rodgers Creek Neighbourhood area is intact and vegetation is dominated by maturing second-growth western redcedar, Douglas-fir, salmonberry, red huckleberry and sword ferns (Photo 4). Canopy cover ranges from 75% to nearly 100%.

2.4.4 Turner Creek

Turner Creek originates from waters collected above a culvert that conveys the flows under the first switchback of Cypress Bowl Road, immediately above the District of West Vancouver Operations Centre. Below Highway 1, Turner Creek flows generally southeastward through the Westmount neighbourhood, and discharges to English Bay at West Bay Park, a short distance west of the mouth of Cave Creek.

Biophysical Environment

Turner Creek is culverted under the Operations Centre property, and the outfall is located immediately below lower Cypress Bowl Road, a short distance east of the gated entrance to Eagle Lake Road. From there to Highway 1, the stream flows in a steep, partially confined channel within a shallow ravine (Photo 5). In August 2008, during ISMP investigations, SLR completed site card data and conducted a RAR assessment along this section of Turner Creek. The substrate, dominated by cobble-gravel, exhibited an unusual amount of sediments (Photo 6), originating from construction activities adjacent to the left (east) side of the ravine, which appeared to include fill placement and materials stockpiling.

Below Highway 1, much of Turner Creek has been modified by adjacent residential development and roads, with sections that have been channelized or used as landscape features. A weir that had been situated a short distance above Mathers Avenue on a residential property was removed in 2006 (Alex Sartori, pers. comm.).

Fisheries Information

No information on Turner Creek was found in the FISS database. It is likely that anadromous cutthroat trout and coho salmon have access as far upstream as the culvert under Marine Drive. The steep gradient above Highway 1 would preclude fish presence, but it is unknown whether resident cutthroat trout inhabit the section of Turner Creek between the highway and Marine Drive.

Riparian Habitat

Above Highway 1, the ravine slopes adjacent to Turner Creek are treed by a mixed coniferous-deciduous forest with a diverse and dense understorey. Downstream of the highway, some sections of the riparian area are treed, while other sections of the stream are flanked by residential gardens and lawns.

2.4.5 Godman Creek

Godman Creek is approximately 4.8 km long, with a total drainage area of approximately 1.8 km^2, and an elevation range of sea level to approximately 800 m. Below Highway 1, Godman Creek flows through the Bayridge neighbourhood of West Vancouver, and enters English Bay a short distance west of Sandy Cove Park.

Godman Creek has a mainstem, a major tributary (West Branch), and a minor tributary (East Branch) that appears to have been formed by diversion of a former side channel by the alignment of Eagle Lake Road.

Mainstem

The mainstem of Godman Creek drains an area north of Eagle Lake Road, and flows to English Bay.

Biophysical Environment

From the headwaters, the Godman Creek mainstem channel becomes increasingly steep toward Eagle Lake Road, a short distance above where it is very steep (>30% slope) and the

stream flows over bedrock chutes and large boulder cascades. The flow type is primarily cascade-pool, with small amounts of pool and riffle habitat, and the substrate consists mainly of large gravels, cobbles and boulders, with more bedrock upstream. This part of the channel is likely a fish migration barrier (Photo 7). Closer to Eagle Lake Road, the mainstem of the creek is moderately steep (18%), with step-pool habitat, and having some braiding.

Immediately above Eagle Lake Road, the main branch splits into two channels. Prior to 2004, the eastern channel drained to the ditch along the north side of Eagle Lake Road and flowed both east and west in the ditch (as it entered at a drainage divide point). The eastward flow in the ditch passed under both the original and new roads in that area and joined the mainstem at a point approximately 40 m below the new road. The westward flow joined the flow from the other braid of the creek where it entered the ditch and the combined flow passed through a culvert under Eagle Lake Road. Drainage control, and deepening of the culvert inlet by District of West Vancouver appears to have cut off the East Branch, so that in spring 2004 all flow was observed to drain directly under the Eagle Lake Road. In November 2005, it was observed that some flows remain in the East Branch, which appeared to function as an overflow channel loop. Waters entering the East Branch channel flow eastward to a culvert under the old roadbed, and enter a treed wetland, before passing through another culvert under the curve in Eagle Lake Road. From there, waters flow approximately 20 m through an artificial channel and then into the Godman mainstem.

Below the points where the East Branch and West Branch enter, the Godman Creek mainstem has lower gradient and substrate of smaller sizes as it flows toward the Upper Levels Highway (Photo 8). This section of the creek, up to the channel drop down to the Upper Levels Highway, has several pockets of potential spawning habitat. Cutthroat trout were captured in minnow traps along this section. The creek is very steep immediately above Highway 1 and would form a fish access barrier (Photo 9). Remnants of an old weir structure and fence were found, a short distance downstream of the BC Hydro right-of-way.

Fisheries Information

FISS data for Godman Creek document coho salmon at the mouth and cutthroat trout in the upper reaches. The creek contained resident cutthroat trout upstream and downstream of Eagle Lake Road in 2000.

The main branch of Godman Creek would be classified as fishbearing, owing to cutthroat trout having been captured and observed in the watercourse in 2000. Cutthroat trout appear to have been planted in upper Godman Creek, as there is a significant natural drop in the creek above the Upper Levels Highway, and it is unlikely that they would historically have been able to move up from tidewater. The upstream limit of fish distribution probably varies by season and year, but is approximately 200 m upstream of Eagle Lake Road. Above the rock chutes, the stream would be classified as non-fishbearing, but it contributes significant water and nutrient supply to fish habitat downstream.

A local resident interviewed on April 22, 2004, stated that he had not observed fish in Godman Creek near Eagle Lake Road since the extremely low water of summer 2003. Previously, cutthroat trout could readily be observed in the pool on Godman Creek immediately downstream of Eagle Lake Road. These populations may be recovering, however, as there has been a recent (2008) report from a BPPL employee of fish presence in the vicinity of Eagle Lake Road (Alex Sartori, pers. comm.).

Riparian Habitat

Above Highway 1, the riparian area along the mainstem of Godman Creek is largely intact, dominated by maturing Douglas-fir and western redcedar trees. Tree growth is controlled along the powerline right-of-way above the highway, and shrubs dominate the section immediately downstream of Eagle Lake Road. Above Eagle Lake Road is a network of mountain-bike trails that includes several small bridge crossings, but riparian areas did not appear to have been seriously affected by disturbance.

Below Highway 1, the riparian area is well-treed downslope to Viewridge Place. The location chosen for sampling of the benthic invertebrate community, as part of ISMP investigations, is situated between Westridge Avenue and Viewridge Place.

West Branch

The West Branch of Godman Creek originates from a point near the BC Hydro substation and flows approximately 800 m, primarily in the north-side ditch of Eagle Lake Road (Photo 10), to a culvert through which it passes under Eagle Lake Road. This culvert is located approximately 60 m west of the culvert that conveys the Godman Creek mainstem under Eagle Lake Road. During high flows, a portion of West Branch waters may continue along the roadside ditch to join waters of the mainstem.

Biophysical Environment

Along several hundred metres of the middle portion of its course, the West Branch is somewhat removed from Eagle Lake Road (10 m to 50 m) and, with natural substrate, resembles more a creek than a ditch.

A very small overland flow drains the east side of the BC Hydro substation before joining the north-side ditch and flowing to the east. The ditch along the east side of the BC Hydro substation has no developed channel and was judged to be an ephemeral surface water flow.

Below the BC Hydro substation, a small ditch on the south side of Eagle Lake Road carries periodic flow that eventually passes under the road and joins the West Branch in a small wetland on the north side of the road. From there, the combined flow runs eastward along the north-side ditch until it passes under Eagle Lake Road in a culvert and into a relatively large pool at the downstream end of the culvert.

Below Eagle Lake Road and a small pool, the West Branch of Godman Creek enters a small wetland. In this short section, there are also several pockets of potential spawning habitat. The wetland has standing water areas, fine-grain and organic substrate materials, green algae, skunk cabbage, sedges, sapling red alder and western redcedar, and numerous fallen trees forming woody debris. The wetland is approximately 60 m long by up to 12 m wide and drains to the east in a single channel. This channel then passes through a culvert (damaged) under an abandoned and overgrown north-south logging road before joining the flow from the main branch (Figure 2).

The upstream limit of cutthroat trout in the West Branch of Godman Creek likely varies with seasonal flow conditions. Nevertheless, below the upstream limit of fish movement, the West Branch would be classified as fishbearing, unless it is confirmed that populations of cutthroat trout are no longer present.

Fisheries Information

Along the West Branch, there are pockets of potential spawning habitat in the ditch-stream on the north side of Eagle Lake Road. Minnow trapping in May 2000 resulted in captures at a station located immediately below an 80 cm drop in the channel. At the roadside pool, approximately ten cutthroat trout were observed during the habitat survey, and trout were captured in minnow traps set out in the pool. Fish captured were all in the 53 mm to 144 mm size range. Cutthroat trout have been salvaged from this pool during very low water periods in the past (Alex Sartori, pers. com.).

Riparian Habitat

The section of the West Branch between Eagle Lake Road and the point where it enters the mainstem is well treed, including the perimeter of the wetland. The riparian area has been impaired along the section of the West Branch where it flows alongside, and close to, Eagle Lake Road.

2.5 Riparian Area Assessments

The major portion of stream riparian assessment fieldwork along Pipe, Westmount, Cave and Godman creeks was undertaken between November 14 and 24, 2005, with periodic follow-up data-gathering through February 2006. A riparian assessment was conducted along Turner Creek on August 27, 2008.

2.5.1 Application of the Riparian Areas Regulation to Area Planning

The study team applied a tailored assessment method based on the methodology that forms part of the BC Riparian Areas Regulation (RAR) under the provincial *Fish Protection Act*. Though the RAR methodology is not entirely applicable to a large-scale neighbourhood planning process, the same type of information was collected, at the same level of detail, and using the same terminology. In this way, information can be readily cross-referenced over time. The RAR methodology has consensus among regulatory agencies as being ecologically relevant and scientifically sound. The RAR is intended to satisfy requirements of the federal *Fisheries Act* principle of "No-Net-loss" of fish habitat by helping developers avoid, mitigate, or compensate for "harmful alteration, disruption or destruction" of fish habitat (HADD).

2.5.2 Definitions and Process

Under the RAR, a ***stream*** is (1) a watercourse that provides fish habitat (whether or not it usually contains water); (2) a pond, lake, river, creek or brook that provides fish habitat, and (3) a ditch, spring or wetland that is connected by surface flow to a waterbody containing fish habitat. ***Ravine*** is defined as "a narrow, steep-sided valley that is commonly eroded by running water and has a slope grade greater than 3:1." ***Top of ravine bank*** is defined as "the first significant break in a ravine slope where the break occurs such that the grade beyond the break is flatter than 3:1 for a minimum distance of 15 meters (sic) measured perpendicularly from the break, and the break does not include a bench within the ravine that could be developed."

For a stream not in a ravine, the Riparian Assessment Area (RAA) is a 30-m strip of land on each side of the stream, measured from the high water mark (HWM). For a stream in a ravine narrower than 60 m (excluding the HWM stream width), the RAA is measured from the HWM to a point 30 m beyond the top of the ravine bank. For a stream in a ravine 60 m wide or wider

(excluding the HWM stream width), the RAA is measured from the HWM to a point 10 m beyond the top of the ravine bank.

To develop areas within the RAA, a Qualified Environmental Professional (QEP) must conduct a Simple or Detailed Assessment to determine the width of the Streamside Protection and Enhancement Area (SPEA) and applicable mitigation measures.

Simple Assessment

Under the RAR assessment methodology, a Simple Assessment is essentially a desktop exercise in which air photos, existing fish habitat databases, and other information is used to determine the SPEA width. Simple Assessments may be advantageous for small developments or re-development sites in areas already substantially built-out. As Simple Assessments were not applicable for neighbourhood planning purposes, SLR (2008a,b) undertook Detailed Assessments.

Detailed Assessment

Owners have the option of having a QEP conduct a Detailed Assessment, which evaluates site-specific factors and determines whether the SPEA width could be narrower than that determined under a Simple Assessment without resulting in HADD. A Detailed Assessment is conducted within the RAA to determine Zones of Sensitivity (ZOSs) for certain features, functions and conditions (FFCs) of the riparian area. Before ZOSs are determined, various stream parameters are determined, including reach breaks, channel width, slope and type, and site potential vegetation type. Based on these parameters, the QEP determines ZOSs for three FCCs: input of large woody debris (LWD); litter fall and insect drop; and shade. The resultant SPEA is the widest ZOS from among the FFCs.

2.6 Riparian Assessment Results

Results of the RAR-based Detailed Assessments are summarized in Table 2. These results were reported by SLR (2008a,b), with the exception of that for Turner Creek, which was assessed as part of the ISMP investigation.

2.7 Riparian Forest Integrity

As part of the ISMP process, a riparian corridor assessment was carried out to derive a measure of the Riparian Forest Integrity (RFI). This indicator is determined by examining two main riparian characteristics: the proportion of the stream that has been enclosed in culverts, and the degree to which forested riparian setbacks are narrower than 30 m from HWM along one or both sides of a stream channel. The RFI is 100% if the entire length of a stream has intact 30-metre treed riparian zones along both sides, as measured from HWM.

2.7.1 Methods For Deriving Riparian Forest Integrity

The methodology followed is consistent with that described in the Metro Vancouver ISMP Template (Kerr Wood Leidal Associates Limited 2005).

The map layer showing the study area streams was overlaid on a recent orthophoto image. AutoCad was then used to draw lines parallel to each stream depicting a 30-m riparian zone along both sides, measured from the stream centre line (approximating the top-of-bank for this

purpose). An SLR Professional Biologist familiar with the study area then examined the image to evaluate the amount of each stream having treed vegetation areas 30 m wide or greater along both sides, and these lengths were measured using AutoCad.

Table 2
Summary of Applicable Stream Setbacks

Stream	General Location of Assessment	RAR[1] SPEA Setback (Metres From High-Water Mark)
Tributary N	Tributary of Pipe Creek; Above Cypress Bowl Road	10.53
Tributary M	Tributary of Tributary N; Above Cypress Bowl Road	10.0
Tributary L	Tributary of Tributary N; Above Cypress Bowl Road	10.0
Tributary P	Tributary of Pipe Creek; Above Cypress Bowl Road	10.1
Tributary PP	Tributary of Tributary P; Above Cypress Bowl Road	10.0
Pipe Creek	Above Cypress Bowl Road	14.6
Tributary Q	Tributary of Pipe Creek, above Cypress Bowl Road	10.0
Tributary R	Tributary of Pipe Creek, above Cypress Bowl Road	10.0
Westmount Creek	Above Cypress Bowl Road	16.3
Tributary W	Tributary of Westmount Creek, above Cypress Bowl Road	10.0
Tributary U	east of Cave Ck, above Cypress Bowl Road (unknown connection)	10.0
Cave Creek	Above Cypress Bowl Road	11.3
Turner Creek	Between Highway I and Cypress Bowl Road	10.0
Godman Creek Mainstem, Reach 1	Below Eagle Lake Road down to the powerline cut above Highway 1	10.6
Godman Creek Mainstem, Reach 2	Above Eagle Lake Road	12.6
Godman Creek West Branch, Reach 1	Between the mainstem and wetland, below Eagle Lake Road	10.0
Godman Creek West Branch, Reach 2	Along Eagle Lake Road	10.0
Godman Creek, Old Side Channel	At bend in Eagle Lake Road; flows through a culvert south of the bend	10.0

Note 1: Riparian Areas Regulation, under the provincial *Fish Protection Act*

2.7.2 Riparian Forest Integrity Results

Riparian Forest Integrity results are presented in Table 3. As study area streams flow through existing residential neighbourhoods below Highway 1, while portions above Highway 1 flow mainly through forested areas, separate RFI percentages are provided for portions of these streams above and below Highway 1, as well as for the total stream length extending from the headwaters down-gradient to English Bay.

For future monitoring purposes along such stream reaches, it may be appropriate to base the RFI on the assessed SPEA width rather than the full RAA width. This method would better enable tracking of the integrity of assessed and approved riparian setbacks, monitoring of results of habitat improvements, and applicable adaptive-management responses to observed degradation of setbacks. Otherwise, if a 30-m standard were applied to stream sections approved to have narrower SPEAs, these sections would be considered dysfunctional though the RAR assessment considered the setbacks to be ecologically sound. The Metro Vancouver ISMP Template does not address this consideration, and it pre-dates the RAR.

Table 3
Riparian Forest Integrity For Study Area Streams

Stream	Portion Below Highway 1			Portion Above Highway 1			Total Stream		
	Length[1] (m)	Length With Full Riparian Zone		Length (m)	Length With Full Riparian Zone		Length[2] (m)	Length With Full Riparian Zone	
		m	%		m	%		m	%
Pipe Creek	1,046	0	0	2,091	1,781	85	3,206	1,781	56
Westmount Creek	691	0	0	2,042	1,708	84	2,797	1,708	61
Cave Creek	548	0	0	784	720	92	1,412	720	51
Turner Creek	807	0	0	308	218	71	1,173	218	19
Godman Creek	1,019	0	0	1,913	1,690	88	3,028	1,690	56
Godman Creek West Branch	NA	NA	NA	1,000	200	20	1,000	200	20

Note 1: All stream length measurements are approximate

Note 2: Total stream length includes the portion culverted under Highway 1

3.0 WATER QUALITY MONITORING

Quality of waters in study area streams has been monitored on several occasions since 1999. Both *in situ* analyses and sampling for laboratory analyses have been undertaken.

3.1 Methods for Monitoring Water Quality

Water samples were collected for quality testing from Pipe, Westmount and Cave creeks on August 6, 2003, and from Godman Creek on April 22, 2004. Godman Creek was again sampled on August 29, 2008, in conjunction with the benthic invertebrate sampling program. Water samples were sent to a commercial laboratory for analysis.

Quality of waters in various study-area streams was measured *in situ* on the following dates:

- December 16, 17, 20 and 21, 2000[1];
- August 7 and 22, 2003;
- January 24 and June 23 to 30, 2006; and
- August 27-28, 2008.

A YSI Mini-Sonde (Model 6583) data-logger was used to measure temperature, dissolved oxygen, pH, specific conductivity, and salinity on most occasions, and a HACH turbidimeter was used on some occasions to measure turbidity. Sampling sites for Pipe, Westmount and Cave creeks in 2000, 2003 and 2006 were located along lower Cypress Bowl Road, and those for Godman Creek in January and June 2006, were near Eagle Lake Road.

Water quality measurements on January 24, 2006, were undertaken concurrently with fish presence surveys in stream mainstems and major tributaries. To ensure access and establish sampling locations for later investigations, data were collected from waters at points upstream of roadways crossing each stream. Data were stored electronically by the data-logger in the field, and were also transcribed on-site by hand to ensure data integrity.

Water quality parameters were not measured during SPEA assessment work in November 2005, as flow levels in study area streams were considered low and unrepresentative.

Water quality monitoring in June 2006 was undertaken in association with surveys for presence of tailed frogs in the same streams.

In situ measurements in August 2008 were undertaken to provide recent baseline data for the ISMP investigations (Photo 11). Measurements were taken at two locations along each stream: for Godman Creek, near Eagle Lake Road and near Bayridge Avenue, and for the other streams, near lower Cypress Bowl Road and near Mathers Avenue. No *in situ* water quality monitoring of Turner Creek had been previously undertaken, as this stream was not included in previous study areas.

1 Results of sampling conducted in December 2000 have been recorded as “1-Dec-2000” in Appendix B as precise dates when each stream was sampled could not be confirmed for this report.

3.2 Results of Water Quality Monitoring

Results of water quality sample analyses and *in situ* measurements are presented below.

3.2.1 Laboratory Analyses

Results of laboratory analyses of water samples from study area streams are provided in Appendix C[2], and summarized in Tables 4, 5, and 6.

Table 4
Summary of Water Sample Chemistry (Nutrients and General Parameters)

Parameter	Unit	WQG	Creek and Sampling Date				
			Pipe	Westmount	Cave	Godman	
			7-Aug-2003	7-Aug-2003	7-Aug-2003	22-Apr-2004	29-Aug-2008
PHYSICAL PARAMETERS							
Colour True	Col. Unit		<5	5	<5	<5	NM
Residue Nonfilterable (TSS)	mg/L	5	<4	<4	<4		NM
Residue Filterable (TDS)	NTU		88	70	82	50	NM
Turbidity	mg/L	8	0.34	0.47	0.52	0.71	NM
Hardness Total - T	mg/L		37.3	22.5	42.9	23.1	21.8
CARBON							
Dissolved Organic Carbon	mg/L		<0.5	2.3	1.2	2.2	NM
NITROGEN							
Total Kjeldahl Nitrogen	mg/L		0.06	0.1	0.08	0.07	NM
Total Nitrogen	mg/L		0.58	0.34	0.39	0.31	NM
Total Organic Nitrogen	mg/L		<0.10	0.1	<0.10	<0.10	NM
Ammonia Nitrogen	mg/L	17-25	0.005	<0.005	<0.005	0.013	0.05
Nitrate Nitrogen Dissolved	mg/L	40	0.52	0.24	0.31	0.24	0.95
Nitrate + Nitrite	mg/L		0.52	0.24	0.31	0.24	0.95
Nitrite Nitrogen	mg/L	0.02	<0.005	<0.005	<0.005	<0.005	<0.005
PHOSPHORUS							
Orthophosphorus	mg/L		<0.005	<0.005	<0.005	<0.005	<0.005
Phosphorus Total Dissolved	mg/L		<0.005	<0.005	<0.005	<0.005	<0.005
Phosphorus Total	mg/L		<0.005	0.005	<0.005	<0.005	0.005

Notes:
Pipe Creek was sampled approximately 50 m upstream of lower Cypress Bowl Road
Westmount Creek was sampled approximately 10 m upstream of lower Cypress Bowl Road
Cave Creek was sampled approximately 5 m upstream of lower Cypress Bowl Road
Godman Creek was sampled a short distance above Eagle Lake Road in 2004 and immediately above Westridge Ave. in 2008
WQG = BCMOE Approved or Working Water Quality Guidelines for the protection of aquatic life
NM = not measured

2 The lab results state 28-August-2008 as the sampling date, as some sample labels erroneously carried that date. The samples were taken 29-August-2008, immediately before benthic invertebrate sampling.

Table 5
Microbiology Results for Godman Creek Waters, Sampled 29-August-2008

Microbiological Parameter	Units	WQG	Result	Detection Limit
Coliform	CFU/100 mL	-	1,500	100
Escherichia coli	CFU/100 mL	≤43 (90^{th} percentile)	500	20
Faecal Coliform	CFU/100 mL	≤43 (90^{th} percentile)	500	1

Notes: CFU = Colony Forming Unit

WQG = BCMOE Approved or Working Water Quality Guidelines for the protection of aquatic life (shellfish harvesting)

Table 6
Metals Detected in Godman Creek Waters, Sampled 29-August-2008

Metal	Units	WQG	Result	Detection Limit
Dissolved Aluminum (Al)	µg/L	100	59	1
Dissolved Arsenic (As)	µg/L	5	0.1	0.1
Dissolved Barium (Ba)	µg/L	1,000	14	1
Dissolved Cadmium (Cd)	µg/L	0.01 (at 30 mg/L $CaCO_3$)	0.1	0.1
Dissolved Calcium (Ca)	mg/L	up to 4 mg/L, dissolved, highly sensitive to acid inputs 4 to 8, moderately sensitive over 8 low sensitivity; refer to alkalinity – the more restrictive of calcium or alkalinity applies	7.37	0.05
Dissolved Copper (Cu)	µg/L	≤2 (when average water hardness as $CaC0_3$ is less than or equal to 50 mg/L)	1.0	0.2
Dissolved Iron (Fe)	µg/L	300	75	5
Total Lead (Pb)	µg/L	18 (water hardness as $CaCO_3$ less than or equal to 30 mg/L)	0.2	0.2
Dissolved Magnesium (Mg)	mg/L	none	0.82	0.05
Dissolved Manganese (Mn)	µg/L	800 (maximum at specified $CaCO_3$ hardness of 25)	5	1
Dissolved Potassium (K)	mg/L	373 to 432	0.59	0.05
Dissolved Silicon (Si)	µg/L	process dependent	3,860	100
Dissolved Sodium (Na)	mg/L	none	8.27	0.05
Dissolved Strontium (Sr)	µg/L	none	39	1
Dissolved Uranium (U)	µg/L	300	0.1	0.1
Dissolved Zinc (Zn)	µg/L	33 (for water hardness ≤90)	5	5

Note: WQG = BCMOE Approved or Working Water Quality Guidelines for the protection of aquatic life

Nutrients and General Parameters (Table 4)

Low levels of nutrients characterized the laboratory analysis of water sampled from Godman Creek on August 29, 2008. The results in Table 4 indicate that the nitrogenous compounds were readily assimilated and oxidized to nitrate in Godman Creek. In this respect, Godman Creek differs significantly from other streams draining Hollyburn Mountain that were sampled during the summer period in previous years of study.

August phosphorus concentrations in 2003 and 2008 water samples collected from Pipe, Westmount, Cave, and Godman creeks were all below the detection limit. Phosphorous levels in a sample collected from Godman Creek on April 22, 2004 were also less than detection. Low concentrations of nitrogen and phosphorus are considered typical of streams draining Hollyburn Mountain, as well as other streams draining steep slopes along coastal areas.

Results of laboratory analysis for physical parameters are also considered to be typical of regional high-gradient streams that drain soils with limited ion content and that are subject to seasonal scour.

Given relatively low summer water temperatures (Appendix D) and observed low levels of epilithic algal growth in steep and scoured subject streams, low concentrations of dissolved organic carbon (indicating low primary productivity) are also considered to be typical of short, rapidly descending and flashy mountainous streams in the study area, as well as elsewhere in coastal regions.

Microbiological Analyses (Table 5)

The laboratory analysis of total coliform levels in water sampled from Godman Creek on August 29, 2008, was characterized by unexpectedly high levels of faecal coliforms, at 500 CFU/100 mL (considering the detection limit for this parameter is 100 CFU/100 mL). Total coliforms (for which there are water quality guidelines) are common in undeveloped terrain, and, as they include inputs from wildlife, do not necessarily indicate a polluted environment. Faecal coliforms in any quantity, however, suggest human input (such as from septic fields), or other animal sources, and are a cause for concern.

Since District sanitary system follows Westridge Avenue and the water samples were taken from Godman Creek upstream of Westridge Avenue, the sanitary system cannot be the source of the faecal coliforms. The source of faecal coliforms may have been dog faeces not recovered by owners in Westridge Park, where dogs are often allowed to be unleashed (Naizam Jaffer, pers. comm.). The stream was sampled following three days of rain, and it is possible that saturated conditions in soils adjacent to the stream contributed to ongoing accumulations of coliforms being flushed into the channel.

While it is anticipated that the elevated occurrence of faecal coliforms on 29 August 2008 would not be detected often, a more intensive sampling program extending along Godman Creek would confirm the source(s) of this microbial parameter.

Metal Analyses (Table 6)

For the most part, concentrations of total and dissolved metals analyzed in Godman Creek water samples collected on August 29, 2008, were below detection limits (Appendix C), and a majority of metals detected occurred at concentrations well below the BCMOE water quality

guidelines. The measured concentrations of dissolved iron, aluminium, barium, and calcium are considered to be somewhat typical of streams draining Hollyburn Mountain and other high-elevation areas in the lower mainland. These parameters often increase during surface and groundwater runoff events that follow extended dry periods. Over the course of an intense short-term precipitation event (or longer-term winter rainy season), the concentrations of particulate and dissolved metals typically decline.

In contrast to other August 29, 2008, low metal concentrations measured in Godman Creek water samples, dissolved silicon (a form of silica) measured a high 3,860 µg/L (3.8 mg/L). As indicated in Table 6, the water quality guideline for silicon is process dependent. Where food and industrial processing are concerned, water quality guidelines range from 0 mg/L to 50 mg/L and 0.01 mg/L to 200 mg/L, respectively. The measured concentration is considered to be anomalous, given there is no readily apparent source in the Godman Creek watershed. Whereas silicon is an essential element in biological processes, only tiny traces of it appear to be required by terrestrial and aquatic biota. It is important to the metabolism of plants, particularly many grasses,while silicic acid forms the basis of the striking array of protective shells of the microscopic diatoms (an alga).

3.2.2 In Situ *Analyses*

Results of *in situ* analyses undertaken 2000 to 2008 are summarized in Appendix D.

Waters are slightly acidic to neutral, with low hardness interpreted as representing low total dissolved solids, and low nutrients (nitrogen and phosphorous). Dissolved oxygen (DO) values in waters of most creeks were relatively high, indicative of steep gradients with high turbulence, and seasonally low water temperature that increase oxygen solubility. Turbidity was very low at all sites, with the exception of Turner Creek, based on visual observation. Low turbidity levels indicated that particulate materials, both organic and inorganic, were somewhat limited. Higher levels of organic material would be subject to increased bacterial decomposition, reducing the measured DO concentration and degree of saturation.

Water Temperature

Appendix D indicates, *in situ* water temperatures measured in study area streams had the following ranges when sampled:

- Pipe Creek, from 3.2ºC during December 2000 to 14.5ºC in August 2003;
- Westmount Creek, from 3.1ºC during December 2000 to 16.4ºC in August 2003;
- Cave Creek, from 6.9ºC during December 2000 to 15.4ºC in August 2003;
- Turner Creek, measured only in August 2008, were 14.5ºC on August 27 near Mathers Avenue and 14.4ºC on August 28 near lower Cypress Bowl Road; and
- Godman Creek, from 6.1ºC during January 2006 to 14.2ºC in August 2008.

The winter water temperatures suggest that flows in Pipe and Westmount creeks originate more from surface runoff than groundwater, while the reverse may be the case for Cave, Turner and Godman creeks.

The Canadian Water Quality Guidelines for the protection of aquatic life, Version 7 (CCME in 2007), provides a narrative of temperature criteria as referenced in CCREM 1987 guidelines and the CCME summary table.

BCMOE (2006) water quality guidelines for temperature are summarized as follows:

Freshwater Aquatic Life - streams with known fish distribution	+/- 1 degree Celsius change beyond optimum temperature range…for each life history phase of the most sensitive salmonid species present Hourly rate of change not to exceed 1 degree Celsius
Freshwater Aquatic Life - streams with unknown fish distribution	MWMT = 18 degrees Celsius (Maximum Daily Temperature = 19 degrees Celsius) Hourly rate of change not to exceed1 degree Celsius Maximum Incubation Temperature = 12 degrees Celsius (in spring and fall)

Water pH

As Appendix D indicates, *in situ* water pH levels in study area streams were in the following ranges when sampled:

- Pipe Creek, from pH 6.3 in December 2000 to pH 7.2 in August 2003;
- Westmount Creek, from pH 6.5 in August 2003 to pH 7 in August 2008 (near Mathers Avenue);
- Cave Creek, from pH 6.3 in August 2008 to pH 7.7 in August 2003;
- Turner Creek, from pH 6.8 in August 2008 near lower Cypress Bowl Road to pH 7.5 in August 2008 near Mathers Avenue; and
- Godman Creek, from pH 6.3 in June 2006 to pH 7.5 in August 2008 (near Bayridge Avenue).

Overall, pH values were lowest in December 2000 and highest in late August 2003. It is anticipated that pH levels generally increase to some extent during the summer in Study Area streams usually due to the uptake of carbon dioxide during the growth of epilithic (attached) algae and predominance of groundwater inputs during dry seasons.

While the BCMOE water pH guideline for protection of aquatic life ranges from 6.5 to 9.0, it should be noted that BCMOE (2001) reports that water of the Fraser Lowlands region is characterized by an average pH of 7.5 (range 5.8 to 8.3), based on a sample size of 254 measurements.

According to the Canadian Water Quality Guidelines for the protection of aquatic life, Version 7 (CCME 2007), water pH should not vary beyond 6.5 to 9.0 Units.

Water pH results are considered to be typical of both the region and the streams in which measurements were made. Most measured pH values were within the accepted range, with a small number of results being somewhat acidic.

Specific Conductance

As Appendix D indicates, *in situ* specific conductance levels in study area streams were in the following ranges when sampled:

- Pipe Creek, from 40 µS/cm in December 2000 to 112 µS/cm in both August 2003 and August 2008;
- Westmount Creek, from 44 µS/cm in January 2006 to 124 µS/cm in August 2003;
- Cave Creek, from 39 µS/cm in January 2006 to 131 µS/cm August 2008;
- Turner Creek, from 208 µS/cm in August 2008 near lower Cypress Bowl Road to 317 µS/cm in August 2008 near Mathers Avenue; and
- Godman Creek, from 28 µS/cm in January 2006 to 149 µS/cm in August 2008 (near Bayridge Avenue).

Specific conductance (conductivity) of water provides an indirect measure of the dissolved ion component of the total dissolved solids present. Overall, conductivity readings were considered typical of these small streams that have very small drainage areas and limited amounts of appropriate parent material from which to accumulate dissolved substances (through surface and subsurface flows and runoff).

There are no applicable BCMOE or CCME water quality guidelines/standards for the protection of aquatic life. Provincial standards for drinking water (2001), however, do specify that levels should not exceed 700 µS/cm (a value that is approximately equal to a total dissolved solids concentration of 500 mg/L).

Dissolved Oxygen

As summarized in Appendix D, *in situ* dissolved oxygen levels in study area streams were in the following ranges when sampled:

- Pipe Creek, from 8.4 mg/L in August 2003 to 13.1 mg/L in December 2000;
- Westmount Creek, from 7.4 mg/L in August 2003 to 13.0 mg/L in January 2006;
- Cave Creek, from 8.1 mg/L in August 2003 to 12.6 mg/L in January 2006;
- Turner Creek, from 9.8 mg/L in August 2008 near Cypress Bowl Road to 10.0 in August 2008 near Mathers Avenue; and
- Godman Creek, from 9.8 in August 2008 (near Bayridge Avenue) to 12.9 mg/L in January 2006).

According to BCMOE (2001) water quality guidelines for the protection of aquatic life, recommended dissolved oxygen concentrations are based on known or potential fish (salmonid) presence. Criteria are as follows:

Fish Life Stages:	All Life Stages Other Than Buried Embryo/Alevin	Buried Embryo Alevin Life Stages	Buried Embryo/Alevin Life Stages
Dissolved Oxygen - concentration	Water Column mg O/L	Water Column mg O/L	Interstitial Water mg O/L
Instantaneous Minimum	5	9	6
30-day Mean	8	11	8

According to CCME (2007) guidelines (which are based on the 1987 CCREM guidelines), dissolved oxygen concentrations should approach 9.5 mg/L for early life stages of fish (salmonids) inhabiting cold water and should not decline below 6.5 mg/L for other life stages.

As Appendix D indicates, dissolved oxygen concentrations in Study Area streams at most times meet provincial and federal guidelines and are suitable for the protection of sensitive early life stages (eggs and alevins) of salmonid fish. It follows that the habitat is also suitable for juvenile and adult fish.

Salinity

Salinity levels in waters of study area streams, measured in winter and summer of 2006, were between 0.01% and 0.04%. These low salinity levels are considered typical of freshwater streams in the region. There are no CCME or BCMOE guidelines for levels of salinity in freshwater environments.

4.0 BENTHIC INVERTEBRATE COMMUNITY INVESTIGATIONS, GODMAN CREEK

ISMP investigations included sampling and analyses of the benthic invertebrate community at a representative site. The population density and composition of benthic communities is known to be an indicator of the relative "health" of a watershed, through analyses based on the degree to which community characteristics differ from those expected of communities within a pristine, "natural" stream in a similar Biogeoclimatic zone. A monitoring program can be used to track changes in the benthic community over time, revealing changes in the health trajectory of the surrounding watershed as it undergoes land-use change, and enabling adaptive-management responses to adverse environmental impacts (e.g., reduced riparian function, or impaired water quality). Adaptive management is an heuristic (i.e., "learning by doing") approach to design of monitoring programs that can effectively address unforeseen change.

4.1 Methods For Sampling Benthic Communities

Benthic invertebrates were sampled and analyzed in a manner consistent with the Module 4 Stream Invertebrate Survey developed by DFO for Streamkeeper organizations, and with Benthic Index of Biological Integrity (B-IBI) as applied by Metro Vancouver during ISMP investigations.

4.1.1 Sampling-Site Selection

The five streams of the study area were examined to identify potential benthic sampling stations. Criteria used for choosing potential sampling stations included:

- sites downstream of potential development effects;
- sites with elevation and surrounding land uses similar to those of previous ISMP studies in West Vancouver (Kerr Wood Leidel 2002; Associated Engineering and Jacques Whitford AXYS 2008);
- sites with a relatively intact, treed riparian area on both sides of the stream;
- sites readily accessible and repeatable for future monitoring purposes; and
- sites along stream reaches known to flow year-round and offering suitable riffle habitat.

As benthic-sampling sites chosen for both previous ISMP studies were situated approximately mid-slope between Highway 1 and sea level within developed areas of West Vancouver, portions of study area streams at similar topographic positions were investigated as potential sampling sites. Areas examined included Pipe, Westmount, Cave and Turner creeks near the Mathers Avenue crossings, and Godman Creek downstream of Westridge Avenue. Though both Pipe Creek and Godman Creek appeared to have suitable characteristics, Godman Creek was chosen because it is more readily accessible without a need to cross private property. The other streams in the study area lacked suitable riffle habitat.

The chosen Godman Creek Sampling Site G1 is located within a 52 m reach immediately below Westridge Avenue and upstream of Viewridge Place (Photo 12). The channel at this location has riffle-pool morphology with cobble/gravel substrate, relatively homogeneous banks, flow characteristics, width, gradient, and riparian vegetation, and is of sufficient length to

accommodate four replicate samples. The site was geo-referenced with GPS, flagged, and photographed .

4.1.2 Benthic Invertebrate Sampling

SLR sampled benthic invertebrate populations and measured basic water quality physical parameters at Site G1 along Godman Creek on August 29, 2008. Methods used were consistent with protocols described in Module 3 (Water Quality Survey) and Module 4 (Stream Invertebrate Survey) of the Streamkeepers Handbook (Tacogna and Munro 1995) and with the Metro Vancouver B-IB1.

Benthic invertebrates were sampled with a 0.09 m^2 Wildco Surber sampler with 500-micron mesh. This sampler was selected because other samplers are too large for the streams in Neighbourhood One. Four replicate benthic invertebrate samples were collected from gravel-cobble riffle substrates of Godman Creek to minimize variability in community composition that could otherwise have occurred had the replicates also been collected from run and pool areas. Specific sampling sites were approached from downstream to avoid disturbing the substrate, with each subsequent replicate taken immediately upstream of the previous one.

To collect each replicate sample, the Surber sampler was placed firmly on or slightly into the substrate with the net opening facing upstream (Photo 13). The downstream side of the rectangular Surber frame was placed on the stream bottom first to prevent dislodging surface-dwelling invertebrates. Cobble and gravel substrate within the sampler frame were carefully turned over by hand and gently washed to dislodge any aquatic invertebrates into the cod end of the net. Each rock was examined to ensure that no invertebrates (including larval or pupal cases) were missed, and then placed in a plastic tub to be photographed (Photo 14). Once larger gravels and cobbles had been removed, the remaining substrate within the Surber sampler frame was stirred with an iron bar to a depth of 5 cm to 10 cm for two minutes to wash any invertebrates remaining in the interstices into the net. After stirring, the Surber sampler was lifted slowly out of the water, mouth first and facing upstream. The outside of the net was then washed with stream water to ensure that any invertebrates remaining inside the net were flushed into cod end of the net.

Photographs taken for each replicate included the substrate before sampling, the washed substrate in the plastic tub, and the replicate location before the washed substrate was replaced.

4.1.3 Field Sorting

The Streamkeepers Module 4 protocol includes field sorting of live aquatic invertebrate specimens, rather than lab sorting of preserved samples, to facilitate identification by community stewardship groups. For this study, sorted aquatic invertebrates and remaining detritus were preserved separately for later identification and further lab sorting respectively. Replicates were collected and sorted in pairs to reduce the lag time between capture and sorting. The first and second replicate samples were transported respectively in a plastic tub and the Surber net from the sample site to the field vehicle. After the first replicate, the net was turned inside out into a plastic tub partly filled with stream water and the specimens were washed into the tub. The net was carefully inspected and any remaining invertebrates removed with jeweller's forceps. Aquatic invertebrates from the second replicate were then transported in the Surber net. At the field vehicle, samples from the second replicate were washed with stream water from the Surber net into a sorting tray. The net was inspected and any remaining invertebrates transferred with

jeweller's forceps to the sorting tray. Benthic invertebrates from each replicate were picked from the sorting trays with jeweller's forceps, eyedroppers, or spoons and placed in separate ice cube trays filled with stream water (Photo 15).

Sorted invertebrates from each replicate were placed in a 25-ml glass sample bottle and preserved in 70% Ethanol. The remaining detritus was concentrated, placed in a second 250 ml sample bottle and preserved in 70% Ethanol for further lab sorting and to determine field sorting efficiency. The lid and sample bottle for each sorted and detritus sample was labelled with the date, creek, site and replicate number, sample type (benthos or detritus), and names of field personnel. This procedure was repeated for all samples.

4.1.4 Water Quality and Physical Parameters

Immediately before invertebrate sampling began, grab samples of Godman Creek water were collected from a location immediately above Westridge Avenue, a short distance upstream of the invertebrate sampling site. These samples were submitted to the lab within two hours for analyses of nutrients, metals and microbiology. Results are reported above in Section 3.2.1. Turbidity in NTUs was also measured *in situ* at the same time and location with a HACH 2100P Turbidimeter.

In addition, the previous day, on August 28, a YSI 556 MPS unit was used *in situ* to measure water temperature (°C), dissolved oxygen concentration and percent saturation, pH, and total dissolved solids (g/L).

Concurrent with invertebrate sampling, air and water temperature (hand held thermometer), turbidity (NTU visual estimate), % embeddedness, % compaction, substrate, % gradient, average riffle depth, bankfull and wetted depths, and bankfull and wetted channel profiles were recorded once at the location of Replicates 1 and 2 (due to their close proximity), and at locations of both Replicates 3 and 4. Weather conditions at time of sampling were also noted.

4.1.5 Methods for Analysing Benthic Community Data

Data were analysed in accordance with the Streamkeepers Module 4 document, augmented by some additional analyses (e.g., such measures as richness and species diversity and other indices in the Metro Vancouver ISMP Template, Kerr Wood Leidal Associates Limited. 2005).

4.1.6 Lab Sorting

Detritus samples from each of the four replicates were further sorted in the lab using a 500-micron mesh brass sieve to remove any remaining aquatic invertebrates from the gravel, sand, and organic material, and to determine field sorting efficiency. Aquatic invertebrate specimens from the detritus were bottled separately from the field-sorted specimens and re-preserved in 70% Ethanol.

4.1.7 Identification

Karen Needham, of the University of British Columbia Entomology Museum, identified both field- and lab-sorted samples to the lowest practical level. Field- and lab-sorted samples were identified, enumerated, and presented separately in an Excel spreadsheet so that efficiency of field sorting could be assessed. Suitable voucher-specimens of representative taxa were collected and stored in labelled vials for a reference collection.

4.1.8 Statistical Analyses and Rationale

Benthic invertebrate data were analyzed and interpreted according to protocols described in Streamkeepers Module 4 (Taccogna and Munro 1995) to enable comparability of data collected over time and by different individuals during future monitoring. It is anticipated that a benthic-invertebrate monitoring program may be undertaken in the future for Godman Creek and streams investigated during other ISMP studies.

Metric analyses included the Shannon-Weaver Diversity Index[3] (Shannon and Weaver 1963; also known as the Shannon-Wiener Index), the Pielou Evenness metrics (Malick 1977), mean abundance and density, taxon proportion (%), and the Benthic Index of Biological Integrity (B-IBI) protocol (EVS 2003; Kerr Wood Leidal 2005).

The B-IBI protocol is based on the Puget Sound Lowlands (State of Washington) genus-level (pre-1999) B-IBI (Salmon Web internet site), adapted for the Lower Mainland climate and geography (EVS 2003). The B-IBI protocol was developed to provide a consistent method for evaluating effects of stormwater discharges on small-stream receiving environments. Use of the B-IBI approach will enable baseline and future data to be compared with other datasets from ISMP investigations in Metro Vancouver.

4.1.9 Streamkeepers Module 4 Analyses

To perform the Streamkeepers Module 4 analyses, the mean benthic invertebrate abundance for each Family, Order, or Phylum was calculated from the four replicates for a sampling area of 0.09 m^2. Mean abundance data were then reorganized into the broad Streamkeeper taxonomic groups (e.g., Caddisfly Larva, Riffle Beetle, or Midge Larvae) and Pollution Tolerance categories. Due to the broad taxonomic groups used in Module 4, not all taxa collected were included in Module 4 calculations.

Numbers of individuals and taxa for each broad taxonomic group were calculated and then totalled for each Pollution Tolerance category for the complete Site G1. Abundance and Density, Predominant Taxon, Water Quality and Diversity Assessments, and Site Assessment Ratings were calculated.

Finally, the efficiency of field versus lab sorting was assessed.

3 The **Shannon Index**, also known as **Shannon-Weaver Index** and the **Shannon-Wiener Index**, is one of several indices used to measure diversity in categorical data. The advantage of this index in measuring biodiversity is that it takes into account the number of species and the evenness of the species. The index is increased either by having additional unique species, or by having a greater species evenness.

The "Shannon-Weaver" name is a misnomer; though Warren Weaver (an influential early administrator of the Rockefeller Foundation) wrote a preface to the book form of Claude Shannon's 1948 paper founding information theory, he was not a cofounder of this theory. Norbert Wiener had no hand in the index either, although his influential popularisation of cybernetics was often conflated with information theory in the 1950s.

(reference: http://en.wikipedia.org/wiki/Shannon-Wiener_Index)

4.1.10 Metrics

Mr. Will Gibson, of Environment Resolution Services, analyzed the benthic invertebrate taxonomic data on behalf of SLR. All metrics were calculated using Microsoft Excel.

The Shannon-Weaver Diversity Index and Pielou Evenness Index were described in detail by Malick (1977). Both indices were calculated for Site G1 and for each replicate to quantify the variability between replicates. The mean, SD, and SE of replicate indices were also calculated to evaluate sampling precision.

Shannon-Weaver Diversity Index

Wilhm and Dorris (1968) proposed the information theory-based Shannon-Weaver Diversity Index (Shannon and Weaver 1963) as a means of assessing benthic invertebrate diversity:

$$H = -\sum (Ni/N) \log2 (Ni/N),$$

where N_i is the number of individuals in the i^{th} species and N is the total number of individuals in the sample.

The index measures the uncertainty of finding an individual of a given taxon when randomly selecting an organism from a community. For instance, large numbers of organisms distributed over a small number of taxa would result in lower H values. Wilhm (1972) and Cole and Cole (1973) suggested that the decreased sensitivity of the Shannon-Weaver index to the presence or absence of rare species was an advantage since rare groups are more readily overlooked during sampling and add little to the community ecology.

Although H was originally calculated using logarithms to the base 2 (Wilhm and Dorris 1968), diversity calculations for the current study were based on natural logarithms (Appendix E, Table 4). According to Pielou (1966), the base of the logarithm will only affect the size of the value.

Wilhm (1970; 1972) compared H values of several North American streams and concluded that H values greater than three (>3) should reflect a “clean” stream, while values less than one (<1) should indicate a “polluted” stream. To assess stream condition, SLR recalculated Shannon-Weaver for Site G1 and for the four replicates using the logarithm to the base 2.

Pielou’s Evenness (Equitability) Index

Evenness measures how evenly taxa are distributed within the benthic community. Pielou (1966) used the formula:

$$J = H/\log s,$$

where H is the Shannon index and s is the number of species in the sample.

For Pielou’s index, similar numbers of organisms in each taxon will yield a value near 0 while differing numbers of organisms in each taxon will result in values closer to 1. J will be closely correlated with values of H.

Other Metrics

Mean abundance and density (plus median, SD, SE, Min, and Max), and Proportion (%) were calculated for Site G1 (for a sampling area of 0.09 m^2) for each Family and Order (or highest taxonomic level where Order was not available).

4.1.11 GVRD B-IBI

Calculation of the Genus Level (pre-1999) B-IBI (EVS 2003) requires that benthic invertebrates be identified to the following levels:

- Most aquatic invertebrates – to Genus or Species, except for the Rhyacophylid caddisflies, which can only be identified to sub-group
- Chironomids – to Family, and only to pupal or larval stages
- Non-insects – to Order or Family
- Turbellaria, Nematoda, Copepoda, and Oligochaeta – to Phylum or Class

Each taxon is then classified according to four ecological characteristics:

- Lifespan – long- or short-lived
- Pollution tolerance – tolerant or intolerant
- Functional feeding group – predator or non-predator
- Habit - clinger or non-clinger

For all Godman Creek taxa, available information for the four ecological characteristics was obtained from the EVS (2003) classification table, from spreadsheets prepared by Wisseman and Fore (SalmonWeb web site), and from Merritt *et al*. (2008).

These ecological characteristics were used to calculate the following ten metrics:

- Taxa Richness and Composition
  - Total number of taxa
  - Number of mayfly taxa (Ephemeroptera)
  - Number of stonefly taxa (Plecoptera)
  - Number of caddisfly taxa (Trichoptera)
  - Number of long-lived taxa, defined as living at least 2-3 years in the immature state
- Pollution Tolerance
  - Number of pollution-intolerant taxa

- Percent of pollution-tolerant individuals

- Feeding Ecology
  - Percent of predator individuals

- Population Attributes
  - Number of clinger taxa
  - Percent dominance: the sum of individuals in the three most abundant taxa, divided by the total number of individuals found in the sample.

Finally, each metric value was given a B-IBI Score and the ten scores summed to result in an overall Riffle B-IBI Score for categorizing the stream condition as Excellent, Good, Fair, Poor, or Very Poor. Only one set of B-IBI scores was calculated as the four replicates were from a single site or riffle. Only those taxa for which information was available on ecological characteristics were included in the B-IBI calculations.

The ranges of 10-Metric B-IBI Scores for categorizing stream condition are as follows (scores can only be even numbers).

Score 46 – 50	=	Excellent Stream Condition
Score 38 – 44	=	Good Stream Condition
Score 28 – 36	=	Fair Stream Condition
Score 18 – 26	=	Poor Stream Condition
Score 10 – 16		Very Poor Stream Condition

4.1.12 Quality Assurance and Quality Control

Several QA/QC measures were inherent in the methodology.

Two Professional Biologists independently inspected and approved the proposed sampling site.

All benthic invertebrate samples were collected, sorted, and identified by experienced, qualified individuals to minimize bias. Four replicates were collected to address variability due to patchy distributions.

Care was taken to ensure that, during collection, transport, and sorting, no sample material was lost nor any foreign material introduced to the samples. Detailed field notes were taken to document procedures, field conditions, or other relevant factors that might affect the results. Identified specimens have been retained for future reference or verification.

4.2 Benthic Communities Results

This section presents results of taxonomic and statistical analyses of benthic samples collected from Godman Creek Site G1. The text below provides summary data tables, while detailed tables are provided in Appendix E.

4.2.1 Taxonomic Analysis of Benthic Communities

Most aquatic stages of insects in the Orders Ephemeroptera (mayflies), Trichoptera (caddisflies), and Plecoptera (stoneflies), sometimes referred to as "EPT", require well-oxygenated gravel or cobble substrates and are considered to be indicators of healthy, fast-flowing streams.

In contrast, Nematodes (roundworms), Oligochaeta (aquatic worms), and Turbellaria (flatworms) may be characteristic of slow-moving waters with soft substrates. Due to their tolerance of low oxygen levels, their presence may also indicate polluted conditions. Invertebrates such as Diptera (true flies) are considered to be intermediate in their habitat needs and pollution sensitivity, although this is largely the result of an inability of ecologists to easily identify the larval stage of the organisms beyond the Family level.

The above broad characterization of pollution tolerance or sensitivity, however, must be considered in light of the species present and the proportion of the various taxonomic groups.

4.2.2 Taxonomic and Statistical Analysis

Abundance, density, and percent composition of benthic invertebrates in Sample G1 are tabulated in Appendix E, Table 2, and arranged by Order and Family.

Benthic invertebrate composition and taxonomy are presented in Table 7. The dominance of Oligochaetes rather than EPT taxa suggests that, although the Godman Creek site exhibited riffle pool morphology, a substrate dominated by gravels and cobbles with moderate amounts of fines, and a moderate flow, other factors may also have influenced composition of the benthic invertebrate fauna.

4.2.3 Physical Parameters and Water Quality Data

Physical parameters and water quality data are tabulated in Appendix E, Table 1.

The wetted widths for Replicates 1 through 4 increased with distance upstream, from 2.55 m to 3.44 m, with wetted depths from 1 cm to 30 cm. Bankfull widths also increased with distance upstream, from 3.35 m to 4.10 m, with bankfull depths from 7 cm to 68 cm. Average riffle depth was 11 cm. The gradient within the sampling area was generally low, from 3% to 4%, while the gradient increased downstream of the sample site to 9%. Visually estimated turbidity for all replicates (below Westridge Avenue) was 0 NTU to 1 NTU, while turbidity measured *in situ* with a meter above Westridge Avenue was 0.9 NTU.

Gravel and cobble substrates over the four replicates decreased with distance upstream, from 40% to 30%, while fines and boulders both increased with distance upstream, from 15% to 25% and from 5% to 15%, respectively. Embeddedness and compaction both decreased with distance upstream, from 25% to 10%, and from 60% to 30%, respectively.

Water temperatures at the three replicate sites were stable, from 14.0°C to 14.5°C, whereas air temperatures decreased from downstream to upstream, from 23.0°C to 18.0°C, reflecting late afternoon cooling.

Table 7
Results of Benthic Community Sampling, Godman Creek, Site G1

Taxon					Number Per Sample and Replicate														
					Rep. 1			Rep. 2			Rep. 3			Rep. 4			MEANS		
PHYLUM	ORDER	FAMILY	GENUS	SP	B	D	TOT	B	D	TOT	B	D	TOT	B	D	TOT	B	D	TOT
ARTHROPODA	Acariformes (Acarina)	Hydracarina									2	2	4				0.5	0.5	1.0
	Collembola	Anthropleona			1		1										0.25		0.25
	Ephemeroptera	Baetidae	*Baetis*					1		1	8	7	15	4	1	5	3.25	2.0	5.25
		Heptageniidae	*Cinygma*		1		1	1		1							0.5		0.5
			Epeorus												1	1		0.25	0.25
		Leptophlebiidae	*Paraleptophlebia*					2		2					1	1	0.5	0.25	0.75
	Plecoptera	Chloroperlidae	*Sweltsa*					1		1							0.25		0.25
		Leuctridae										1	1					0.25	0.25
		Nemouridae	*Zapada*			1	1					1	1					0.5	0.5
		Pteronarcyidae	*Pteronarcys*											1		1	0.25		0.25
	Trichoptera	Calamoceratidae	*Heteroplectron*	*californicum*		4	4				2	7	9		3	3	0.5	3.5	4.0
		Glossosomatidae	*Glossosoma*			1	1				1		1		1	1	0.25	0.5	0.75
		Hydropsychidae	*Parapsyche*						1	1				2	2	4	0.5	0.75	1.25
		Lepidostomatidae	*Lepidostoma*			1	1		2	2	2		2				0.5	0.75	1.25
		Limnephilidae	*Limnephilus*		1	6	7				2	4	6		15	15	0.75	6.25	7.0
		Polycentropodidae	*Polycentropus*												2	2		0.5	0.5
		Rhyacophilidae	*Rhyacophila*		1		1										0.25		0.25
		Uenoidae	*Neophylax*					1		1							0.25		0.25
		Pupal cases			4	1	5				1	3	4	19	23	42	6.0	6.75	12.75
	Coleoptera	Elmidae	*Lara*											1		1	0.25		0.25
	Diptera	Ceratopogonidae										1	1					0.25	0.25
		Chironomidae	*Orthocladiinae* (larvae)			7	7		2	2	1	2	3		9	9	0.25	5.0	5.25
			Tanytarsini (larvae)			3	3	1		1					7	7	0.25	2.5	2.75
		Culicidae										1	1					0.25	0.25
		Simuliidae	*Simulium*			1	1							1		1	0.25	0.25	0.5
	Hemiptera	Gerridae	*Aquarius*	*remigis*							1		1				0.25		0.25
ANNELIDA Class Hirudinea					1		1				1		1	2		2	1.0		1.0
Class Oligochaeta					10	51	61	7	37	44	1	39	40	2	39	41	5.0	41.5	46.5
				Number of Specimens	19	76	95	14	42	56	22	68	90	32	104	136	21.75	72.5	94.25
				Percent of Total Specimens	20	80		25	75		24	76		24	76		23	77	
				Number of Taxa	7	10	17	7	4	11	11	11	22	8	12	20	22	17	28
				Percent of Total Taxa	41	59		64	36		50	50		40	60		79	61	

Notes: Sample Type: B - Field Sorted: D - Lab Sorted Detritus; TOTAL - TOTAL per replicate

4.2.4 Invertebrate Community Metrics

Table 8 summarizes metrics for the August 2008 survey at Godman Creek Site G1. All values are based on means of four replicates. Detailed abundance, density, proportion, and diversity indices for G1 and replicates are presented in Appendix E, Tables 2, 3, and 4. Proportions of taxa are presented graphically in Figure 3 (back of this report).

Table 8
Summary of Benthic Invertebrate Metrics, Godman Creek Site G1

Metric	Results						Proportion of Taxa	
	Value	SD	SE	Median	Min	Max	**Taxon**	**%**
Mean Abundance	94	32.8	16.4	92.5	56.0	136.0	Acarina	1.1
							Collembola	0.3
							EPT	38.2
Mean Density	1047	364.3	182.1	1027.8	622.2	1511.1	• Ephemeroptera	7.2
							• Plecoptera	1.3
							• Trichoptera	29.7
Shannon-Weaver Diversity Index	**ln (natural logarithm)**			**log_2 (logarithm to base 2)**			Coleoptera	0.3
							Diptera	9.5
With Caddisfly pupal cases:	1.94			2.80			Hemiptera	0.3
Without Caddisfly pupal cases:	1.79			2.58			Hirudinea	1.1
Pielou's Evenness							Oligochaeta	49.3
With Caddisfly pupal cases:	0.74							
Without Caddisfly pupal cases:	0.70							

The benthic invertebrate community was dominated by Annelid taxa, which comprised 50.4% of the fauna. Annelids are generally characteristic of slow-flowing or still waters with soft substrates, but may also be indicative of polluted waters. Of the Annelida, aquatic worms (Oligochaeta) constituted 49.3% of the community, and leeches (Hirudinea) 1.1%. Unlike the other taxa, Oligochaetes were distributed across all replicates and both field and lab-sorted samples. EPT taxa, which are characteristic of well-oxygenated, fast flowing streams, comprised 38.2% of the benthic community. Caddisflies (Trichoptera) were the dominant EPT taxon, constituting 29.7% of the fauna, followed by mayflies (Ephemeroptera) at 7.2%, and stoneflies (Plecoptera) at 1.3%. However, Trichopteran and EPT abundance was influenced by the presence of Trichoptera pupal cases, which constituted 15.1% of the total.

True flies (Dipera) comprised 9.5% of the community, with midges (Chironomidae), which can account for at least half of the overall aquatic invertebrate composition (Merritt *et al*., 2008), constituting 8.5% of the total. Small numbers of water mites (Acari) were present in Replicate 3 and leeches (Hirudinea) in replicates 1, 3, and 4. Single specimens of springtails (Collembola), riffle beetles (Coleoptera - Elmidae), and true bugs (Hemiptera) were observed in Replicates 1, 4, and 3, respectively.

The Mean Abundance at Site G1 was 94 (Table 8), and ranged from 56 to 136 individuals per replicate, reflecting the variability commonly found among benthic populations. The Mean Density was 1,047/m^2, with replicate density varying from 622.2/m^2 to 1,511.1/m^2.

The Shannon-Weaver Diversity Index for Site G1 (i.e., combined replicates, using 0.09/m^2 area) was 1.94 using natural logs, suggesting that Godman Creek falls somewhere between a "polluted" and a "clean" stream, according to Wilhm's classification. Wilhm's classification was based, however, on logarithms to base 2. Converting the diversity values to logarithms to base 2 yielded a value of 2.80 for G1, again suggesting that Godman Creek lies between a "polluted" and a "clean" stream stream (i.e., < 3) (Table 8; Appendix E, Table 3).

Diversity indices for the four individual replicates, converted to logarithms to base 2, were also less than 3, although the upstream replicates 3 and 4 were closer to 3 (Appendix E, Table 4). Higher diversity suggests that niches, habitat, and food sources are sufficient to support the survival and reproduction of many species or taxa.

Pielou's Evenness Index for Site G1 was 0.74, indicative of a community with individuals distributed unevenly among the taxa, possibly reflecting the dominance of the Oligochaetes (49.3%) and the abundance of pupal cases.

The caddisfly pupal cases, a potential outlier, were removed and the Shannon-Weaver Diversity and Pielou Evenness indices recalculated to assess their effect on the metrics (Table 8). Excluding the Caddisfly cases did not markedly change either the Shannon-Weaver or Pielou Evenness indices. The Shannon-Weaver Index (logarithms to base 2) remained below 3, indicative of a stream classified between a polluted and a clean stream.

4.2.5 Streamkeepers Module 4

Table 9 presents the Streamkeepers Survey Field Data and Table 10 summarizes the Streamkeepers Invertebrate Survey Interpretation Sheet for the August 2008 benthic invertebrate survey.

Using the Streamkeeper Module 4 calculations, the total number of aquatic invertebrates counted (93.5) was essentially equal to the metric Mean Abundance (94, Table 8). Streamkeeper Density (Table 10) and metric Mean Density (Table 8) were similar, 1,038.90/m^2 and 1047/m^2, respectively.

Pollution Tolerant organisms (Table 9) comprised 57.25 (average per replicate) or 61.2 % of the total whereas Pollution Intolerant organisms accounted for 36.25 (average per replicate), or 39% of the total. In contrast, of the 24 taxa present, 6 were Pollution Tolerant while 18 were Pollution Intolerant. Taxa for which no information is available regarding pollution tolerance have not been included for purposes of calculating the B-IBI score presented in Table 11.

Oligochaeta (Pollution Tolerant aquatic worms) was the Predominant Taxon (46.5 individuals), with a Predominant Taxon Ratio of 0.5, or Acceptable (equal to 50% of the total number of aquatic invertebrates captured), compared to 49.3% for the metric calculation (Table 8).

Of the Water Quality Assessments, the EPT to Total Ratio and EPT Index were Marginal and Good respectively, while the Pollution Tolerant Index was near the low end of Acceptable with respect to organic pollution tolerance. The overall Site Assessment Rating was 3, or Acceptable.

Table 9
Invertebrate Survey Field Data Using Streamkeeper Protocols
Godman Creek Site G1

A Pollution Tolerance	B Number Counted [1,2]	C Number of Taxa [1,2]	D Broad Taxonomic Group[3]
Category 1: **Pollution Intolerant**	28.0	9	Caddisfly Larvae: O. Trichoptera (EPT[4])
	6.75	4	Mayfly Nymph: O. Ephemeroptera (EPT)
	0.25	1	Riffle Beetle: O. Coleoptera, F. Elmidae
	1.25	4	Stonefly Nymph: O. Plecoptera (EPT)
Subtotal	36.25	18	
Category 2: **Somewhat Pollution Tolerant**	0	0	na
Subtotal	0	0	
Category 3: **Pollution Tolerant**	46.5	1	Aquatic Worm: P. Annelida, Cl. Oligochaeta
	0.5	1	Blackfly Larvae: O. Diptera, F. Simuliidae
	1.0	1	Leech: P. Annelida, Cl. Hirudinea
	8.0	1	Midge Larvae: O. Diptera, F. Chironomidae
	0.25	1	True Bug Adult: O. Hemiptera, F. Gerridae
	1.0	1	Water Mite: O. Acarina, F. Hydracarina
Subtotal	57.25	6	
TOTAL	93.5	24	

Note 1: All values are based on the mean of 4 replicates at the site; therefore, total area sampled = 0.09 m^2

Note 2: Number Counted (= Mean Abundance) and Number of Taxa in the Streamkeepers protocol may differ from values in Table 7

Note 3: Common and Scientific Names, Broad Taxonomic Groups: P. - Phylum; Cl. - Class; O. - Order; F. - Family

Note 4: EPT: Ephemeroptera, Plecoptera, Trichoptera

4.2.6 Comparison of Field and Lab Sorting

Table 7 provides the proportions of individual invertebrates and taxa sorted in the field versus the lab by replicate and for Site G1 as a whole (i.e., mean of four replicates, area 0.09 m^2).

The proportion of individuals sorted in the field by replicate ranged from 20% to 25% of the totals, compared to 75% to 80% for those sorted in the lab. In contrast, the proportion of taxa sorted by replicate in the field versus in the lab were similar, ranging from 40% to 64% and from 36% to 60%, respectively.

For Site G1, field sorting captured 23% of the organisms and 79% of the taxa, whereas further lab sorting captured 77% of the organisms and 61% of the taxa; 22 of the total 28 taxa were collected during field sorting and 17 during lab sorting.

The Godman Creek results suggest that for future studies, although field sorting can provide a start to the sorting process, lab sorting of the remaining detritus is essential both to ensure data quality and to ensure sorting efficiency and completeness. If Streamkeepers groups are involved, field sorting should not be carried out without subsequent lab sorting.

Table 10
Invertebrate Survey Interpretation Using Streamkeeper Protocols
Godman Creek Site G1

Analysis		Value[1]	Assessment[2]	Rating
A. Abundance and Density				
Abundance (Total Column B)		93.5	na	na
Density (Total Column B/0.09 m^2)		1038.90	na	na
B. Predominant Taxon	(Broad Taxonomic Group with highest number of organisms)	Aquatic Worms (P. Annelida, Cl. Oligochaeta)	na	na
C. Water Quality Assessments				
Pollution Tolerant Index (no. of Broad Taxonomic Groups, Column D) (3x Category 1) + (2x Category 2) + (Category 3)		18	Acceptable	3
EPT[3] Index (Total EPT Taxa, Column C)		17	Good	4
EPT to Total Ratio (Total EPT Column B/Total Column B)		0.38	Marginal	2
D. Diversity Assessment				
Total Number of Taxa (Column C)		24	na	na
Predominant Taxon Ratio (Predominant Taxon, Column B/Total Column B)		0.50	Acceptable	3
E. Site Assessment Rating[1]				
Total				12
Average			Acceptable	3

Note 1: Common and Scientific Names, Broad Taxonomic Groups: P. - Phylum; Cl. - Class; O. - Order; F. - Family

Note 2: Site Assessment Ratings: Good - 4, Acceptable - 3, Marginal - 2, Poor - 1

Note 3: EPT: Ephemeroptera, Plecoptera, Trichoptera

4.2.7 GVRD B-IBI

Known ecological characteristics of Site G1 benthic invertebrates are presented in Appendix E, Table 5. Table 11 presents the ten genus-level B-IBI scores for Site G1. Five of the B-IBI metric scores were “5” (indicative of an undisturbed site), four scores were “3” (indicative of a somewhat degraded site), and one score was “1” (indicative of a severely degraded site), resulting in an overall B-IBI score of 38 or Good stream condition, although the overall score was at the bottom of the “Good” range (see Section 4.1.11).

Total Number of Taxa, Caddisfly and Long-lived Taxa, Number of Intolerant Taxa, and Number of Clinger Taxa contributed undisturbed site scores of 5, while Number of Mayfly and Stonefly Taxa, Predator Individuals, and Dominance yielded scores of 3. The Tolerant Individuals metric yielded a score of 1.

Table 11
Genus-Level B-IBI Scores,
Godman Creek Site G1

Metric	Value	B-IBI Score[1]
Taxa Richness & Composition		
Total number of Taxa[2]	26	5
Number of Mayfly Taxa	4	3
Number of Stonefly Taxa	4	3
Number of Caddisfly Taxa	8	5
Number of Long-lived Taxa	5	5
Pollution Tolerance		
Number of Intolerant Taxa[3]	13	5
Tolerant Individuals (%, as a whole number)	58	1
Feeding Ecology		
Predator Individuals (%, as a whole number)	5	3
Population Attributes		
Number of Clinger Taxa	15	5
Dominance (Top 3 Taxa) (%, as a whole number)	62	3
Riffle B-IBI Score (SUM of B-IBI Scores)		38
Stream Condition		Good

Note 1: Severely degraded site=1; Somewhat degraded site=3; Undisturbed site=5

Note 2: Total Number of Taxa = number of taxa for which some information on ecological characteristics is available

Note 3: Number of Intolerant Taxa = number of taxa that are not tolerant; does not include taxa for which no Tolerance information is available

Note 4: Percentage metrics are reported as number of individuals divided by the total number of individuals x 100. The total number of individuals included Caddisfly pupal cases.

4.3 Conclusions and Recommendations

Although Godman Creek Site G1 exhibited the riffle-pool morphology, gravel and cobble substrates with moderate fines, and moderate flows characteristic of a more natural, undisturbed stream, the benthic invertebrate community was dominated by Pollution-Tolerant Oligochaetes rather than EPT taxa, suggesting that factors in addition to habitat may have been determining community composition. Of note, two minor and one significant rain event occurred in the days preceding sampling, which may have reduced EPT abundance and taxa. In addition, lab analysis of water samples collected the same day as the benthic invertebrate samples revealed high faecal coliform levels, indicative of organic pollution, which may also affect EPT composition.

The metric Shannon-Weaver Diversity Index suggested that, according to Wilhm's classification, the Godman Creek Site fell between a "polluted" and a "clean" stream, whereas the Pielou Evenness Index reflected a community with individuals distributed unevenly among the taxa, likely due to Oligochaete dominance. Streamkeeper and B-IBI protocols yielded, respectively,

an Acceptable Site Assessment Rating, and a B-IBI Good Stream Condition (although at the bottom of the scale).

By contrast, Associated Engineering *et al*. (2008) reported B-IBI Poor Stream Condition for both both Rodgers Creek and Marr Creek, to the east of the current study area. A “poor” score is indicative of moderate-to-notable urbanization (EVS 2003). These results reflect higher levels of urbanization in the Rodgers and Marr watersheds, compared with the Godman watershed.

Although the data provide a baseline, further annual sampling is recommended to more accurately determine the benthic community composition.

5.0 TERRESTRIAL ECOSYSTEM AND VEGETATION CHARACTERISTICS

Reconnaissance level vegetation surveys and ecosystem mapping were completed for various parts of the ISMP study area to characterize forests of the proposed Rodgers Creek and Cypress Creek neighbourhoods (SLR 2008a,b). As such, areas already developed for urban land uses, primarily below Highway 1, were not included. Figure 4 depicts ecosystems of the Rodgers Creek Neighbourhood area (including portions of the watersheds of Pipe, Westmount, and Cave creeks) and Figure 5 depicts ecosystems of the Cypress Creek Neighbourhood area (including portions of the Godman Creek and Turner Creek watersheds).

Field inspection methods were based on provincial inventory standards (Resources Inventory Standards Committee, under BCMSRM and BCMOF 1998). Ecosystem units were identified using the Ministry of Forests "*A Field Guide for Site Identification and Interpretation for the Vancouver Forest Region"* (Green and Klinka 1994) and the provincial site series coding list (BCMSRM 2001). Surveys were undertaken between February 2000 and November 2006.

5.1 Biogeoclimatic Ecosystem Classification

The provincial Biogeoclimatic Ecosystem Classification (BEC) system enables a standardized approach to ecosystem description and mapping, and facilitates interpretations of wildlife habitat and assessments of at-risk species and ecosystems. Such field data and interpretive mapping forms an essential part of baseline inventory for land use planning.

The BEC system groups together ecosystems with similar climate, soils, and vegetation (Pojar *et al.* 1987). At the regional level, vegetation, soils, and topography are used to infer the regional climate and to identify biogeoclimatic units that have relatively uniform climate. Biogeoclimatic units are further divided into site series, which characterize sites capable of producing the same mature or climax plant communities. Green and Klinka (1994) described site series that form the basis of BEC interpretation and mapping for Vancouver Forest Region biogeoclimatic units. In addition, a standardized provincial database (BCMOE 2006) provides accepted nomenclature for site series and non-forested ecosystem units (and their typical environments).

The ISMP study area straddles two biogeoclimatic units, subzones of the Coastal Western Hemlock zone (BCMOF 2003): the Very Dry Maritime subzone (CWHxm1) and the Dry Maritime subzone (CWHdm). The CWHxm1 extends from sea level to elevations of approximately 200 m where it grades into the CWHdm, with local variation influenced by aspect, exposure, and topography.

The CWHxm1 has warm, dry summers and moist, mild winters with relatively little snowfall. Water deficits may occur on typical sites during the long growing season. Climax forests typical of the area have a canopy of Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), with western redcedar (*Thuja plicata*) less common. Major understorey species include salal (*Gaultheria shallon*), dull Oregon-grape (*Mahonia nervosa*), red huckleberry (*Vaccinium parvifolium*), step moss (*Hylocomium splendens*), and Oregon beaked-moss (*Eurhynchium oreganum*) (Green and Klinka 1994).

The CWHdm has warm, relatively dry summers and moist, mild winters with little snowfall. Growing seasons are long, and minor water deficits occur on typical sites. Mature forests typical of the area have a canopy of Douglas-fir, western redcedar, and western hemlock. Major

understorey species include salal, red huckleberry, step moss, Oregon beaked-moss, lanky moss (*Rhytidiadelphus loreus*), and flat-moss (*Plagiothecium undulatum*) (Green and Klinka 1994).

5.2 Ecosystem Mapping and Map Units

Ecosystem maps of the BPPL neighbourhood planning study areas were produced (see Figures 4 and 5) with an accompanying legend and table listing polygon descriptive labels and attributes. Ecosystem maps are mapping products based on the provincial BEC system. Field data were analysed and air photos interpreted to describe and map ecosystems of the study area. The ecosystem mapping methodology is based on the BC provincial inventory standard (RISC 1998).

Structural stages describe the vegetation structure and successional status according to a seven-level system (Table 12). Air photo interpretation and field observations were used to map structural stages. Stand composition modifiers have been added to differentiate among coniferous, mixed, or broadleaf stands (Table 13). Because stand composition can vary as a stand regenerates, stand composition modifiers have not been specified for regenerating stands (structural stages 3 or less).

Table 12
Study Area Ecosystem Structural Stages

Code	Structural Stage	Definition[1]
1	Sparse/ Bryoid	Initial stages of primary and secondary succession; bryophytes and lichens often dominant; time since disturbance <20 years for normal forest succession, may be prolonged (50-100+ years) where there is little or no soil development (bedrock, boulder fields); total shrub and herb cover <20%; total tree cover <10%.
1a	Sparse	Less than 10% vegetation cover.
1b	Bryoid	Bryophyte and lichen-dominated community (>50% of total vegetative cover)
2	Herb	Early successional stage or herb communities maintained by environmental conditions or disturbance (e.g., snow fields, avalanche tracks, wetlands, flooding, grasslands, intensive grazing, intense fire damage); dominated by herbs (forbs, graminoids, ferns); some invading or residual shrubs and trees may be present; tree cover < 10%, shrubs $\leq$ 20% or < 33% of total cover, herb-layer cover > 20%, or $\geq$ 33% of total cover; time since disturbance < 20 years for normal forest succession; many non-forested communities are perpetually maintained in this stage.
2a	Forb-dominated	Includes non-graminoid herbs and ferns.
2b	Graminoid-dominated	Includes grasses, sedges, reeds, and rushes.
2c	Aquatic	Floating or submerged; does not include sedges growing in marshes with standing water (classed as 2b).
2d	Dwarf shrub-dominated	Dominated by dwarf woody species such as *Arctostaphylos alpina*, *Salix reticulata*, *Rhododendron lapponicum*, *Cassiope tetragona.*
3	Shrub/Herb	Early successional stage or shrub communities maintained by environmental conditions or disturbance; dominated by shrubby vegetation; seedlings and advance regeneration may be abundant; tree cover < 10%, shrub cover > 20% or $\geq$ 33% of total cover.
3a	Low shrub	Dominated by shrubby vegetation < 2 m tall; seedlings and advance regeneration may be abundant; time since disturbance < 20 years for normal forest succession; may be perpetuated indefinitely by environmental conditions or disturbance.
3b	Tall shrub	Dominated by shrubby vegetation that is 2-10 m tall; seedlings and advance regeneration may be abundant; time since disturbance < 40 years for normal forest succession; may be perpetuated indefinitely.
4	Pole/Sapling	Trees > 10 m tall, typically densely stocked, have overtopped shrub and herb layers; younger stands are vigorous (usually > 10-15 years old); older stagnated stands (up to 100 years old) are also included; self-thinning and vertical structure not yet evident in the canopy - this often occurs by age 30 in vigorous broadleaf stands, which are generally younger than coniferous stands at the same structural stage; time since disturbance < 40 years for normal forest succession; up to 100+ years for dense (5000-15000+ stems per ha) stagnant stands.

Code	Structural Stage	Definition[1]
5	Young Forest	Self-thinning has become evident and the forest canopy has begun to differentiate into distinct layers (dominant, main canopy, and overtopped); vigorous growth and a more open stand than in the PS stage; begins as early as age 30 and extends to 50-80 years; time since disturbance generally 40-80 years, depending on tree species and ecological conditions.
6	Mature Forest	Trees established after the last disturbance have matured; a second cycle of shade-tolerant trees may have become established; understories become well developed as the canopy opens up; time since disturbance generally 80-140 years in interior biogeoclimatic units and 80-250 years in coastal biogeoclimatic units.
7	Old Forest	Old, structurally complex stands comprised mainly of shade-tolerant and regenerating tree species, although older seral and long-lived trees from a disturbance such as fire may still dominate the upper canopy; snags and coarse woody debris in all stages of decomposition and patchy understories typical; understories may include tree species uncommon in the canopy, because of inherent limitations of these species under the given conditions; time since disturbance generally >140 years in interior biogeoclimatic units and >250 years in coastal biogeoclimatic units.
Note 1:	Adapted from BCMELP and MOF 1998	

Table 13
Forest Ecosystem Structural Stage Stand Composition Modifiers

Code	Definition[1]
C	coniferous (>75% of total tree cover is coniferous)
B	broadleaf (>75% of total tree cover is broadleaf)
M	mixed (neither coniferous or broadleaf account for >75% of total tree cover)
Note 1:	These modifiers apply only to structural stages 3 to 7; adapted from BCMELP and MOF 1998

5.3 Ecosystem Unit Descriptions

The gradation between the upper extent of the CWHxm1 and the lower extent of the CWHdm biogeoclimatic units begins at approximately the elevation of the lower portion of Cypress Bowl Road. As such, lower portions of study area watersheds, including developed areas, are within the CWHxm1 unit, while the upper portions are within the CWHdm unit.

5.3.1 Overview

The undeveloped portions of study area watersheds are dominated by forested ecosystems located primarily on moderately well-drained sites. Sites richer than average are relatively common because the study area comprises a lower macroslope position where many sites receive nutrient-rich soil and moisture from upslope. Occasionally, drier than average sites occur, with thin soil underlain by convex bedrock. Very dry sites occur rarely, only where soil is virtually absent and vegetation grows on humus and bedrock. Streamsides tend to be moist and rich. Wetlands in the study area are associated mainly with Godman Creek.

Young forests that cover most of the upper study area consist of second growth stands that have regenerated following clear-cut logging in the early 20th century. In addition to logging, ecosystems have historically been disturbed by chairlift construction, operation and placement of water reservoir tanks, and other infrastructure, such as powerline rights of way. Recent disturbances include clearing, residential building, and road construction. No old forest or mature structural stages (as defined in Table 12) were observed in the ISMP study area.

Ecosystem units of the study area are summarized in Table 14, and described in the sections that follow.

Table 14
Study Area Ecosystem Units

Biogeoclimatic Unit	Site Series No.	Ecosystem Unit Symbol	Ecosystem Unit Name
CWHdm	01	HM	Western hemlock – Flat moss
	03	DS	Douglas-fir – Western hemlock – Salal
	05	RS	Western redcedar – Sword fern
	07	RF	Western redcedar – Foamflower
CWHxm1	01	HK	Western hemlock – Douglas-fir – Kindbergia
	02	DC	Douglas-fir – Lodgepole Pine – Cladinia
	03	DS	Douglas-fir – Western hemlock – Salal
	05	RS	Western redcedar – Sword fern
	07	RF	Western redcedar – Foamflower
CWHdm/CWHxm1	–	ES	Exposed Soil
CWHdm/CWHxm1	–	PL	Powerline
CWHdm/CWHxm1	–	RZ	Road/Trail
CWHdm/CWHxm1	–	UR	Urban/Suburban

5.3.2 Ecosystem Units of the CWHdm

Western Hemlock – Flat moss (01/HM)

The Western Hemlock – Flat moss (01/HM) ecosystem unit of the CWHdm is considered "zonal". Zonal ecosystems have moisture and nutrient regimes typical of the climate and location in which they occur. Within the study area, the HM ecosystem unit occurs on level to sloping sites, often on ridges that trend downslope. Soils have submesic-to-mesic soil moisture regimes and poor-to-medium soil nutrient regimes. Surficial material is usually coarse till.

Young forests are dominated by Douglas-fir, often with western redcedar, red alder (*Alnus rubra*), or both. Western hemlock and bigleaf maple (*Acer macrophyllum*) are occasional components of the canopy. The understorey varies according to the degree of canopy shading, with salal, red huckleberry, dull Oregon-grape and sparse amounts of salmonberry (*Rubus spectabilis*) in the shrub layer. Scattered sword fern (*Polystichum munitum*) and trailing blackberry (*Rubus ursinus*) are common in the herb layer. The moss layer is generally poorly developed and consists of Oregon beaked moss and flat moss.

Douglas-fir – Western Hemlock – Salal (03/DS)

The Douglas-fir – Western Hemlock – Salal (03/DS) ecosystem unit is very restricted in extent in the study area, occurring on sites with coarse, shallow soil overlying bedrock. Such sites tend to be convex, thereby shedding moisture. Consequently, the soil moisture regime is xeric-to-subxeric (very dry conditions), with a poor-to-medium soil nutrient regime.

Species composition of this unit is similar to that of the HM unit described above. Trees tend to grow more slowly than those in the HM unit, and with a more open canopy, reflecting poorer

growing conditions. The lower understorey tends to be well developed, with abundant salal and dull Oregon-grape.

Western redcedar – Sword fern (05/RS)

The Western redcedar – Sword fern (05/RS) ecosystem unit is dominant in the Rodgers Creek Neighbourhood area, occurring on colluvial slopes with coarse soil and angular coarse fragments. The moderately well-drained sites have submesic-to-mesic soil moisture regimes. Because they receive moisture and soil from above, the sites also have rich-to-very-rich soil nutrient regimes, constituting good growing sites. In the Cypress Creek Neighbourhood area, this unit is restricted to an eastern portion of the upper watershed of Godman Creek.

Young forests are dominated by Douglas-fir, often with western redcedar, red alder, or both. Stands dominated by red alder often have western redcedar regenerating in the sub-canopy, as western redcedar saplings are shade-tolerant. Western hemlock and bigleaf maple are occasional components of the canopy. The understorey varies according to the degree of canopy shading, with salmonberry tending to be the dominant species. Other shrubs include salal, red huckleberry, and dull Oregon-grape. Lush sword fern is typical of the herb layer. Spiny wood fern (*Dryopteris expansa*), bracken fern (*Pteridium aquilinum*), and trailing blackberry can be common in the herb layer. The moss layer is generally poorly developed and consists of Oregon beaked moss and flat moss.

Western redcedar – Foamflower (07/RF)

The Western redcedar – Foamflower (07/RF) ecosystem unit tends to occur as a narrow fringe along streams, which are sources of moisture and nutrients. The coarse soils tend to be fluvial in origin, and consequently have a subhygric-to-hygric soil moisture regime, with a rich-to-very-rich soil nutrient regime, providing good growing sites.

Young forests tend to be dominated by broadleaf trees, mainly red alder, black cottonwood (*Populus balsamifera* ssp. *trichocarpa*), and bigleaf maple. Coniferous stands are dominated by western redcedar, with a minor component of western hemlock. The shrub layer often has vigorous growth of salmonberry, red elderberry (*Sambucus racemosa* spp. *pubens*), and red huckleberry. The herb layer tends to be lush, and can include sword fern, spiny wood fern, bracken, lady fern (*Athyrium felix-femina* ssp. *cyclosorum*), three-leaved foamflower (*Tiarella trifoliata* var. *trifoliata*), goatsbeard (*Aruncus dioicus*), coast boykinia (*Boykinia occidentalis*), large-leaved avens (*Geum macrophyllum*), giant horsetail (*Equisetum telmateia*), fireweed (*Epilobium angustifolium*), and trailing blackberry. The moss layer ranges from sparse on the forest floor to well developed on moist rocks.

5.3.3 Ecosystem Units of the CWHxm1

Western hemlock – Douglas-fir – Kindbergia (01/HK)

The Western hemlock – Douglas-fir – Kindbergia (01/HK) ecosystem unit has site characteristics and vegetation similar to those of the HM ecosystem unit of the CWHdm (see above).

Douglas-fir – Lodgepole pine – Cladina (02/DC)

The Douglas-fir – Lodgepole pine – Cladina forest type occurs on bedrock outcrops on knoll crests and on steeply sloping, south-facing aspects. Moss- and lichen-vegetated rock outcrops (described later) and the DS ecosystem unit (described below) typically occur in complex with this ecosystem unit. Stands of this forest type appear to be young (40-80 years in age).

Douglas-fir and shore pine (*Pinus contorta* var. *contorta*) are dominant in the tree canopy. Arbutus (*Arbutus menziesii*) is also common, generally with low cover (about 10%). Salal and oceanspray (*Holodiscus discolor*) are dominant species in the shrub layer; a low cover of red huckleberry and dull Oregon-grape is also present. Falsebox (*Paxistima myrsinites*) and red-flowering currant (*Ribes sanguineum*) were occasionally observed. The herb layer is generally very sparse; a low cover of trailing blackberry, sword fern, and rattlesnake plantain (*Goodyera oblongifolia*) may be present. The moss layer is generally poorly to moderately well-developed under the tree canopy. Oregon beaked moss, juniper haircap moss (*Polytrichum juniperinum*), *Dicranum* sp., red-stemmed feathermoss (*Pleurozium schreberi*), and reindeer lichen (*Cladina* sp.) may be found.

Douglas-fir – Western hemlock – Salal (03/DS)

The Douglas-fir – Western hemlock – Salal (03/DS) ecosystem unit has site characteristics and vegetation similar to those of the DS ecosystem unit of the CWHdm (see above). Oceanspray (*Holodiscus discolor*) and baldhip rose (*Rosa gymnocarpa*) are more common in the shrub layer here than in the CWHdm, reflecting drier conditions.

Western redcedar – Sword fern (05/RS)

The Western redcedar – Sword fern (05/RS) ecosystem unit has site characteristics and vegetation similar to those of the RS ecosystem unit of the CWHdm (see above).

Western redcedar – Foamflower (07/RF)

The Western redcedar – Foamflower (07/RF) ecosystem unit has site characteristics and vegetation similar to those of the RF ecosystem unit of the CWHdm (see above).

Western redcedar – Sitka spruce – Skunk cabbage (12/RC)

The Western redcedar – Sitka spruce – Skunk cabbage ecosystem unit, consisting of swamp forest, is found on wet, level-to-depressional sites with rich nutrient regimes, often in association with streams. Fluctuating water tables may be present and some characteristics of the Western redcedar – Slough sedge (CWHxm/15) ecosystem may be present.

Due to disturbance history, stands of this ecosystem unit are young and sometimes less than 20 m tall. In coniferous stands, western redcedar is dominant in the tree canopy, while western hemlock and Douglas-fir are found on hummocks and on the fringe of wetlands. Western white pine (*Pinus monticola*) trees may also be present. Mixed stands include red alder. Salal shrubs are often found on elevated microsites, while salmonberry dominates the wetter areas in the shrub layer. Other shrubs may include Scouler's willow (*Salix scouleri*), hardhack (*Spiraea douglasii*), and black twinberry (*Lonicera involucrata*). Skunk cabbage (*Lysichiton americanus*) dominates the herb layer. Lady fern and other graminoid species typically occur. A low cover of

slough sedge (*Carex obnupta*) may be found under the tree canopy. The sparse moss layer can include leafy moss.

Crabapple – Skunk Cabbage Wetland (CS)

The Crabapple – Skunk cabbage wetland ecosystem unit occurs, dominated by tall shrubs in complex with the RC unit (described above), is very restricted in extent within the study area. It is associated with past disturbance and the sites share some characteristics with young RC ecosystems, though fluctuating water tables may be a more important influence.

The shrub layer in this wetland is generally diverse and well developed. Western redcedar, salmonberry, hardhack, pacific crabapple (*Malus fusca*), and salal are common species. Red huckleberry, ninebark (*Physocarpus capitatus*), and Labrador tea (*Ledum groelandicum*) are less abundant. Skunk cabbage and slough sedge are common in the herb layer; bracken and deer fern are less common species. *Sphagnum* species are common in the moss layer; lanky moss is found on coarse woody debris.

Hardhack – Skunk Cabbage Wetland (HS)

The Hardhack – Skunk cabbage wetland ecosystem unit is dominated by low shrubs, and occurs in complex with RC (described above). Like the CS, it is also very restricted in extent within the study area, and associated with past disturbance, with sites that share some characteristics with young RC ecosystems, and with fluctuating water tables perhaps being a more important influence. Sites typically have some standing water.

The shrub layer consists of a dense thicket of hardhack. Scouler's willow, salal, and spiny wood fern also occur.

5.3.4 Non-forested and Anthropogenic Map Units

RO Rock Outcrop

Non-forested rock outcrops are found throughout the study area and they cover 3% of the land base. They occur on bedrock hummock crests and steep south-facing bedrock slopes.

Moss and lichen vegetation dominates these sites. Grey rock-moss is the dominant species (*Racomitrium canescens*), often growing along with juniper haircap moss and reindeer lichens (*Cladina* spp.). Scattered vascular plants also occur. Various plants may be present in low cover in the herb layer: parsley fern (*Cryptogramma acrostichoides*), many-flowered wood-rush (*Luzula multiflora*), western fescue (*Festuca occidentalis*), Alaska saxifrage (*Saxifraga ferruginea*), poverty oatgrass (*Danthonia spicata*) small flowered alumroot (*Heuchera micrantha*), sword fern, licorice fern (*Polypodium glycyrrhiza*), trailing blackberry, tall rein orchid (*Piperia elongata*), and hooded ladies' tresses (*Spiranthes romanzoffia*). A very low cover of oceanspray is typical, and red-flowering currant may occur. Scotch broom (*Cytisus scoparius*) was observed in the openings toward the east end of the site.

GP Gravel Pit

The GP Gravel Pit ecosystem unit is a non-vegetated, anthropogenic unit associated with sites where gravel is removed.

ES Exposed Soil

The ES Exposed Soil unit consists of exposed soil resulting from human disturbance.

PL Powerline

The PL Powerline unit consists of the vegetation along a transmission line right-of-way. The soil moisture and nutrients regimes are variable, as are site characteristics. Vegetation is highly variable, ranging from moss- to herb- to shrub-dominated.

RZ Road/Trail Surface

The RZ Road/Trail Surface unit consists of the unvegetated surfaces of roads and trails.

UR Urban/Suburban

The UR Urban/Suburban unit includes residential areas, buildings, road surfaces, lawns, clearings, and other developed areas. This unit predominates on portions of the watersheds below Highway 1.

5.4 Rare Element Occurrences

Rare elements, including species and plant communities, are surveyed within the context of national and provincial ranking systems. Over the past 25 years, the international organization NatureServe (formerly the Nature Conservancy and the Association for Biodiversity Information) has developed methods for ranking the conservation status of species and plant communities. These methods have been adopted at the national level in Canada by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and at the provincial level by the BC Conservation Data Centre (BCCDC).

At the national level, the *Species at Risk Act* was enacted to "prevent Canadian indigenous species, subspecies and distinct populations of wildlife from becoming extirpated or extinct, to provide for the recovery of endangered or threatened species, to encourage the management of other species to prevent them from becoming at risk" (House of Commons Canada 2002). The Act establishes COSEWIC as an independent body of experts responsible for assessing and identifying at-risk species. The legislation does not address rare plant communities.

At the BC provincial level, the BCCDC systematically collects and disseminates information on rare and endangered plants, animals and plant communities. This information is compiled and maintained in a computerized database that provides a centralized and scientific source of information on the status, locations, and level of protection of these rare organisms and plant communities. The BCCDC tracks rare species on Red, Blue, and Yellow lists. The lists are defined as follows:

> The Red list includes species that have been legally designated as Endangered or Threatened under the *Wildlife Act* […], are extirpated, or are candidates for such designation. The Blue List includes species not immediately threatened, but of concern because of characteristics that make them particularly sensitive to human activities or natural events. The Yellow List includes uncommon, common, declining and increasing species – all species not included on the Red or Blue Lists (BCMSRM 2002).

For the purposes of this report, Red- and Blue-listed species and plant communities are considered “rare”.

Within the province, some rare entities are also listed under the provincial Identified Wildlife Management Strategy (IWMS). The goals of the IWMS are to minimize the effects of forest practices on Identified Wildlife, and to maintain their critical habitats. The term “Identified Wildlife” refers to at-risk species and endangered or threatened plant communities that have been designated as requiring special management attention under the *Forest and Range Practices Act* by the Ministry of Environment. The IWMS provides foresters with best management practices for managing habitats for specific species and plant communities, though no plant communities are currently listed (BCWLAP 2004b).

5.4.1 Rare Vascular Plants

The study area is within the Chilliwack Forest District (part of the Vancouver Forest Region), within which 72 Red- and Blue-listed vascular plant species have potential to occur in the CWH Zone.

Among the COSEWIC-listed species in BC, Vancouver Island beggarticks (*Bidens amplissima*) and giant helleborine (*Epipactis gigantea*) are ranked as Species of Concern; phantom orchid (*Cephalanthera austiniae*) is ranked as a Threatened Species; and streambank lupine (*Lupinus rivularis*) and tall bugbane (*Cimicifuga elata*) are ranked as Endangered Species.

At the provincial level, only two plant species have been designated as Identified Wildlife in the latest version of the IWMS (BCWLAP 2004a): tall bugbane and Scouler’s corydalis (*Corydalis scouleri*). Tall bugbane is known only from the Chilliwack area, and Scouler’s corydalis is known only from southwestern Vancouver Island, therefore neither species is expected to occur within the ISMP study area.

According to the BCCDC web-based records search, no rare vascular plant species have been recorded for the study area (BCCDC 2007).

Methods for Assessing Presence of Rare Vascular Plants

The effort involved in surveying for rare plants in the field requires that resources be carefully allocated through an effective sampling strategy to increase the likelihood of locating occurrences within the study area. This strategy included a habitat analysis, a search of herbarium specimens, and preparation of a field guide prior to field sampling.

Evaluation of Potential Occurrence of Rare Vascular Plants in the Study Area

For the habitat analysis, each species in the Chilliwack Forest District rare vascular plant tracking list for the CWH Zone was assessed to determine its potential habitat and whether it would likely occur within the study area. A database was created for the purpose of habitat analysis. Of the 72 listed vascular plant species that have been identified in the Chilliwack Forest District, 65 species were found to potentially occur within the CWHxm1 and CWHdm, the two biogeoclimatic subzones that occur in the study area.

Habitat types for each species (according to Douglas *et al.* 2002a) were then entered into the database. There were a total of 98 habitat types, and these were grouped into 24 habitat classes to make them more comparable. Some of the very general habitat types were included

in more than one of the final habitat classes. Some of the habitat classes are known to be absent from the ISMP study area and were excluded (e.g., riverbanks, lakes, sloughs, ponds, vernal pools, bogs, fens, coastal mudflats, hot springs, and alkaline/saline pond edges). The final species-habitat table includes habitats that potentially occur within the study area and within the CWHxm1 and CWHdm biogeoclimatic units of the Chilliwack Forest District (Appendix F). Taking into account habitat, biogeoclimatic unit, and forest district, a total of 45 plant species were assessed as having *some potential* to occur within the study area.

As all the species of interest have an herbaceous life form, specimens of many of the species were inspected at the University of British Columbia herbarium to enable the ecologist to become fully familiar with the features of each species. While herbarium specimens differ substantially from plants growing in the wild, information about size, pattern, and texture can be gained, as well as the opportunity to closely inspect identification characteristics.

The field guide compiled for the species was based on the final species-habitat table for the study area. In combination with inspecting the herbarium specimens, the field guide was intended to facilitate developing a "search image" for each species being sought. For each species, a line drawing, a colour photograph, and habitat information were included. Where appropriate, notes were made to facilitate field identification.

Field Sampling for Rare Vascular Plants

Two surveys were completed during appropriate times of the growing season. Early growing season surveys were timed to coincide with the flowering period of many species that occur on mesic to dry sites, including forests and rock outcrops. The Cypress Creek Neighbourhood was surveyed on May 17 and 18 (Upper Cypress) and May 24 (Lower Cypress), 2004 (SLR 2008b), and the Rodgers Creek Neighbourhood on June 9, 2004 (SLR 2008a).

Late growing season surveys were timed to coincide with the flowering period for many species that grow in wetlands, as well as late-flowering species on mesic sites (such as purple-leaved willowherb, *Epilobium ciliatum*) and dry sites (including tall rein orchid and hooded ladies' tresses). The Cypress Creek Neighbourhood was surveyed on July 22 (Upper Cypress) and August 5 (Lower Cypress), 2004 (SLR 2008b), and the Rodgers Creek Neighbourhood on August 8, 2004 (SLR 2008a). Many species that were fruiting at this time were also still in an identifiable condition.

Vascular plant species that could not be identified in the field were collected and identified using magnification and taxonomic references (Douglas *et al.* 1998a; 1998b; 1999a; 1999b; 2000; 2001a; 2001b; 2002).

Rare Vascular Plant Results for the Study Area

No Red- or Blue-listed vascular plants species were found during field surveys or sampling within the Cypress Creek Neighbourhood or Rodgers Creek Neighbourhood study areas.

Potential rare plant habitat in the study area is limited in extent. Shady forests that cover much of the study area provide inadequate light for all but the most shade-tolerant herbaceous species. Parts of the study area have also been subject to erosion from human use (including mountain biking) and generally have a very sparse herbaceous understorey. Further, in many habitats of the study area, vigorous growth of sword fern out-competes other herbaceous

species, so that there is little opportunity for other herbaceous vegetation to become established.

Among the wetlands, an herb-dominated wetland type provides the best potential rare plant habitat, though it shows evidence of past disturbance. Shrub-dominated wetlands and treed swamps provide little habitat for herbaceous species other than skunk cabbage, and some ferns and sedges. The highest potential for rare plants occurs on some of the rock outcrops and adjacent dry, open, woodlands. The most interesting rock outcrops occur in the Upper Cypress area, north of Eagle Lake Road. Those rock outcrops have significant moisture early in the growing season, and thin soils that support the growth of diverse herbs.

5.4.2 Rare Ecological Communities

Identifying rare ecological communities requires an understanding of concepts of plant communities, rarity, and element occurrences. A plant community is a unit of vegetation with a relatively uniform species composition and physical structure. Several plant communities can occur within an ecosystem unit, or mapped polygon. Plant communities also tend to have characteristic environmental features such as bedrock geology, soil type, topographic position, climate, and energy, nutrient and water cycles (BCCDC 2007c). An element occurrence is an area of land, water, or both in which a species or natural community is, or once was, present (NatureServe 2002).

Plant communities are assessed from a provincial perspective only, as federal legislation does not address plant communities.

Methods for Assessing Presence of Rare Ecological Communities

The element occurrence is an important concept in determining whether a specific plant community is rare. An element occurrence is defined as “a location representing a habitat which sustains or otherwise contributes to the survival of a population [or plant community]” (BCCDC 2007b). Plant communities that occur on the BCCDC tracking lists are potential rare-element occurrences. However, there are factors that need to be considered in determining whether a tracked rare plant community actually qualifies as a rare-element occurrence, such as size, condition, and landscape context (BCCDC 2007c).

Assessing Rare Element Occurrences

A rare-element occurrence of a plant community must be of sufficient size for conservation purposes (often larger than a typical ecosystem map polygon). Condition is “an integrated measure of the quality of biotic and abiotic factors, structures, and processes within the occurrence, and the degree to which they affect the continued existence of the element occurrence” (BCCDC 2007c). For a plant community, the assessment of condition includes considering whether it can sustain habitat-specific animal species that are characteristic of that community. Assessment of landscape context also includes considering the condition of the surrounding landscape.

Air photos and ecosystem mapping for the Rodgers Creek Neighbourhood and Cypress Creek Neighbourhood study areas were consulted to locate potential rare plant communities. Field surveying for rare plant communities was carried out concurrently with rare plant surveys, and notes on plant communities were taken along survey routes.

Known Rare Element Occurrences

The BCCDC's Rare Ecological Community Tracking List for the province includes 31 communities that occur within the CWHxm1 and the CWHdm subzones (see Appendix F; BCCDC 2007). According to a search of the web-based information from the BCCDC, no specific rare ecological community element occurrences have been recorded for the study area.

Rare Ecological Community Results for the Study Area

Most forested plant communities of the CWHxm1 and CWHdm in the Lower Mainland are Red- or Blue-listed; therefore the forested plant communities of the study area represent potential Rare Element Occurrences. Specifically, the forested plant communities of the study area fall within the classification of the Red- and Blue-listed communities presented in Table 15.

Table 15
Rare Ecological Communities and Potential Ranks

English Name	Scientific Name	Global Rank[1]	Provincial Rank[2]	BC Status	BGC Unit/Site Series
Douglas-Fir - Western Hemlock / Salal Dry Maritime	*Pseudotsuga menziesii - Tsuga heterophylla / Gaultheria shallon* Dry Maritime	GNR	S2S3	Blue	CWHdm/03; CWHxm1/03; CWHxm2/03
Western Hemlock - Douglas-Fir / Oregon Beaked-Moss	*Tsuga heterophylla - Pseudotsuga menziesii / Eurhynchium oreganum*	GNR	S2	Red	CWHxm1/01; CWHxm2/01
Western Hemlock / Flat-Moss	*Tsuga heterophylla / Plagiothecium undulatum*	GNR	S2S3	Blue	CWHdm/01
Western Redcedar / Sword Fern Dry Maritime	*Thuja plicata / Polystichum munitum* Dry Maritime	GNR	S2S3	Blue	CWHdm/05
Western Redcedar / Sword Fern Very Dry Maritime	*Thuja plicata / Polystichum munitum* Very Dry Maritime	GNR	S2S3	Blue	CWHxm1/05; CWHxm2/05
Western Redcedar / Three-Leaved Foamflower Dry Maritime	*Thuja plicata / Tiarella trifoliata* Dry Maritime	GNR	S2S3	Blue	CWHdm/07
Western Redcedar / Three-Leaved Foamflower Very Dry Maritime	*Thuja plicata / Tiarella trifoliata* Very Dry Maritime	GNR	S2	Red	CWHxm1/07; CWHxm2/07

Note 1: 1. A Global Rank applies to a species/ecological community across its entire range.
1 = critically imperilled
2 = imperilled
3 = vulnerable to extirpation or extinction
4 = apparently secure
5 = demonstrably widespread, abundant, and secure.
GNR = unranked - Global Rank not yet assessed.

Note 2: 2. Provincial Ranks apply to a species' or ecological community's conservation status in BC.
1 = critically imperilled
2 = imperilled
3 = special concern, vulnerable to extirpation or extinction
4 = apparently secure
5 = demonstrably widespread, abundant, and secure.

Following the assessment, however, none of the plant communities within the ISMP study area were considered Rare Element Occurrences, for the following reasons:

- only large areas of intact ecosystems are considered Rare Element Occurrences and the ecosystem units that occur on the site are mostly smaller units;
- forested stands in the study area are generally young, with only remnant older trees from historic logging (stands are generally less than 80 years old);
- the landscape has been fragmented by logging, fires, roads, mountain bike trails, and adjacent residential and school developments; and
- the hydrological regime of the area has been altered by significant road development upslope of the site (Cypress Bowl Road).

5.5 Sensitive Ecosystem Inventory

While the BCCDC tracks specific plant communities, the provincial government is also involved in Sensitive Ecosystem Inventory (SEI) where broader classes of rare ecosystems are assessed. The purpose of SEI is to "identify remnants of rare and fragile terrestrial ecosystems and to encourage land-use decisions that will ensure the continued integrity of these ecosystems".

5.5.1 Existing SEI Information

The ISMP study area is not included in any previous SEI projects. According to the SEI program, sensitive ecosystems include old forest, mature forest, woodland, herbaceous, riparian, wetland, cliffs, and seasonally flooded agricultural fields (Ward *et al.* 1998). Various criteria are used for designating herbaceous ecosystems as sensitive.

5.5.2 Sensitive Ecosystems Identified in the Field

During surveys in the Rodgers Creek Neighbourhood study area (SLR 2008a), no sensitive ecosystems were identified, apart from several small herbaceous plant communities on rock outcrops, particularly on steeper terrain between Westmount Creek and Cave Creek. These sensitive ecosystems are localized and strongly influenced by site conditions related to substrate, aspect and moisture regime. They can often be incorporated into retention areas as part of site development and could, therefore, be afforded some form of conservation focus.

Small areas of Sensitive Ecosystems were found within the Cypress Creek Neighbourhood study area (SLR 2008b), including Terrestrial Herbaceous (dominated by rock outcrops), Swamp Wetland, and Riparian. Ward *et al.* (1998) discuss the criteria for designating these ecosystems as sensitive in more detail in. Table 16 provides a summary of Figure 4 polygons in which these ecosystems are located, and many are located outside the current ISMP study area.

Table 16
Cypress Creek Neighbourhood
Sensitive Ecosystems and Locations

Sensitive Ecosystem Classification	Figure 4 Polygon Locations	Comments
Terrestrial Herbaceous	120*, 126*, 145*, 151, 152, 154, 158, 173*, 186*, 192, 201*	Terrestrial herbaceous communities occur mostly on rock outcrops; the rock outcrops in Polygons 152, 154, and 192 and have the best-developed herbaceous vegetation on the site.
Riparian – Low Bench Floodplain	131, 138, 143*, 163*, 164*, 165*, 172	Riparian habitats in these polygons represent narrow streamside ecosystems subject to seasonal flooding and erosion.
Riparian – Gully Riparian	128, 148	Riparian zone along Cypress Creek.
Swamp Wetland	132, 133, 144, 153, 157*, 161*, 242*	Small treed swamps occur in these polygons; some have been disturbed by past land use.

* indicates polygons within the Godman Creek watershed (other polygons lie outside the ISMP study area)

Terrestrial Herbaceous

Vegetated bedrock outcrops cover approximately 3% of the land base in the Cypress Creek Neighbourhood study area (RO1b map unit; SLR 2008b). Less disturbed outcrops within the study area (mostly in the northern portion) are representatives of the Terrestrial Herbaceous Sensitive Ecosystem. Terrestrial Herbaceous ecosystems are sensitive for the following reasons (from Ward *et al.* 1998):

- Rarity: Undisturbed sites are rare both within the SEI study area and in the rest of coastal B.C. A variety of individual rare species also occur here.

- Fragility: Whereas the bedrock beneath is generally stable, the species that inhabit these ecosystems are less so. Micro-habitats and niches may encompass only a few square inches or feet. Thin soils are easily disturbed, and herbaceous plants can be easily trampled, or dislodged onto bare rock where they cannot re-establish.

- High biodiversity: The various combinations of environmental factors affecting these terrestrial herbacious sites have created a diversity of micro-habitats that meet the requirements of many different plants, animals and invertebrate species. These include hummocks, hollows and vernal pools.

- Specialized habitats: There are a number of species unique to these habitats within the SEI study area. Some are rare, and are only known to occur in these ecosystems. Others represent populations surviving at their most northern or western range limits.

Swamp Wetland

Swamp Wetland Sensitive Ecosystems cover approximately 2% of the land base in the Cypress Creek Neighbourhood study area (SLR 2008b). These ecosystems are identified as CS, HS, and RC map units on the ecosystem map. Wetland ecosystems are sensitive for the following reasons (from Ward *et al.* 1998):

- Rarity: Wetlands are naturally uncommon in this area because of the rain-shadow climate with its low annual precipitation and pronounced summer dry period, and also because of the steep topography.

- High biodiversity: Wetlands support a high number of habitat niches that provide critical habitats for numerous mammal, bird, reptile, amphibian, fish and vertebrate species.

- Vulnerability to changes in hydrology and water quality: Wetlands respond to small changes to hydrology such as reduced summer flow or lowering of the water table through drainage.

Riparian

The RF map unit covers 9% of the land base in the Cypress Creek Neighbourhood study area (SLR 2008b). A significant portion of the RF ecosystem unit is riparian vegetation associated with streams and is considered a Riparian Sensitive Ecosystem. Riparian ecosystems are sensitive for the following reasons (from Ward *et al.* 1998):

- High biodiversity: Riparian areas support a disproportionately high number of species for the area they occupy. They contain water, cover and food, the three critical habitat components for wildlife, and have a concentration of varied habitat niches that are important for wildlife species. They also have a greater diversity of plant composition and structure than uplands. The elongated shape of most riparian ecosystems maximizes the amount of edge habitat and creates diverse and productive habitats for many species. Riparian ecosystems also have different microclimates from surrounding coniferous forests due to increased humidity, a higher rate of transpiration, and greater air movement. These conditions are preferred by some species during hot weather.

- Aquatic Habitat Protection: Riparian ecosystems contribute to the ecological health of adjacent aquatic areas through shading, bank stability, and the addition of large logs into larger streams or lake margins.

- Wildlife corridors: Riparian ecosystems are often linear and may function as linkages or corridors within the broader landscape. In highly fragmented landscapes such as eastern Vancouver Island, wildlife species depend on a series of inter-connected habitat patches.

5.6 Conclusion

On the basis of information available, there are no known rare element occurrences of vascular plants or ecological communities in the ISMP study area, and sensitive ecosystems are quite limited in area, consisting mainly of riparian areas, wetlands, and rock outcrops.

6.0 WILDLIFE OF THE ISMP STUDY AREA

Wildlife occurrence has been investigated in the Rodgers Creek Neighbourhood area (SLR 2008a) and the Cypress Creek Neighbourhood area (SLR 2008b) through ground reconnaissance and from a review of existing information sources. These study areas included large forested portions of the watersheds of Pipe, Westmount, Cave, and Godman creeks. In addition, systematic studies have been undertaken in these study areas in 2007 (SLR 2008a,b) to document presence of breeding birds and species of concern.

6.1 General Methodology for Wildlife Surveys

Reconnaissance walks of the subject area were conducted in October 1999 and March 2000, and focussed surveys for wildlife on the following dates:

- raptor and great blue heron stick nest survey (Rodgers Creek Neighbourhood area only) on November 17-18, 2005;
- coastal tailed frog surveys in November 2005 (along with stream survey assessment) and in June-July 2006 (focussed on population surveys);
- red-legged frog searches on June 30, 2006 (Cypress Creek Neighbourhood) and July 5, 2006 (Rodgers Creek Neighbourhood);
- listed insect species on September 22, 2006;
- Western screech owl playback surveys in April-May 2007; and
- Breeding bird surveys in May-June 2007.

The biologist also noted evidence of other wildlife use (sightings or signs) and relevant features during these surveys. Other field workers provided additional incidental information on wildlife occurrence during various other activities during these investigations. Specific survey methods for birds and listed species are provided in relevant sections below.

6.2 Results of Wildlife Surveys

Vertebrate wildlife species that could potentially occur in or near the subject area are listed in Appendix G. This list is based on review of several documents describing occurrence and habitat relationships of vertebrate wildlife in the Lower Mainland, known distribution of vertebrates in the area, and on assessment of habitat types available in the study area. Not all species may in fact occur, owing to habitat conditions or present distribution limits. The following sections provide a general description of wildlife that can be expected in this part of West Vancouver.

6.2.1 Birds

Investigations of birds inhabiting the study area have included surveys of bird presence and focussed breeding bird surveys.

General Occurrence

Bird species observed during the non-breeding season or post-breeding period on the Rodgers Creek Neighbourhood site (i.e., portions of the watersheds of Pipe, Westmount, and Cave creeks) before the focussed 2007 Breeding Bird Surveys included red-tailed hawk (*Buteo jamaicensis*), band-tailed pigeon (*Patagioenas fasciata*), hairy woodpecker (*Picoides villosus*), downy woodpecker (*Picoides pubescens),* Steller's jay (*Cyanocitta stelleri*), winter wren (*Troglodytes troglodytes*), black-capped chickadee (*Poecile atricapillus*), chestnut-backed chickadee (*Poecile rufescens*), golden-crowned kinglet (*Regulus satrapa*), varied thrush (*Ixoreus naevius*), hermit thrush (*Catharus guttatus*) American robin (*Turdus migratorius*), Hutton's vireo (*Vireo huttoni*), song sparrow (*Melospiza melodia*), and dark-eyed junco (*Junco hyemalis*).

It was observed during surveys in November 2005 that bird life of the study area is characteristic of coastal coniferous forests in the region. Winter wrens and golden-crowned kinglets were the most numerous species, and varied thrushes, characteristic of older forests, were frequently encountered. Three hermit thrushes were also observed; these birds breed in higher altitude coniferous forests and also winter in small numbers in dense older and second-growth coniferous forests along the south coast of BC (Campbell *et al*. 1997). Most species listed in the next two paragraphs (except owls) were confirmed during surveys and other fieldwork during spring 2007.

Birds expected to be year-round residents in this area of West Vancouver (breeding and non-breeding season) include Cooper's hawk (*Accipiter cooperi*), great horned owl (*Bubo virginianus*), barred owl (*Strix varia*), northern saw-whet owl (*Aegolius acadicus*), western screech owl (*Otus kennicottii*), blue grouse, (*Dendragapus obscurus*), ruffed grouse (*Bonasa umbellus*), hairy woodpecker, downy woodpecker, pileated woodpecker (*Dryocopus pileatus*), northern flicker (*Colaptes auratus*), red-breasted sapsucker (*Sphyrapicus ruber*), common raven (*Corvus corax*), northwestern crow (*Corvus caurinus*), Steller's jay, chestnut-backed chickadee, black-capped chickadee, bushtit (*Psaltriparus minimus*), red-breasted nuthatch (*Sitta canadensis*), brown creeper (*Certhia americana*), Bewick's wren (*Thryomanes bewickii*), winter wren, golden-crowned kinglet, American robin, varied thrush, purple finch (*Carpodacus purpureus*), spotted towhee (*Pipilo maculatus*), song sparrow, red crossbill (*Loxia curvirostra*), pine siskin (*Carduelis pinus)*, and evening grosbeak (*Coccothraustes vespertinus*).

Summer resident breeding birds (spring and summer) likely include rufous hummingbird (*Selasphorus rufus*), Pacific-slope flycatcher (*Empidonax difficilis*), Hutton's vireo, Cassin's vireo (*Vireo cassinii*), red-eyed vireo (*Vireo olivaceous*), warbling vireo (*Vireo gilvus*), tree swallow (*Tachycineta bicolor*), Swainson's thrush (*Catharus minimus*), Cedar waxwing (*Bombycilla cedrorum*), black-throated gray warbler (*Dendroica nigrescens*), MacGillivray's warbler (*Oporornis tolmiei*), orange-crowned warbler (*Vermivora celata*), Townsend's warbler (*Dendroica townsendii*), Wilson's warbler (*Wilsonia pusilla*), black-headed grosbeak (*Pheucticus melanocephalus*), western tanager (*Piranga ludoviciana*), brown-headed cowbird (*Molothrus ater*), and American goldfinch (*Carduelis tristis*).

Bird species that may pass through forested West Vancouver slopes during migration (spring and fall) include sharp-shinned hawk (*Accipiter striatus*), ruby-crowned kinglet (*Regulus satrapa*), Townsend's solitaire (*Myadestes townsendi*), hermit thrush (*Catharus guttatus*), yellow-rumped warbler (*Dendroica coronata*), dark-eyed junco, and white-crowned sparrow (*Zonotrichia leucophrys*). While the majority of individuals of these species would be migrant in this area, some individuals may also breed or winter here. Other species, such as fox sparrow

(*Passerella iliaca*), Lincoln's sparrow (*Melospiza lincolnii*), and golden-crowned sparrow (*Zonotrichia atricapilla*) are entirely migratory in West Vancouver.

Breeding Bird Surveys

Breeding bird surveys were completed in May-June 2007, and species detected were consistent with the list of year-round and summer residents provided in the previous section. These surveys were conducted to document the presence of resident and neotropical migrant songbirds and resident cavity nesting species. No species federally listed under *SARA* as threatened or endangered, or provincially Red- or Blue-listed, were expected to occur in the study area, but field surveys were undertaken to provide documentation and to provide adequate baseline data for assessment of available habitats for future planning purposes.

Methods

Four breeding bird surveys were conducted at six sites in the Rodgers Creek Neighbourhood area and four sites in the Cypress Creek Neighbourhood area between April and June 2007. Sites were chosen that represented both deciduous and coniferous forest types. Surveys were completed between approximately 0515 PDT and 1030 PDT, the order in which plots were surveyed differed among days, and no surveys were affected by excessive rain. Survey methods followed were the RISC *Standard Inventory Methods for Forest and Grassland Songbirds Standards for Components of British Columbia's Biodiversity No. 15*, (March 1999, Ver. 2.0).

Results

Birds of 23 species were recorded in the Rodgers Creek Neighbourhood area during 2007 surveys (SLR 2008a). The average number of singing birds per plot per survey (1.5 to 3.0, average 2.2) followed no trends, although the comparatively low result for the May 21st survey is to be expected because not all neotropical migrants had yet arrived. The number of other (non-singing) birds between the second and forth surveys was possibly influenced by nesting chronology, as foraging and post-fledging birds become more evident as the nesting season progresses.

Birds of 32 species were recorded in the Cypress Creek Neighbourhood area during 2007 surveys (SLR 2008b). The average number of singing birds per plot per survey was 0.6 birds for the May survey and 2.2 birds for each of the other three surveys. The result for the May 21st survey was also comparatively low here. The number of non-singing birds per survey was also lowest in May, highest (3.7 birds) on June 11th, and intermediate during the 2nd and 4th surveys.

The species composition observed was typical of mid-elevation mixed coniferous-deciduous coastal rainforest. No species of concern was recorded.

Key observations from the breeding bird surveys were that:

- no threatened or endangered species were observed in the study area, nor are they expected to occur there;
- species observed were typical of mid-elevation, south coastal, second-growth mixed deciduous-coniferous rainforest; and

- differences observed in bird abundance among plots cannot be obviously explained by habitat differences, but there was a trend of increasing abundance from west to east.

Raptor and Heron Surveys

A wildlife biologist conducted an overview wildlife assessment in the Rodgers Creek Neighbourhood area (including portions of the watersheds of Pipe, Westmount and Cave creeks) on November 17 and 18, 2005, with a focus on identifying raptor and heron nests.

Methods

The biologist traversed the study area on foot, and used a Magellan SporTrak GPS unit to create a track log and to record waypoints of notable features or for orientation purposes.

Results For Raptors

No raptors, raptor nests, or other evidence of their presence were encountered during the November 2005 survey. Many large Douglas-fir trees in the study area exceed 0.75 m DBH (diameter at breast height), making them suitable for bald-eagle nests, but no nests were observed; the site is farther from the coast than is usual for bald-eagle nests. Many of the smaller trees appeared suitable for nests of Cooper's hawk or sharp-shinned hawk, but no nests of these species were observed. Site characteristics are also suitable for inclusion in the home range of nesting northern goshawks; non-breeding goshawks have been recorded at all times of year in areas depicted on the 92G/6 CGS map sheet in which the site occurs (Campbell *et al.* 1990).

A lack of snags in the area reduces its attractiveness for nesting owls or other cavity nesting birds. There was also little evidence of woodpeckers or woodpecker activity, except for the westernmost end of the study area and along the edge of the existing subdivision. Overall, trees appeared quite healthy and it will likely be many years before the naturally occurring snags characteristic of older forests begin to appear.

Results of the Western screech-owl surveys are summarized in Section 7.3.2.4.

Results for Herons

No great blue heron nests were observed in the Rodgers Creek Neighbourhood area; the species is unlikely to choose this site for nesting as it is distant from suitable foraging areas.

6.2.2 Mammals

Numerous species of large mammals, smaller omnivores and carnivores, and small mammals have been documented as inhabiting the study area.

Large Mammals

Large mammals present on West Vancouver's lower forested mountain slopes include coast black-tailed deer (*Odocoileus hemionus hemionus*) and black bear (*Ursus americanus*). Members of these species and their sign were frequently observed during site reconnaissance, and also frequently by other environmental surveyors in the area. The mixed and deciduous-dominated forests in the study area provide good cover and abundant woody browse as a food

supply for deer, and they are considered to be year-round residents of the area. Deer sign was common on the site.

Cougar (*Felis concolor*) use the site occasionally, but are not usually common this close to urban areas. The varied and rocky terrain and presence of deer as prey suggest that cougar may occasionally pass through the site.

Smaller Carnivores and Omnivores

Several smaller carnivores and omnivores may inhabit the study area. Among them, coyotes are now common on the North Shore, frequenting old logging roads and openings while foraging for prey. Coyotes prey on a wide variety of food sources and exploit whatever is available; their sign was commonly observed in the area. Bobcat (*Lynx rufus*) can be expected occasionally, although they are secretive and would not often be observed. Marten (*Martes americana*), mink (*Mustela vison*), and short-tailed weasel (*Mustela erminea*) are also resident in forests of West Vancouver. Mink are most commonly associated with riparian habitats where fish, small mammals, and amphibians are available as food sources; as such, they are likely more common along the tidal shoreline of West Vancouver and along streams in less-developed areas. Raccoons (*Procyon lotor*) are also likely residents, as are spotted skunk (*Spilogale gracile*) and striped skunk (*Mephitis mephitis*); skunks are secretive and seldom observed in shrubby deciduous habitats.

Recent sightings of wolverine (*Gulo luscus*) at lower elevations of North Vancouver and Port Moody suggest that this species may not be as rare as previously thought, and may in fact travel extensively in forested mountainous terrain adjacent to urbanized areas of the Lower Mainland.

Small Mammals

Three species of squirrels are present in the study area. Douglas's squirrels (*Tamiasciurus douglasii*) were commonly seen and heard during field investigations, and are likely more numerous than observations suggested, as abundant food was available in the forests surveyed. This species prefers maturing-to-mature stands of Douglas-fir or western hemlock. Squirrels are preyed on by marten and forest dwelling raptors, such as barred owls and great horned owls.

A cluster of rabbit pellets found near the water tower was likely that of a snowshoe hare (*Lepus americanus*) rather than a domestic rabbit, although a residential subdivision is present less than 200 m south at the bottom of the water tank road. Further investigation would be required to determine whether the rare *washingtonii* subspecies of the snowshoe hare occurs here, although the site may be outside its range.

Though not confirmed and known to frequent more-mature coniferous forests, northern flying squirrels (*Glaucomys sabrinus*) may be found in the general area. Flying squirrels are a preferred prey of nocturnal raptors.

Other small mammal species expected include: yellow-pine chipmunk (*Tamias amoenus*), deer mouse (*Peromyscus maniculatus*), southern red-backed vole (*Clethrionomys gapperi*), Pacific jumping mouse (*Zapus trinotatus*), several species of shrews (*Sorex* spp.), shrew-mole (*Neurotrichus gibbsii*), and possibly several species of bats (Family Chiroptera) (Cowan and Guiguet 1965; Nagorsen 1990; Nagorsen and Brigham 1993; Nagorsen 1996). Deer mouse and

shrews (most species) are common and are expected to inhabit the subject area; the other species may be present, but are more specific in habitat requirements.

6.2.3 Amphibians and Reptiles

Several species of amphibians may occur in the area, near streams or wet forest micro-habitats, such as depressions in the forest that collect moisture during wet periods of the year. Pacific chorus frogs (*Pseudacris regilla*) are common amphibians and are expected in study area. Western toad (*Bufo boreas*) were formerly abundant in many areas but populations appear to have been significantly reduced at present; their occurrence in the study area is inferred, but not documented. Red-legged frog (*Rana aurora*) is associated with ponds and wetlands in the Godman Creek watershed, but the other watersheds of the ISMP study area do not provide appropriate habitat Several salamanders, such as ensatina (*Ensatina eschscholtzi*), rough-skinned newt (*Taricha granulosa*), long-toed salamander (*Ambystoma macrodactylum*), northwestern salamander (*A. gracile*), and western red-backed salamander (*Plethodon vehiculum*) may occur in the study area (Green and Campbell 1984; Corkran and Thoms 1996). Coastal tailed-frogs (*Ascaphus truei*) are resident in several West Vancouver streams and their presence and distribution has previously been studied by TERA Planning Ltd. and subsequently by SEACOR in studies sponsored by BPPL. This species is further discussed in Section 7.3.4.1.

The northern alligator lizard (*Gerrhonotus coerulus*) is a possible resident on drier micro-habitats (i.e., near rock outcrops, drier exposures with a shrub cover); such micro-habitats are not common in the study area. Common garter snakes (*Thamnophis sirtalis*) and northwestern garter snakes (*T. ordinoides*) may occur along ravine banks and areas with open exposures. The western terrestrial garter snake (*T. elegans*) is primarily associated more with stream habitats of gentler gradient, wetlands, ponds, and marine shores, and may occur along Godman Creek or in the small wetlands on the site.

6.2.4 Listed Vertebrates

Implications of the federal *Species at Risk Act* have been discussed in Section 5.4. Of primary interest to the present study area are species listed under COSEWIC as endangered or threatened wildlife and ones provincially listed by the BCCDC.

An analysis of potential occurrence of Red- and Blue-listed terrestrial and amphibious vertebrate species was undertaken to identify species that have some likelihood of occurring within or near the Rodgers Creek and Cypress Creek Neighbourhood areas (SLR 2008a,b). This analysis was based on the BCCDC tracking list for the Chilliwack Forest District, which includes many species not found in the study area (based on known range or absence of suitable habitat in the study area, such as marine species). On the basis of habitat availability, this list was reduced to a total of 9 species (2 amphibians, 3 birds, and 4 mammals), as discussed in the following sections. Terrestrial and amphibious vertebrate wildlife included were assessed on the basis of known distribution in the region, habitat preferences, and likelihood of occurrence based on habitat available in and near the study area.

Key reference sources used in the analysis for listed vertebrates include Campbell *et al*. (1990a, 1990b, 1997, 2001), Cowan and Guiguet (1965), Nagorsen and Brigham (1993), Nagorsen (1996), Green and Campbell (1984), Gregory and Campbell (1984), Cannings *et al*. (1999), and Fraser *et al*. (1999).

Listed Birds

Five listed bird species have ranges that may include the ISMP study area. None has actually been confirmed as being present.

- Peregrine Falcon (Subspecies anatum – Red-listed; COSEWIC: Threatened)

The breeding range of the *anatum* subspecies of peregrine falcon (*Falco peregrinus anatum*) formerly included much of the forested area of North America, including the southern coast of BC. They formerly bred in the interior valleys of the province, but the present breeding range and distribution of known nest locations are far more restricted, mostly to the southern coast and islands. Their status as a threatened species is attributed to historical declines brought about by pesticide poisoning and effects on egg survival.

Peregrine falcons typically nest on cliffs overlooking shorelines and wetlands and subsist mainly by hunting birds. No aeries of peregrine falcons have been reported within or near the study area. Falcons may occasionally forage near the study area, although they generally prefer more open habitats for foraging. Their occurrence in the study area is regarded as incidental.

- Marbled Murrelet (Red-listed; COSEWIC: Threatened)

Marbled murrelets (*Brachyramphus marmoratus*) inhabit the Pacific coastline from Alaska to central California. These murrelets typically nest in large, mature coniferous trees, generally (though not exclusively) in proximity to the ocean, and at lower elevations. Large, old trees with a thick cover of moss on the limbs are preferred nesting sites. Populations of marbled murrelets have shown a declining trend in recent years, linked to reduction in old-growth forest in coastal areas.

Marbled murrelets are not expected in the study area, owing to a lack of larger, mature (or old-growth) coniferous trees that could be used as nesting sites. Murrelets are expected to forage in small numbers in marine waters off West Vancouver, mostly in winter as populations from northern coastal regions move southward.

- Band-Tailed Pigeon (CDC: Blue-listed; COSEWIC: Not Addressed)

The breeding range of the band-tailed pigeon (*Columba fasciata*) extends from southeastern Alaska, through the central and southern coastal lands of BC, southward into Utah, Colorado and Baja California, and farther into Mexico and the mountains of Central America and South America. In BC, the breeding range is situated on the westward side of the Coast Mountains, from the Prince Rupert area southward, and on Vancouver Island.

This species utilizes open woodlands (coniferous and deciduous) for breeding and shelter and feeds extensively on berries, seeds and acorns. Band-tailed pigeons make use of taller, maturing trees as well as tall snags, which are used for roosting. The listed status of this species is due to concern for habitat reduction (coastal forests), predation, and competition with similar species. Campbell *et al*. (1990b) state that, as of 1990, the species was considered to be expanding its range northward and eastward.

Suitable nesting habitat for band-tailed pigeons is found in the study area, but nearby foraging opportunities may be limited. Several individuals were heard cooing during site surveys in 2005, and one was also heard cooing during red-legged frog surveys in 2006. Ground-based surveys

for band-tailed pigeons were carried out in May-June 2007 in the Rodgers Creek Neighbourhood area (i.e., surveys included portions of the Pipe, Westmount and Cave creek watersheds) by listening during the breeding bird surveys. The biologist traversed the forest and an old road more than one kilometre for one hour on April 18, 2007, from 18:45 to 19:45 PDT, looking and listening for pigeons. None were detected. As pigeon vocalizations carry a long distance, the lack of detected vocalizations during the 2007 is a good indication that the species was not present that year.

- Western Screech-Owl (Blue-listed; COSEWIC: Special Concern)

Western screech-owls (*Megascops kennicottii*) of several subspecies breed from southeastern Alaska, southern Canada and into the southern USA and Mexico, in open, mixed coniferous-deciduous forests or riparian zones, often using artificial cavities. The subspecies *M. k. kennicottii* was recently blue-listed for the Chilliwack Forest District and is limited to coastal forests of BC and Washington State (USA). Its listing status is due to concern for loss of breeding habitat (maturing to mature mixed forests with tree cavities) and increasing competition from larger owls.

Western screech-owls are expected to be a resident breeding bird on the forested slopes of Mount Hollyburn and may occur in the study area, though nesting opportunities may be limited. Foraging, however, likely occurs, as the area provides suitable prey in the form of small mammals and birds.

Surveys of the Rodgers Creek and Cypress Creek Neighbourhood study areas for western screech-owl were carried out in April and May 2007 (SLR 2008a,b). None were detected during the course of four evening/night surveys.

- Northern Spotted Owl (Red-listed; COSEWIC: Endangered)

The northern spotted owl (*Strix occidentalis caurina*) is an endangered species that is at its northern limit of distribution in southwestern British Columbia. Very few breeding pairs have been documented in southwestern BC, though the North Shore Mountains are expected to support several breeding pairs. Northern spotted owls have been reported in the Capilano River watershed and other areas with old growth forest near West Vancouver. Within the wetter subzones of the CWH biogeoclimatic zone, no northern spotted owls have been observed in forests with trees less than 120 years old (Blackburn *et al*. 1997).

Coniferous forests in the study area are generally immature to mature, with only a few stands in structural stage 6 (age 80 to 250 years). Based on logging and fire history in the area, coniferous forest stands in the ISMP study area presently have low potential value for breeding by spotted owls.

Listed Mammals

Five listed species of mammal have ranges that may include ISMP study area.

- Pacific Water Shrew (Red-listed; COSEWIC: Endangered)

The Pacific water shrew (*Sorex bendiri*) occurs from the northern coastal areas of California northward to southwestern BC, where the species is at the northern limits of its range. They

have been found in isolated locations in the Lower Mainland, including the north side of the Fraser River Valley and on the North Shore of Burrard Inlet into the Seymour River valley.

The species has been assigned red-listed status due to its historical rarity, in conjunction with incremental habitat loss and fragmentation as a result of agriculture, urban development and degradation of watersheds within its limited range in the province. In addition to being provincially red-listed, the Pacific water shrew was listed as threatened by COSEWIC in 1994 based on the report by Galindo-Leal and Runciman (1994). Its status was re-assessed by COSEWIC and confirmed as threatened in 2000, and is presently listed as endangered under COSEWIC.

Pacific water shrews are semi-aquatic, inhabiting slow-moving streams and adjacent riparian areas, in gently to moderately sloping terrain, generally below 650 m elevation. Their optimal requirements are older forests with a dense shrub understorey and an abundance of large woody debris. Their diet consists of stream and riparian invertebrates, and they are seldom found more than 25 m from stream or wetland habitat. Pacific water shrews may also occur in younger forests or non-forested habitats if the other habitat characteristics (and food resources) are met, as suggested by their recent occurrence in Fraser Lowland habitats where old forests are less common.

A majority of stream reaches within undeveloped portions of the study area are generally too steep and high-energy for Pacific water shrew, and few suitable microhabitats would be available. It is considered unlikely that Pacific water shrews occur in riparian habitats along most streams in the ISPM study area, though limited suitable habitat may be present, such as lower gradient portions of Godman Creek.

- Townsend's Big-eared Bat (Blue-listed; COSEWIC: Not Listed)

The distribution of Townsend's big-eared bat (*Corynorhinus townsendii*) includes southern BC, the western USA and into Mexico. This species appears to be sparsely distributed in BC, with populations in developed regions. In the interior of the province, it has been documented as far north as Williams Lake and as far east as Cranbrook. There are few records of Townsend's big-eared bat in the Lower Mainland; currently the only known maternity colony in the area is a barn in Minnekhada Regional Park in Coquitlam (Mitch Firman, pers. comm.).

Day roosts include old buildings, caves and mine shafts. Caves and mine shafts also are used as hibernacula. The blue-listed status of this species is owing to the limited availability of hibernacula and the high sensitivity of hibernacula to disturbance.

This species also uses large coniferous trees as day roosts, especially crevices in thick scaly bark of mature Douglas-fir trees. Though the study area contains several larger, maturing Douglas-fir trees with folds of heavy bark in the that may afford some suitable roosting sites for bats, veteran trees or large snags that provide cavities for nesting or roosting are lacking. The study area has no large open areas, wetlands or other habitats that would produce an insect food source for feeding bats. On the basis of available habitat, this species is not likely to occur in the study area.

- Keen's Long-Eared Myotis (Red-listed; COSEWIC: Special Concern)

Keen's long-eared myotis (*Myotis keenii*) is limited to the Pacific coast where its range extends from southeast Alaska to the Olympic Peninsula in Washington State. It appears to be

associated with coastal forests and uses tree cavities, crevices in rocks, and caves as day roosts. Information on hibernation behaviour for this species is lacking. Keen's long-eared myotis is red-listed because the species is rare throughout its limited range, and the older growth coastal forests it inhabits are becoming fragmented and less common. Its biological attributes are poorly understood, and scientific studies complicated by the close similarity of its external anatomical features to those of the closely related western long-eared myotis (*Myotis evotis*), making the two species difficult to distinguish.

Like most bats, Keen's long-eared myotis forages over water and other habitats that produce insect prey, and such foraging habitat is not available in the study area. On the basis of available habitat, this species is not likely to occur in the study area.

- Long-Tailed Weasel (Red-listed; COSEWIC: Not Listed)

The long-tailed weasel *Mustela frenata* ranges throughout southern and central Canada to northern South America, while the *M. f. altifrontalis* subspecies ranges southward from the Lower Fraser Valley along the Pacific coast to Oregon. The species inhabits open forests, shrub habitats, edges of agricultural lands, and riparian zones; it consumes a variety of small mammals and at times small birds. Long-tailed weasels may still occur in remnants of suitable habitat in parts of the Lower Mainland.

The listed status of the subspecies *M. f. altifrontalis* is due to its restricted distribution and the significant reduction in suitable habitat in the Lower Mainland in recent decades. Some elements of suitable habitat for long-tailed weasels occur along the riparian zones of larger streams in the study area, and along forest openings and old roads. There is a potential that this subspecies could occur in the study area.

- Wolverine (Blue-listed; COSEWIC: Special Concern)

Wolverine (*Gulo luscus luscus*) inhabit mountainous, boreal and arctic terrain across northern Eurasia and North America, at very low population densities. The *G .l. luscus* subspecies occurs in most of BC (except for Vancouver Island) and across the rest of the specie's range in North America. Its listed status is due to concern for declining populations from hunting and trapping, and increased access into wilderness regions.

Wolverines are highly mobile and have very large home ranges. They may occur at any time in the mountains of the North Shore and recent sightings at lower elevation near developed areas suggest that they may enter lower elevations to forage. This species is at most, however, an incidental visitor to the slopes of Hollyburn Mountain.

Listed Amphibians

Two at-risk species of frog, the coastal tailed frog and the red-legged frog, were known to inhabit, or suspected of inhabiting, the study area vicinity. Surveys were conducted to identify specific locations where they may be found.

- Coastal Tailed Frog (Blue-listed; COSEWIC: Special Concern)

The coastal tailed frog (*Ascaphus truei*) is present in some creeks in West Vancouver. Suitable habitat for coastal tailed frogs consists of cool, perennial mountain streams with coarse substrates of cobble and gravel, good riparian growth and lack of predatory fish. All life stages,

and particularly eggs, have a narrow temperature tolerance, from 6°C to 18°C (in summer; Dupuis and Friele, 2003). Riparian vegetation is essential to maintaining cool water temperatures, clear, silt-free water, and cooler microclimates for foraging adults (Dupuis and Friele 2003; Frid *et al*. 2003). The coastal tailed frog is a blue-listed species in BC, being "vulnerable…because of characteristics making them sensitive to human activities or natural events" (e.g., habitat destruction or drought).

Sponsored by BPPL, TERA Planning Ltd. conducted coastal tailed frog surveys between 1998 and 2002 along many West Vancouver creeks. The TERA Planning studies demonstrated that coastal tailed frogs were resident in several permanent West Vancouver steams: Brothers Creek, Lawson Creek, McDonald Creek East, McDonald Creek Centre East, McDonald Creek Centre West, McDonald Creek West, Marr Creek, and Rodgers Creek. TERA Planning did not observe any coastal tailed frog tadpoles during surveys of Westmount Creek. TERA did not investigate other streams within the ISMP study area.

TERA Planning had eliminated Pipe and Cave creeks from future sampling during preliminary 1998 assessments owing to poor habitat, very low and possibly ephemeral flows, sedimentation, channelization, extensive culverting, and in some cases, dewatering. Although initial 1998 assessments by TERA suggested that Westmount, Godman, and Eagle (west of Godman) creeks contained relatively poor habitat, they were intensively sampled in June-July 1998 due to possible tadpole presence (TERA Planning 2004).

SEACOR conducted additional surveys for coastal tailed frog presence during November 2005 stream assessments to build on existing information about distribution of populations of this species. Fourteen streams were investigated, including Pipe, Westmount, Cave, and Godman Creeks. Turner Creek was located outside the study area.

During June-July 2006, SEACOR resurveyed streams identified during the November 2005 surveys as having either previous sightings or higher potential coastal tailed frog habitat. Table 17 summarizes results of the November 2005 and June-July 2006 baseline coastal tailed frog surveys. No coastal tailed frogs were observed along Pipe, Westmount, or Cave creeks, though one tadpole was found in Tributary N of Pipe Creek. Tailed frog tadpoles were also identified in the section of Godman Creek above Eagle Lake Road (Photos 16, 17 and 18).

The 1998 surveys of Godman Creek had been conducted at three sites below the Upper Levels Highway and two sites in the steep reach between the Upper Levels Highway and Eagle Lake Road. The absence of coastal tailed frogs in Godman Creek below Eagle Lake Road during 2006 surveys, and their presence above the road, is consistent with TERA Planning's results.

During the fish habitat survey of the section of Turner Creek above Highway 1 undertaken by SLR in August 2008, no habitat suitable for coastal tailed frogs was identified. The substrate of the stream section between lower Cypress Bowl Road and Highway 1 contained high amounts of sediments, and availability of boulder-cobble habitat appeared insufficient (Photo 6). Presence of tailed frogs in Turner Creek above Highway 1 cannot be ruled out on the basis of this limited survey.

Although the absence of coastal tailed frogs during 2006 baseline surveys of other streams does not eliminate the possibility of their presence, the stream habitat assessments indicate they are unlikely to support coastal tailed frogs.

Table 17
Known Coastal Tailed Frog and Red-Legged Frog Presence Associated with Study Area Watersheds

Creek	Presence of Coastal Tailed Frog[1]	Presence of Red-Legged Frog[2]
Tributary N of Pipe Creek – above lower Cypress Bowl Road		No
Pipe Creek – above Highway 1	No	No
Pipe Creek – downstream of Highway 1	unknown	No
Westmount Creek – above Highway 1	No	No
Westmount Creek – downstream of Highway 1	unknown	No
Cave Creek – above Highway 1	No	No
Cave Creek – downstream of Highway 1	unknown	No
Turner Creek – above Highway 1	very unlikely[3]	No
Turner Creek – below Highway 1	unknown	No
Godman Creek mainstem – above Eagle Lake Road		No
Godman Creek mainstem – below Eagle Lake Road	No	No
Godman Creek mainstem – below Highway 1	unknown	No
Godman Creek West Branch – below Eagle Lake Road	No	

Note 1: Presence of coastal tailed frogs is based on both habitat capability and survey results. Stream sections below Highway 1 have not been surveyed, but tailed frog presence is unlikely.

Note 2: Presence of red-legged frogs is based on both habitat capability and survey results. It is highly unlikely that frogs would be found in watersheds that do not have significant wetlands.

Note 3: No dedicated surveys for coastal tailed frogs have been conducted along Turner Creek, but the habitat did not appear to be suitable.

- Red-Legged Frog (Blue-listed) (COSEWIC: Special Concern)

Red-legged frogs (*Rana aurora*) occur west of the Coast Range, from Southwestern BC southward to northern Baja California. In BC, they are found on Vancouver Island and the Sunshine Coast, and in the Lower Mainland eastward approximately to Manning Park. In the study area region, they are closely associated with forest habitats, requiring moist forest floor, wetlands or slow moving streams. They can be found far from riparian habitat, but are most often found near the banks of streams, ponds or wetlands. Their listed status is due to concern for habitat loss and alteration in the Lower Mainland, as intact riparian zones and moist forests are a diminishing resource in the region.

SEACOR conducted surveys for red-legged frogs in the Cypress Creek Neighbourhood study area on June 30, 2006 (SLR 2008b), and in the Rodgers Creek Neighbourhood area (Marr Cr. to Westmount Cr.) on July 5, 2006 (SLR 2008a). In Cypress Creek Neighbourhood area, the survey entailed visiting wetland shorelines and shallows, and surveying for adults and larvae. In the Rodgers Creek Neighbourhood area, however, where there are no breeding ponds, surveys were only for adult frogs on the forest floor in the vicinity of creeks containing flowing or standing water, including the banks of Pipe and Westmount creeks.

No red-legged frogs were observed during surveys of the Rodgers Creek Neighbourhood area in July 2006. The lack of breeding habitat (small ponds, wetlands) in the Rodgers Creek Neighbourhood area, which includes Pipe, Westmount and Cave creeks, suggests that the presence of red-legged frogs is highly unlikely.

One adult red-legged frog and a number of tadpoles were observed in small wetlands in the Cypress Creek Neighbourhood area in June 2006. The adult frog, but none of the tadpoles, was observed within the ISMP study area, in Godman Creek West Branch, downstream of Eagle Lake Road near the wetland of Polygon 157. Known presence of red-legged frogs in the ISMP study area is summarized in Table 17.

6.2.5 Listed Insects

A SEACOR biologist traversed the Rodgers Creek and Cypress Creek Neighbourhood study areas on September 22, 2006, to assess occurrence probability and habitat for significant species of damselflies, dragonflies and butterflies (SLR 2008a,b). As suitable habitat for insects of concern, the Rodgers Creek Neighbourhood area (including portions of the watersheds of Pipe, Westmount, and Cave creeks) provides only small seeps and steep-gradient streams. Wetlands, which are more characteristic of breeding habitat for insects of concern, are located within the Godman Creek watershed (within the Cypress Creek Neighbourhood and ISMP study areas).

Although the 2006 survey took place during ideal weather conditions (sunny, 15ºC to 20ºC), the date may have been past the usual flight time for many common species, as few were observed. The potential for rare butterflies in the study area was rated as low to nil, as plants used by larvae as food were not present. The only exception would consist of accidental species and infrequent migrating Monarch butterflies passing through the area.

As results of the 2006 surveys suggested the timing may have been late, additional surveys were conducted in 2007, focussed on detection of potential for two blue-listed dragonfly species: the Emma's Dancer (*Argia emma*) and the Black Petaltail (*Tanypteryx hageni*).

The Emma's Dancer is associated with creeks flowing from lakes, with their larvae using creek pools and riffles (Kenner 2000). There is little information on habitat requirements of this species, but the in-stream temperatures of these creeks may be too low to support Emma's dancer larvae. There are no historic records of Emma's dancer in the immediate area.

The Black Petaltail breeds on hillsides where its larvae can burrow into moss and mud saturated by seeps (Cannings 2002). As this species prefers spring fed mountain bogs (Cannings *et al*. 1977), and given the abundance of creeks on the hillsides in the study area, there is a low-to-moderate likelihood that it could occur in the study area. There are historic records of the Black Petaltail at higher elevations in the nearby Cypress Bowl area.

During the 2007 surveys, in addition to numerous common butterfly species, three common dragonfly species were observed in the ISMP study area: the Shadow Darner, the Blue-eyed Darner, and the Paddle-tailed Darner. The dragonflies observed were located some distance from any of the water sources, foraging in upland habitats. Of the species observed, none exhibited mating or chasing behaviour typical of breeding and territorial behaviour. No dragonflies were observed at any of the ponds, seeps, or slow moving watercourses.

Although habitat in the ISMP study area had limited potential to support listed dragonflies, none were located. The area provides only low-quality habitat for listed dragonfly and butterfly species, and supports a low diversity of common species. The Black Petaltail, historically recorded at higher elevations in the Cypress Bowl area, was not located, likely due to the low elevation of the study area and inadequate breeding habitat associated with bogs and hillside seeps. Appropriate breeding habitat for Emma's Dancer associated with creek pools and riffles was limited by steep topography associated with creek pools.

6.3 Conclusion

While the ISMP study area potentially provides habitat to a wide variety of animals, the presence of only two listed species has been confirmed: the red-legged frog and the tailed frog.

7.0 WATERSHED HEALTH

The watershed health tracking system recommended by Kerr Wood Leidel (2005) in the ISMP template is based on correlation among three quantifiable biophysical characteristics of watersheds:

1. Effective Impervious Area (EIA);

2. Percent Riparian Forest Integrity (RFI); and

3. the Benthic Index of Biotic Integrity (B-IBI).

The baseline watershed health can be determined for the Godman Creek watershed, based on the RFI and B-IBI scores derived from investigations reported above, and from the EIA calculated by Dayton & Knight Ltd. (2008).

The Total Impervious Area (TIA) for the entire Godman Creek watershed is 11%, as reported by Dayton & Knight (2008), and approximately 5% for the portion above Highway 1 (Sean Rooney, pers. comm.).

The RFI for the entire mainstem of Godman Creek is 56%, and 88% for the portion above Highway 1, as presented in Section 2.7.2, Table 3.

The overall B-IBI score for Godman Creek, Site G1, was 38 or “Good”, as presented in Section 4.2.7, Table 11.

Given that it is located a short distance below Highway 1, the benthic invertebrate population at Site G1 is influenced mainly by conditions in the upper, mostly undeveloped, part of the Godman watershed, and very little by conditions below the highway. As the impervious portions of the upper watershed consist only of Eagle Lake Road, the BC Hydro substation, and a small portion of Cypress Bowl Road, the TIA very closely approximates the EIA for purposes of tracking watershed health.

With reference to Figure 6, which is based on the blank graph in Kerr Wood Leidel (2005, Appendix F), the predicted B-IBI score for a watershed with an EIA of 5% and an RFI of 88% would be approximately 34 (indicated by the diagonal lines with values in small, red numerals). The actual B-IBI score of 38 for Site G1 exceeds this predicted score, indicating that there are no concerns related to the baseline health level of the Godman Creek Watershed.

As development progresses in the upper Godman Creek Watershed, the watershed health tracking system may be used to evaluate the effectiveness of low-impact development (LID) practices and riparian habitat conservation measures as they are implemented. Effective LID measures would result in little rightward movement of the EIA-RFI point on the graph.

8.0 CLOSURE

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Naizam Jaffer, Superintendent, Utilities, Engineering and Transportation Division, District of West Vancouver.

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Alex Sartori, R.P.Bio., Sartori Environmental Services, North Vancouver, BC.

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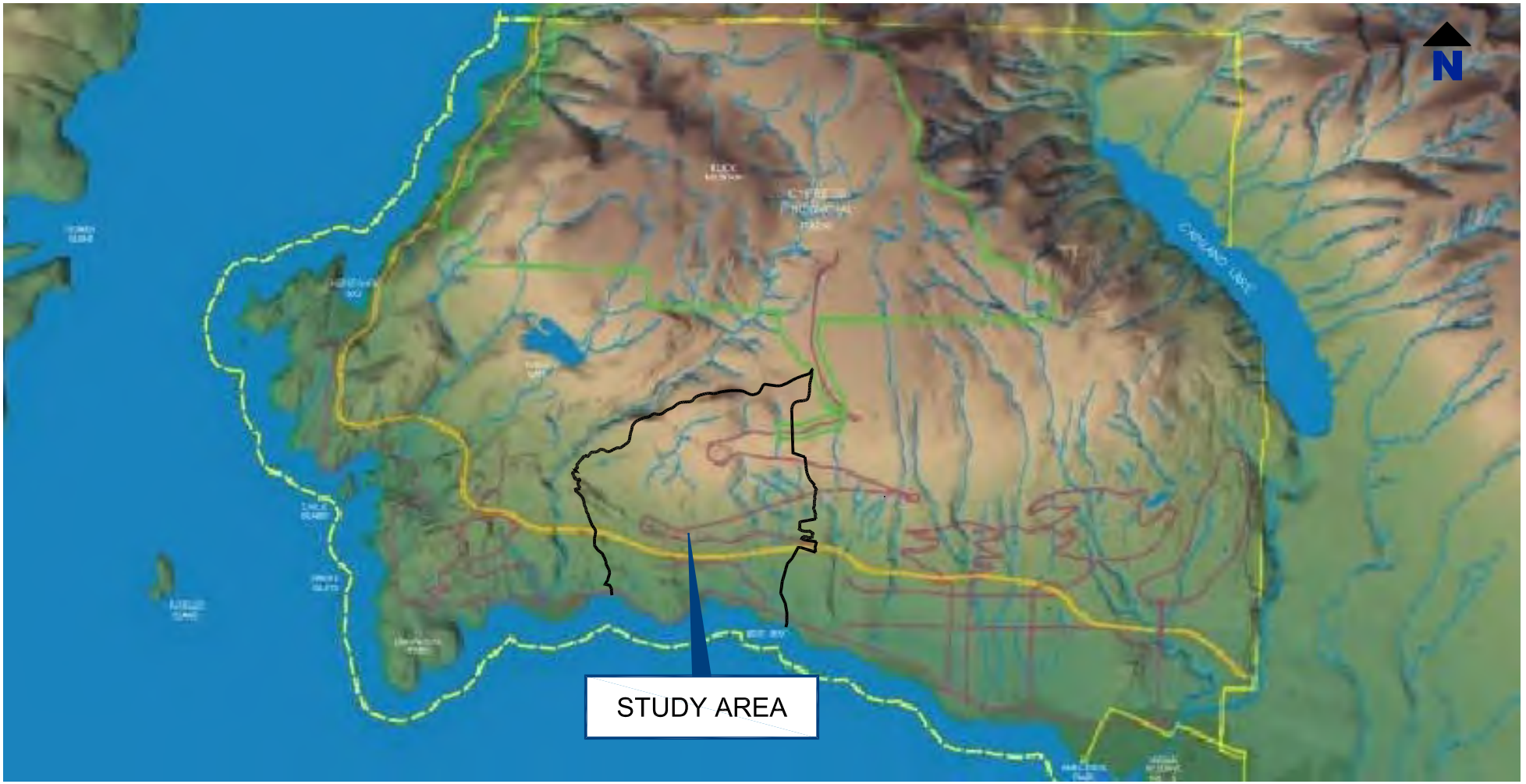
DRAWINGS

Ecological Overview Report
Integrated Stormwater Management Plan
for Pipe, Westmount, Cave, Turner and Godman Creeks
SLR Project No. 201.88342



MAP REFERENCED FROM: WESTMAP.WESTVANCOUVER.CA

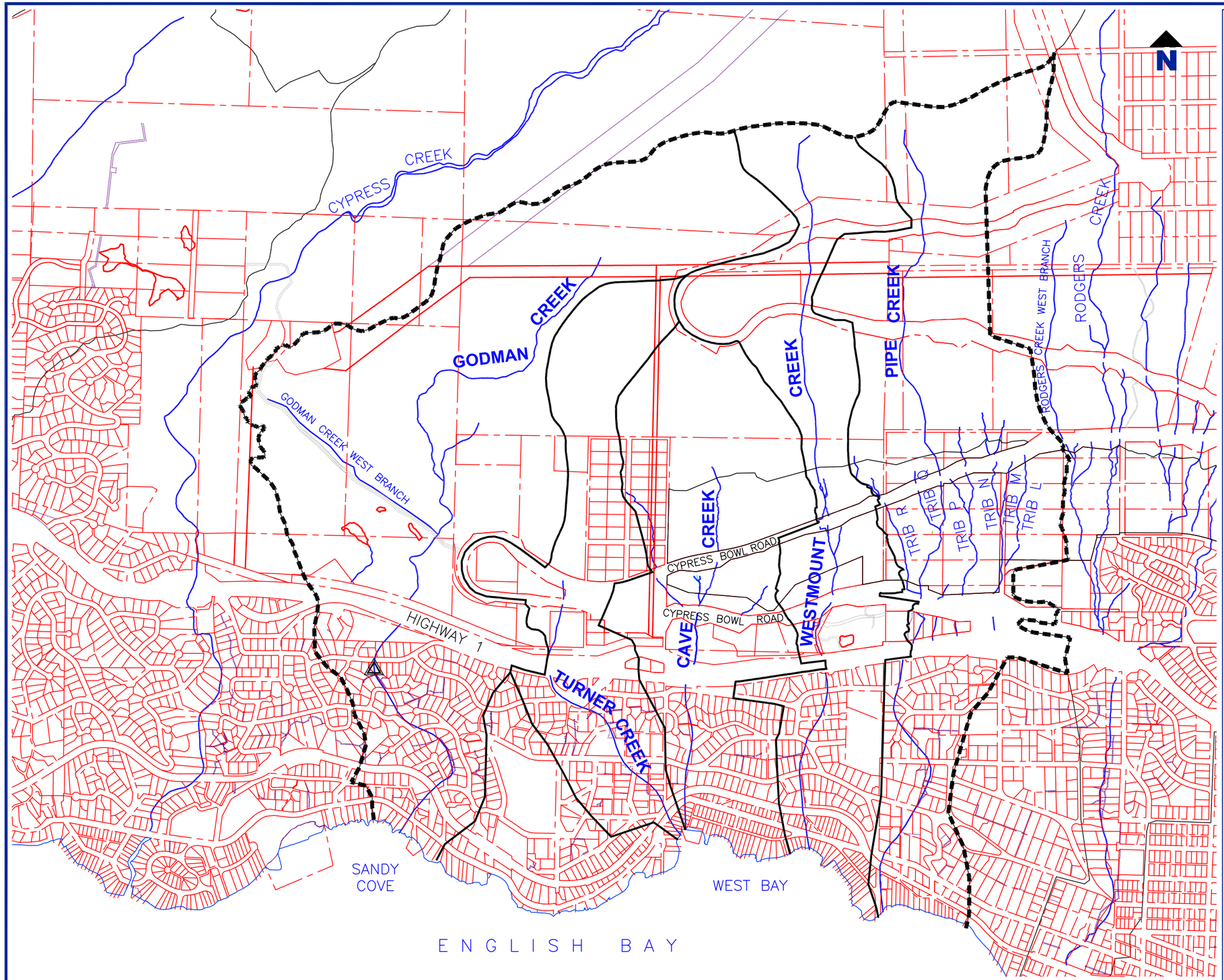
DAYTON & KNIGHT LTD.
INTEGRATED STORMWATER MANAGEMENT PLAN FOR PIPE, WESTMOUNT, CAVE, TURNER, AND GODMAN CREEKS
WEST VANCOUVER, BC

Report
ECOLOGICAL OVERVIEW REPORT

Drawing STUDY AREA LOCATION WITHIN THE DISTRICT OF WEST VANCOUVER

Date September 25, 2008	Scale NTS	Fig. No. 1
File Name S_201-88342-00-B1	Project No. 201.88342.00	

SLR



NOTES

LEGEND

- PROPERTY BOUNDARY
- CREEK
- OVERALL STUDY AREA BOUNDARY
- WATERSHED BOUNDARY
- BENTHIC INVERTEBRATE SAMPLING SITE G1

THIS DRAWING IS FOR CONCEPTUAL PURPOSES ONLY. ACTUAL LOCATIONS MAY VARY AND NOT ALL STRUCTURES ARE SHOWN.

SCALE 1:15,000
WHEN PLOTTED AT 17 x 11 PAGE SIZE

0 250 500 1000 m

DAYTON & KNIGHT LTD.
INTEGRATED STORMWATER MANAGEMENT PLAN FOR PIPE, WESTMOUNT, CAVE, TURNER, AND GODMAN CREEKS
WEST VANCOUVER, BC

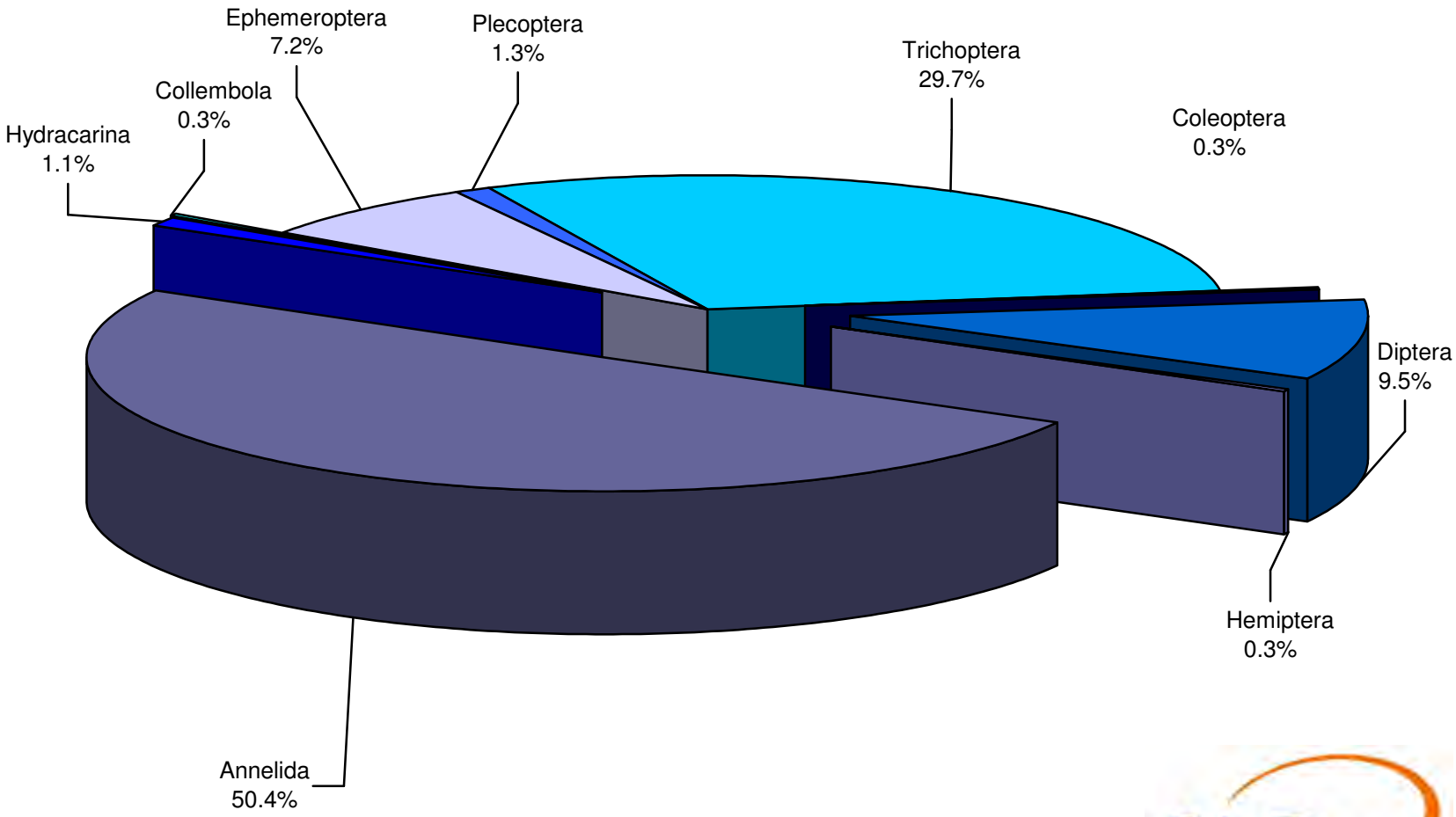
Report
ECOLOGICAL OVERVIEW REPORT

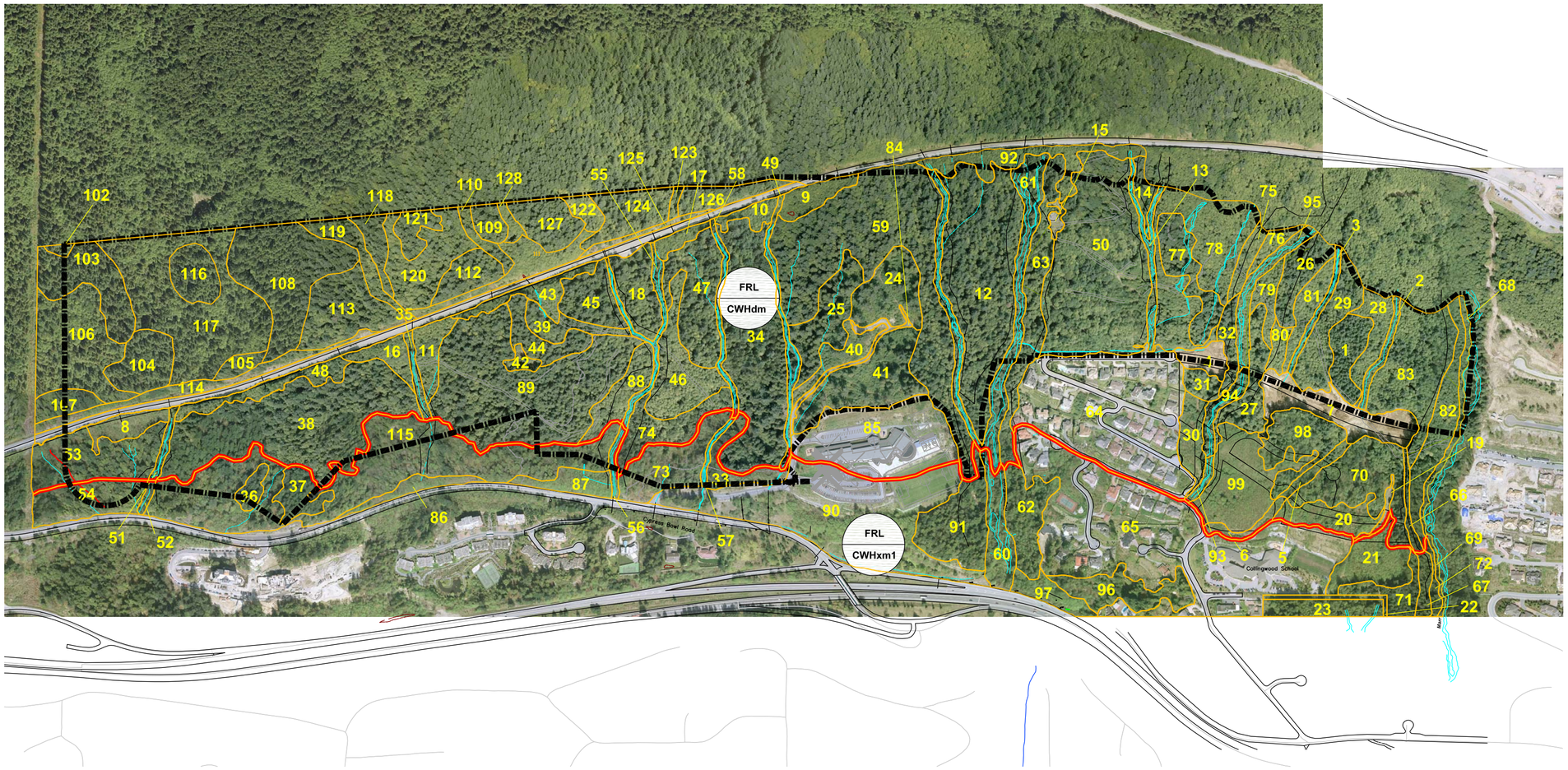
Drawing
STUDY AREA STREAMS AND WATERSHED BOUNDARIES

Date September 25, 2008	Scale AS SHOWN	Drawing No. 2
File Name S_201-88342-00-B4	Project No. 201.88342.00	

SLR

FIGURE 3: COMPOSITION OF THE BENTHIC INVERTEBRATE COMMUNITY SAMPLED AT GODMAN CREEK, SITE G1





N

LEGEND:

- ADP Boundary
- Creeks
- Wetland Area
- Biogeoclimatic unit
- Ecosystem Unit with Polygon Number (50)

MAP UNIT LABEL

Site Series 1 — Decile 2 — Structural Stage 2
Decile 1 — 8HM5B-2RS5B — Structural Stage Modifier 2
Structural Stage 1 — Site Series 2
Structural Stage Modifier 1

Ecosection

FRL Fraser Lowland

Biogeoclimatic Units

CWHdm Dry Maritime Subzone of the Coastal Western Hemlock Zone
CWHxm1 Very Dry Maritime Subzone of the Coastal Western Hemlock Zone

Site Series, Non-vegetated, and Anthropogenic Units

CWHdm

Ecosystem Unit Symbol	Ecosystem Unit Name	Site Series Number
HM	Western hemlock - Flat moss	01
DS	Douglas-fir - Western hemlock - Salal	03
RS	Western redcedar - Sword fern	05
RF	Western redcedar - Foamflower	07
ES	Exposed Soil	-
RZ	Road/trail surface	-
UR	Urban/suburban	-

CWHxm1

Ecosystem Unit Symbol	Ecosystem Unit Name	Site Series Number
HK	Western Hemlock - Douglas-fir - Kindbergia	01
DS	Douglas-fir - Western hemlock - Salal	03
RS	Western redcedar - Sword fern	05
RF	Western redcedar - Foamflower	07
PL	Powerline	-
UR	Urban/suburban	-

Structural Stages

Structural Stage Symbol	Structural Stage	Description
1b	Bryoid	Bryophyte- and lichen-dominated communities
2	Herb	Herbaceous communities
3a	Low Shrub	(< 2m)
3b	Tall Shrub	(< 10m)
4	Pole/sapling	Stands typically 20 -40 years old
5	Young Forest	Stands typically 40 -80 years old
6	Mature Forest	Stands typically 80 -250 years old
7	Old Forest	Stands typically > 250 years old

Stand Composition Modifiers

Structural Stage Symbol	Structural Stage	Description
C	Coniferous	Greater than 3/4 of tot al tree layer cover is coniferous
B	Broadleaf	Greater than 3/4 of total tree layer cover is broadleaved
M	Mixed	Neither coniferous or broadleaf account for greater than 3/4 of total tree layer cover

ECOSYSTEM UNIT LABELS

Polygon ID	BGC Unit	Ecosystem Units
1	CWHdm	4HM5C 4RS5C 2RS5M
2	CWHdm	RF5B
3	CWHdm	RF5B
4	CWHdm	ES
5	CWHdm	RF5M
6	CWHdm	RF4B
7	CWHdm	ES
8	CWHdm	RS4B
9	CWHdm	RS4B
10	CWHdm	RS5B
11	CWHdm	8RS5B 2RS5M
12	CWHdm	5HM5M 5RS5M
13	CWHdm	5RF5M 5RF5B
14	CWHdm	RS5M
15	CWHdm	UR
16	CWHdm	RS5B
17	CWHdm	RS5B
18	CWHdm	RS5M
19	CWHdm	ES
20	CWHdm	9RS4B 1RS5M
21	CWHxm1	RS4B
22	CWHxm1	PL
23	CWHxm1	8RS5C 2RS5M
24	CWHdm	5RS4B 4RS5M 1HM5M
25	CWHdm	7HM5C 3RS5C
26	CWHdm	HM5C
27	CWHdm	5HM5M 5RS5M
28	CWHdm	7RS5B 3RS5M
29	CWHdm	5RS5B 5RS5M
30	CWHdm	RS4B
31	CWHdm	RS5M
32	CWHdm	7HM5C 3HM5M
33	CWHxm1	RS4M
34	CWHdm	4HM5C 4HM5M 2RS5M
35	CWHdm	8RF5B 2RF5M
36	CWHxm1	HK5C
37	CWHxm1	HK5C
38	CWHdm	5HM5C 5RS5C
39	CWHdm	HM5C
40	CWHdm	UR
41	CWHdm	6RS4B 4RS5M
42	CWHdm	DS5C
43	CWHdm	RS5B
44	CWHdm	7RS5M 3RS5C
45	CWHdm	6RS5C 4HM5C
46	CWHdm	4HM5B 4RS5B 2RS5M
47	CWHdm	5HM5M 5RS5M
48	CWHdm	5RS5B 5RS5M
49	CWHdm	8RF5M 2RF5B
50	CWHdm	6RS4B 4RS5M
51	CWHdm	RS5C
52	CWHxm1	RF5M
53	CWHdm	6HM5C 3DS5M 1RS5C
54	CWHxm1	5HK5C 4DS5M 1RS5M
55	CWHdm	7RF5B 3RF5M
56	CWHxm1	RF5B
57	CWHxm1	RF5M
58	CWHdm	7RF5M 3RF5B
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61	CWHdm	RF5M
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63	CWHdm	7RS5M 3RS5C
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75	CWHdm	9HM5B 1HM5M
76	CWHdm	RS5B
77	CWHdm	8RS5B 1RS5M 1RF5B
78	CWHdm	6RS5C 4RS5M
79	CWHdm	RS5B
80	CWHdm	HM5B
81	CWHdm	8RS5B 2RS5M
82	CWHdm	5RS5B 5RS5M
83	CWHdm	4HM5M 3RS5M 3RS5B
84	CWHdm	RZ
85	CWHdm	UR
86	CWHxm1	RS4B
87	CWHxm1	RS4B
88	CWHdm	6RS5B 4RS5M
89	CWHdm	5HM5M 5RS5M
90	CWHxm1	UR
91	CWHxm1	5HK5M 5RS5M
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93	CWHdm	6RF4B 4RF5M
94	CWHdm	RF5M
95	CWHdm	RF5B
96	CWHxm1	5HK5C 4DS5M 1UR
97	CWHxm1	RS4B
98	CWHdm	5RS5M 4HM5M 1HM5C
99	CWHdm	8RS4B 2RS5B
100	CWHdm	4DS4M 3HM4M 3RS4M
101	CWHdm	RZ
102	CWHdm	RS5M
103	CWHdm	8HM5C 2RS5C
104	CWHdm	6HM5C 4RS5C
105	CWHdm	HM5C
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108	CWHdm	9HM5C 1RS5C
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113	CWHdm	6HM5C 2RS5M 2RS5B
114	CWHdm	6HM5C 2RS5M 2DS5C
115	CWHxm1	6DS5M 2HK5M 2RS5M
116	CWHdm	HM5C
117	CWHdm	4RS5B 4HM5C 2RS5M
118	CWHdm	HM5C
119	CWHdm	6HM5C 3RS5M 1HM5C
120	CWHdm	5HM5M 5RS5M
121	CWHdm	HM5C
122	CWHdm	6RS5B 4RF5M
123	CWHdm	RF5M
124	CWHdm	7HM5C 3RS5M
125	CWHdm	4RS5M 4DS5M 2RO1b
126	CWHdm	8HM5M 2RS5M
127	CWHdm	9HM5C 1RS5C
128	CWHdm	7RF5B 3RS5B

note: polygons 100 and 128 have been interpreted based on aerial photography only (no field visitation)

SCALE 1:6000 (APPROX.)
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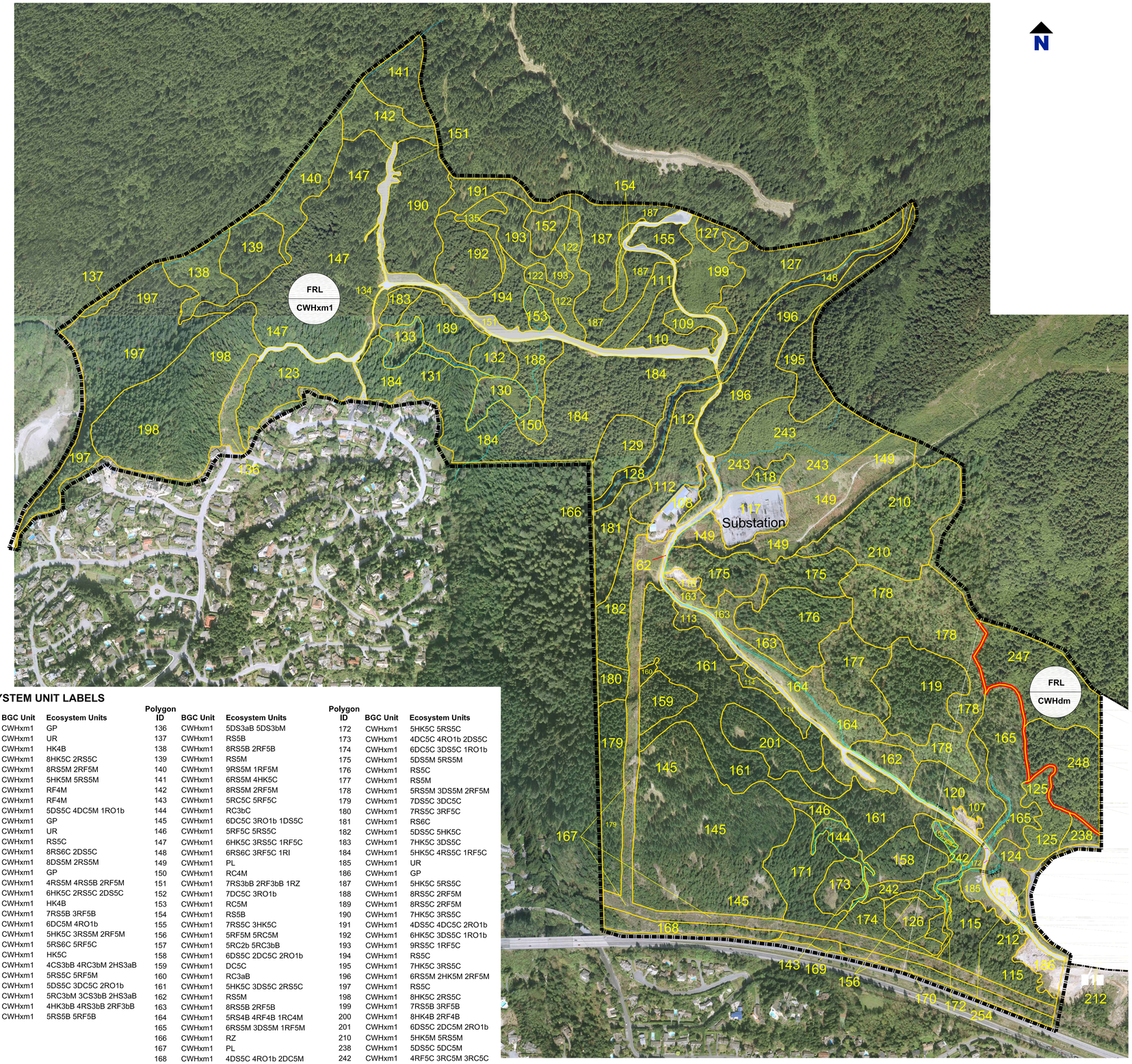
DAYTON & KNIGHT LTD.
INTEGRATED STORMWATER MANAGEMENT PLAN FOR PIPE, WESTMOUNT, CAVE, TURNER, AND GODMAN CREEKS
WEST VANCOUVER

Report
ECOLOGICAL OVERVIEW REPORT

Drawing
ECOSYSTEM MAP, INCLUDING PORTIONS OF THE PIPE, WESTMOUNT AND CAVE WATERSHEDS

Date September 25, 2008
Scale AS SHOWN
Fig. No. 4
File Name S_201-88342-00-B2
Project No. 201.88342.00

SLR



LEGEND:

- Project Area Boundary
- Creeks
- Wetland Area
- Biogeoclimatic Sub-zone Boundary
- Ecosystem Unit with Polygon Number (50)

MAP UNIT LABEL

Site Series 1 — Decile 2 — Structural Stage 2

Decile 1 — 8HM5B-2RS5B — Structural Stage Modifier 2

Structural Stage 1 — Site Series 2

Structural Stage Modifier 1

Ecosection

FRL Fraser Lowland

Biogeoclimatic Unit

CWHdm Dry Maritime Subzone of the Coastal Western Hemlock Zone

CWHxm1 Very Dry Maritime Subzone of the Coastal Western Hemlock Zone

Site Series, Non-vegetated, and Anthropogenic Units

CWHdm

Ecosystem Unit Symbol	Ecosystem Unit Name	Site Series Number
HM	Western hemlock - Flat moss	01
RS	Western redcedar - Sword fern	05
RF	Western redcedar - Foamflower	07

CWHxm1

Ecosystem Unit Symbol	Ecosystem Unit Name	Site Series Number
HK	Western Hemlock - Douglas-fir - Kindbergia	01
DC	Douglas-fir - Lodgepole pine - Cladina	02
DS	Douglas-fir - Western hemlock - Salal	03
RS	Western redcedar - Sword fern	05
RF	Western redcedar - Foamflower	07
RC	Western redcedar - Sitka spruce - Skunk cabbage (Treed Swamp)	12
CS	Crabapple - Skunk cabbage Wetland	00
HS	Hardhack - Skunk cabbage Wetland	00
GP	Gravel Pit	-
PL	Powerline	-
RI	River	-
RO	Rock Outcrop	-
RZ	Road/trail Surface	-
UR	Urban/suburban	-

Vegetation Development Units

Structural Stages

Structural Stage Symbol	Structural Stage	Description
1b	Bryoid	Bryophyte and lichen-dominated communities
2	Herb	Herbaceous communities
3a	Low Shrub	(< 2m)
3b	Tall Shrub	(< 10m)
4	Pole/sapling	Stands typically 20 -40 years old
5	Young Forest	Stands typically 40 -80 years old
6	Mature Forest	Stands typically 80 -250 years old
7	Old Forest	Stands typically > 250 years old

Stand Composition Modifiers

Structural Stage Symbol	Structural Stage	Description
C	Coniferous	Greater than 3/4 of total tree layer cover is coniferous
B	Broadleaf	Greater than 3/4 of total tree layer cover is broadleaved
M	Mixed	Neither coniferous or broadleaf account for greater than 3/4 of total tree layer cover

ECOSYSTEM UNIT LABELS

Polygon ID	BGC Unit	Ecosystem Units
107	CWHxm1	GP
108	CWHxm1	UR
109	CWHxm1	HK4B
110	CWHxm1	8HK5C 2RS5C
111	CWHxm1	8RS5M 2RF5M
112	CWHxm1	5HK5M 5RS5M
113	CWHxm1	RF4M
114	CWHxm1	RF4M
115	CWHxm1	5DS5C 4DC5M 1RO1b
116	CWHxm1	GP
117	CWHxm1	UR
118	CWHxm1	RS5C
119	CWHxm1	8RS6C 2DS5C
120	CWHxm1	8DS5M 2RS5M
121	CWHxm1	GP
122	CWHxm1	4RS5M 4RS5B 2RF5M
123	CWHxm1	6HK5C 2RS5C 2DS5C
124	CWHxm1	HK4B
125	CWHxm1	7RS5B 3RF5B
126	CWHxm1	6DC5M 4RO1b
127	CWHxm1	5HK5C 3RS5M 2RF5M
128	CWHxm1	5RS6C 5RF5C
129	CWHxm1	HK5C
130	CWHxm1	4CS3bB 4RC3bM 2HS3aB
131	CWHxm1	5RS5C 5RF5M
132	CWHxm1	5DS5C 3DC5C 2RO1b
133	CWHxm1	5RC3bM 3CS3bB 2HS3aB
134	CWHxm1	4HK3bB 4RS3bB 2RF3bB
135	CWHxm1	5RS5B 5RF5B
136	CWHxm1	5DS3aB 5DS3bM
137	CWHxm1	RS5B
138	CWHxm1	8RS5B 2RF5B
139	CWHxm1	RS5M
140	CWHxm1	9RS5M 1RF5M
141	CWHxm1	6RS5M 4HK5C
142	CWHxm1	8RS5M 2RF5M
143	CWHxm1	5RC5C 5RF5C
144	CWHxm1	RC3bC
145	CWHxm1	6DC5C 3RO1b 1DS5C
146	CWHxm1	5RF5C 5RS5C
147	CWHxm1	6HK5C 3RS5C 1RF5C
148	CWHxm1	6RS6C 3RF5C 1RI
149	CWHxm1	PL
150	CWHxm1	RC4M
151	CWHxm1	7RS3bB 2RF3bB 1RZ
152	CWHxm1	7DC5C 3RO1b
153	CWHxm1	RC5M
154	CWHxm1	RS5B
155	CWHxm1	7RS5C 3HK5C
156	CWHxm1	5RF5M 5RC5M
157	CWHxm1	5RC2b 5RC3bB
158	CWHxm1	6DS5C 2DC5C 2RO1b
159	CWHxm1	DC5C
160	CWHxm1	RC3aB
161	CWHxm1	5HK5C 3DS5C 2RS5C
162	CWHxm1	RS5M
163	CWHxm1	8RS5B 2RF5B
164	CWHxm1	5RS4B 4RF4B 1RC4M
165	CWHxm1	6RS5M 3DS5M 1RF5M
166	CWHxm1	RZ
167	CWHxm1	PL
168	CWHxm1	4DS5C 4RO1b 2DC5M
169	CWHxm1	8RS4M 2RF4M
170	CWHxm1	6DC3bM 4RO1b
171	CWHxm1	5HK5C 4RS5C 1RF5C
172	CWHxm1	5HK5C 5RS5C
173	CWHxm1	4DC5C 4RO1b 2DS5C
174	CWHxm1	6DC5C 3DS5C 1RO1b
175	CWHxm1	5DS5M 5RS5M
176	CWHxm1	RS5C
177	CWHxm1	RS5M
178	CWHxm1	5RS5M 3DS5M 2RF5M
179	CWHxm1	7DS5C 3DC5C
180	CWHxm1	7RS5C 3RF5C
181	CWHxm1	RS6C
182	CWHxm1	5DS5C 5HK5C
183	CWHxm1	7HK5C 3DS5C
184	CWHxm1	5HK5C 4RS5C 1RF5C
185	CWHxm1	UR
186	CWHxm1	GP
187	CWHxm1	5HK5C 5RS5C
188	CWHxm1	8RS5C 2RF5M
189	CWHxm1	8RS5C 2RF5M
190	CWHxm1	7HK5C 3RS5C
191	CWHxm1	4DS5C 4DC5C 2RO1b
192	CWHxm1	6HK5C 3DS5C 1RO1b
193	CWHxm1	9RS5C 1RF5C
194	CWHxm1	RS5C
195	CWHxm1	7HK5C 3RS5C
196	CWHxm1	6RS5M 2HK5M 2RF5M
197	CWHxm1	RS5C
198	CWHxm1	8HK5C 2RS5C
199	CWHxm1	7RS5B 3RF5B
200	CWHxm1	8HK4B 2RF4B
201	CWHxm1	6DS5C 2DC5M 2RO1b
210	CWHxm1	5HK5M 5RS5M
238	CWHdm	5DS5C 5DC5M
242	CWHxm1	4RF5C 3RC5M 3RC5C
243	CWHxm1	5RS5B 3RS5M 2RF5B
247	CWHdm	5RS5M 3HM5C 2RF5M
248	CWHdm	5RF5C 4HM5C 1RF5M

THIS DRAWING IS FOR CONCEPTUAL PURPOSES ONLY. ACTUAL LOCATIONS MAY VARY AND NOT ALL STRUCTURES ARE SHOWN.

THIS DRAWING IS FOR CONCEPTUAL PURPOSES ONLY. ACTUAL LOCATIONS MAY VARY AND NOT ALL STRUCTURES ARE SHOWN.

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DAYTON & KNIGHT LTD.
INTEGRATED STORMWATER MANAGEMENT PLAN FOR PIPE, WESTMOUNT, CAVE, TURNER AND GODMAN CREEKS
WEST VANCOUVER, BC

Report: ECOLOGICAL OVERVIEW REPORT

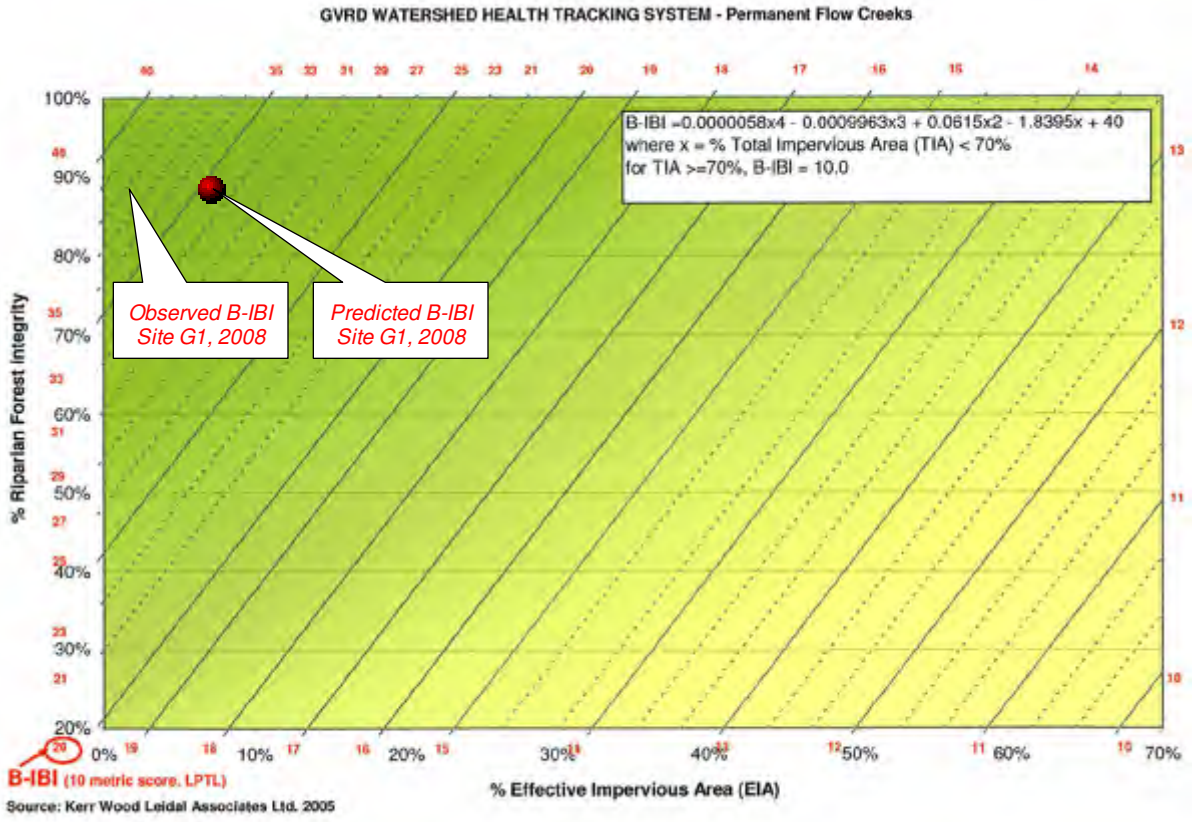
Drawing: ECOSYSTEM MAP, INCLUDING PORTION OF THE GODMAN CREEK WATERSHED

Date September 25, 2008 | Scale AS SHOWN | Fig. No. 5

File Name S_201-88342-00-B3 | Project No. 201.88342.00

SLR

FIGURE 6: WATERSHED HEALTH ASSESSMENT, GODMAN CREEK, SITE G1



SITE PHOTOGRAPHS

Ecological Overview Report
Integrated Stormwater Management Plan
for Pipe, Westmount, Cave, Turner and Godman Creeks
SLR Project No. 201.88342

Photo 1: SLR Biologist M. Lashmar climbing up the steep channel of Pipe Creek, above lower Cypress Bowl Road, during the assessment of riparian setbacks (November 18, 2005).

Photo 2: Tributary N, within the Pipe Creek watershed, has a gravel-cobble substrate with occasional bounders; though the channel was dry above lower Cypress Bowl Road in summer 2006, one tailed frog tadpole was found in a pool that still contained water (July 4, 2006).

Photo 3: The steep channel of Westmount Creek above lower Cypress Bowl Road contains sections of riffles, steps, pools and chutes, depending on local gradient (November 22, 2005).

Photo 4: The riparian forest along Cave Creek, above lower Cypress Bowl Road, is characterized by maturing second-growth western redcedar, Douglas-fir, salmonberry, red huckleberry and sword ferns; canopy cover ranges from 75% to nearly 100% (November 22, 2005).

Photo 5: Turner Creek channel, typical step-pool section, above Highway 1 (August 27, 2008).

Photo 6: Turner Creek channel, portions of the channel above Highway 1 exhibited sedimentation (August 27, 2008)

Photo 7: Steep section of the Godman Creek mainstem above Eagle Lake Road (November 24, 2005)

Photo 8: Godman Creek, low gradient section, a short distance downstream of the inflow of the Godman Creek West Branch tributary (November 23, 2005).

Photo 9: Immediately above Highway 1, the channel of Godman Creek is very steep and would form a fish access barrier; remnants of an old weir structure and fence were found, a short distance downstream of the BC Hydro right-of-way (November 23, 2005).

Photo 10: Environmental scientist Chris MacMillan labelling a survey transect along Godman Creek West Branch (November 24, 2005).

Photo 11: SLR Environmental Scientist Stef Lee measuring Pipe Creek water quality *in situ*, a short distance upstream of Mathers Avenue, using a mini-sonde and data logger (August 27, 2008).

Photo 12: Godman Creek, Benthic Invertebrate Sampling Site G1, view upstream from a point immediately above a footbridge downstream of Westridge Avenue (August 27, 2008).

Photo 13: SLR Biologist John McCulloch using a Surber Sampler to collect a sample of benthic invertebrates at Godman Creek Site G1 (August 29, 2008).

Photo 14: SLR Biologist John McCulloch transferring substrate material from the Surber Sampler to a plastic tub, Godman Creek Site G1 (August 29, 2008).

Photo 15: SLR Biologist John McCulloch using jeweller's forceps to field-sort benthic invertebrates sampled from Godman Creek Site G1 (August 29, 2008).

Photo 16: Coastal tailed frog tadpole captured from a pool along Godman Creek, above Eagle Lake Road (June 26, 2006).

Photo 17: Coastal tailed frog tadpole captured from a pool along Godman Creek, above Eagle Lake Road, after being released (June 26, 2006).

Photo 18: Habitat along upper Godman Creek in which the coastal tailed frog tadpole depicted in Photos 16 and 17 was found (June 26, 2006).

APPENDIX A
DFO/MOEP Stream Survey Forms

Ecological Overview Report
Integrated Stormwater Management Plan
for Pipe, Westmount, Cave, Turner and Godman Creeks
SLR Project No. 201.88342

NOTES FOR APPENDIX A

The stream cards provided in this appendix originate from three sources: SEACOR (2004), SLR (2008b) and one card (for Turner Creek) completed for the current report. As the provincial standard stream card has changed, the card completed recently for Turner Creek differs from those used for previous surveys, which were conducted in 1999-2000.

Cards for streams in the Rodgers Creek Neighbourhood (in SEACOR 2004) and the Cypress Creek Neighbourhood (in SLR 2008b) were completed before stream and tributary names were standardized on more recent maps. As a result, the stream names identified on some cards differ from those in current use. The following table notes changes to stream names in the order the cards are presented in this appendix.

Steam Name on Card	Stream Name in Current Use
Unnamed Trib. (Trib. C)	Tributary L
Unnamed trib. to Pipe Creek (Trib. D)	Tributary M
Unnamed trib to Pipe Creek (Trib. E)	Tributary N
Unnamed trib. to Pipe Creek (Trib. F)	Tributary O
Unnamed trib. to Pipe Creek (Trib. G)	Tributary P
Pipe Creek	Pipe Creek
Unnamed trib. to Pipe Creek (Trib. H)	Tributary Q
Unnamed Watercourse (Trib. I)	Tributary R
Unnamed Watercourse (Trib. J)	Tributary S
Westmount Creek	Westmount Creek
Unnamed Stream (Trib. K)	Tributary T
Cave Creek	Cave Creek
Unnamed Watercourse (Trib. L)	Tributary U
Turner Creek	Turner Creek
Godman Creek	Godman Creek West Branch
Unnamed trib. to Godman Creek	Godman Creek (above Eagle Lake Road)

DFO/MOEP
STREAM SURVEY FORM

Stream Name (gaz.): Unnamed Trib. (local): Trib C | Access | | Method

Watershed Code | Reach No. | Length(km)

Location: 190 m d/s of Cypress Bowl Rd. | Maps | Site No. 1 | Lthaur(m)

U.T.M. | Fish Card: Y (N) | Field ☑ Hist. ☐

Date Y M D: 00 12 16 | Time: 1456 | Agency | Crew: ASI / | Photos: 76 B | Air Photos

C	PARAMETER	VALUE	METH.
	Ave.Chan.Width (m)	2.0	
	Ave.Wet.Width (m)	0.15	
	Ave.Max.Riffle Depth (cm)	—	
	Ave.Max.Pool Depth (cm)	—	
	Gradient %	22	
	% Pool — Riffle — Run — Other —		
	Side Chan.% 0 ☐ 5-10 ☐ 10-40 ☐ >40 ☐		
	Debris Area% 0 ☐ 5 ☐ 5-15 ☑ 15-40 ☐ >40 ☐		
	Stable % 100		
	COVER: Total % —		
	Comp. sum 100% —	Dp Pool —	L.O.D. —	Boulder —	In Veg —	Over Veg —	Cutbank —
	Crown Closure % 80	Aspect SW	

SPECIFIC DATA: Mostly Dry with patches of flowing water

OBSTRUCTIONS

Ht(m)	Type	Loc'n
—		

BED MATERIAL

		%
Fines	clay, silt, sand (<2mm)	40
Gravels	small (2-16mm)	5
	large (16-64mm)	5
Larges	sm.cobble (64-128mm)	30
	lge.cobble (128-256mm)	20
	boulder (>256mm)	0
Bedrock (R)		

D_{50} (cm): | Composition: (C) M H

BANKS

Height(m): 0 | %Unstable: 0

Texture: F (G) L R

Confinement: (EN) CO FC OC UC N/A

Valley: Channel Ratio: 0-2 (2-5) 5-10 10+ N/A

Stage: (Dry) L M H Flood

Flood Signs Ht(m): — | Braided: Y (N)

Bars (%): — | pH: 6.7 | O2ppm: 10.9B

Water Temp.(°C): 4.2 | Turb.(cm): 0.15 | Cond.(25°C): 57.2 →

DISCHARGE

Parameter	Value	Method	Specific Data
Wetted Width (m)			
Mean Depth (m)			Mostly Dry
Mean Velocity (m/s)			
Discharge (m^3/s)			

REACH SYMBOL (Plan)

Width,Valley/Channel,Slope | Bed Material

REVISED DEC. 87 SG187

FISH SUMMARY

Species	No.	Size Range(mm)	Life Phase	Use	Method/Ref.

STREAM/VALLEY CROSS-SECTION ☑ (Looking Downstream)

L R

PLANIMETRIC VIEW ☐

COMMENTS

Channel Stability ☐, Debris ☐, Management Concerns ☐, Obstructions ☐, Riparian Zone ☐, Valley Wall Processes ☐, Etc.

Edited by:

Date Y M D:

DFO / MOEP
STREAM SURVEY FORM

Stream Name (gaz.) Unnamed trib to Pipe Cr. (local) Trib D					Access		Method
Watershed Code			Reach No.		Length(km)		
Location 175 m d/s of Cypress Bowl Rd.	Map#		Site No.	1	Lthaury(m)		
	U.T.M.	385841 5466625	Fish Card	Y (N)	Field ☑	Mist. ☐	
Date Y M D 01 12 17	Time 0900	Agency	Crew DS /	Photos 9-10	Air Photos		

C	PARAMETER	VALUE	METH.	SPECIFIC DATA
	Ave.Chan.Width (m)	0.9		
	Ave.Wet.Width (m)	0.2		
	Ave.Max.Riffle Depth (cm)	0.02		
	Ave.Max.Pool Depth (cm)	0.03		
	Gradient %	18		
	% Pool — Riffle (90) Run + Other —			
	Side Chan.% 0 (90-100) 10-40 ☐ >40 ☐			
	Debris Area% 0 (0-5) ☑ 5-15 ☐ >15 ☐			
	Debris Stable % 100			
	COVER: Total %	10		
	Comp. Sum 100% — Dp Pool 0 — L.O.D. 0 — Boulder 0 — In Veg 0 — Ovrh Veg 100 — Current 0			
	Crown Closure % 60	Aspect S		

BED MATERIAL		%
Fines	clay, silt, sand (<2mm)	90
Gravels	small (2-16mm)	0
	large (16-64mm)	0
Larges	sm. cobble (64-128mm)	0
	lge. cobble (128-256mm)	10
	boulder (>256mm)	0
Bedrock (R)		0
D_{50} (mm) —	Compaction (L) M H	

BANKS					
Height(m) 0.1	% Unstable —				
Texture (F) G L R					
Confinement	EN CO FC (UC) UC	N/A			
Valley: Channel Ratio	(0-2) 2-5 5-10 10+	N/A			
Stage	Dry (L) M H	Flood			
Flood Signs Ht(m) —	Braided	Y (N)			
Bars (%) —	pH 6.24	O_2 ppm 10.2°C			
Water Temp (°C) 7.0	Turb.(cm) 0.24	Cond.(µS°C) 33.5 → 37.1			

OBSTRUCTIONS		
Ht(m)	Type	Loc'n

DISCHARGE			
Parameter	Value	Method	Specific Data
Wetted Width (m)	0.3		
Mean Depth (m)	0.01		
Mean Velocity (m/s)	0.05		
Discharge (m^3/s)			

REACH SYMBOL (Fish)

1118 | 9010

(Width,Valley,Channel,Slope) (Bed Material)

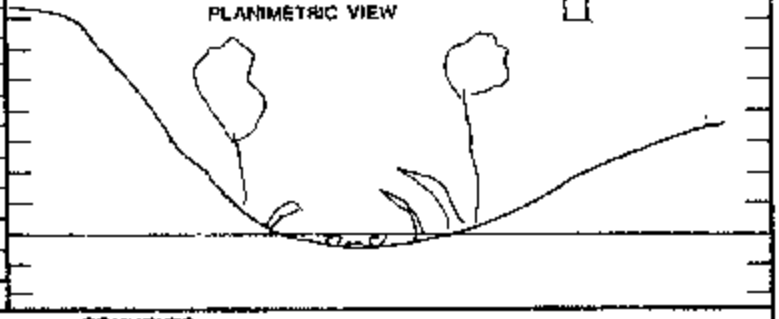
REVISED DEC. 87 SS187

FISH SUMMARY

Species	No.	Size Range(mm)	Life Phase	Use	Method/Rel.
No Fish Observed					

STREAM/VALLEY CROSS-SECTION ☑ (Looking Downstream)

PLANIMETRIC VIEW ☐



COMMENTS

Channel Stability ☐, Debris ☐, Management Concerns ☐, Obstructions ☐, Riparian Zone ☐, Valley Wall Processes ☐, Etc.

Edited by:

Date Y M D:

DFO/MOEP
STREAM SURVEY FORM

Stream Name (gaz.)	Unnamed trib. to Nile Creek (local)	Trib E				Access		Method
Watershed Code				Reach No.		Length(km)		
Location	200 d/s of Cypress Bowl Rd.	Map#		Site No.	1	Lthaur(km)		
		U.T.M.	485736 5462587	Fish Card	Y (N)	Field ☑	Hist. ☐	
Date Y M D	010 | 12 | 20	Time 0940	Agency	Crew	MS /	Photos 11&12	Air Photos	

PARAMETER	VALUE	METH.
Ave.Chan.Width (m)	3.5	
Ave.Wet.Width (m)	1.8	
Ave.Max.Riffle Depth (cm)	0.10	
Ave.Max.Pool Depth (cm)	0.25	
Gradient %	27	
% Pool 20 Riffle 50 Rapid 30 Other —		
Side Chan.%	0 ☐ 0-10 ☐ 10-30 ☐ >30 ☐	
Debris Area%	0 ☐ 0-5 ☑ 5-15 ☐ ≥15 ☐	
Debris Stable % 75		
COVER: Total %	25	

Comp. sum 100%	Dp Pool	L.O.D.	Boulder	Sh Veg	Over Veg	Cutbank
	30	30	20	0	10	10

Crown Closure % 85 Aspect S

SPECIFIC DATA

OBSTRUCTIONS

Ht(m)	Type	Loc'n
—		

BED MATERIAL

		%
Fines	clay, silt, sand (<2mm)	10
Gravels	small (2–16mm)	10
	large (16–64mm)	15
Larges	sm. cobble (64–128mm)	15
	lge cobble (128–256mm)	20
	boulder (>256mm)	30
Bedrock (R)		0

D_{50}(cm) Compaction (L) M H

BANKS

Height(m) / 0 %Unstable 0

Texture F (S) L R

Confinement	EN	CO	FC	OC	UC	N/A
Valley: Channel Ratio	0-2	2-5	5-10	10+	N/A	
Stage	Dry	L	(M)	H	Flood	

Flood Signs Ht(m) — Braided Y (N)

Bars (%) — pH 6.68 O_2(ppm) 10.2

Water Temp.(°C) 5.5 Turb.(ntu) 0.41 Cond.(25°C) 57.1

DISCHARGE

Parameter	Value	Method	Specific Data
Wetted Width (m)	1.5		
Mean Depth (m)	0.15		
Mean Velocity (m/s)	0.35		
Discharge (m^3/s)	0.08		

REACH SYMBOL (Fish)

4 | 1, 27 | 1270

(Width, Valley, Channel, Slope) (Bed Material)

REVISED DEC. 97 55187

FISH SUMMARY

Species	No.	Size Range (mm)	Life Phase	Use	Method/Ref.
No Fish Observed					

STREAM/VALLEY CROSS-SECTION ☑ (Looking Downstream)

L R

PLANIMETRIC VIEW ☐

COMMENTS

Channel Stability ☐, Debris ☐, Management Concerns ☐, Obstructions ☐, Riparian Zone ☐, Valley Wall Processes ☐, Etc.

Edited by:

Date Y M D:

DFO/MOEP
STREAM SURVEY FORM

Stream Name (gaz.): Unnamed tributary (local): Trib F | Access: | Method:
Watershed Code: 1 | Reach No.: | Length(m): | Lthaur(km):
Location: 50m o/s of Mulgrave Access Rd. | Map#: 49 | U.T.M.: 5466303 | Site No.: 1 | Fish Card: Y (N) | Field ☑ Hist. ☐
Date Y M D: 010 | 12 | 210 | Time: 0910 | Agency: | Crew: IAS/ | Photos: 22-7 | Air Photos:

C	PARAMETER	VALUE	METH.	SPECIFIC DATA
	Ave.Chan.Width (m)	1.1		
	Ave.Wet.Width (m)	0.7		
	Ave.Max.Riffle Depth (cm)	0.05		
	Ave.Max.Pool Depth (cm)	0.10		
	Gradient %	12		
	% Pool 10 Rifle 90 Run — Other —			
	Side Chan.% 0 ☑ 0-10 ☐ 10-40 ☐ >40 ☐			
	Debris Area% 0 ☐ 0-5 ☑ 5-15 ☐ >15 ☐			
	Debris Stable % 90			
	COVER: Total % 10			
	Comp. sum 100% / Dp Pool / L.O.D. / Boulder / In Veg / Ovst Veg / Outbank: 5 / 75 / 10 / — / 10 / —			
	Crown Closure % 65% Aspect S			

BED MATERIAL

		%
Fines	clay,silt,sand (<2mm)	70
Gravels	small (2-16mm)	5
	large (16-64mm)	5
Larges	sm.cobble (64-128mm)	5
	lge.cobble (128-256mm)	5
	boulder (>256mm)	10
Bedrock (R)		0

D_{50} (cm): | Compaction: (L) M H

BANKS

Height(m): 0.8 | %Unstable: 0
Texture: F (G) L R

Confinement	EN	CO	(FC)	CC	UC	N/A
Valley: Channel Ratio	(0-2)	2-5	5-10	10+	N/A	
Stage	Dry	L	(M)	H	Flood	
Flood Signs Ht(m)	—	Braided	Y (N)		
Bars (%)	—	pH	6.92	O2ppm	11.1
Water Temp.(°C)	4.7	Turb.(cm)	—	Cond.(25°C)	50.5

OBSTRUCTIONS

C	Ht(m)	Type	Loc'n

DISCHARGE

Parameter	Value	Method	Specific Data
Wetted Width (m)			
Mean Depth (m)			
Mean Velocity (m/s)			
Discharge (m^3/s)			

REACH SYMBOL (Fish)

1119 | 7120

(Relief, Valley:Channel, Slope) (Bed Material)

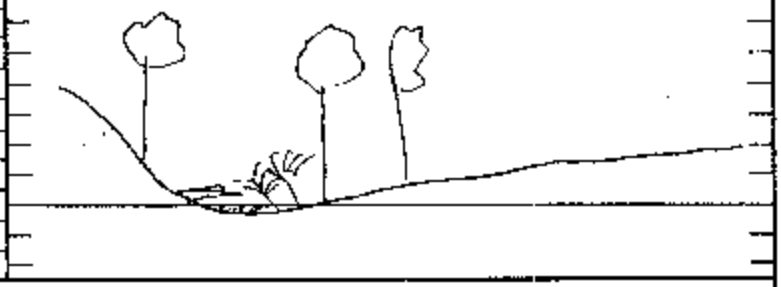
REVISED DEC. 87 SS1.87

FISH SUMMARY

C	Species	No.	Size Range (mm)	Life Phase	Use	Method/Ref.
	No Fish Observed					

STREAM/VALLEY CROSS-SECTION (Looking Downstream) ☑ — L — R

PLANIMETRIC VIEW ☐



COMMENTS

Channel Stability ☐, Debris ☐, Management Concerns ☐, Obstructions ☐, Riparian Zone ☐, Valley Wall Processes ☐, Etc.

Survey by:
Date Y M D

DFO/MOEP
STREAM SURVEY FORM

Stream Name (gaz.) Unnamed Trib to Pipe (local) TRIB G | Access | | Method
Watershed Code | Reach No. | | Length(km) |
Location 100 m u/s of Cypress Bowl Rd. | Map 48 56 08 | Site No. 1 | Lithaury(m) |
U.T.M. 5466317 | Fish Card Y (N) | Field ☑ Hist ☐
Date Y M D 00 12 20 | Time 1010 | Agency | Crew AS1 / | Photos 15-16 | Air Photos

C	PARAMETER	VALUE	METH.
	Ave.Chan.Width (m)	2.2	
	Ave.Wet.Width (m)	1.0	
	Ave.Max.Riffle Depth (cm)	3	
	Ave.Max.Pool Depth (cm)	8	
	Gradient %	17	
	% Pool 20 Rifle 80 Run + Other +		
	Side Chan.%	0 ☑ 0-10 ☐ 10-40 ☐ >40 ☐	
	Debris Amt%	0 ☐ 0-5 ☑ 6-15 ☐ >15 ☐	
	Stable % 75		
	COVER: Total % 5		
	Comp. sum 100%	Op Pool 60	L.O.D. 5	Boulder 35	Ab Veg –	Over Veg –	Cutbank –
	Crown Closure % 60	Aspect S	

SPECIFIC DATA

BED MATERIAL

		%
Fines	clay,silt,sand (<2mm)	10
Gravels	small (2–16mm)	20
	large (16–64mm)	20
Larger	sm.cobble (64–128mm)	25
	lge.cobble (128–256mm)	15
	boulder (>256mm)	10
Bedrock (R)		0

D_{90}(cm) – Compaction L (M) H

BANKS

Height(m) 0.5 %Unstable 10
Texture F G (L) R
Confinement BN (CO) FC OC UC N/A
Valley: Channel Ratio (1-1) 2-5 5-10 10+ N/A
Stage Dry L (M) H Flood
Flood Signs H(m) – Braided Y (N)
Bank (%) – pH 7.0 D.Oxy(mg) 12.4
Water Temp.(°C) 4.3 Turb.(cm) 0.33 Cond.(25°C) 59.6 ⇒ 96.6

DISCHARGE

Parameter	Value	Method	Specific Data
Wetted Width (m)	1.0		
Mean Depth (m)	0.05		
Mean Velocity (m/s)	0.15		
Discharge (m^3/s)	0.01		

REACH SYMBOL (Flush)

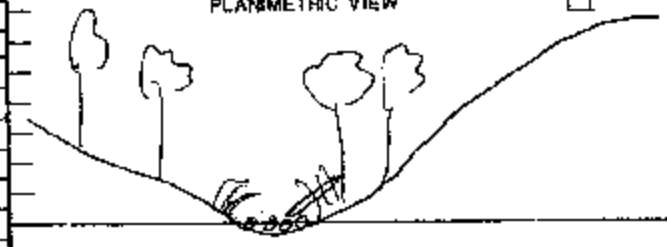
2117 | 1450
Width,Valley,Channel,Slope | Bed Material

REVISED DEC. 87 551 97

FISH SUMMARY

Species	No.	Size Range(mm)	Life Phase	Use	Method/Ref.
No Fish Observed					

STREAM/VALLEY CROSS-SECTION (Looking Downstream) ☐
L R
PLANIMETRIC VIEW ☐



COMMENTS

Channel Stability ☐, Debris ☐, Management Concerns ☐, Obstructions ☐, Riparian Zone ☐, Valley Wall Processes ☐, Etc.

Edited by:
Date Y M D:

DFO / MOEP
STREAM SURVEY FORM

Stream Name (geo.)	Pipe Creek	(local)					Access		Method
Watershed Code					Reach No.		Length(km)		
Location	170 m d/s of Cypress Bowl Rd.	Map#	48552.4		Site No.		Length(m)		
		U.T.M.	5466534		Fish Card	Y (N)		Field ☑	Hist. ☐
Date Y M D	00 12 20	Time	1100	Agency	Crew	AS /	Photos	17 – 18	Air Photos	

C	PARAMETER	VALUE	METH.	SPECIFIC DATA
	Ave.Chan.Width (m)	3.0		
	Ave.Wet.Width (m)	1.3		
	Ave.Max.Riffle Depth (cm)	3		
	Ave.Max.Pool Depth (cm)	15		
	Gradient %	36		
	% Pool 10 Rifle 90 Run + Other +			
	Side Chan.% 0 ☑ 0–10 ☐ 10–40 ☐ >40 ☐			
	Debris Amt% 0 ☐ 0–5 ☑ 5–15 ☐ >15 ☐			
	Debris Stable % 20			
	COVER: Total % 20			
	Comp. sum 100% 20	Dp Pool 5	L.O.D.	Boulder 75	In Veg —	Over Veg —	Cutbank —
	Crown Closure % 75	Aspect 5		

BED MATERIAL		%
Fines	clay, silt, sand (<2mm)	5
Gravels	small (2–16mm)	5
	large (16–64mm)	15
Larges	sm. cobble (64–128mm)	10
	lge. cobble to sm. boulder (128–256mm)	20
	boulder (>256mm)	30
Bedrock (R)		15

D_{50} (cm) — Compaction L M (H)

BANKS					
Height(m)	0.5	%Unstable	0		
Texture	F G (D) R				
Confinement	EN CO (FC)	OC	UC	N/A	
Valley: Channel Ratio	(0–2)	2–5	5–10	10+	N/A
Stage	Dry	L (M)	H	Flood	
Flood Signs Ht(m)	—	Braided	Y (N)		
Bars (%)		pH	6.37	D.O.ppm	13.1
Water Temp.(°C)	3.2	Turb.(cm)	0.33	Cond.@25°C	40.3

OBSTRUCTIONS

C	Ht(m)	Type	Loc'n
	1.2	LS	

DISCHARGE

Parameter	Value	Method	Specific Data
Wetted Width (m)	1.2		
Mean Depth (m)	0.05		
Mean Velocity (m/s)	0.5		
Discharge (m^3/s)	0.03		

REACH SYMBOL (Fish)

3136 | 1261

(Width, Valley:Channel, Slope) (Bed Material)

REVISED DEC. 87 SS187

FISH SUMMARY

Species	No.	Size Range (mm)	Life Phase	Use	Method/Ref.
No Fish Observed					

STREAM/VALLEY CROSS-SECTION ☐ (Looking Downstream)

PLANIMETRIC VIEW ☐

L R

COMMENTS

Channel Stability ☐, Debris ☐, Management Concerns ☐, Obstructions ☐, Riparian Zone ☐, Valley Wall Processes ☐, Etc.

Edited by:

Date Y M D:

DFO / MOEP
STREAM SURVEY FORM

Stream Name (gaz.) Unnamed trib to Pipe Cr. (local) Trib H — Access — Method

Watershed Code — Reach No. — Length (m) — Meander (m)

Location 20 m u/s of Pipe Cr. Confluence — Map # 485504 — Site No. — Fish Card Y (N) — Field ☑ Hist. ☐

U.T.M. 5466536 — Photos 19 to 20 — Air Photos

Date Y M D 00 12 20 — Time 1115 — Agency — Crew AS/ —

C	PARAMETER	VALUE	METH.	SPECIFIC DATA
	Ave. Chan. Width (m)	2.2		
	Ave. Wet. Width (m)	1.1		
	Ave. Max. Riffle Depth (cm)	3		
	Ave. Max. Pool Depth (cm)	6		
	Gradient %	33		
	% Pool 30 Riffle 70 Run — Other +			
	Side Chan. % 0 (✓) 5–10 10–40 >40			
	Debris Area % 0 (✓) 5–8 8–15 >15			
	Stable % 50			
	COVER: Total % 10			
	Comp. sum 100% — Dp Pool 70 — L.O.D. — Boulder 30 — In Veg — Over Veg — Outbank			
	Crown Closure % 60 — Aspect SE			

BED MATERIAL

		%
Fines	clay, silt, sand (<2mm)	10
Gravels	small (2–16mm)	5
	large (16–64mm)	5
Larger	sm. cobble (64–128mm)	10
	lge. cobble (128–256mm)	10
	boulder (>256mm)	60
Bedrock (BR)		0

D_{50} (cm) — Compaction (L) M H

BANKS

Height (m) 1.2 — % Unstable 0 — Texture F S (L) R

Confinement EN (CO) FC DC UC N/A

Valley: Channel Ratio 0–2 (2–5) 5–10 10+ N/A

Stage Dry L (M) H Flood

Flood Signs Ht (m) — — Braided Y (N)

Bars (%) — — pH 6.92 — D.O. (ppm) 9.85

Water Temp. (°C) 8.1 — Turb. (cm) 0.48 — Conduct. (25°C) 80.7 → 119.3

OBSTRUCTIONS

C	Ht (m)	Type	Loc'n
	—	—	—

DISCHARGE

Parameter	Value	Method	Specific Data
Wetted Width (m)	1.0		
Mean Depth (m)	0.05		
Mean Velocity (m/s)	0.6		
Discharge (m^3/s)	0.03		

REACH SYMBOL (Fish)

2133 | 1140

(W-Rib, Valley, Channel, Slope) — (Bed Material)

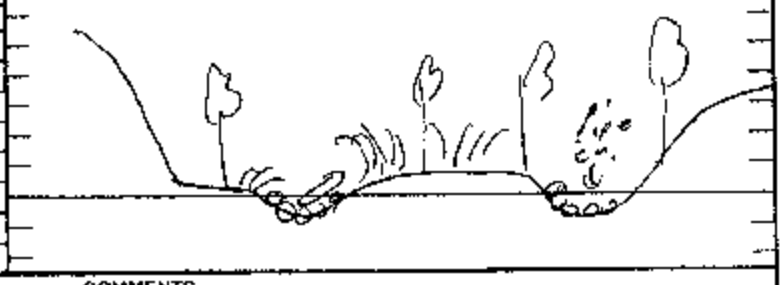
REVISED DEC. 87 — SS127

FISH SUMMARY

C	Species	No.	Size Range (mm)	Life Phase	Use	Method/Rel.
	No Fish Observed.					

STREAM/VALLEY CROSS-SECTION ☐ (Looking Downstream)

PLANIMETRIC VIEW ☐



COMMENTS

Channel Stability ☐, Debris ☐, Management Concerns ☐, Obstructions ☐, Riparian Zone ☐, Valley Wall Processes ☐, Etc.

Edited by:

Date Y M D:

DFO/MOEP
STREAM SURVEY FORM

Stream Name (gaz.) Unnamed Watercourse (local) Trib I — Access — Method

Watershed Code — Reach No. — Length(km)

Location 180 m d/s of Cypress Bowl Rd. — Map# 48537.4 — Site No. 1 — Length surv.(m)

U.T.M. 5466460 — Fish Card Y (N) — Field ☑ Hist. ☐

Date Y M D 01 12 20 — Time 1135 — Agency — Crew AS / — Photos 21-22 — Air Photos

C	PARAMETER	VALUE	METH.
	Ave.Chan.Width (m)	3.0	
	Ave.Wet.Width (m)	1.9	
	Ave.Max.Riffle Depth (cm)	4	
	Ave.Max.Pool Depth (cm)	8	
	Gradient %	25	
	% Pool 30 Rapids 70 Run + Other +		
	Side Chan.% 0 ☑ 0-10 ☐ 10-40 ☐ >40 ☐		
	Debris Area% 0 ☐ 0-5 ☑ 5-15 ☐ >15 ☐		
	Debris Stable % 20		
	COVER: Total % 50		
	Comp. sum 100% — Op Pool 15 — L.C.D. 5 — Boulder 180 — In Veg — — Over Veg — — Outbank — —		
	Crown Closure % 100 — Aspect SW		

SPECIFIC DATA

BED MATERIAL		%
Fines	clay,silt,sand (<2mm)	5
Gravels	small (2-16mm)	5
	large (16-64mm)	5
Larges	sm.cobble (64-128mm)	20
	lge.cobble (128-256mm)	20
	boulder (>256mm)	45
Bedrock (R)		0

D_{50} (cm) — — Compaction L (M) H

BANKS					
Height(m) 2.0	%Unstable 0				
Texture	F	G	(L)	R	
Confinement	(CN)	(CS)	FC	OC	UC N/A
Valley: Channel Ratio	0-2	2-5	(5-10)	10+	N/A
Stage	Dry	L	(M)	H	Flood
Flood Signs Ht(m) —		Braided		Y (N)	
Bars (%) —		pH	6.8	O2(ppm)	12.05
Water Temp.(°C) 5.4	Turb.(cm) 0.30	Cond.(25°C)	65.2		

OBSTRUCTIONS

Hist#	Type	Loc'n
Abundant		
Cascades		

DISCHARGE

Parameter	Value	Method	Specific Data
Wetted Width (m)	1.5		
Mean Depth (m)	0.04		
Mean Velocity (m/s)	0.70		
Discharge (m^3/s)	0.04		

REACH SYMBOL [Fish]

3525 | 1180

(Width,Valley:Channel,Slope) (Bed Material)

REVISED DEC 87 SS1 07

10.4.2

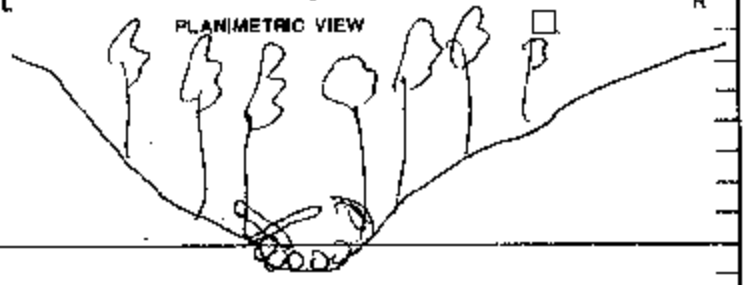
FISH SUMMARY

Species	No.	Size Range(mm)	Life Phase	Use	Method/Ref.
No Fish Observed					

STREAM/VALLEY CROSS-SECTION ☑
(Looking Downstream)

L R

PLAN/METRIC VIEW ☐



COMMENTS

Channel Stability ☐, Debris ☐, Management Concerns ☐, Obstructions ☐, Riparian Zone ☐, Valley Wall Processes ☐, Etc.

Edited by:

Date Y M D:

DFO/MOEP
STREAM SURVEY FORM

Stream Name (gaz.)	Unnamed Watercourse (local)	Trib J				Access		Method	
Watershed Code				Reach No.		Length(km)			
Location	150 m d/s of Cypress Bowl Rd.	Map#	48 5230	Site No.	1	Distance(m)			
		U.T.M.	5466 451	Fish Card	Y (N)		Field ☑	Hist. ☐	
Date Y M D	00 12 20	Time	1200	Agency		Crew	AS/ 1	Photos	23	Air Photos	

C	PARAMETER	VALUE	METH.
	Ave.Chan.Width (m)	2.2	
	Ave.Wet.Width (m)	0.8	
	Ave.Max.Riffle Depth (cm)	2	
	Ave.Max.Pool Depth (cm)	4	
	Gradient %	26	
	% Pool 5 Riffle 95 Run + Other +		
	Side Chan.% 0 ☑ 0–10 ☐ 10–40 ☐ >40 ☐		
	Debris Area% 0 ☐ 0–5 ☐ 5–15 ☐ >15 ☑ Stable % 50		
	COVER: Total %	10	
	Comp. Sum 100% — Dp Pool 5 — L.O.B. 20 — Boulder 75 — In Veg — — Over Veg — — Cutbank —		
	Crown Closure % 100 — Aspect S		

SPECIFIC DATA

BED MATERIAL

		%
Fines	clay, silt, sand (<2mm)	20
Gravels	small (2–16mm)	5
	large (16–64mm)	5
Larger	sm. cobble (64–128mm)	5
	lge. cobble (128–256mm)	30
	boulder (>256mm)	35
Bedrock (B)		0

D_{50} (cm) — Compaction L (M) H

BANKS

Height(m) 0.5 — % Unstable 0

Texture F G (I) R

Confinement EN CO (FC) OC UC N/A

Valley: Channel Ratio 0–2 2–5 (5–10) 10+ N/A

Stage D:Y L (M) H Flood

Flood Signs Ht(m) — — Braided Y (N)

Bars (%) — — pH 6.88 — O_2(ppm) 11.75

Water Temp.(°C) 6.6 — Turb.(cm) — — Cond.(25°C) 73.5-314.0

OBSTRUCTIONS

ID	#/km	Type	Loc'n

DISCHARGE

Parameter	Value	Method	Specific Data
Wetted Width (m)			
Mean Depth (m)			Minimal Flow
Mean Velocity (m/s)			
Discharge (m^3/s)			

REACH SYMBOL (Fish)

2526 | 2170

(Width, Valley, Channel, Slope) (Rosgen Modified)

REVISED DEC. 87 — SS187

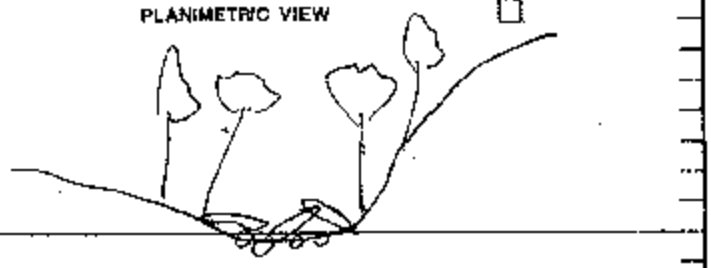
FISH SUMMARY

Species	No.	Size Range (mm)	Life Phase	Use	Method/Ref.
No Fish Observed					

STREAM/VALLEY CROSS-SECTION ☐ (Looking Downstream)

L — R

PLANIMETRIC VIEW ☐



COMMENTS

Channel Stability ☐, Debris ☐, Management Concerns ☐, Obstructions ☐, Riparian Zone ☐, Valley Wall Processes ☐, Etc.

Called by:

Date Y M D:

DFO / MOEP
STREAM SURVEY FORM

Stream Name (gaz.) Westmount Cr (local)
Watershed Code
Location 100 m d/s of Cypress Bowl Rd
Map 48 513
U.T.M. 546453
Date Y M D 01 12 20 Time 1230 Agency
Crew AS / /
Photos 83-162
Air Photos
Reach No. Site No. 1 Fish Card Y (N)
Access Length(m) Ltrsur(m) Method
Field ☑ Hist. ☐

C	PARAMETER	VALUE	METH.
	Ave.Chan.Width (m)	4.5	
	Ave.Wet.Width (m)	2.3	
	Ave.Max.Riffle Depth (cm)	5	
	Ave.Max.Pool Depth (cm)	20	
	Gradient %	21	
	% Pool 40 Riffle 60 Rapid — Other —		
	Side Chan.% 0 ☑ 0-5 ☐ 5-10 ☐ 10-40 ☐ >40 ☐		
	Debris Area% 0 ☐ 0-5 ☑ 5-25 ☐ >25 ☐		
	Stable % 50		
	COVER: Total % 20		
	Comp sum 100% 40	Dp Pool 10	L.O.D. 50	Boulder —	In Veg —	Over Veg —	Cutbank —
	Crown Closure % 75	Aspect 5	

SPECIFIC DATA

OBSTRUCTIONS

C	Hdml	Type	Loc'n

BED MATERIAL

		%
Fines	clay,silt,sand (<2mm)	5
Gravels	small (2-16mm)	5
	large (16-64mm)	10
Larges	sm.cobble (64-128mm)	10
	lge.cobble (128-256mm)	20
	boulder (>256mm)	50
Bedrock (R)		0

D_{50}(cm) — Compaction L (M) H

BANKS

Height(m) 1.5 %Unstable 0
Texture F G (V) R
Confinement EN (CO) FC OC UC N/A
Valley: Channel Ratio 0-2 (2-5) 5-10 10+ N/A
Stage Dry L (M) H Flood
Flood Signs Ht(m) — Braided Y (N)
Bars (%) — pH 6.63 O2(ppm) 12.6
Water Temp.(°C) 3.1 Turb.(cm) 0.41 Cond.(25°C) 51.2 → 788.8

DISCHARGE

Parameter	Value	Method	Specific Data
Wetted Width (m)	2.0		
Mean Depth (m)	0.05		
Mean Velocity (m/s)	0.6		
Discharge (m^3/s)	0.06		

REACH SYMBOL (Fish)

5221 | 0280

(Width,Val-y,Channel,Slope) (Bed Material)

REV SPD DEC 97 SS187

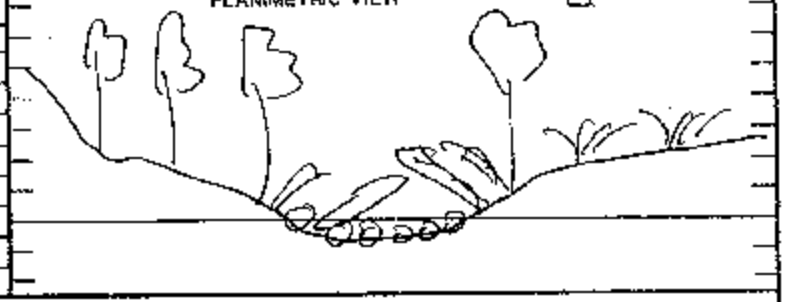
FISH SUMMARY

Species	No.	Size Range (mm)	Life Phase	Use	Method/Ref.
No Fish Observed					

STREAM/VALLEY CROSS-SECTION (Looking Downstream) ☐

L R

PLANIMETRIC VIEW ☐



COMMENTS

Channel Stability ☐, Debris ☐, Management Concerns ☐, Obstructions ☐, Riparian Zone ☐, Valley Wall Processes ☐, Etc.

Edited by:
Date Y M D:

DFO/MOEP
STREAM SURVEY FORM

Stream Name (gaz.) Unnamed Stream (local) Trib 12					Access		Method
Watershed Code			Reach No.		Length(km)		
Location 75 Metres South of Cypress Bowl Road	Map# 48507.9		Site No.	1	Lithology(m)		
	U.T.M. 5466477		Fish Card	Y (N)	Sketch	Field ☑	Mist. ☐
Date Y M D 00 12 20	Time 1251	Agency	Crew AS /	Photos R3 - 3	Air Photos		

C	PARAMETER	VALUE	METH.
	Ave.Chan.Width (m)	0.9	
	Ave.Wet.Width (m)	0.5	
	Ave.Max.Riffle Depth (cm)	2	
	Ave.Max.Pool Depth (cm)	3	
	Gradient %	21	
	% Pool — Riffle 100 Run — Other —		
	Side Chan.% 0 (0–10) ☐ (10–40) ☐ (>40) ☐		
	Debris Area% 0 ☐ (0–5) ☑ (5–15) ☐ (>15) ☐		
	Debris Stable % 100		
	COVER: Total % 10		
	Comp. sum 100% — Dp Pool 5 — LWD 75 — Boulder — — In Veg — — Over Veg 20 — Cutbank —		
	Crown Closure % 75 — Aspect SW		

SPECIFIC DATA: Flow starts ~~under~~ ~~from~~ under Large Boulder, possibly seeping from Upstream Cr.

BED MATERIAL		%
Fines	clay, silt, sand (<2mm)	90
Gravels	small (2–16mm)	0
	large (16–64mm)	0
Larges	sm. cobble (64–128mm)	5
	lge. cobble (128–256mm)	10
	boulder (>256mm)	5
Bedrock (R)		0

D_{50} (cm) — Compaction (L) M H

BANKS						
Height(m)	0.1	%Unstable	0			
Texture	(F) G L R					
Confinement	EN CO FC (CC) UC N/A					
Valley: Channel Ratio	(1-2) 2-5 5-10 10+ N/A					
Stage	Dry (L) M H Flood					
Flood Signs Hi(m)	—	Braided	Y (N)			
Bare (%)	—	pH	6.65	O2ppm	11.87	
Water Temp.(°C)	3.6	Turb.(cm)	0.18	Cond.(25°C)	51.4	

DISCHARGE			
Parameter	Value	Method	Specific Data
Wetted Width (m)			
Mean Depth (m)			Minimal Flow
Mean Velocity (m/s)			
Discharge (m^3/s)			

REACH SYMBOL (Fish)

1121 | 8020

(Width, Valley/Channel, Slope) (Bed Material)

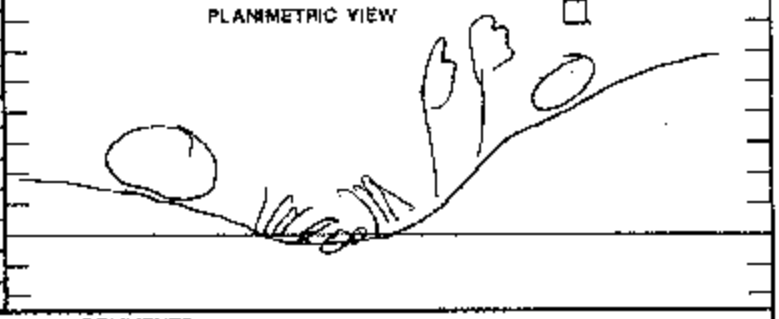
REVISED DEC. 87 SS167

FISH SUMMARY

Species	No.	Size Range (mm)	Life Phase	Use	Method/Ref.
No Fish Observed					

STREAM/VALLEY CROSS-SECTION (Looking Downstream) ☐

PLANIMETRIC VIEW ☐



COMMENTS

Channel Stability ☐, Debris ☐, Management Concerns ☐, Obstructions ☐, Riparian Zone ☐, Valley Wall Processes ☐, Etc.

Edited by:

Date Y M D:

DFO / MOEP
STREAM SURVEY FORM

Stream Name (gaz.) Cave Cr. (local) | Access | | Method

Watershed Code | Reach No. | Length (km) |

Location 30 m u/s of Cypress Bowl Rd. | Map # 484641 | Site No. 1 | Lithology |

U.T.M. 5466254 | Fish Card Y (N) | Field ☑ Hist. ☐

Date Y M D 90/12/20 | Time 1420 | Agency | Crew AS/ 1 | Photos 123:5-6 | Air Photos

C	PARAMETER	VALUE	METH.	SPECIFIC DATA
	Ave. Chan. Width (m)	2.5		
	Ave. Wet. Width (m)	23		
	Ave. Max. Riffle Depth (cm)	10		
	Ave. Max. Pool Depth (cm)	17		
	Gradient %	32		
	% Pool 10 Rifle 90 Run + Other +			
	Side Chan. % 0 ☐ 0-10 ☑ 10-40 ☐ >40 ☐			
	Debris Area % 0 ☐ 0-5 ☐ 5-15 ☑ >15 ☐			
	Stable % 75			
	COVER: Total % 25			
	Comp. sum 100% Dp Pool 10 L.O.D. 30 Boulder 60 m Veg — Over Veg — Outbank —			
	Crown Closure % 90	Aspect 5		

BED MATERIAL		%
Fines	clay, silt, sand (<2mm)	5
Gravels	small (2–16mm)	5
	large (16–64mm)	10
Larges	sm. cobble (64–128mm)	10
	lge. cobble (128–256mm)	30
	boulder (>256mm)	40
Bedrock (R)		0

D_{50} (cm) — | Compaction L (M) H

BANKS					
Height (m) 1.5	% Unstable 0				
Texture F G (S) R					
Confinement	EN	CD	(FC)	DC	UC N/A
Valley: Channel Ratio	0–2	(2–5)	5–10	10+	N/A
Stage	Dry	L	(M)	H	Flood
Flood Signs Ht (m)	—	Braided	(Ø)		
Bars (%) —	pH	7.04	O2 (ppm)	11.7	
Water Temp (°C) 6.9	Turb. (cm)	0.39	Cond. (25°C)	60.8	792.9

OBSTRUCTIONS

	Ht (m)	Type	Loc'n
	—		

DISCHARGE

Parameter	Value	Method	Specific Data
Wetted Width (m)			
Mean Depth (m)			
Mean Velocity (m/s)			
Discharge (m^3/s)			

REACH SYMBOL (Fish)

3232 | 0280

(Width, Valley, Channel) (Bed Material)

REVISED DEC. 87 SS137

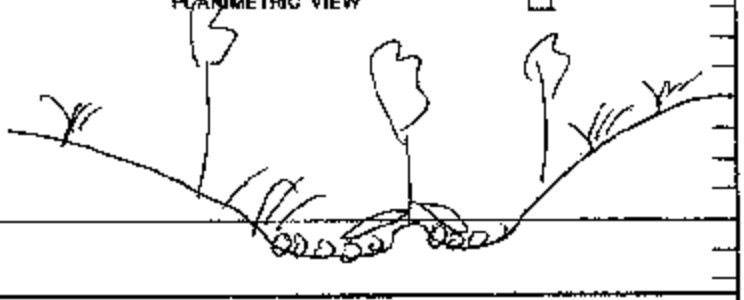
FISH SUMMARY

Species	No.	Size Range (mm)	Life Phase	Use	Method/Ref.
No Fish observed					

STREAM/VALLEY CROSS-SECTION ☐ (Looking Downstream)

L R

PLANIMETRIC VIEW ☐



COMMENTS

Channel Stability ☐, Debris ☐, Management Concerns ☐, Obstructions ☐, Riparian Zone ☐, Valley Wall Processes ☐, Etc.

Edited by

Date Y M D:

DFO / MOEP
STREAM SURVEY FORM

Stream Name (gaz.): Unnamed Watercourse (local): Trib. L — Access: — Method: —
Watershed Code: — Reach No.: — Length(km): —
Location: 30m u/s of Cypress Boul. Rd. — Map#: 48.4795 — Site No.: 1 — Lthaurv(m): —
U.T.M.: 5746212 — Fish Card: Y (N) — Field: ☑ Hist.: ☐
Date Y M D: 00 12 20 — Time: 1330 — Agency: — Crew: AS / — Photos: #23 - 4 — Air Photos: —

C	PARAMETER	VALUE	METH.	SPECIFIC DATA
	Ave.Chan.Width (m)	1.5		
	Ave.Wet.Width (m)	0.9		
	Ave.Max.Riffle Depth (cm)	3		
	Ave.Max.Pool Depth (cm)	6		
	Gradient %	17		
	% Pool 20 — Rffle 80 — Run — — Other —			
	Side Chan.% — 0 ☑ 0-10 ☐ 10-40 ☐ >40 ☐			
	Debris: Area% — 0 ☐ 0-5 ☑ 5-15 ☐ >15 ☐			
	Debris: Stable % 75			
	COVER: Total % 20			
	Comp. sum 100% — Dp Pool 5 — L.O.D. 75 — Boulder 20 — Ov Veg — — Over Veg — — Cutbank —			
	Crown Closure % 75 — Aspect SW			

SED MATERIAL

		%
Fines	clay,silt,sand (<2mm)	60
Gravels	small (2–16mm)	5
	large (16–64mm)	5
Larges	sm.cobble (64–128mm)	5
	lge.cobble (128–256mm)	5
	boulder (>256mm)	20
Bedrock (B)		0

D_{50}(cm): — Compaction: L (M) H

BANKS

Height(m): 0.8 — %Unstable: 0
Texture: F G (L) B
Confinement: EN CO (FC) OC UC N/A
Valley: Channel Ratio: (0-1) 1-2 2-5 5-10 10+ N/A
Stage: Dry L (M) H Flood
Flood Signs Ht(m): — — Braided: Y (N)
Bars (%): — — pH: 6.94 — D.(ppm): 11.0
Water Temp.(°C): 6.8 — Turb.(cm): — — Cond.(25°C): 59.7

OBSTRUCTIONS

O	Hkt(m)	Type	Loc'n
	—		

DISCHARGE

Parameter	Value	Method	Specific Data
Wetted Width (m)	0.75		
Mean Depth (m)	0.03		
Mean Velocity (m/s)	0.4		
Discharge (m^3/s)	0.008		

REACH SYMBOL (Fish): —

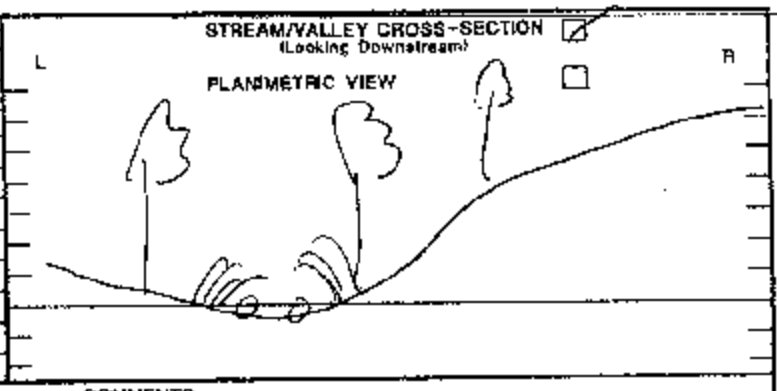
2117 | 6140
Bk(gh),Valley,Channel,Slope — Bed Material

REVISED DEC. 97 — SS#27

FISH SUMMARY

Species	No.	Size Range(mm)	Life Phase	Use	Method/Ref.
No Fish Observed.					

STREAM/VALLEY CROSS-SECTION ☑ (Looking Downstream)
PLANIMETRIC VIEW ☐



COMMENTS

Channel Stability ☐, Debris ☐, Management Concerns ☐, Obstructions ☐, Riparian Zone ☐, Valley Wall Processes ☐, Etc.

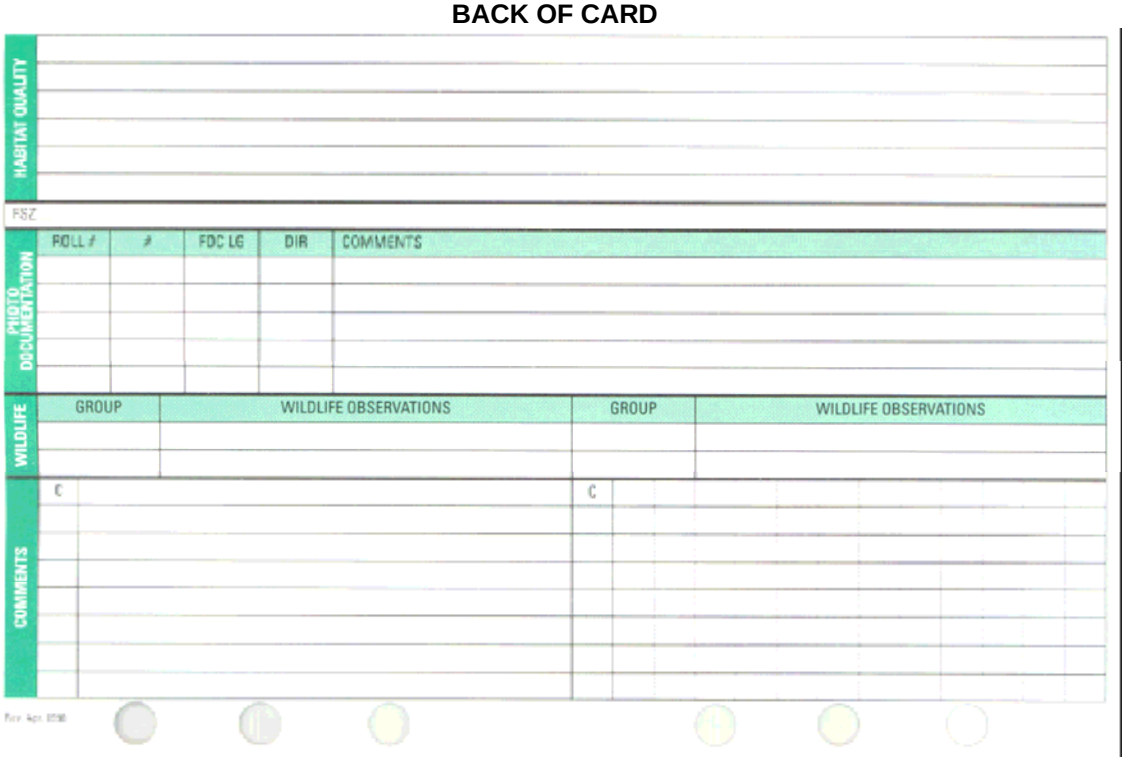
Edited by:
Date Y M D:

APPENDIX A – BLANK SITE CARD, TURNER CREEK

A blank Site Card of the type used for the Turner Creek survey is provided below for the convenience of the reader. As data-field titles on Site Cards are printed in black type on a grey background, their legibility when copied is limited. The standard provincial site card has changed in recent years from that used for the earlier stream surveys.

FRONT OF CARD

BACK OF CARD



7610000593

SITE CARD

TURNER

D	1	100 0494 065 5466 149 G P2	1000 HC	FT

2010 810 08 27	1 6 08	SL ML	Y (N)

CHANNEL

mhl	0	20	40	60	80	100		DN	C	UP
T	2.2	1.5	1.5	2.9	2.8	2.5				
T	1.7	0.9	0.5 2.0	1.8	1.2		T1	-20	+30	0
T	0.2	0.1	0.2 0.3	0.1	0.1		T11	-4	+15	100

0.6 0.5 0.5 T | L (M) H | No Vis. Ch. DW | Dry/Int. Tribs.

M

COVER

Type	SWD	LWD	B	U	DP	OV	IV
AMT	S	D	S	T	N	SD	N
LOC	P	P	P	P	P	P	P

0	1-20%	21-40%	41-70%	71-90%	>90%
0	1	2	(3)	4	5

N (F) A | C (E) | N A (M) V

U V (S) O | U V (S) O

(F) G C (B) R A | (F) G C (B) R A

N G S C D (M) W | N G S C D (M) W

INIT SHR (PS) YF MF NA | INIT SHR (PS) YF MF NA

WATER

C

S/cm

T M L C

NONE

MORPHOLOGY

B | F

50 | 6 | SPb-w

bedrdam	span ch	rdpls	bvd	SWD	LWD	jam
O1	B1	(B2)	B3	(D1)	(D2)	D3

cs ch	no pl	rilev br	mult ch	dv sne	hrm br	finger	lg wdg	ex bar	ex bd scr
C1	C2	C3	C4	C5	S1	S2	S3	S4	S5

TM ME IM IR (SI) ST

(N) O I F S AN

(N) SIDE DIAG MID SPAN BR

DC PC CO N/A

EN CO (FC) OC UN N/A

C

FEATURES

R__ F__

R__ F__

R__ F__

R__ F__

HABITAT QUALITY

FSZ

PHOTO DOCUMENTATION

PHOTOS - UP, DN, E W - STEVE'S PHOTOS FOR RAR TRANSECTS

- SEE RAR CARDS FOR TRANSECTS 1-11

WILDLIFE

COMMENTS

C Significant increase in fines in upper 50 m of reach

C

Rev. Apr. 1998
4500057365

DFO/MOEP
STREAM SURVEY FORM

Stream Name (gaz.) Godman Creek (local) Same — Access V, F — Method

Watershed Code — Length(km) —

Location ~ 90 m west of junction of access roads @ works yard = west branch — Map — U.T.M. — Photos (Y) N — Field ☐ Video ☐

Date Y M D 90 08 28 — Time — Agency CS — Crew SS / / — Photos — Air Photos

PARAMETER	VALUE	METH.	SPECIFIC DATA
Ave.Chan.Width (m)	2.3	TM	2.3 2.5 2.0
Ave.Wet.Width (m)	2.1	"	2.1 2.2 2.0
Ave Max.Riffle Depth (cm)	5	MS	5 6 5 4
Ave.Max.Pool Depth (cm)	30	"	25 40 45 very low d/s of road
Gradient %	5	CL	
% Pool 5 Rime 40 Rom 55 Other		GE	
Bank Chan.%		"	
Bank Wet%		"	
Stable %	50	"	
COVER: Total %	75	%	

Comp. sum 100%	Dp Pool	L.O.B.	Boulder	In Veg	Over Veg	Cutbank
	15	10	5		65	5

Crown Closure % 70 — Aspect S

BED MATERIAL

	%
Fines (clay,silt,sand <2mm)	10
small (2–16mm)	15
large (16–64mm)	20
sm.cobble (64–128mm)	25
lge cobble (128–256mm)	25
Boulder (>256mm)	

D_{50}(cm) 20 — Compaction L M H

BANKS

Height(m) .5 — %Unstable 15 — Texture (F) G L R

Confinement EN CO (FC) OC UC N/A

Valley: Channel Ratio (0–2) 2–5 5–10 10+ N/A

Dry L (M) H Flood

Flood Signs H(m) .5 — Braided Y (N)

Bars (%) 20 — pH — O2(ppm) —

Water Temp.(°C) — Turb.(cm) — Cond.(25°C) —

OBSTRUCTIONS

Num	Type	Loc'n

DISCHARGE

Parameter	Value	Method	Specific Data
Wetted Width (m)			
Mean Depth (m)			
Mean Velocity (m/s)			
Discharge (m^3/s)			

REACH SYMBOL (Fish)

CT

2A5 | 1450

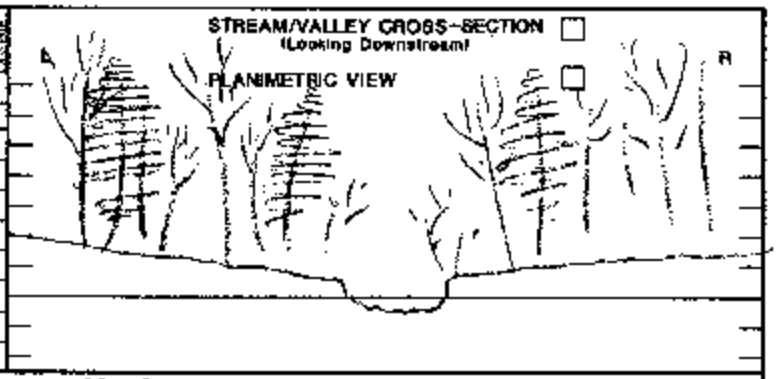
(Width,Valley,Channel,Shape) (Bed Material)

REVISED DEC. 87 — 5-81 87

FISH SUMMARY

Species	No.	Size Range (mm)	Life Phase	Use	Meth/Obs/Ref
CT		100-200			V

STREAM/VALLEY CROSS-SECTION (Looking Downstream) ☐



COMMENTS

Channel Stability ☐, Debris ☐, Management Concerns ☐, Obstructions ☐, Riparian Zone ☐, Valley Wall Processes ☐, Etc.

Surveyed creek below road where it flows from a wetland with large pool area ~ 0.5 m deep. Observed exit of wetland - single channel with small gravels over hardpan that is culverted under an old seismic road diff ward road + then joins the creek near the works yard (see diagram in notes) Upstream of road this creek is ditched along the north side of the road as it flows west - east along the ditch. CT observed in pool immediately below culvert under road.

Class A salmonid - bearing stream

Edited by:

Date Y M D:

DFO/MOEP
STREAM SURVEY FORM

(gaz.) Unnamed (local)

Access: V2 Method:

Length (km): 100

~30 m west of road junction west of work yard - East side Goodman Ck

Map: UTM: Y N

Date: 00 07 25 Time: Agency: Crew: SS / / Photos: Air Photos:

PARAMETER	VALUE	METH.	SPECIFIC DATA
Ave.Chan.Width (m)	2.9	TM	2.4 3.6 1.9 2.2 4.6
Ave.Wet.Width (m)	2.5	"	2.2 3.0 0.8 2.2 4.1
Ave.Max.Riffle Depth (cm)	4	MS	4 4 5
Ave.Max.Pool Depth (cm)	35	"	32 29 44
Gradient %	18	CL	
	10 10 10 10	GE	
	10	"	
Stable %	20	"	
COVER: Total %	50	"	

Comp. sum 100%	Sp Pool	L.O.D.	Boulder	In Veg	Over Veg	Outbank
	30	10	30		25	5

Crown Closure %: 80 Aspect: S

BED MATERIAL	%
clay,silt,sand (<2mm)	5
small (2–16mm)	5
large (16–64mm)	20
sm.cobble (64–128mm)	25
lg.cobble (128–256mm)	25
boulder (>256mm)	20
Bedrock	10

D_{90} (cm): 40 Compaction: L (M) H

BANKS					
Height (m): 1	% Unstable: 10				
Texture: (F) G L (R)					
Confinement: EN CO (FC) OC UC N/A					
Valley: Channel Ratio: (0-2) 2-5 5-10 10+ N/A					
	Dry L (M) H Flood				
Flood Signs Ht(m): 1	Braided: Y (N)				
Bars (%): 15	pH: 5.9	Cyprin: 12.2			
Water Temp.(°C): 5.2	Turb.(cm): 0.0	Cond.(25°C): 72			

REACH	Length	Type	Loc'n
5	C	4/8	

DISCHARGE

Parameter	Value	Method	Specific Data
Wetted Width (m)	2	TM	
Mean Depth (m)	.08	GE	
Mean Velocity (m/s)	.5	GE	
Discharge (m^3/s)			

REACH SYMBOL (Flah)

CT

3A 18 | 12 b 1

(Width,Valley,Channel,Slope) (Bed Material)

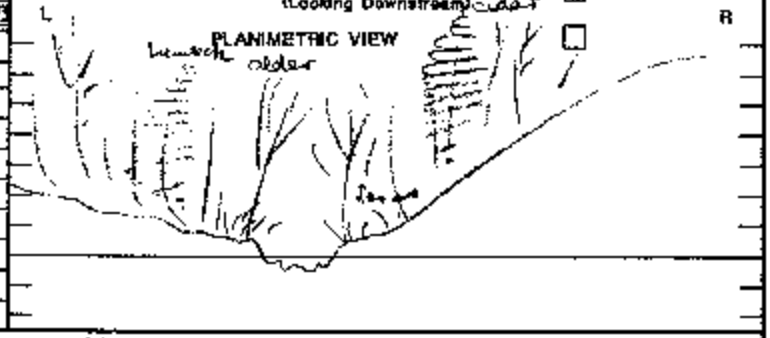
REVISED INFO BY: BS 87

FISH SUMMARY

Species	No.	Size Range (mm)	Life Phase	Use	Method (Ref.)
CT		100 - 200			

STREAM/VALLEY CROSS-SECTION

(Looking Downstream) ☐ ☐



COMMENTS

Channel Stability ☐, Debris ☐, Management Concerns ☐, Obstructions ☐, Riparian Zone ☐, Valley Wall Processes ☐, Etc.

Above road creek is braided for lower 50 m + other single thread spreading creek over boulders + bedrock. Hiked up ~ 100 m to where trail crosses creek. Cascades + chutes over bedrock. Braiding along road + above trail. Small ravine between trail + road. Step-pool habitat. Very steep u/s (>30°) with solid BR chutes + falls. Channel up to 11 m wide at base of BR chutes.

Top of bank was flagged by others using orange tape.

Class A stream to base of bedrock chute ~ 250 m u/s of road.

Edited by:

Date Y M D:

APPENDIX B
FISS Search Results for Westmount Creek and Godman Creek

Ecological Overview Report
Integrated Stormwater Management Plan
for Pipe, Westmount, Cave, Turner and Godman Creeks
SLR Project No. 201.88342

Back Main Queries Page

FISS Report

Gazetted Name :	WESTMOUNT CREEK
Watershed Code :	900-072700
Waterbody Identifier :	00000SQAM
Region :	2
Alias :	
Type :	**S**
Report created on :	Tue Nov 18 15:32:27 PST 2008

Water Quality Stations

No records found

Water Survey Stations

No records found

Management Objectives

Habitat Type	Objective 1	Objective 2
Anadromous River		

Enhancement

Activity	Start Year	Finish Year	Species Name	Comments	Reference Number	Geo Ref 1	Geo Ref 2
123 Bank Stabilization	9999			THIS REACH IS CONTROLLED BY WATERWAYS AND CULVERTS	2FBSRY	U 092G06 135	
210 Biophysical Surveys (unspecified)	9999			MOE STREAM REACH AND SITE CARDS AND SLIDES ON FILE	2FBSRY	W 264254	

Harvests and Uses

No records found

Resource Use

No records found

Resource Values

No records found

Resource Sensitivities

No records found

Land Use

No records found

Fisheries Potentials and Constraints

No records found

Obstructions

No records found

Escapements

No records found

Fish Distributions

No records found

Species and Life Phase History

No records found

Fiss References

Search EcoCat for keywords: WESTMOUNT CREEK

Reference Number :	2FBSRY
Title :	**FISHERIES BRANCH, SURREY: FISHERIES FILES: INVENTORY; ENHANCEMENT; BIOPHYSICAL DATA; & RECORDS OF PERSONAL COMMUNICATION**
Description :	UNPUBLISHED GOVERNMENT RECORDS
Location :	MOELP, FISHERIES BRANCH, SURREY
Reference code :	Personal Information/Communication
Year :	1995
Author :	MELP

1 references were found.

Top of Page

Back Main Queries Page

FISS Report

Gazetted Name :	GODMAN CREEK
Watershed Code :	900-073200
Waterbody Identifier :	00000SQAM
Region :	2
Alias :	
Type :	**S**
Report created on :	Tue Nov 18 15:30:33 PST 2008

Water Quality Stations

No records found

Water Survey Stations

No records found

Management Objectives

Habitat Type	Objective 1	Objective 2
Anadromous River		

Enhancement

Activity	Start Year	Finish Year	Species Name	Comments	Reference Number	Geo Ref 1	Geo Ref 2
210 Biophysical Surveys (unspecified)	1980			MOELP-STREAM REACH/SITE CARD SURVEY	2FBSRY	W 264255	

Harvests and Uses

No records found

Resource Use

No records found

Resource Values

No records found

Resource Sensitivities

No records found

Land Use

No records found

Fisheries Potentials and Constraints

No records found

Obstructions

Description	Height	Length	Comments	Species Name	Reference Number	Geo Ref 1	Geo Ref 2
Culvert	6	0	(MARINE DRIVE CULVERT REF# = 2FBSRY)		2FBSRY	P 092G06 140	

Escapements

No records found

Fish Distributions

Species Name	Stock / Stock Type	Stock Char	Management Class	Activity	Comments	Refs And Dates	Geo Ref 1	Geo Ref 2
Cutthroat Trout	/ NOT SPECIF	Adfluvial	Wild indigenous	OBL Fish observed at this point or zone	(PRESENCE NOTED REF# = 2FBSRY)	(2FBSRY, 01-JAN-1995)	W 264255	

Species and Life Phase History

No records found

Fiss References

Search EcoCat for keywords: GODMAN CREEK

Reference Number :	2FBSRY
Title :	**FISHERIES BRANCH, SURREY: FISHERIES FILES: INVENTORY; ENHANCEMENT; BIOPHYSICAL DATA; & RECORDS OF PERSONAL COMMUNICATION**
Description :	UNPUBLISHED GOVERNMENT RECORDS
Location :	MOELP, FISHERIES BRANCH, SURREY
Reference code :	Personal Information/Communication
Year :	1995
Author :	MELP

1 references were found.

Top of Page

APPENDIX C
Surface Water Sample Laboratory Data

Ecological Overview Report
Integrated Stormwater Management Plan
for Pipe, Westmount, Cave, Turner and Godman Creeks
SLR Project No. 201.88342

15-Aug-03

ANALYTICAL REPORT
Form 08123018

Client : SEACOR ENVIRONMENTAL INC.
Project : ROGERS 201.00890.00.0005

	Philip ID :	13038414	13038415	13038416	13038417	13038418
	Client ID :	MARR	ROGERS CREEK WEST	WESTMOUNT	CAVE	PIPE

Sparcode	Parameter	Unit	MDL					
PHYSICAL								
00021300	Color True	Col.Unit	5	20	5	5	< 5	< 5
00081071	Residue Nonfilterable (TSS)	mg/L	4	< 4	< 4	< 4	< 4	< 4
007H1035	Residue Filterable 1.0u (TDS)	mg/L	10	40	102	70	82	88
00151140	Turbidity	NTU	0.10	0.80	0.52	0.47	0.52	0.34
0107CALC	Hardness Total -T	mg/L		7.3	24.7	22.5	42.9	37.3
CARBON								
DOC-0913	Diss Org Carbon	mg/L	0.5	4.4	2.4	2.3	1.2	< 0.5
NITROGEN								
0113CALC	Total Kjeldahl Nitrogen (N)	mg/L		0.24	0.14	0.10	0.08	0.06
TN-WDGWA	Total Nitrogen	mg/L	0.02	1.04	0.73	0.34	0.39	0.58
0112CALC	Total Organic Nitrogen (N)	mg/L		0.22	0.14	0.10	< 0.10	< 0.10
11081351	Ammonia Nitrogen (N)	mg/L	0.005	0.023	< 0.005	< 0.005	< 0.005	0.005
1110CALC	Nitrate Nitrogen Dissolved (N)	mg/L		0.80	0.59	0.24	0.31	0.52
11091350	Nitrate+Nitrite (N)	mg/L	0.02	0.80	0.59	0.24	0.31	0.52
11111354	Nitrite Nitrogen (N)	mg/L	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
PHOSPHORUS								
11181380	Ortho-Phosphorus (P)	mg/L	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
P--D1390	Phosphorus Total Dissolved (P)	mg/L	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
P--T139A	Phosphorus Total (P)	mg/L	0.005	0.006	< 0.005	0.005	< 0.005	< 0.005
METALS TOTAL								
Ca-T0042	Calcium	mg/L	0.05	2.05	6.40	6.70	15.3	12.8
Mg-T0042	Magnesium	mg/L	0.05	0.53	2.11	1.41	1 15	1.29

Matrix :	Water	Water	Water	Water	Water
Sampled on:	03/08/06 11:00	03/08/06 15:45	03/08/07 13:30	03/08/07 16:00	03/08/07 09:00

PSC
ANALYTICAL SERVICES

8577 Commerce Court
Burnaby, B.C.
Canada V5A 4N5
Tel 604 444 4808
Fax 604 444 4511

Certificate of Analysis

Reported To :

SEACOR ENVIRONMENTAL INC. Client Code U1

200-1620 WEST 8TH AVENUE
VANCOUVER, BC
V6J 1V4

Attention : CHRIS SCHMIDT
Phone : (604) 738-2500
FAX : (604) 738-2508

Project Information :

Project ID : BPPL CYPRESS 201.00890.00.0006
Submitted By: CHRIS SCHMIDT

Requisition Forms :

Form 08103631 logged on 26-Apr-04 completed on 1-May-04

Remarks :

+ All blank values are reported. Associated data are not blank corrected.
+ 'MDL' = Method Detection Limit, '<' = Less than MDL, '—' = Not analyzed
+ Solids results are based on dry weight except Biota Analyses & Special Waste Oil & Grease
+ Organic analyses are not corrected for extraction recovery standards except for Isotope Dilution methods, (i.e. CARB 429 PAH, all PCDD/F and DBD/DBF analyses)
+ All CCME and/or BC CSR results met required criteria unless otherwise stated in the report. All data on final reports are validated by technical personnel. Signature on file at laboratory. Deviations from Reference Method for the Canadian-wide Standard for Petroleum Hydrocarbons in Soil - Tier 1 Method:
  - FI data - None
  - F2/F3/F4 data reported using validated cold solvent extraction instead of Soxhlet extraction
+ All Groundwater samples except BTEX/VOC's or Purgeable Hydrocarbons are decanted and/or filtered prior to analysis unless otherwise mandated by regulatory agency
+ This report shall not be reproduced except in full, without the written approval of the laboratory

Methods used by PSC are based upon those found in 'Standard Methods for the Examination of Water and Wastewater', 20th Edition, published by the American Public Health Association, or on US EPA protocols found in the 'Test Methods For Evaluating Solid Waste, Physical/Chemical Method, SW846', 3rd Edition. Other procedures are based on methodologies accepted by the appropriate regulatory agency. Methodology briefs are available by written request.

All work recorded herein has been done in accordance with normal professional standards using accepted testing methodologies, quality assurance and quality control procedures except where otherwise agreed to by the client and testing company in writing. Liability for any and all use of these test results shall be limited to the actual cost of the pertinent analysis done. There is no other warranty expressed or implied.
Your samples will be retained at PSC for a period of 30 days from receipt of data or as per contract.

PSC Project Manager: Chris Liu

Per: 21

ANALYTICAL REPORT
Form 08103631

Client : SEACOR ENVIRONMENTAL INC.
Project : BPPL CYPRESS 201.00890.00.0006

Sparcode	Parameter	Unit	MDL	Lab ID : 14016303 Client ID : GODMAN CREEK	14016304 SUBSTATION CREEK	14016305 CAULFIELD CREEK
PHYSICAL						
00021300	Color True	Col.Unit	5	< 5	< 5	30
007H1035	Residue Filterable 1.0u (TDS)	mg/L	10	50	10	16
00151140	Turbidity	NTU	0.10	0.71	0.11	0.58
1107CALC	Hardness Total -D	mg/L		23.1	6.9	7.3
CARBON						
DOC-0913	Diss Org Carbon	mg/L	0.5	2.2	1.9	4.9
NITROGEN						
0113CALC	Total Kjeldahl Nitrogen (N)	mg/L		0.07	0.05	0.19
TN-WDGWA	Total Nitrogen	mg/L	0.02	0.31	0.21	0.25
0112CALC	Total Organic Nitrogen (N)	mg/L		< 0.10	< 0.10	0.19
I112CALC	Total Inorganic Nitrogen (N)	mg/L		0.25	0.17	0.06
11081351	Ammonia Nitrogen (N)	mg/L	0.005	0.013	0.007	0.005
1110CALC	Nitrate Nitrogen Dissolved (N)	mg/L		0.24	0.16	0.06
11091350	Nitrate+Nitrite (N)	mg/L	0.02	0.24	0.16	0.06
11111354	Nitrite Nitrogen (N)	mg/L	0.005	< 0.005	< 0.005	< 0.005
PHOSPHORUS						
11181380	Ortho-Phosphorus (P)	mg/L	0.005	< 0.005	0.005	< 0.005
P--D1390	Phosphorus Total Dissolved (P)	mg/L	0.005	< 0.005	< 0.005	0.006
P--T139A	Phosphorus Total (P)	mg/L	0.005	< 0.005	< 0.005	0.009
METALS DISSOLVED						
Ca-D0031	Calcium Dissolved	mg/L	0.05	7.72	2.24	2.34
Mg-D0031	Magnesium Dissolved	mg/L	0.05	0.92	0.32	0.35
			Matrix :	Water	Water	Water
			Sampled on:	04/04/22 09:30	04/04/22 12:30	04/04/22 14:35

DUPLICATE SUMMARY
Form 08103631

Parameter	Client ID	Lab ID	Sample Conc.	Duplicate Conc.	MDL	Unit	Relative % Diff.
Calcium Dissolved	GODMAN CREEK	14016303	7.72	8.12	0.05	mg/L	-5.05
Magnesium Dissolved	GODMAN CREEK	14016303	0.92	0.94	0.05	mg/L	-2.15
Total Nitrogen	SUBSTATION CREEK	14016304	0.21	0.21	0.02	mg/L	0.00

03-May-04
Page 4 of 4

SPIKE SUMMARY
Form 08103631

Parameter	Client ID	Lab ID	Sample Conc.	Sample & Spike Conc.	Spike Amount	Unit	Percent Recovery
Residue Filterable 1.0u (TDS)	Blank Spike. Batch :	44401513	< 10	94	100	mg/L	94
Nitrite Nitrogen (N)	Blank Spike. Batch :	44101201	< 0.005	0.190	.2	mg/L	95
Nitrate+Nitrite (N)	Blank Spike. Batch :	44101201	< 0.02	0.80	.8	mg/L	101
Ammonia Nitrogen (N)	Blank Spike. Batch :	44101201	< 0.005	0.192	.2	mg/L	96
Total Nitrogen	Blank Spike. Batch :	44101204	< 0.02	0.59	.6	mg/L	97
Ortho-Phosphorus (P)	Blank Spike. Batch :	44101218	< 0.005	0.019	.02	mg/L	92
Phosphorus Total Dissolved (P)	Blank Spike. Batch :	44101197	< 0.005	0.019	.02	mg/L	94
Diss Org Carbon	Blank Spike. Batch :	44101199	< 0.5	10.6	10	mg/L	106
Turbidity	Blank Spike. Batch :	44401505	< 0.10	2.04	2	NTU	100
Calcium Dissolved	Blank Spike. Batch :	44201000	< 0.05	10.3	10	mg/L	103
Magnesium Dissolved	Blank Spike. Batch :	44201000	< 0.05	4.96	5	mg/L	99
Total Nitrogen	SUBSTATION CREEK	14016304	0.21	0.60	.4	mg/L	97

Your Project #: 201.88342.00
Your C.O.C. #: F115155

Attention: Jim Neville
SLR CONSULTING (CANADA) LTD.
#200 - 1620 WEST 8TH AVENUE
VANCOUVER, BC
Canada V6J 1V4

Report Date: 2008/09/05

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: A844687
Received: 2008/08/29, 11:10

Sample Matrix: Water
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Coliform by membrane filtration (1)	1	N/A	2008/08/29	BIO102 Rev 2.1	Based on SM-9222
E.coli by membrane filtration in Water (1)	1	N/A	2008/08/29	BIO102 Rev 2.1	Based on SM-9222
Fecal Coliform by membrane filtration (1)	1	N/A	2008/08/29	BIO102 Rev 2.1	Based on SM-9222
Hardness (calculated as CaCO3)	1	N/A	2008/09/04		
Na, K, Ca, Mg, S by CRC ICPMS (diss.)	1	N/A	2008/09/03	BRN SOP-00206	Based on EPA 200.8
Elements by CRC ICPMS (dissolved) (1)	1	N/A	2008/09/03	BRN SOP-00206	Based on EPA 200.8
Elements by CRC ICPMS (total) (1)	1	2008/09/04	2008/09/04	BRN SOP-00206	Based on EPA 200.8
Ammonia-N	1	N/A	2008/09/02	BRN SOP-00232 R3.0	SM-4500 NH3 G
Nitrate + Nitrite (N)	1	N/A	2008/09/03	ING233 Rev.4.4	Based on EPA 353.2
Nitrite (N) by CFA	1	N/A	2008/09/03	BRN SOP-00233 R1.0	EPA 353.2
Nitrogen - Nitrate (as N)	1	N/A	2008/09/03		
Filter and HNO3 Preserve for Metals	1	N/A	2008/09/03	BRN WI-00006 R1.0	Based on EPA 200.2
Orthophosphate by Konelab	1	N/A	2008/09/03		
Phosphorus-P (Total, dissolved) (1)	1	2008/09/02	2008/09/03	BRN SOP-00236 R4.0	SM-4500PF
Total Phosphorus	1	N/A	2008/09/03	BRN SOP-00236 R4.0	SM 4500

* Results relate only to the items tested.

(1) SCC/CAEAL

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

KIMBERLEY WEBBER, BBY Customer Service
Email: kim.webber@maxxamanalytics.com
Phone# (604) 444-4808 Ext:259

==========

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. SCC and CAEAL have approved this reporting process and electronic report format.

Total cover pages: 1

Maxxam Job #: A844687
Report Date: 2008/09/05

SLR CONSULTING (CANADA) LTD.
Client Project #: 201.88342.00

Sampler Initials: JN

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		L36378		
Sampling Date		2008/08/28 9:30		
	Units	**GODMAN CREEK**	**RDL**	**QC Batch**
Preparation				
Filter and HNO3 Preservation	N/A	FIELD	N/A	ONSITE
ANIONS				
Nitrite (N)	mg/L	ND	0.005	2544608
Calculated Parameters				
Nitrate (N)	mg/L	0.95	0.02	2540804
Nutrients				
Ammonia (N)	mg/L	0.05	0.01	2545502
Orthophosphate (P)	mg/L	ND	0.005	2543981
Dissolved Phosphorus (P)	mg/L	ND	0.005	2543918
Nitrate plus Nitrite (N)	mg/L	0.95	0.02	2544601
Total Phosphorus (P)	mg/L	0.005	0.005	2543927

MICROBIOLOGY (WATER)

Maxxam ID		L36378		
Sampling Date		2008/08/28 9:30		
	Units	**GODMAN CREEK**	**RDL**	**QC Batch**
Microbiological Param.				
Coliform	CFU/100mL	1500	100	2542455
Escherichia coli	CFU/100mL	500	20	2542485
Fecal coliform	CFU/100mL	500	1	2542807

N/A = Not Applicable
ND = Not detected
RDL = Reportable Detection Limit

Maxxam Job #: A844687
Report Date: 2008/09/05

SLR CONSULTING (CANADA) LTD.
Client Project #: 201.88342.00

Sampler Initials: JN

CSR DISSOLVED METALS - WATER (WATER)

Maxxam ID		L36378		
Sampling Date		2008/08/28 9:30		
	Units	**GODMAN CREEK**	**RDL**	**QC Batch**
Misc. Inorganics				
Dissolved Hardness (CaCO3)	mg/L	21.8	0.5	2540203
Dissolved Metals by ICPMS				
Dissolved Aluminum (Al)	ug/L	59	1	2546749
Dissolved Antimony (Sb)	ug/L	ND	0.5	2546749
Dissolved Arsenic (As)	ug/L	0.1	0.1	2546749
Dissolved Barium (Ba)	ug/L	14	1	2546749
Dissolved Beryllium (Be)	ug/L	ND	0.1	2546749
Dissolved Bismuth (Bi)	ug/L	ND	1	2546749
Dissolved Boron (B)	ug/L	ND	50	2546749
Dissolved Cadmium (Cd)	ug/L	0.01	0.01	2546749
Dissolved Chromium (Cr)	ug/L	ND	1	2546749
Dissolved Cobalt (Co)	ug/L	ND	0.5	2546749
Dissolved Copper (Cu)	ug/L	1.0	0.2	2546749
Dissolved Iron (Fe)	ug/L	75	5	2546749
Dissolved Lead (Pb)	ug/L	ND	0.2	2546749
Dissolved Manganese (Mn)	ug/L	5	1	2546749
Dissolved Mercury (Hg)	ug/L	ND	0.02	2546749
Dissolved Molybdenum (Mo)	ug/L	ND	1	2546749
Dissolved Nickel (Ni)	ug/L	ND	1	2546749
Dissolved Selenium (Se)	ug/L	ND	0.1	2546749
Dissolved Silicon (Si)	ug/L	3860	100	2546749
Dissolved Silver (Ag)	ug/L	ND	0.02	2546749
Dissolved Strontium (Sr)	ug/L	39	1	2546749
Dissolved Thallium (Tl)	ug/L	ND	0.05	2546749
Dissolved Tin (Sn)	ug/L	ND	5	2546749
Dissolved Titanium (Ti)	ug/L	ND	5	2546749
Dissolved Uranium (U)	ug/L	0.1	0.1	2546749
Dissolved Vanadium (V)	ug/L	ND	5	2546749
Dissolved Zinc (Zn)	ug/L	5	5	2546749
Dissolved Zirconium (Zr)	ug/L	ND	0.5	2546749
Dissolved Calcium (Ca)	mg/L	7.37	0.05	2547108
Dissolved Magnesium (Mg)	mg/L	0.82	0.05	2547108
Dissolved Potassium (K)	mg/L	0.59	0.05	2547108
Dissolved Sodium (Na)	mg/L	8.27	0.05	2547108
Dissolved Sulphur (S)	mg/L	ND	3	2547108

ND = Not detected
RDL = Reportable Detection Limit

Maxxam Job #: A844687
Report Date: 2008/09/05

SLR CONSULTING (CANADA) LTD.
Client Project #: 201.88342.00

Sampler Initials: JN

CSR TOTAL METALS - WATER (WATER)

Maxxam ID		L36378		
Sampling Date		2008/08/28 9:30		
	Units	**GODMAN CREEK**	**RDL**	**QC Batch**
Total Metals by ICPMS				
Total Lead (Pb)	ug/L	0.2	0.2	2550003

RDL = Reportable Detection Limit

Maxxam Job #: A844687
Report Date: 2008/09/05

SLR CONSULTING (CANADA) LTD.
Client Project #: 201.88342.00

Sampler Initials: JN

General Comments

Maxxam Job #: A844687
Report Date: 2008/09/05

SLR CONSULTING (CANADA) LTD.
Client Project #: 201.88342.00

Sampler Initials: JN

QUALITY ASSURANCE REPORT

			Matrix Spike		Spike		Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits
2542455	Coliform	2008/08/29					ND, RDL=1	CFU/100mL	NC	45
2542485	Escherichia coli	2008/08/29					ND, RDL=1	CFU/100mL	NC	45
2542807	Fecal coliform	2008/08/29					ND, RDL=1	CFU/100mL	8.7	45
2543918	Dissolved Phosphorus (P)	2008/09/03	112	80 - 120	115	80 - 120	ND, RDL=0.005	mg/L	0.2	20
2543927	Total Phosphorus (P)	2008/09/03	94	80 - 120	108	80 - 120	ND, RDL=0.005	mg/L	NC	25
2543981	Orthophosphate (P)	2008/09/03	115	80 - 120	113	80 - 120	ND, RDL=0.005	mg/L	NC	20
2544601	Nitrate plus Nitrite (N)	2008/09/03	100	80 - 120	103	80 - 120	ND, RDL=0.02	mg/L	0.5	25
2544608	Nitrite (N)	2008/09/03	103	80 - 120	103	80 - 120	ND, RDL=0.005	mg/L	NC	25
2545502	Ammonia (N)	2008/09/02	98	80 - 120	96	80 - 120	ND, RDL=0.01	mg/L	2.3	25
2546749	Dissolved Arsenic (As)	2008/09/03	93	75 - 125	98	75 - 125	ND, RDL=0.1	ug/L	NC	25
2546749	Dissolved Beryllium (Be)	2008/09/03	98	75 - 125	97	75 - 125	ND, RDL=0.1	ug/L	NC	25
2546749	Dissolved Cadmium (Cd)	2008/09/03	97	75 - 125	98	75 - 125	ND, RDL=0.01	ug/L	0.3	25
2546749	Dissolved Chromium (Cr)	2008/09/03	94	75 - 125	97	75 - 125	ND, RDL=1	ug/L	NC	25
2546749	Dissolved Cobalt (Co)	2008/09/03	88	75 - 125	92	75 - 125	ND, RDL=0.5	ug/L	NC	25
2546749	Dissolved Copper (Cu)	2008/09/03	89	75 - 125	95	75 - 125	ND, RDL=0.2	ug/L	NC	25
2546749	Dissolved Lead (Pb)	2008/09/03	95	75 - 125	100	75 - 125	ND, RDL=0.2	ug/L	NC	25
2546749	Dissolved Nickel (Ni)	2008/09/03	95	75 - 125	99	75 - 125	ND, RDL=1	ug/L	NC	25
2546749	Dissolved Selenium (Se)	2008/09/03	98	75 - 125	96	75 - 125	ND, RDL=0.1	ug/L	NC	25
2546749	Dissolved Uranium (U)	2008/09/03	95	75 - 125	99	75 - 125	ND, RDL=0.1	ug/L	NC	25
2546749	Dissolved Vanadium (V)	2008/09/03	93	75 - 125	97	75 - 125	ND, RDL=5	ug/L	NC	25
2546749	Dissolved Zinc (Zn)	2008/09/03	NC	75 - 125	107	75 - 125	ND, RDL=5	ug/L	NC	25
2546749	Dissolved Aluminum (Al)	2008/09/03					ND, RDL=1	ug/L	11.8	25
2546749	Dissolved Antimony (Sb)	2008/09/03					ND, RDL=0.5	ug/L	NC	25
2546749	Dissolved Barium (Ba)	2008/09/03					ND, RDL=1	ug/L	NC	25
2546749	Dissolved Bismuth (Bi)	2008/09/03					ND, RDL=1	ug/L	NC	25
2546749	Dissolved Boron (B)	2008/09/03					ND, RDL=50	ug/L	NC	25
2546749	Dissolved Iron (Fe)	2008/09/03					ND, RDL=5	ug/L	3.9	25
2546749	Dissolved Manganese (Mn)	2008/09/03					ND, RDL=1	ug/L	NC	25
2546749	Dissolved Mercury (Hg)	2008/09/03					ND, RDL=0.02	ug/L	NC	25
2546749	Dissolved Molybdenum (Mo)	2008/09/03					ND, RDL=1	ug/L	NC	25
2546749	Dissolved Silicon (Si)	2008/09/03					ND, RDL=100	ug/L	0.4	25
2546749	Dissolved Silver (Ag)	2008/09/03					ND, RDL=0.02	ug/L	NC	25
2546749	Dissolved Strontium (Sr)	2008/09/03					ND, RDL=1	ug/L	2.3	25
2546749	Dissolved Thallium (Tl)	2008/09/03					ND, RDL=0.05	ug/L	NC	25
2546749	Dissolved Tin (Sn)	2008/09/03					ND, RDL=5	ug/L	NC	25
2546749	Dissolved Titanium (Ti)	2008/09/03					ND, RDL=5	ug/L	NC	25
2546749	Dissolved Zirconium (Zr)	2008/09/03					ND, RDL=0.5	ug/L	NC	25
2547108	Dissolved Calcium (Ca)	2008/09/03					ND, RDL=0.05	mg/L		
2547108	Dissolved Magnesium (Mg)	2008/09/03					ND, RDL=0.05	mg/L		
2547108	Dissolved Potassium (K)	2008/09/03					ND, RDL=0.05	mg/L		

Maxxam Job #: A844687
Report Date: 2008/09/05

SLR CONSULTING (CANADA) LTD.
Client Project #: 201.88342.00

Sampler Initials: JN

QUALITY ASSURANCE REPORT

			Matrix Spike		Spike		Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits
2547108	Dissolved Sodium (Na)	2008/09/03					ND, RDL=0.05	mg/L		
2547108	Dissolved Sulphur (S)	2008/09/03					ND, RDL=3	mg/L		
2550003	Total Lead (Pb)	2008/09/04	100	75 - 125	101	75 - 125	ND, RDL=0.2	ug/L	NC	25

N/A = Not Applicable
ND = Not detected
NC = Non-calculable
RDL = Reportable Detection Limit
RPD = Relative Percent Difference

APPENDIX D
In Situ Water Quality Data

Ecological Overview Report
Integrated Stormwater Management Plan
for Pipe, Westmount, Cave, Turner and Godman Creeks
SLR Project No. 201.88342

APPENDIX D: ISMP STUDY AREA
IN SITU WATER QUALITY DATA, SAMPLED VARIOUS TIMES 2000 TO 2008

Creek	Date	Time	Temp (°C)	Dissolved Oxygen Concentration (mg/L)	Dissolved Oxygen (% Saturation)	pH	Specific Conductivity (µS/cm)	Salinity (%)	Turbidity (NTU)	Location
Pipe Creek [b]	22-Aug-2003	9:00	14.5	9.5	NM	7.2	112	NM		Approximately 15 m upstream of Cypress Bowl Road
Pipe Creek [a]	7-Aug-2003	9:00	13.99	8.4	NM	6.9	104	NM		Approximately 50 m upstream of Cypress Bowl Road
Pipe Creek	1-Dec-2000	NM	3.2	13.1	NM	6.3	40.3	NM		Above Cypress Bowl Road
Pipe Creek	24-Jan-2006	14:25	7.18	12.8	103.8	7.1	45	0.02		Just above culvert at Cypress Bowl Road
Pipe Creek	29-Jun-2006	9:35	12.46	11.3	105.9	6.5	78	0.04		5 m above culvert at lower Cypress Bowl Road
Pipe Creek	27-Aug-2008	10:00	13.15	10.34	98.6	6.5	112	NM	3.69	Approximately 60 m north of Mathers Avenue
Pipe Creek	28-Aug-2008	8:30	11.9	10.8	99.8	6.47	53	NM	0.41	Approximately 8 m north of Cypress Bowl Road
Westmount Creek [a]	7-Aug-2003	13:00	16.4	7.9	NM	6.9	89	NM		Approximately 10 m upstream of Cypress Bowl Road
Westmount Creek [b]	22-Aug-2003	9:15	15.1	7.4	NM	6.5	124	NM		Approximately 10 m upstream of Cypress Bowl Road
Westmount Creek	1-Dec-2000	NM	3.1	12.6	NM	6.6	51.2	NM		Above Cypress Bowl Road
Westmount Creek	24-Jan-2006	14:40	6.1	13	105	6.9	44	0.02		Bottom of waterfall above Cypress Bowl Road
Westmount Creek	28-Jun-2006	9:00	13.58	11.2	107.8	6.5	66	0.03		Above culvert at lower Cypress Bowl Road
Westmount Creek	27-Aug-2008	11:40	13.61	10.32	99.3	7.05	90	NM	2.01	Approximately 5 m north of Mathers Ave.
Westmount Creek	28-Aug-2008	8:45	12.3	10.59	98.8	6.52	58	NM	1.23	Approximately 6 m north of Cypress Bowl Road
Cave Creek [a]	7-Aug-2003	15:30	15.38	8.1	NM	6.9	85	NM		Approximately 10 m upstream of Cypress Bowl Road (right side flow)
Cave Creek [b]	22-Aug-2003	9:40	13.2	10.1	NM	7.7	125	NM		Approximately 10 m upstream of Cypress Bowl Road (left side flow)
Cave Creek	1-Dec-2000	NM	6.9	11.7	NM	7	60.8	NM		Above Cypress Bowl Road
Cave Creek	24-Jan-2006	14:55	7.04	12.6	NM	7	39	0.02		Culvert entry above Cypress Bowl Road
Cave Creek	30-Jun-2006	12:46	12.94	11.2	106.5	6.7	63	0.03		Above culvert at lower Cypress Bowl Road
Cave Creek	27-Aug-2008	12:20	13.78	9.75	94.3	7.48	131	NM	0.99	Approximately 4 m above Mathers Avenue
Cave Creek	28-Aug-2008	9:00	12.89	10.58	100	6.28	50	NM	0.54	Approximately 8 m above Cypress Bowl Road
Turner Creek	27-Aug-2008	13:00	14.52	10.01	98.2	7.47	317	NM	2.07	Approximately 3 m above Mathers Avenue
Turner Creek	28-Aug-2008	9:30	14.4	9.83	96.4	6.84	208	NM	75.2	Approximately 8 m south of the culvert under Cypress Bowl Road
Godman Creek	24-Jan-2006	15:15	6.13	12.9	104.4	7	28	0.01		Just above culvert at Eagle Lake Road
Godman Creek	23-Jun-2006	15:55	12.09	11.2	105.9	6.3	42	0.02		7 m below culvert at Eagle Lake Road
Godman Creek	27-Aug-2008	14:45	14.15	9.79	95.3	7.51	149	NM	1.4	Approximately 25 m downstream of Bayridge Avenue
Godman Creek	28-Aug-2008	9:45	12.53	10.39	97.6	6.5	44	NM	0.27	Approximately 5 m north of Eagle Lake Road

NOTES:

[a] Minisonde used. Automatic water circulator not functioning. DO readings have limited accuracy

[b] pH/cond. meter #1 used. Hoskin rental DO meter used. Both calibrated by MM.

NW = No water (no flow, no standing water).

NM = Not measured or not recorded

Results dated 1-Dec-2000 were actually for work conducted December 16, 17, 20 and 12, 2000; precise dates when each site was sampled could not be confirmed

APPENDIX E
Benthic Invertebrae Community Sampling Results, Godman Creek, Site G1

Ecological Overview Report
Integrated Stormwater Management Plan
for Pipe, Westmount, Cave, Turner and Godman Creeks
SLR Project No. 201.88342

APPENDIX E, TABLE 1: PHYSICAL AND WATER QUALITY DATA, BENTHIC INVERTEBRATE SURVEY, GODMAN CREEK SITE G1

Rep.[1]	Distance Downstream of Westridge Culvert	UTM	Time	Weather	Temperature		Turbidity	Wetted Width	Bankfull Width	Wetted Depths[3]	Bankfull Depths[3]	Average Riffle Depth	Embeddedness	Compaction	Substrate (%)					Gradient (%)	
					Water	Air									Fines	Gravel	Cobble	Boulder	Rock	Up	Down
	(m)				(°C)	(°C)	(NTU)[2]	(m)	(m)	(cm)	(cm)	(cm)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
1	46.3	0483994 5466984	1840	Clear	14.5	22.0	0 - 1	2.55	3.35	10, 10, 12, 11, 10, 7, 0, 0	22, 56, 51, 39, 52, 46, 43, 7	11	25	50	15	40	40	5	0	+4	-1
2	40.4												25	50							
3	32.5	0483980 5465985	1716	Clear	14.0	20.0	0 - 1	2.60	3.35	0, 30, 8, 10, 7, 5, 0, 0	38, 65, 60, 66, 58, 65, 41, 24	10	20	40	15	40	35	10	0	+3	-4
4	11.5	0483992 5466003	1737	Clear	14.0	18.0	0 - 1	3.40	4.10	0, 5, 6, 5, 4, 6, 11, 17, 5, 0	12, 21, 35, 34, 32, 34, 38, 34, 25, 19	11	10	30	25	30	30	15	0	+3	-3
Above Westridge Avenue[4]:			0935				0.87														

Notes:

1. Due to the relatively short distance between Replicates 1 and 2 and their habitat similarity, all physical and water quality measurements (except Embeddedness and Compaction) for Replicates 1 and 2 were taken at the Replicate 1 location.
2. Turbidity above Westridge Avenue measured with a HACH 2100P Turbidimeter at same time as in situ water samples were taken for lab analysis. Turbidity at Replicates 1 - 2, 3, and 4was estimated visually during benthic invertebrate sampling.
3. Bankfull and Wetted Channel Depths are 0.5 m apart from the 5 banks with the first and last measurements taken 0.1 m from the streambank edge.
4. Embeddedness - the extent to which gravel, cobble and boulders and snags are covered or sunken into the silt, sand or mud of the stream bottom
5. Compaction - the degree to which stream substrates become cemented as gaps become packed with sediment or when high flows scour the stream bottom (The Stream Reach in the Stream Sense Manual http://www.ew.govt.nz)

m = metres
cm = centimetres
mps = metres per second
°C = degrees Celsius
NTU = Nephelometric Turbidity Units

APPENDIX B, TABLE 2: BENTHIC INVERTEBRATE ABUNDANCE, DENSITY, AND PROPORTION BY ORDER/PHYLUM, GODMAN CREEK SITE G1

Taxon	Number of Taxa	Mean Density (Individuals/m^2)	Standard Deviation	Standard Error	Median	Minimum	Maximum	Mean Abundance (Individuals/ 0.09 m^2 - Per Replicate)	Standard Deviation	Standard Error	Median	Minimum	Maximum	Proportion of Sample (%)	TOTAL Abundance (Individuals/ 0.36 m^2 -Sum of Replicates)
Arthropoda - Hydracarina	1	11.11	22.22	11.11	0.00	0.00	44.44	1.00	2.00	1.00	0.00	0.00	4.00	1.1%	4
Collembola	1	2.78	5.56	2.78	0.00	0.00	11.11	0.25	0.50	0.25	0.00	0.00	1.00	0.3%	1
Ephemeroptera	4	75.00	66.90	33.45	61.11	11.11	166.67	6.75	6.02	3.01	5.50	1.00	15.00	7.2%	27
Plecoptera	4	15.89	5.56	2.78	11.11	11.11	22.22	1.25	0.50	0.25	1.00	1.00	2.00	1.3%	5
Trichoptera	8	311.11	301.00	150.92	227.78	44.44	744.44	28.00	27.17	13.58	20.50	4.00	67.00	29.7%	112
Coleoptera	1	2.78	5.56	2.78	0.00	0.00	11.11	0.25	0.50	0.25	0.00	0.00	1.00	0.3%	1
Diptera	5	100.00	70.27	35.14	88.89	33.33	188.89	9.00	6.32	3.16	8.00	3.00	17.00	9.5%	36
Hemiptera	1	2.78	5.56	2.78	0.00	0.00	11.11	0.25	0.50	0.25	0.00	0.00	1.00	0.3%	1
Annelida	2	527.78	100.30	54.15	483.33	455.56	666.99	47.50	9.75	4.87	43.50	41.00	62.00	50.4%	190

APPENDIX E, TABLE 3: BENTHIC INVERTEBRATE ABUNDANCE, DENSITY, AND PROPORTION BY TAXA, GODMAN CREEK SITE G1

TAXON				Total Station - Godman Creek													
ORDER	FAMILY	GENUS	SPECIES	Mean Density (individuals/m²)	Standard Deviation	Standard Error	Median	Minimum	Maximum	Mean Abundance (individuals/ 0.09 m² Per Replicate)	Standard Deviation	Standard Error	Median	Minimum	Maximum	Proportion of Sample (%)	TOTAL Abundance (individuals/ 0.36 m² Sum of Replicates)
PHYLUM ARTHROPODA																	
Acariformes (Acarina)	Hydracarina			11	22.2	11.1	0.0	0.0	44.4	1.0			1.0	1.0	4.0	1.1%	4
Collembola	Arthropleona			3	5.6	2.8	0.0	0.0	11.1	0.3			1.0	1.0	1.0	0.3%	1
Ephemeroptera	Baetidae	Baetis		50	76.1	38.1	33.3	0.0	188.7	5.0	7.2	3.6	5.0	1.0	15.0	5.0%	21
	Heptageniidae	Cinygma		6	6.4	3.2	5.6	0.0	11.1	0.5	0.0	0.0	1.0	1.0	1.0	0.5%	2
		Epeorus		3	5.6	2.8	0.0	0.0	11.1	0.3			1.0	1.0	1.0	0.3%	1
	Leptophlebiidae	Paraleptophlebia		8	10.6	5.3	5.6	0.0	22.2	0.8	0.7	0.4	1.5	1.0	2.0	0.8%	3
Plecoptera	Chloroperlidae	Sweltsa		3	5.6	2.8	0.0	0.0	11.1	0.3			1.0	1.0	1.0	0.3%	1
	Leuctridae			3	5.6	2.8	0.0	0.0	11.1	0.3			1.0	1.0	1.0	0.3%	1
	Nemouridae	Zapada		6	6.4	3.2	5.6	0.0	11.1	0.5	0.0	0.0	1.0	1.0	1.0	0.5%	2
	Pteronarcyidae	Pteronarcys		3	5.6	2.8	0.0	0.0	11.1	0.3			1.0	1.0	1.0	0.3%	1
Trichoptera	Calamoceratidae	Heteroplectron	californicum	44	41.6	20.8	38.9	0.0	100.0	4.0	3.2	1.6	4.0	8.0	9.0	4.2%	16
	Glossosomatidae	Glossosoma		8	5.6	2.8	11.1	0.0	11.1	0.8	0.0	0.0	1.0	1.0	1.0	0.8%	3
	Hydropsychidae	Parapsyche		14	21.0	10.5	5.6	0.0	44.4	1.3	2.1	1.7	2.5	1.0	4.0	1.3%	5
	Lepidostomatidae	Lepidostoma		14	10.6	5.3	16.7	0.0	22.2	1.3	0.6	0.3	2.0	1.0	2.0	1.3%	5
	Limnephilidae	Limnephilus		78	68.5	34.2	72.2	0.0	166.7	7.0	4.9	2.5	7.0	9.0	15.0	7.4%	22
	Polycentropodidae	Polycentropus		6	11.1	5.6	0.0	0.0	22.2	0.5			2.0	2.0	2.0	0.5%	2
	Rhyacophilidae	Rhyacophila		3	5.6	2.8	0.0	0.0	11.1	0.3			1.0	1.0	1.0	0.3%	1
	Uenoidae	Neophylax		3	5.6	2.8	0.0	0.0	11.1	0.3			1.0	1.0	1.0	0.3%	1
	pupal cases			142	218.0	109.0	50.0	0.0	466.7	12.8	21.7	10.8	5.0	4.0	42.0	13.5%	51
Coleoptera	Elmidae	Lara		3	5.6	2.8	0.0	0.0	11.1	0.3			1.0	1.0	1.0	0.3%	1
Diptera	Ceratopogonidae			3	5.6	2.8	0.0	0.0	11.1	0.3			1.0	1.0	1.0	0.3%	1
	Chironomidae	Orthocladiinae (larvae)		58	36.7	18.4	55.6	22.2	100.0	5.3	3.3	1.7	5.0	2.0	9.0	5.0%	21
		Tanytarsini (larvae)		31	34.4	17.2	22.2	0.0	77.8	2.8	3.1	1.5	3.0	1.0	7.0	2.9%	11
	Culicidae			3	5.6	2.8	0.0	0.0	11.1	0.3			1.0	1.0	1.0	0.3%	1
	Simuliidae	Simulium		6	6.4	3.2	5.6	0.0	11.1	0.5	0.0	0.0	1.0	1.0	1.0	0.5%	2
Hemiptera	Gerridae	Aquarius	remigis	3	5.6	2.8	0.0	0.0	11.1	0.3			1.0	1.0	1.0	0.3%	1
PHYLUM ANNELIDA																	
Class Hirudinea				11	9.1	4.5	11.1	0.0	22.2	1.0	0.6	0.3	1.0	1.0	2.0	1.1%	4
Class Oligochaeta				517	108.1	54.5	472.2	444.4	677.8	46.5	9.5	4.6	42.5	40.0	61.0	49.3%	186
Total	# of Individuals			1047	364.0	182.1	1027.8	622.2	1511.1	94	32.8	16.4	92.5	56.0	136.0		377
	# of Taxa			16						14							28
	With Trichoptera Pupal Cases Removed:																
	# of Individuals			906	192.0	96.2	977.8	622.2	1044.4	82	17.3	8.7	88.0	56.0	94.0		329
	# of Taxa			27						13							27
Indices	Shannon Weiner - Diversity	Ln								1.94							1.94
		Log²								2.80							2.80
	Pielou - Evenness									0.74							0.58
	With Trichoptera Pupal Cases Removed:																
	Shannon Weiner - Diversity	Ln								1.79							1.79
		Log²								2.58							2.58
	Pielou - Evenness									0.70							0.54

APPENDIX E TABLE 4: DIVERSITY INDICES, GODMAN CREEK SITE G REPLICATES								
Index		**Rep. 1**	**Rep. 2**	**Rep. 3**	**Rep. 4**	**Mean**	**Standard Deviation**	**Standard Error**
Including Trichoptera Pupal Cases:								
Shannon Weiner Diversity	Ln	1.45	0.98	1.89	1.95	1.57	0.45	0.23
	Log^2	2.09	1.41	2.73	2.81			
Pielou - Evenness		0.55	0.42	0.70	0.70	0.59	0.13	0.07
Excluding Trichoptera Pupal Cases:								
Shannon Weiner Diversity	Ln	1.31	0.98	1.79	1.93	1.50	0.44	0.22
	Log^2	1.89	1.41	2.59	2.78			
Pielou - Evenness		0.51	0.42	0.68	0.71	0.58	0.14	0.07

APPENDIX E, TABLE 5: B-IBI BENTHIC INVERTEBRATE ECOLOGICAL CHARACTERISTICS, GODMAN CREEK SITE G1

ORDER	FAMILY	GENUS	SPECIES	Long Lifespan?	Life History	Tolerance	Tolerant?	# Tolerant Individuals	Predator?	# Predator Individuals	Clinger?	Taxa	Abundance
PHYLUM ARTHROPODA													
Acariformes (Acarina)	Hydracarina			N	M				Y	1.00	N		1.00
Collembola	Anthropleona								N		N		0.25
Ephemeroptera	Baetidae	Baetis		N	M	2	N		N		Y	4	5.25
	Heptageniidae	Cinygma		N	U	4	N		N		Y		0.50
		Epeorus		N	U	0	N		N		Y		0.25
	Leptophlebiidae	Paraleptophlebia		N	U	1	N		N		Y		0.75
Plecoptera	Chloroperlidae	Sweltsa		N	U	2	N		Y	0.25	Y	4	0.25
	Leuctridae			N	U	0	N		N		Y		0.25
	Nemouridae	Zapada		N	U	2	N		N		Y		0.50
	Pteronarcyidae	Pteronarcys		Y	S	0	N		N		Y		0.25
Trichoptera	Calamoceratidae	Heteroplectron	californicum	Y	S							5	4.00
	Glossosomatidae	Glossosoma		N	U	0	N		N		Y		0.75
	Hydropsychidae	Parasyche		Y	S	3	N		Y	1.25	Y		1.25
	Lepidostomatidae	Lepidostoma		N	U	1	N		N		Y		1.25
	Limnephilidae	Limnephilus		N	U		Y	7.00	N		Y		7.00
	Polycentropodidae	Polycentropus		N	U or M				Y	0.50			0.50
	Rhyacophilidae	Rhyacophila		Y	S	0	N		Y	0.25	Y		0.25
	Uenoidae	Neophylax		N	U				N				0.25
	pupal cases												12.75
Coleoptera	Elmidae	Larva		Y	S	4	N		N		Y	1	0.25
Diptera	Ceratopogonidae			N	U	6			Y	0.25	N	1	0.25
	Chironomidae	larvae:		N	M				N		N		
		Orthocladiinae											5.25
		Tanycarsini											2.75
	Culicidae			N	M or U	6	Y	0.25	N		N		0.25
	Simuliidae	Simulium		N	U	6			N		Y		0.50
Hemiptera	Gerridae	Aquarius	remigis	N	U								0.25
PHYLUM ANNELIDA													
Class Hirudinea				N	U	10	Y	1.00	Y	1.00	N		1.00
Class Oligochaeta				N	U	5	Y	46.50	N		N		46.50
TOTAL								54.75		4.50		15	94.25

Notes
Ecological Characteristics: Lifespan, PollutionTolerance, Functional Feeding Group (Predator or not), and Habit (Clinger or not). Y=yes, N=no, U=univoltine, M=multivoltine, S=semivoltine

APPENDIX F
Provincial Site Series and Typical Environmental Condition of the CWHdm and CWHxm1 Biogeoclimatic Units

Ecological Overview Report
Integrated Stormwater Management Plan
for Pipe, Westmount, Cave, Turner and Godman Creeks
SLR Project No. 201.88342

Appendix F: Provincial Site Series and Typical Environment Conditions of the CWHdm and CWHxm1 Biogeoclimatic Units.

(adapted from BC Ministry of Environment 2006)

Biogeoclimatic Unit	Site Series	Map Code	Site Series Name	Assumed Situation	Assumed Site Modifiers	Typical Soil Moisture Regime	Structural Stages
CWHdm	00	CT	Cattail Marsh	wetland dominated by emergent vegetation; level or depression; usually mineral soils			2,3,4,5,6,7
CWHdm	00		Cw - Bluffs	forested bluff sites			2,3,4,5,6,7
CWHdm	00	RM	Cw - Fern bluffs	dry to moist/poor to medium sites on forested bluffs and cliffs (extreme microsite variation)			2,3,4,5,6,7
CWHdm	00		Cw - Swamp	poorly drained swamp forest			2,3,4,5,6,7
CWHdm	00	HL	Hardhack - Labrador tea	wetland dominated by low shrubs; on organic or mineral soils			2,3,4,5,6,7
CWHdm	00	BS	unknown				2,3,4,5,6,7
CWHdm	00	FC	unknown				2,3,4,5,6,7
CWHdm	00	HG	unknown				2,3,4,5,6,7
CWHdm	00	RR	unknown				2,3,4,5,6,7
CWHdm	00	SA	unknown				2,3,4,5,6,7
CWHdm	00	TS	unknown				2,3,4,5,6,7
CWHdm	01	HM	Hw - Flat moss	significant slopes; middle slope position; deep medium textured soils (use aspect modifiers)	d m	mesic	2,3,4,5,6,7
CWHdm	02	DC	FdPl - Cladina	gentle slope; crest position; shallow soil	j r s	xeric	2,3,4,5,6,7
CWHdm	03	DS	FdHw - Salal	significant slope, middle to upper slope position; warm aspect; deep medium textured soils	d m w	xeric - subxeric	2,3,4,5,6,7
CWHdm	04	DF	Fd - Sword fern	significant slopes deep medium - textured soils; richer nutrient regime (use aspect modifiers)	d m	xeric - subxeric	2,3,4,5,6,7
CWHdm	05	RS	Cw - Sword fern	significant slope, middle slope position, deep medium - textured soils; richer nutrient regime (use aspect modifiers)	d m	submesic - mesic	2,3,4,5,6,7
CWHdm	06	HD	HwCw - Deer fern	gentle slope; lower slope position, receiving moisture, deep medium - textured soils	d j m	subhygric - hygric	2,3,4,5,6,7
CWHdm	07	RF	Cw - Foamflower	gentle slope; lower slope position; richer nutrient regime, receiving moisture, medium - textured soil	d j m	subhygric - hygric	2,3,4,5,6,7
CWHdm	08	SS	Ss - Salmonberry	active floodplain, high fluvial bench, deep medium - textured soil	a d j m	subhygric - hygric	2,3,4,5,6,7
CWHdm	09	CD	Act - Red-osier dogwood	active floodplain, middle fluvial bench, deep medium - textured soil	a j m	subhygric - hygric	2,3,4,5,6,7
CWHdm	10	CW	Act - Willow (Fl50 - Sitka willow - False lily-of-the-valley)	active floodplain, low bench, deep coarse - textured soil	a c d j	subhygric - hygric	2,3,4,5,6,7
CWHdm	11	LS	Pl - Sphagnum	organic wetland, bog woodland, forested bog	d j p	subhydric	2,3,4,5,6,7
CWHdm	12	RC	CwSs - Skunk cabbage	treed swamp, poorly drained, level to depression, medium - textured mineral soil	d j m	subhydric	2,3,4,5,6,7
CWHdm	13	RB	Cw - Salmonberry	lower slope to level; deep, medium - textured soil	d j m	subhygric	2,3,4,5,6,7
CWHdm	14	RT	Cw - Black twinberry	lower slope to level, or depression; deep, medium - textured soil	d j m	hygric	2,3,4,5,6,7
CWHdm	15	CS	Cw - Slough sedge	depression to flat, treed swamp, poorly drained; deep, medium - textured soil	d j m	subhydric	2,3,4,5,6,7
CWHdm	Wm05		Cattail				2,3,4,5,6,7
CWHxm1	00	AM	Arbutus - Hairy manzanita	gentle upper slopes, ridge crests; shedding sites on shallow soils; rapidly to well drained	j r s	xeric	2,3,4,5,6,7
CWHxm1	00	BS	Bog-laurel - Sphagnum bog	On organic veneer over fluvial plain and Ob. Sitka burnet, sedge, bog St. John's wort, inflated sedge, white bog-orchid, and Sphagnum spp.			2,3,4,5,6,7
CWHxm1	00	FC	Fescue - Common camas	gentle slopes, ridge crests; shallow soils with small pockets of very shallowsoil on rock benches; rapidly to well drained	j r s	xeric	2
CWHxm1	00	HL	Hardhack - Labrador tea	Shrub fen occurring in depressions, poor to very poorly drained, deep organic soils	d j p	subhydric	2,3a,3b
CWHxm1	00	SW	Sedge wetland	level to depressions; poor to very poorly drained, with organic soils.	j p	subhydric	2
CWHxm1	00	SC	Selaginella - Cladina	gentle slope, upper slope and crest positions, very shallow soils, very dry and rapidly drained.	j m r v	very xeric	1b,2
CWHxm1	00	CT	unknown				2,3,4,5,6,7
CWHxm1	00	DM	unknown				2,3,4,5,6,7
CWHxm1	00	FF	unknown				2,3,4,5,6,7
CWHxm1	00	HD	unknown				2,3,4,5,6,7
CWHxm1	00	HF	unknown				2,3,4,5,6,7
CWHxm1	00	HG	unknown				2,3,4,5,6,7
CWHxm1	00	RR	unknown				2,3,4,5,6,7

Appendix F: Provincial Site Series and Typical Environment Conditions of the CWHdm and CWHxm1 Biogeoclimatic Units.

(adapted from BC Ministry of Environment 2006)

Biogeoclimatic Unit	Site Series	Map Code	Site Series Name	Assumed Situation	Assumed Site Modifiers	Typical Soil Moisture Regime	Structural Stages
CWHxm1	00	SF	unknown				2,3,4,5,6,7
CWHxm1	00	SS	unknown				2,3,4,5,6,7
CWHxm1	01	HK	HwFd - Kindbergia	gentle slope; deep medium - textured soils	d j m	submesic - mesic	2,3,4,5,6,7
CWHxm1	02	DC	FdPl - Cladina	gentle slope; crest position; medium textured shallow soil	j m r s	very xeric	2,3,4,5,6,7
CWHxm1	03	DS	FdHw - Salal	significant slope, upper slope position; warm aspect, deep medium - textured soils	d m w	xeric - subxeric	2,3,4,5,6,7
CWHxm1	04	DF	Fd - Sword fern	significant slopes, deep medium - textured soils (use aspect modifiers)	d j m	xeric - subxeric	2,3,4,5,6,7
CWHxm1	05	RS	Cw - Sword fern	significant slope, deep medium - textured soils; richer nutrient regime (use aspect modifiers)	d m	submesic - mesic	2,3,4,5,6,7
CWHxm1	06		HwCw - Deer fern				2,3,4,5,6,7
CWHxm1	07	RF	Cw - Foamflower	gentle slope; lower slope position, receiving moisture; deep medium - textured soil	d j m	subhygric - hygric	2,3,4,5,6,7
CWHxm1	08		Ss - Salmonberry				2,3,4,5,6,7
CWHxm1	09	CD	Act - Red-osier dogwood	active floodplain, middle bench, deep medium - textured soil	a d j m	subhygric - hygric	2,3,4,5,6,7
CWHxm1	10	CW	Act - Willow (Fl50 - Sitka willow - False lily-of-the-valley)	active floodplain, low bench, deep coarse - textured soil	a c d j	subhygric - hygric	2,3,4,5,6,7
CWHxm1	11	LS	Pl - Sphagnum	treed bog; organic	d j p	subhydric	2,3,4,5,6,7
CWHxm1	12	RC	CwSs - Skunk cabbage (Ws53 - Cw - Sword fern - Skunk cabbage)	treed swamp, poorly drained , depression to flat, deep medium - textured mineral soil	d j m	subhydric	2,3,4,5,6,7
CWHxm1	13	RB	Cw - Salmonberry	strongly fluctuating water table, deep medium - textured mineral soil	d j m	subhygric	2,3,4,5,6,7
CWHxm1	14	RT	Cw - Black twinberry	strongly fluctuating water table, deep medium - textured mineral soil	d j m	hygric	2,3,4,5,6,7
CWHxm1	15	CS	Cw - Slough sedge	strongly fluctuating water table, deep medium - textured mineral soil	d j m	subhydric	2,3,4,5,6,7
CWHxm1	Wb50		Labrador tea - Bog-laurel - Peat-moss				2,3,4,5,6,7
CWHxm1	Wf10		Hudson Bay clubrush - Red hook-moss				2,3,4,5,6,7
CWHxm1	Wf52		Sweet gale - Sitka sedge				2,3,4,5,6,7
CWHxm1	Wf53		Slender sedge - White beak-rush				2,3,4,5,6,7
CWHxm1	Wm05		Cattail				2,3,4,5,6,7
CWHxm1	Wm06		Great bulrush				2,3,4,5,6,7
CWHxm1	Wm09		Inflated sedge				2,3,4,5,6,7
CWHxm1	Wm50		Sitka sedge - Hemlock-parsley				2,3,4,5,6,7
CWHxm1	Ws50		Hardhack - Sitka sedge				2,3,4,5,6,7

APPENDIX G
Expected Occurrence of Amphibious and Terrestrial Vertebrates in the ISMP Study Area

Ecological Overview Report
Integrated Stormwater Management Plan
for Pipe, Westmount, Cave, Turner and Godman Creeks
SLR Project No. 201.88342

Appendix G: Expected Occurrence of Amphibious and Terrestrial Vertebrates in the Watersheds of Pipe, Westmount, Cave, Turner, and Godman Creeks

Species	CDC Status Chilliwack Forest District	Likelihood In The Rodgers Neighbourhood
CLASS **AMPHIBIA**: Amphibians		
ORDER **CAUDATA**: Salamanders		
Rough-skinned Newt (*Taricha granulosa*)		These aquatic salamanders are unlikely to occur on the study site because of the lack of nearby permanent standing water, although they are expected in lower elevation CWHdm forests near permanent ponds.
Northwestern Salamander (*Ambystoma racile*)		
Long-toed Salamander (*A. macrodactylum*)		
Ensatina Salamander (*Ensatina eschscholtzii*)		expected
Western Red-backed Salamander (*Plethodon vehiculum*)		expected
ORDER **ANURA**: Frogs and Toads		
Tailed Frog (*Ascaphus truei*)	Blue Listed	expected near creeks
Western Toad (*Bufo boreas*)		expected
Pacific Treefrog (*Hyla regilla*)		expected
Red-legged Frog (*Rana aurora*)	Blue Listed	uncertain
CLASS **REPTILIA**: Reptiles		
ORDER **SQUAMATA**: Lizards and Snakes		
Northern Alligator Lizard (*Gerrhonotus coeruleus*)		possible around roads & dry clearings
Rubber Boa (*Charina bottae*)		uncertain
Western Garter Snake (*Thamnophis elegans*)		possible
Northwestern Garter Snake (*T. ordinoides*)		expected
Common Garter Snake (*Thamnophis sirtalis)*		expected
CLASS **AVES**: Birds		
FAMILY **CATHARTIDAE**: New World Vultures		
Turkey Vulture (*Cathartes aura*)		Incidental (may soar overhead during migration, but are unlikely to use site.)
ORDER **FALCONIFORMES**: Diurnal Birds of Prey		
FAMILY **ACCIPITRIDAE**: Osprey, Eagles and Hawks		
Bald Eagle (*Haliaeetus leucocephalus*)		Resident
Sharp-shinned Hawk (*Accipiter striatus*)		Migration/Winter

Appendix G: Expected Occurrence of Amphibious and Terrestrial Vertebrates in the Watersheds of Pipe, Westmount, Cave, Turner, and Godman Creeks

Species	CDC Status Chilliwack Forest District	Likelihood In The Rodgers Neighbourhood
Cooper's Hawk (*Accipiter cooperii*)		Resident
Northern Goshawk (*Accipiter gentilis*)		Migration/Winter
Red-tailed Hawk (*Buteo jamaicensis*)		Resident
Golden Eagle (*Aquila chrysaetos*)		Incidental
FAMILY **FALCONIDAE**: Falcons		
American Kestrel (*Falco sparverius*)		Migration/Summer
Merlin (*Falco columbarius*)		Resident
Gyrfalcon (*Falco rusticolus*)		Migration/Winter
Peregrine Falcon (*Falco peregrinus*)	Red Listed	Incidental
ORDER **GALLIFORMES**: Gallinaceous Birds		
FAMILY **PHASIANIDAE**: Partridge, Grouse, Ptarmigan, Turkey and Quail		
Blue Grouse (*Dendragapus obscurus*)		Resident
Ruffed Grouse (*Bonasa umbellus*)		Resident
ORDER **COLUMBIDAE**: Pigeons and Doves		
FAMILY **COLUMBIDAE**: Pigeons and Doves		
Band-tailed Pigeon (*Columba fasciata*)	Blue Listed	Resident
ORDER **STRIGIFORMES**: Owls		
FAMILY **STRIGIDAE**: Typical Owls		
Western Screech-Owl (*Otus kennicottii*)	Blue Listed	Resident
Great Horned Owl (*Bubo virginianus*)		Resident
Northern Pygmy-Owl (*Glaucidium gnoma*)		Migration/Winter
Spotted Owl (*Strix occidentalis*)	Red Listed	Extirpated
Barred Owl (*Strix varia*)		Resident
Great Gray Owl (*Strix nebulosa*)		Incidental Migration/Winter
Northern Saw-whet Owl (*Aegolius acadicus*)		Resident
ORDER **APODIFORMES**: Swifts and Hummingbirds		
FAMILY **APODIDAE**: Swifts		
Black Swift (*Cypseloides niger*)		Migration/Summer
Vaux's Swift (*Chaetura vauxi*)		Migration/Summer
FAMILY **TROCHILIDAE**: hummingbirds		

Appendix G: Expected Occurrence of Amphibious and Terrestrial Vertebrates in the Watersheds of Pipe, Westmount, Cave, Turner, and Godman Creeks

Species	CDC Status Chilliwack Forest District	Likelihood In The Rodgers Neighbourhood
Anna's Hummingbird (*Calypte anna*)		Resident in deciduous openings
Rufous Hummingbird (*Selasphorus rufus*)		Spring/Summer
ORDER **PICIFORMES**: Woodpeckers and Allies		
FAMILY **PICIDAE**: Woodpeckers		
Red-breasted Sapsucker (*Sphyrapicus ruber*)		Resident
Downy Woodpecker (*Picoides pubescens*)		Resident
Hairy Woodpecker (*Picoides villosus*)		Resident
Northern Flicker (*Colaptes auratus*)		Resident
Pileated Woodpecker (*Dryocopus pileatus*)		Resident
ORDER **PASSERIFORMES**: Passerine Birds		
FAMILY **TYRANNIDAE**: Tyrant Flycatchers		
Olive-sided Flycatcher *Contopus cooperi*)		Migration/Summer
Western Wood-pewee (*Contopus sordidulus*)		Migration/Summer
Willow Flycatcher (*Empidonax traillii*)		Migration
Hammond's Flycatcher (*Empidonax hammondii*)		Migration
Pacific-slope Flycatcher (*Empidonax difficilis*)		Migration/Summer
FAMILY **LANIIDAE**: Shrikes		
Northern Shrike (*Lanius excubitor*)		Migration
FAMILY **VEREONIDAE**: Vireos		
Cassin's Vireo (*Vireo cassinii*)		Migration/Summer
Hutton's Vireo (*Vireo huttoni*)		Resident
Warbling Vireo (*Vireo gilvus*)		Migration/Summer
Red-eyed Vireo (*Vireo olivaceus*)		Migration/Summer
FAMILY **CORVIDAE**: Jays, Magpies and Crows		
Steller's Jay (*Cyanocitta stelleri*)		Resident
Northwestern Crow (*Corvus caurinus*)		Resident
Common Raven (*Corvus corax*)		Resident
FAMILY **HIRUNDINIDAE**: Swallows		
Tree Swallow (*Tachycineta bicolor*)		Migration/Summer
Violet-green Swallow (*T. thalassina*)		Migration/Summer

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Species	CDC Status Chilliwack Forest District	Likelihood In The Rodgers Neighbourhood
FAMILY **PARIDAE**: Chickadees		
Black-capped Chickadee (*Poecile atricapillus*)		Resident
Mountain Chickadee (*Poecile gambeli*)		Incidental
Chestnut-backed Chickadee (*Poecile rufescens*)		Resident
FAMILY **AEGITHALIDAE**: Bushtits		
Bushtit (*Psaltriparus minimus*)		Resident in shrubby deciduous habitats
FAMILY **SITTIDAE**: Nuthatches		
Red-breasted Nuthatch (*Sitta canadensis*)		Resident
FAMILY **CERTHIIDAE**: Creepers		
Brown Creeper (*Certhia americana*)		Resident
FAMILY **TROGLODYTIDAE**: Wrens		
Bewick's Wren (*Thryomanes bewickii*)		Resident
Winter Wren (*Troglodytes troglodytes*)		Resident
FAMILY **REGULIDAE**: Kinglets		
Golden-crowned Kinglet (*Regulus satrapa*)		Resident
Ruby-crowned Kinglet (*Regulus calendula*)		Migration/Winter
FAMILY **MUSCICAPIDAE**: Bluebirds, Thrushes and Allies		
Townsend's Solitaire (*Myadestes townsendi*)		Migration
Swainson's Thrush (*Catharus ustulatus*)		Migration/Summer
Hermit Thrush (*Catharus guttatus*)		Migration/Winter
American Robin (*Turdus migratorius*)		Resident
Varied Thrush (*Ixoreus naevius*)		Resident
FAMILY **STURNIDAE**: Starlings and Allies		
European Starling (*Sturnus vulgaris*)		Resident
FAMILY **BOMBYCILLIDAE**: Waxwings		
Cedar Waxwing (*Bombycilla cedrorum*)		Resident
FAMILY **PARULIDAE**: Wood-Warblers, Sparrows, Blackbirds and Allies		
Orange-crowned Warbler (*Vermivora celata*)		Migration/Summer
Yellow Warbler (*Dendroica petechia*)		Migration/Summer

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Species	CDC Status Chilliwack Forest District	Likelihood In The Rodgers Neighbourhood
Yellow-rumped Warbler (*Dendroica coronata*)		Migration/Summer
Black-throated Gray Warbler (*D. nigrescens*)		Migration/Summer
Townsend's Warbler (*Dendroica townsendi*)		Migration/Summer
MacGillivray's Warbler (*Oporornis tolmiei*)		Migration/Summer
Common Yellowthroat (*Geothlypis trichas*)		Migration
Wilson's Warbler (*Wilsonia pusilla*)		Migration/Summer
FAMILY **TRAUPIDAE**: Tanagers		
Western Tanager (*Piranga ludoviciana*)		Migration/Summer
FAMILY **CARDINALIDAE**: Cardinals, Grosbeaks and Allies		
Black-headed Grosbeak (*Pheucticus melanocephalus*)		Migration/Summer
FAMILY **EMBERIZIDAE**: Towhees, Sparrows, Longspurs and Allies		
Spotted Towhee (*Pipilo maculatus*)		Resident
Fox Sparrow (*Passerella* spp/ssp)		Migration/Winter
Song Sparrow (*Melospiza melodia*)		Resident
Lincoln's Sparrow (*Melospiza lincolnii*)		Migration
White-crowned Sparrow (*Zonotrichia leucophrys*)		Resident
Golden-crowned Sparrow (*Zonotrichia atricapilla*)		Migration/Winter
Dark-eyed Junco (*Junco hyemalis*)		Resident
FAMILY **ICTERIDAE**: Blackbirds, Orioles and Allies		
Brown-headed Cowbird (*Molothrus ater*)		Resident
FAMILY **FRINGILLIDAE**: Cardueline Finches and Allies		
Purple Finch (*Carpodacus purpureus*)		Resident
Red Crossbill (*Loxia curvirostra*)		Resident
Pine Siskin (*Carduelis pinus*)		Resident
American Goldfinch (*Carduelis tristis*)		Resident
Evening Grosbeak (*Coccothraustes vespertinus*)		Resident
CLASS **MAMMALIA**: Mammals		
ORDER **INSECTIVORA**: Insectivores		
FAMILY **SORICIDAE**: Shrews		
Pacific Water Shrew (*Sorex bendirii*)	Red Listed	uncertain

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Species	CDC Status Chilliwack Forest District	Likelihood In The Rodgers Neighbourhood
Common Shrew (*Sorex cinereus*)		expected
Dusky Shrew (*Sorex monticolus*)		expected
Trowbridge's Shrew (*Sorex trowbridgii*)	Blue Listed	uncertain
Vagrant Shrew (*Sorex vagrans*)		expected
FAMILY **TALPIDAE**:Moles		
Shrew-mole (*Neurotrichus gibbsii*)		expected
ORDER **CHIROPTERA**: Bats		
FAMILY **VESPERTILIONIDAE**: Verpertilionid Bats		
		The following bat species are all expected to, or may potentially, forage over the study area, and indicates possible occurrence of species that typically roost in trees (unless otherwise noted).
Big Brown Bat (*Eptesicus fuscus*)		possible foraging only
Silver-haired Bat (*Lasionycteris noctivangans*)		expected
Hoary Bat (*Lasiurus cinereus*)		expected
California Myotis (*Myotis californicus*)		expected
Western Long-eared Myotis (*Myotis evotis*)		expected
Keen's Long-eared Myotis (*Myotis keenii*)	Red Listed	possible
Little Brown Myotis (*Myotis lucifugus*)		expected
Long-legged Myotis (*Myotis volans*)		expected
Yuma Myotis (*Myotis yumanensis*)		possible foraging only
Townsend's Big-eared Bat (*Corynorhinus townsendii*)	Blue Listed	possible foraging only
ORDER **LAGOMORPHA**: Rabbits, Hares, Pikas		
FAMILY **LEPORIDAE** Hares, Rabbits		
Snowshoe Hare (*Lepus americanus*)		expected
ORDER **RODENTIA**: Rodents		
FAMILY **ARVICOLIDAE**: Voles and Lemmings		
Southern Red-backed Vole (*Clethrionomys gapperi*)		uncertain
Long-tailed Vole (*Microtus longicaudus*)		expected
FAMILY **CRICETIDAE**: Cricetids		

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Species	CDC Status Chilliwack Forest District	Likelihood In The Rodgers Neighbourhood
Bushy-tailed Woodrat (*Neotoma cinerea*)		possible
Deer Mouse (*Peromyscus maniculatus*)		expected
FAMILY **ERETHIZONIDAE**: New World Porcupines		
Porcupine (*Erethizon dorsatum*)		possible
FAMILY **SCIURIDAE**: Squirrels		
Northern Flying Squirrel (*Glaucomys sabrinus*)		expected
Yellow-pine Chipmunk (*Tamias amoenus*)		possible
Douglas' Squirrel (*Tamiasciurus douglasii*)		expected
FAMILY **ZAPODIDAE**: Jumping Mice		
Pacific Jumping Mouse (*Zapus trinotatus*)		expected
ORDER **CARNIVORA**: Carnivores		
FAMILY **CANIDAE**: Canids		
Coyote (*Canis latrans*)		expected
FAMILY **FELIDAE**: Cats		
Cougar (*Felis concolor*)		expected
Bobcat (*Lynx rufus*)		expected
FAMILY **MUSTELIDAE**: Mustelids		
Marten (*Martes americana*)		possible
Fisher (*Martes pennanti*)		uncertain
Striped Skunk (*Mephitis mephitis*)		expected
Ermine (*Mustela erminea*)		expected
Wolverine (*Gulo gulo luscus*)	Blue Listed	uncertain
Long-tailed Weasel (*Mustela frenata*)		expected
Mink (*Mustela vison*)		expected
Spotted Skunk (*Spilogale putorius*)		uncertain
FAMILY **PROCYONIDAE**: Procyonids		
Raccoon (*Procyon lotor*)		expected
FAMILY **URSIDAE**: Bears		
Black Bear (*Ursus americanus*)		expected

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Species	**CDC Status Chilliwack Forest District**	**Likelihood In The Rodgers Neighbourhood**
ORDER **ARTIODACTYLA**: Even-Toed Ungulates		
FAMILY **CERVIDAE**: Cervids		
Black-tail Deer (*Odocoileus hemionus*)		expected

Legend

Amphibians, Reptiles, Mammals

Expected	Known or expected to occur; may not be present at all times but not likely to be absent annually.
Possible	There is a reasonable chance it may occur at some time during the year.
Uncertain	Low abundance, at edge of range, or status unconfirmed and may not occur on the site.

Birds

Resident	Expected to occur all year; for some species individuals & abundance change seasonally.
Migration	Expected to occur during spring and fall (migratory species).
Spring	Expected to occur during spring.
Fall	Expected to occur during fall.
Summer	Expected to occur during the breeding season, either as a breeder or non breeder.
Winter	Expected to occur during winter.
Incidental	Low likelihood of occurrence during one or more seasons.
Extirpated	Former occurrence known or likely, but does not occur at present.