

Bowker Creek Watershed

Proper Functioning Condition Assessment



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Abstract

A Proper Functioning Condition assessment (PFC) was conducted in the Bowker Creek Watershed to determine the condition of the riparian-wetland areas and their influence on the overall functional condition of the stream. This qualitative, yet science-based process considers both abiotic and biotic factors as they relate to physical function. It facilitates communication about the condition of a riparian-wetland area and focuses attention on the physical processes before considering values. A standard checklist is used to ensure consistency in reporting the condition of riparian-wetland areas. The first phase of the assessment was undertaken in November 2004, as part of a PFC training session sponsored by Aqua-Tex. The remaining reaches were assessed in January 2007. The purpose of this assessment was to provide a baseline assessment of the riparian condition, and identify priority areas for protection and restoration as well as longer-term management options. The 7.9 km long creek was divided into 16 reaches. Of these, only five were found to be functional, eight were non-functional, and three were functional at risk. Of those that were functional at risk, two were on a downward trend (reach 2, community gardens to Monteith St. and reach 12, the pond at the UVic University Club) and one was on an upward trend (reach 7, Trent St. to Haultain Rd.). Those reaches that are functional but at risk are the highest priorities for intervention and restoration.

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Contributors and Participants

Project Leader

Wm. Patrick Lucey
Sr. Aquatic Ecologist
Aqua-Tex Scientific Consulting Ltd.
390 7th Avenue
Kimberley, B.C.,
V1A 2Z7
(250) 427-0260
aqua-tex@islandnet.com

Oversight and Training Staff

Cori L. Barracough, R.P. Bio -Editor

Watershed Assessment Team

John Anderson- Fisheries Biologist (Nov. 04)
Paul DeGreeff- Vegetation Ecologist (Nov. 04)
Wayne Elmore- Riparian Specialist (Nov. 04)
Brian LaCas, P.Eng.- Hydrological Engineer
(Jan. 07)
Wm. Patrick Lucey, R.P. Bio.- Sr. Aquatic
Ecologist (Nov. 04 & Jan. 07)
Lehna Malmkvist, R.P. Bio - Vegetation
Ecologist (Nov. 04 & Jan. 07)

Participants

Ian Bruce (Nov. 04)
Brienne Czypka (Nov. 04)
John Hayton (Nov. 04)
Daniel Hegg (Jan. 07)
Rachelle McElroy (Nov. 04)
Tom Sullivan (Nov. 04)
Lise Townsend (Nov. 04 & Jan 07)
Jody Watson (Nov. 04)
Ken Whitcroft (Nov. 04)

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Executive Summary

Creeks and Communities

(Riparian Coordination Network, 2002).

“Healthy watersheds and riparian-wetland areas are critical to providing communities with the economic, ecological, and social benefits that come from the reliable availability of adequate supplies of clean water. The storage of water in riparian-wetland areas is important to ensuring a life-sustaining supply of this precious resource. Riparian-wetland areas are also unique features that connect landscapes and communities, providing unlimited opportunities to bring people together to create a common vision for productive and sustainable conditions. While there is growing agreement regarding the importance of watershed and riparian-wetland function, there continues to be considerable disagreement about existing conditions and appropriate treatments. This disagreement has led to an environment of lawsuits and regulatory approaches, often leaving out the people most affected by the decisions. However, there is increasing evidence that effective solutions arise from the workings of citizens and stakeholders.”

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

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

Background

The Bowker Creek watershed is located on southern Vancouver Island, B.C., in the Capital Regional District (CRD), which includes the city of Victoria (Figure 1). The watershed consists of approximately 1028 hectares of land that is shared by the City of Victoria, the District of Saanich and the District of Oak Bay (Figure 2). This area has been extensively developed, and now consists mostly of residential neighbourhoods, as well as some commercial districts, the University of Victoria campus, the Cedar Hill golf course and a few small public parks.

Sixty three percent of Bowker Creek has been enclosed in storm drains, leaving only 2.9 km as an open channel (CRD, 2003). The creek is about 7.9 km long and flows from a wet meadow on

the University of Victoria (UVic) campus, west (via storm drains) parallel to MacKenzie Avenue, south along Shelbourne St. to the Hillside Mall, southeast past Richmond School and the Royal Jubilee Hospital, to the discharge point in Oak Bay, near Glenlyon-Norfolk school. A tributary of Bowker Creek flows southeast from the Cedar Hill Golf Course and joins the main stem near the Hillside Mall.

The PFC Team responded to a request from the Capital Regional District for assistance in developing a process to assess the current condition of Bowker Creek. Due to time and funding limitations, only two reaches of Bowker Creek were assessed in the original November 2004 assessment. During the second assessment, the original two reaches were subdivided and reassessed in more detail. Funding to complete the assessment was obtained in December 2006. This study represents a demonstration of the process that could be applied to other streams in the Capital Regional District, as a means to prioritize watershed management and restoration options. The CRD Roundtable on the Environment utilized the PFC assessment method as a watershed health indicator in their 2006 annual report.

Key Issues

The Bowker Creek watershed is highly urbanized. The Creek has been culverted for more than 63% of its length and what remains above ground has been largely channelized. The stream receives stormwater flows that exceed its natural channel capacity and the resulting energy has caused extensive scour and erosion. Loss of riparian vegetation due to encroachment of development has resulted in a loss of bank integrity and subsequent “repair” by the municipalities and landowners in the form of rip-rap, concrete armouring and other artificial stabilization measures. This in turn has led to a loss of complex habitat and, combined with degraded water quality due to polluted runoff, to the loss of fish in all but the lowest reaches of the creek.

The community sees this stream as an asset, and wishes to focus its efforts on restoring those areas of the creek where it is practical to do so. This report aims to focus those efforts by determining where the stream remains functional, where it is non-functional and where it is functional at risk, but can still be repaired.

Conclusions

Data Needs

- More recent biological information could be gathered, for example, by community stewardship groups, to document the animal and plant species present.
- Stream flow data could be gathered, in order to construct a hydrograph of the stream. Although general trends are fairly well understood, more detailed information could help convey to the public and involved parties how runoff from impervious surfaces affects the stream. This hydrograph could be compared with one for a more natural watershed.

Education Needs and Public Involvement

- Runoff from impervious surfaces has a major negative effect on the stream. Education should be designed to increase awareness of this concern and to encourage its mitigation through on-site infiltration methods such as rain barrels, infiltration trenches/galleries, vegetated swales and green roofs and by minimizing impervious surfaces.
- Many people in the surrounding area remain unaware of Bowker Creek's existence, and of restoration efforts undertaken to-date. Community outreach, such as the events coordinated by the Friends of Bowker Creek group, helps to increase this awareness. These activities should be continued, and, if possible, expanded.
- School groups have already been involved in restoration projects in the creek, including students from St. Patrick's School and St. Michael's University School. More education programs could be implemented to involve students in stewardship activities.

Recommendations

The following recommendations represent opportunities to ensure Bowker Creek maintains its current function, and progresses toward its potential condition.

General Recommendations:

- 1. There is an opportunity to reassess the land use needs of the institutions in the area of Bowker Creek between Fort Street and Richmond Elementary School and restore this portion of the stream cost-effectively.** Many of the lands in this area are owned by institutions that are faced with issues of expansion of their building programs. There is the potential to take a watershed-scale approach to stream restoration based upon linking specific parcels of land and integrating their land-use. These parcels include, but are not limited to, St. Patrick's School, the triangle of land immediately upstream of the school, Royal Jubilee Hospital, the B.C. Hydro property and the Richmond School property, in addition to several municipal rights-of-way and easements. The feasibility of integrating the future development of these properties with the restoration of the stream and alleviation of flooding issues, should be reviewed. There may be an opportunity for a Restoration Economy approach to the long-term ownership of these lands that would benefit the land owners, neighbouring residents and the creek. Such a review should include other properties in the immediate area and examine the opportunity to create a series of connected ponds and small lakes / wetlands.
- 2. Where possible, reconfigure the stream channel by creating/widening floodplains, and/or constructing adjacent wetlands and stormwater detention ponds.**
 - a. Although the potential for "natural" floodplains is limited, some benefit could be achieved by creating rock-reinforced terraces (with riparian vegetation) along the channel that would allow some energy dissipation.
 - b. Some detailed proposals for detention pond locations and sizes already exist (e.g. RCPL and SHIP, 2000).
 - c. The feasibility of this kind of work depends to a large degree on land ownership. If the city/municipality can buy properties alongside the channel, over time this

option will become more realistic. One of the most likely sites for adjacent ponds or wetlands is the B.C. Hydro property. Education and public involvement would be required to ensure the support of the local community.

- 3. Plant more native riparian and upland species on and near stream banks, control invasive species and use bioengineering techniques to mitigate erosion.**
 - a. Native plants will help to mitigate erosion, increase the available wildlife habitat, and improve hydrological function of the stream. Volunteers have been, and can continue to be, an important force in replanting efforts.
 - b. Bioengineering techniques, such as wattle fences and live staking with willow cuttings, can provide effective erosion control, while restoring a natural appearance and function. Where feasible, this method is generally preferred to hard bank armouring, for example with riprap (angular rock) or concrete.
 - c. Invasive plants are currently a concern along Bowker Creek. They out-compete native plants and do not usually provide valuable food or habitat for wildlife. Where they are removed, care should be taken not to excessively disturb soil and cause erosion of the stream banks, and the area should be immediately replanted with native species in order to prevent re-colonization with invasives.
- 4. Encourage on-site infiltration of stormwater in order to reduce the volume of rainwater that flows into the stream.**
 - a. Bylaws, codes of practice and best management principles can be used to encourage businesses and developers to use proven and available technologies to keep runoff from their sites to a minimum. Tools such as the Water Balance Model (<http://www.waterbalance.ca/waterbalance/home/wbnIndex.asp>) can provide guidance to developers.
 - b. Education materials can be designed for individual property owners and residents in the watershed, in order to increase awareness about the effects of urban runoff, and to provide options to reduce it.
 - c. Examples of possible technologies include infiltration trenches, pervious pavement, vegetated swales, rain barrels, green roofs, detention ponds and constructed wetlands (which can also be features of public green space).
 - d. Consideration should be given to undertaking a first order assessment of the volumes of stormwater that move through the system. This type of first order modeling has been conducted, by the CRD, on other stream systems in the region and should be conducted on Bowker Creek.
 - e. There should be a standardization of stormwater management practices between the three municipal jurisdictions (Victoria, Saanich and Oak Bay), as well as the largest institution within the watershed (University of Victoria).
- 5. Continue the community education program,** to inform residents and users of public areas in the watershed about physical and ecological processes in Bowker Creek, and how their impacts can be reduced.

- a. The resource entitled “On the Living Edge” is an excellent example of an educational publication aimed at streamside and shoreline property owners. This publication, or another similar one, could be distributed to people living along Bowker Creek. It can be ordered online from:
<http://www.livingbywater.ca/main.html>
 - b. Municipal staff, stewardship group coordinators and other spokespeople should continue to make presentations and lead outings for school groups, in order to highlight the importance of streams in an urban setting.
 - c. Signage can be installed along public trails that are located near Bowker Creek, explaining key stream processes and characteristics, such as the function of riparian vegetation, the importance of floodplains, and fish/wildlife habitat requirements. The history of Bowker Creek could also be highlighted.
6. **Develop a monitoring program for Bowker Creek**, in order to more thoroughly assess its current condition, and to measure the effects of restoration and development.
- a. Photo point monitoring can be used to visually document anthropogenic (human-caused) and natural changes that occur in and around the stream.
 - b. PFC assessments can be conducted periodically, to determine whether the condition of the system is static, improving or declining.
 - c. Plant, fish and wildlife inventories can be conducted in order to get a better understanding of the local ecosystems. Sampling can focus on presence/absence and/or population or coverage estimates.
 - d. Water quality should be measured at a number of locations along the creek, testing for the most likely contaminants such as heavy metals, hydrocarbons, pesticides, coliforms and nutrients (nitrates/phosphates).

Recommendations by Reach

Reach 1 (Ocean to Community Gardens)

In the short-term, the erosion behind the concrete retaining wall on the west side of the creek should be re-stabilized (*e.g.* bioengineering, extending the retaining wall).

In the long-term, we recommend that when the properties adjacent to the creek are redeveloped that the morphology of the creek be restored to an appropriate configuration and proper riparian vegetation be established.

Reach 2 (Community Gardens to Monteith St.)

In the community gardens, invasive species control should be implemented, the bioengineering project should be repaired, and riparian vegetation re-established.

The remaining portion of the creek consists of an undersized, underground culvert that periodically floods overland. This portion of the reach should be reviewed for the opportunity to day-light the channel and restore the riparian/wetland, creating fisheries habitat.

Reach 3 (Monterey Avenue to Oak Bay High School)

In the long-term, the hardened banks and bottom should be converted to an appropriate channel morphology and complexity, and riparian vegetation should be re-established.

Reach 4 (Oak Bay High To Oak Bay Recreation Centre)

The north bank of the creek should be re-sloped to provide floodplain and planting terraces, invasive species control and the addition of riparian vegetation.

Reach 5 (Oak Bay Recreation Centre to Bee St.)

Behind Oak Bay Recreation Centre the parking areas on both sides of the creek should be reconfigured to allow resloping and stabilization of the banks, provision of planting terraces and planting of riparian vegetation. Bioengineering may be required to stabilize banks due to space constraints. The parking should be reconfigured by creating a two-tiered structure that would retain an equivalent number of parking stalls, but be confined to a smaller footprint.

Reach 6 (Bee Street to Cadboro Bay Road)

In the long-term, the hardened banks and bottom should be converted to an appropriate channel morphology and complexity, and riparian vegetation should be re-established.

Reach 7 (St. Patrick's School/Royal Jubilee Hospital)

The program of bank stabilization should be continued in the short term using bioengineering in this reach, in addition to controlling invasive species and re-establishing riparian vegetation.

In the long-term, this site should be investigated for the potential to realign the creek, restore appropriate channel morphology and complexity, and plant riparian vegetation. Opportunities to detain and treat surface runoff at this site should also be explored.

Reach 8 and 9 (BC Hydro and Richmond Elementary)

In the short-term, a program of bank stabilization using bioengineering is recommended for this reach, in addition to controlling invasive species and re-establishing riparian vegetation.

In the long-term, this site should be investigated for the potential to realign the creek, restore appropriate channel morphology and complexity, and plant riparian vegetation. Opportunities to detain and treat surface runoff at this site should also be explored.

Reach 10 (North Dairy Road to McRae Avenue)

In the short-term we recommend spot placement of bank stabilization measures (bioengineering) and in stream measures to reduce erosion (e.g. weirs).

In the long-term, as the area is redeveloped the channel should be restored, banks stabilized and riparian vegetation re-established.

Reach 11 (McRae Avenue to Browning Park)

As Browning Park is redeveloped in the near future, invasive species should be controlled, the riparian area widened by planting native riparian species and small rock weirs installed within the channel to improve complexity.

Reach 12 (University Club Pond)

Riparian vegetation around the perimeter of the pond should be increased and the complexity improved by adding large wood. The stop log on the outlet weir is rotting and should be replaced immediately.

Reach 13 (University Club to McGill Rd.)

This reach is very stable and undergoing a significant vegetation change resulting from an increase in surface water. The large floodplain in this reach is now maintained in a wetted condition for prolonged periods of the winter, a condition that is affecting the vegetation. There are numerous mature trees that are subject to blow-down and many individuals are dying as a result of increased soil moisture. There is a new under-story of shrubs that are providing a dense, and diverse, composition of riparian species.

While this reach has been stable, it would be valuable to conduct a thorough review of the channel and the need for additional plant species that could accelerate riparian stability.

Reach 14 (tributary from McKenzie Avenue)

This short reach requires a review to determine the extent to which stormwater is causing channel aggradation; there is a significant blackberry invasion that is resulting in channel bank erosion. The reach would benefit from the addition of large wood to increase channel sinuosity.

Reach 15 and 16 (tributary - Cedar Hill Recreation Centre and Golf Course)

Invasive species should be controlled, the banks should be resloped to create appropriate channel morphology, riparian vegetation should be planted and large wood should be added for complexity.

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Introduction

This report presents the findings, conclusions, and recommendations of the PFC Team's field assessment of the Bowker Creek watershed. The purpose of the assessment was to determine the functional state of the creek and provide recommendations that can be used to design strategies to maintain and/or improve its condition.

The PFC Team responded to a request from the Capital Regional District for assistance in developing a process to assess the current condition of Bowker Creek. Due to time and funding limitations, only two reaches of Bowker Creek were assessed in the original November 2004 assessment. Funding to complete the assessment was obtained in December 2006. The PFC protocol was formally adopted by the CRD in 2006 as a watershed health indicator. This study represents a demonstration of the process that could be applied to other streams in the Capital Regional District, as a means to prioritize watershed management and restoration options.

The PFC Team assessed Bowker Creek in conjunction with interested individuals, agencies, and groups as a PFC training session in November 2004. The team consisted of: John Anderson, fisheries biologist; Paul DeGreeff, vegetation ecologist; Wayne Elmore, riparian specialist; Patrick Lucey, aquatic ecologist; and Lehna Malmkvist, vegetation ecologist. Observers included: Tom Sullivan, Lise Townsend, Jody Watson, Ian Bruce, Ken Whitcroft, John Hayton, Rachelle McElroy and Brianne Czpyha. The remaining fourteen reaches were assessed in January 2007, based on the draft conclusions from the November 2004 study.

Project Area Description

Location

The Bowker Creek watershed is located on southern Vancouver Island, B.C., in the Capital Regional District (CRD), which includes the city of Victoria (Figure 1). The watershed consists of approximately 1028 hectares of land that is shared by the City of Victoria, the District of Saanich and the District of Oak Bay (Figure 2). This area has been extensively developed, and now consists mostly of residential neighbourhoods, as well as some commercial districts, the University of Victoria campus, the Cedar Hill golf course and a few small public parks.

Sixty three percent of Bowker Creek has been enclosed in storm drains, leaving only 2.9 km as an open channel (CRD, 2003). The creek is about 7.9 km long and flows from a wet meadow on the University of Victoria (UVic) campus, west (via storm drains) parallel to MacKenzie Avenue, south along Shelbourne St. to the Hillside mall, southeast past Richmond School and the Royal Jubilee Hospital, to the discharge point in Oak Bay, near Glenlyon-Norfolk school. A tributary of Bowker Creek flows southeast from the Cedar Hill golf course and joins the main stem near the Hillside Mall.

The main sections (reaches) with open channels are numbered in Figure 2, and are located:

- From the mouth of the stream (ocean) to the community allotment gardens. (1)
- From community allotment gardens to Monteith Street. (2)
- Between Monterey Avenue and Oak Bay High School (3)
- Oak Bay High School to Oak Bay Recreation Centre tennis bubble. (4)
- Oak Bay Recreation Centre tennis bubble to Bee Street. (5)
- Bee Street to Cadboro Bay Road. (6)
- Trent Street to Haultain Road. (St. Patrick's School & Royal Jubilee Hospital). (7)
- Haultain Road. to Richmond Road. (BC Hydro property). (8)
- Newton Street to Pearl Street (Richmond Elementary). (9)
- North Dairy Road to McRae Avenue. (10)
- McRae Avenue to Browning Park. (11)
- Pond behind UVic University Club. (12)
- University Club to UVic Road. (13)
- Tributary (McKenzie Avenue and Stadium). (14)
- Tributary at Cedar Hill Road (Cedar Hill Recreation Centre) to the Cedar Hill Golf Course – Cedar Hill up past foot bridge. (15)
- Tributary at Cedar Hill Road (Cedar Hill Recreation Centre) to the Cedar Hill Golf Course – Up past foot bridge to baseball diamond. (16)



Figure 1. Location of Bowker Creek Watershed (area shaded blue) on Southern Vancouver Island, British Columbia

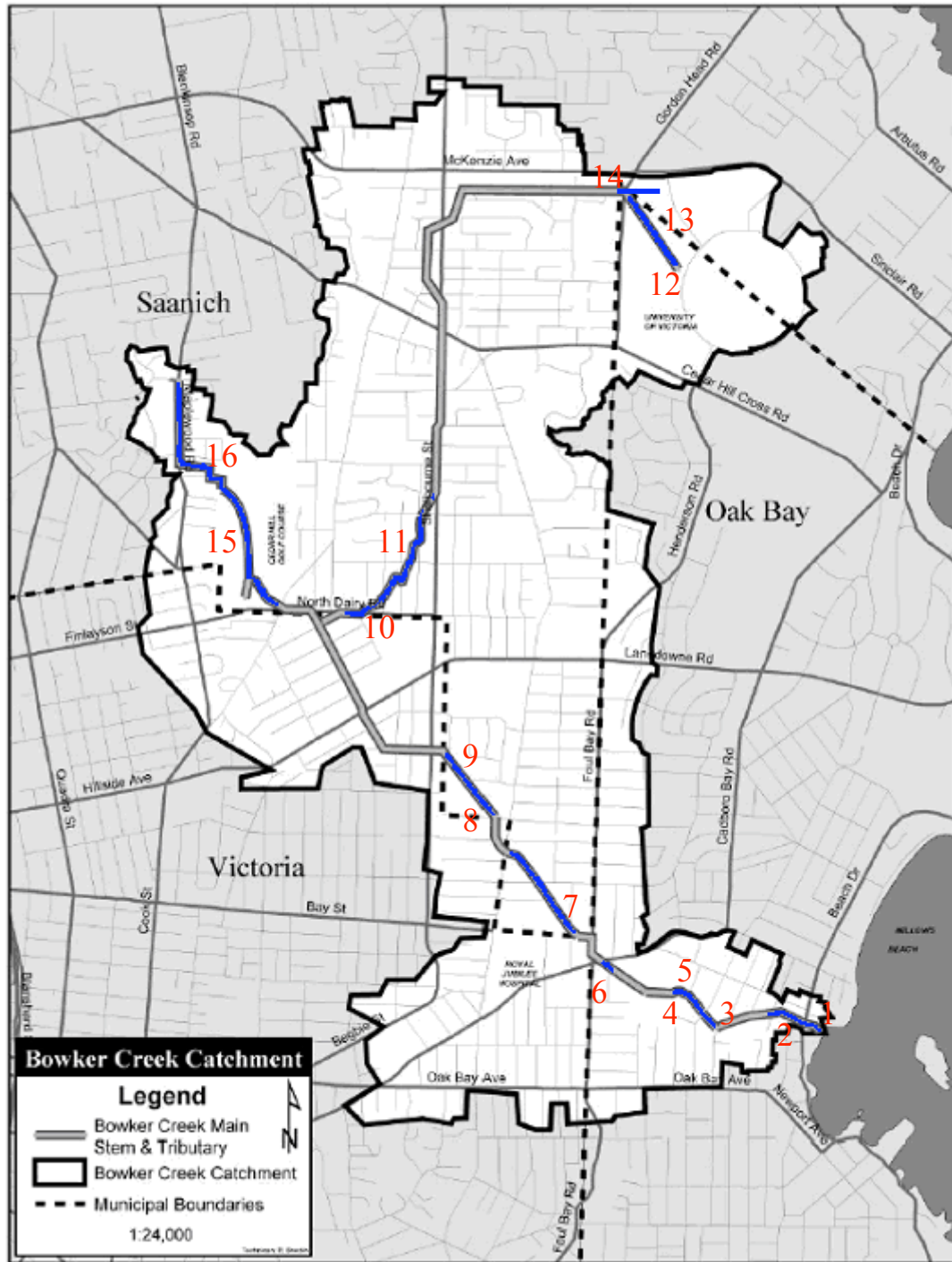
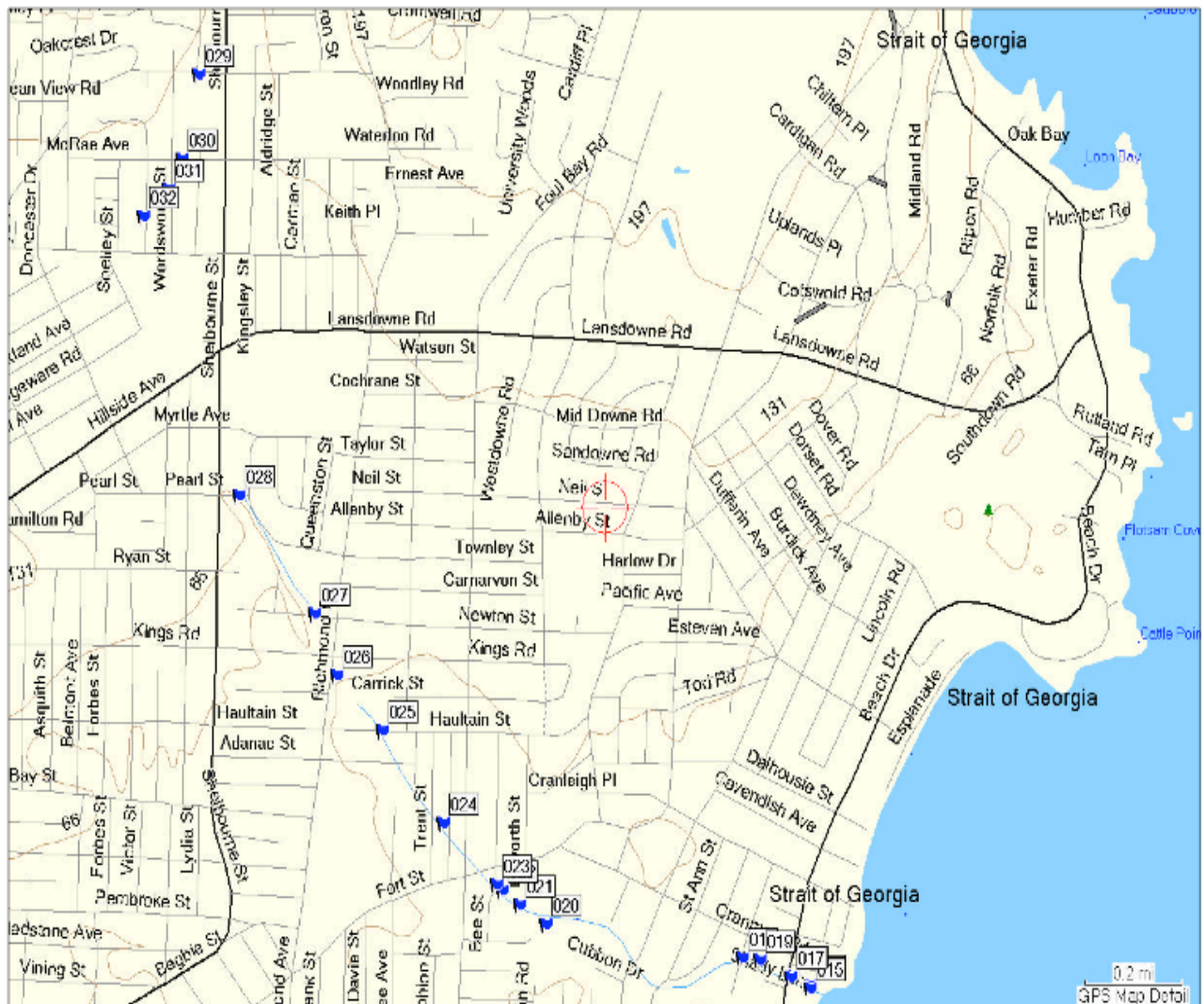


Figure 2. Bowker Creek watershed showing reaches with open channel marked in blue (from CRD, 2003). *Note: open sections are not necessarily continuous.*



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Figure 3: Map of the GPS Way Point Locations within the Bowker Creek watershed as determined during the January 2007 assessment.

Table 1: Reach locations and GPS Way Points.

Reach:	Description of Reach:	GPS Way Point Number and position:
Reach 1	From the mouth of the stream (ocean) to the community allotment gardens.	<i>GPS Way Point #12:</i> N 48° 25.77' W 123° 18.44'
Reach 2	From community allotment gardens to Monteith Street.	<i>GPS Way Point #19:</i> N 48° 25.80' W 123° 18.54'
Reach 3	Between Monterey Avenue and Oak Bay High School	<i>No data</i>
Reach 4	Oak Bay High School to Oak Bay Recreation Centre tennis bubble.	<i>GPS Way Point #20:</i> N 48° 25.852' W 123° 19.119'
Reach 5	Oak Bay Recreation Centre tennis bubble to Bee Street.	<i>GPS Way Point #22:</i> N 48° 25.910' W 123° 19.249'
Reach 6	Bee Street to Cadboro Bay Road.	<i>GPS Way Point #23:</i> N 48° 25.883' W 123° 19.191'
Reach 7	Trent Street to Haultain Road. (St. Patrick's School & Royal Jubilee Hospital).	<i>GPS Way Point #24:</i> N 48° 26.025' W 123° 19.429'
Reach 8	Haultain Road. to Richmond Road. (BC Hydro property).	<i>GPS Way Point #25:</i> N 48° 26.152' W 123° 19.559'
Reach 9	Newton Street to Pearl Street (Richmond Elementary).	<i>Begin Reach GPS Way Point #27:</i> N 48° 26.332' W 123° 19.747' <i>End Reach GPS Way Point #28:</i> N 48° 26.51' W 123° 19.95'
Reach 10	North Dairy Road to McRae Avenue.	<i>Begin Reach GPS Way Point #32:</i> N 48° 26.944' W 123° 20.209' <i>End Reach GPS Way Point #31:</i> N 48° 26.987' W 123° 20.141'
Reach 11	McRae Avenue to Browning Park.	<i>GPS Way Point #29:</i> N 48° 27.158 W 123° 20.062'
Reach 12	Pond behind UVic University Clubhouse.	<i>No data</i>
Reach 13	University Club to McGill Rd.	<i>No data</i>
Reach 14	Tributary (McKenzie Avenue and Stadium).	<i>No data</i>
Reach 15	Tributary at Cedar Hill Road (Cedar Hill Recreation Centre) to the Cedar Hill Golf Course – Cedar Hill up past foot bridge.	<i>No data</i>
Reach 16	Tributary at Cedar Hill Road (Cedar Hill Recreation Centre) to the Cedar Hill Golf Course – Up past foot bridge to baseball diamond.	<i>No data</i>

Past and Present Land Use

Historically, Bowker Creek was a meandering, low gradient stream with numerous small tributaries and wetland areas. Fish and wildlife, including anadromous species such as coho and chum salmon, inhabited Bowker Creek and its tributaries. Local First Nations derived food and fresh water from the stream, and nutrients transported from the watershed helped support a rich marine ecosystem in Oak Bay.

Since the middle of the 1800s, the watershed has become increasingly developed, first for agriculture, and later for residential, commercial, industrial and other urban uses. Agricultural settlement began in 1851, when John Tod established a 200 acre farm in Oak Bay. Shortly thereafter, John and Jessie Irvine began the Rosebank farm, on 100 acres of land near the present day intersection of Cedar Hill Road and Cedar Hill Cross Road. In 1861, the creek was locally known at 'The Thames,' being the largest stream in the vicinity.
(CRD, 2003)

As development expanded, the stream was gradually enclosed in storm drains, and channelized, in order to minimize flooding of the surrounding area. Today, nearly 63% of its length is culverted and a significant portion of the open channel is confined in concrete. The main land use is residential and secondarily commercial and institutional. Impervious surfaces such as roads, parking lots and roofs cover a large percentage of the land in the watershed (Figure 4).

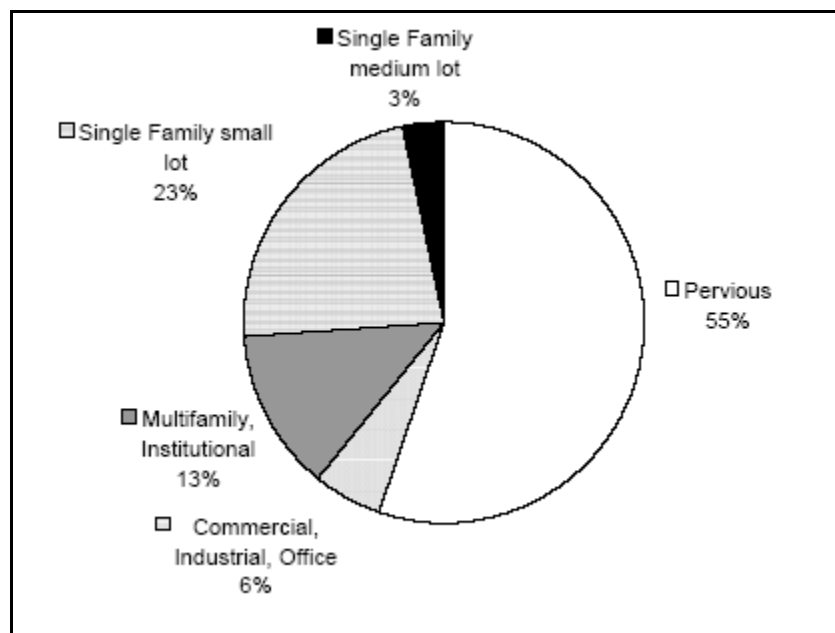


Figure 4. Distribution of impervious and pervious surface area in Bowker Creek watershed (CRD, 2003 from Ruljancich, 2001). Note: More recent detailed work indicates that the pervious area is now 50%.

Background

Assessment of the Bowker Creek Watershed has been on-going for many years. The creek flows through three different municipal jurisdictions, (Saanich, the City of Victoria and Oak Bay), and is bordered by several institutional land owners (UVic, Royal Jubilee Hospital, St. Patrick's School (Independent – Island Catholic Schools), BC Hydro). It therefore requires a co-ordinated management strategy. In 2000, the CRD commissioned a watershed assessment which found that:

- water quality is generally acceptable, and levels of fecal coliform appear to be declining;
- fish are present only between the mouth of the creek and the first culvert;
- riparian vegetation may be limited by clay soils and invasive species are prevalent;
- areas near some open portions of the creek are used recreationally;
- hydraulic limitations are most severe at Monterey Avenue and Trent Street (RCPL, SHIP, 2000).

This watershed assessment, conducted by Reid Crowther & Partners and SHIP Environmental Consultants, identified a number of issues and concerns that could be addressed by the PFC Team and stakeholders, through field assessment and subsequent analysis of findings. These include:

1. Maintain and rehabilitate the open channel portions of Bowker Creek.
2. There is little likelihood in the foreseeable future of successfully introducing a sustainable salmon or trout population in Bowker Creek. It was noted in this report that Bowker Creek will not be able to sustain fish populations in the foreseeable future and therefore fish introductions were not recommended.
3. There is no strong argument to consider daylighting any additional portions of Bowker Creek. It is important to establish both riparian and eventually canopy cover over the existing channel. Without well-established vegetation cover, there is a risk of subjecting the channel to increases in both water temperature and rates of evaporation.
4. Development of improvements in water quality should continue.
5. Many engineering requirements for storm water management and features considered desirable in [a] linear greenway are compatible. Development of stormwater storage with reduced bank heights will allow for improved access to the stream channel for people and the opportunity to establish a more natural riparian vegetation and tree cover along the proposed greenway.
6. The existing Bowker Creek base flow channel should not be widened. Aside from creating floodplain water storage areas adjacent to the Bowker Creek channel, the existing Bowker Creek channel should not be modified by creating ponds or wetland areas, as these will only increase the exposure of the water surface to sunlight, thus risking increases in water temperature and reductions in stream flow and oxygen levels. As well, wetland areas may increase waterfowl use, which could result in an increase of coliform levels and possibly the potential for an increase in mosquito populations.
7. Existing open land adjacent to Bowker Creek should be designated as linear park or greenway. There is a strong desire by the community at large to create a linear park along the open portions of Bowker Creek. All portions of the open channels of Bowker Creek

adjacent to vacant land are areas where people walk. They are not all designated as parks; many are just vacant portions of private land. There is a strong desire by local community groups and a willingness by Saanich and Oak Bay to consider the development of a linear park or greenway along Bowker Creek. This would include all land proposed for restructuring for storm water storage, plus additional lands needed to provide linear connections. Presently occupied land that would be desirable and feasible to include in a green space plan should also be identified. It is recognized that some land that may not presently be available for linear park should be identified so if the opportunity arises in the future, it could be acquired.

8. Existing stream banks should be restructured to facilitate the development of native riparian vegetation and access for people.
9. [Develop] ...water storage or retention techniques to control and treat initial or “first flush” discharges to the storm drainage system.
10. Monitor Bowker Creek water quality to assess whether fish can be supported.

The 2003, Bowker Creek Watershed Management Plan (CRD) identified several goals and objectives for the watershed based on community consultation and discussions with partner municipalities. They are:

Goal 1. Individuals, community and special interest groups, institutions, governments, and businesses take responsibility for actions that affect the watershed
--

- Objective 1A. Ensure all interest holders understand the values of Bowker Creek and the watershed so they can act responsibly.
- Objective 1B. Foster long-term community stewardship of Bowker Creek and celebrate accomplishments.
- Objective 1C. Plan and manage land in the Bowker watershed in ways that create compact and attractive communities, increase areas of green space, reduce stormwater runoff, and improve water quality in Bowker Creek.

Goal 2. Manage flows effectively

- Objective 2A. Base watershed management decisions on a comprehensive understanding of the hydrological characteristics of the watershed; manage the risk of flood damage to property near Bowker Creek; and coordinate flow management decisions among jurisdictions.
- Objective 2B. Encourage onsite retention and infiltration of stormwater to reduce the area of effective impervious surfaces in the watershed.

Goal 3. Improve and expand public areas, natural areas, and biodiversity in the watershed
--

- Objective 3A. Prepare a comprehensive inventory of watershed values.
- Objective 3B. Protect and enhance existing natural areas (or areas with restoration potential) in the watershed, particularly adjacent to Bowker Creek.
- Objective 3C. Create a multi-use greenway corridor from the headwaters to the ocean, in accordance with the Regional greenway system.

Goal 4. Achieve and maintain acceptable water quality in the watershed

Objective 4A. Identify water quality problems and causes.

Objective 4B. Meet or exceed provincial water quality guidelines for aquatic life.

Objective 4C. Establish and maintain stable naturalized banks to protect water quality and public safety.

While water quality analysis was beyond the scope of the PFC assessment, this PFC team sought to verify the above management recommendations and reassess the stream from a functional perspective.

General Physical Character

The riparian area and stream channel are products of the geology and soils, topography, vegetation, large woody material, climate and hydrology of the watershed. Alteration of these attributes can bring about changes in the function of the riparian zone, stream channel and biological habitat related to it. Bowker Creek is an urban stream that has been highly modified from its original form, to the extent that large sections are now enclosed in underground pipes and culverts. This feature, combined with the impervious character of the surrounding catchment area, defines most of the characteristics of the stream today.

The remaining open sections of channel in Bowker Creek have been altered to the point where they are unlikely to recover to their historic condition. The potential of the system has therefore been defined in this newer, altered, context. Channel reinforcements (concrete, rock, brick, etc.) in Reach 6 have created a form similar to a natural bedrock-controlled channel. Reach 4 has not been reinforced as substantially, and is therefore more vulnerable to erosion.

The topography in the Bowker Creek watershed is generally quite flat, with the two most prominent features being Mt. Tolmie, a rocky knoll to the east of the channel (southwest of UVic), and Cedar Hill, a gently sloping hill with numerous rocky outcrops situated to the west of the stream.

The lack of floodplain and constriction of flows has the effect of concentrating energy within the channel. This has led to significant erosion and bank failure in most areas. Because the channel is oversized and entrenched, the creek cannot access its floodplain on a regular basis (1.5- 2 years). The groundwater has thus been depleted, bank storage is minimal and baseflows in the summer months are extremely low.

Climate (precipitation, hydrograph, temperature)

The air temperature in the Bowker Creek watershed, as measured at Gonzales Heights (48° 25' N, 123° 19' W), ranges from an average minimum of 3.7°C during the winter months (November to February) to an average maximum of 19.1°C in the summer months (June-September) (Environment Canada, 2002). The average annual precipitation is 607 mm, almost all of which falls as rain; the months with the most precipitation are November, December and January (Environment Canada, 2002). Peak flows in Bowker Creek consequently occur during these months. Although a hydrograph has not been made for Bowker Creek, flows are generally “flashy” due to extensive surrounding impervious surfaces, and peak sharply after a rainfall. Summer water temperature, assessed during between July and September of 2000 at various points in the stream, ranged from 13.5° C to 21° C (RCPL and SHIP, 2000).

Geomorphology (general geologic type and soils type)

The bedrock in the Victoria area is composed mostly of ancient Wark and Colquitz *gneiss* complexes that were metamorphosed 200 million years ago, from still-older deposits, by intense heat and pressure within the earth's crust (Yorath and Nasmith, 1995). This rock was uplifted when the Crescent Terrane (upon which Colwood and Metchosin are situated) collided with the Wrangellia Terrane, which comprises much of Vancouver Island, the Queen Charlotte Islands and the B.C. coast west of the Coast Mountain range. Millions of years of erosion wore away the more recently formed rock, leaving behind the more durable gneiss (Yorath and Nasmith, 1995). *Vashon till*, poorly sorted sediments ranging in size from silt to cobbles, was deposited in many

locations in the region, under the base of glaciers during the height of the Fraser Glaciation, 29,000 to 13,000 years ago. In many areas this till overlies the *Quadra formation*, sediment that was pushed up in front of the advancing ice sheets (Yorath and Nasmith, 1995). *Victoria clay* is also common in low-lying areas below 60 m above sea level in the Victoria area. This clay is marine in origin and was deposited at the end of the Fraser Glaciation, between 13,000 and 5,000 years ago, when the sea level rose as the ice sheets melted, but the land of southern Vancouver Island had not yet rebounded from under the weight of ice (Yorath and Nasmith, 1995; Kenney, 2004).

In summary, the geology in the Bowker Creek watershed is characterised by deposits of glacial till and glaciomarine clay overlying gneiss bedrock.

Vegetation (forest type, shrub type, grassland type, etc.)

The Bowker Creek watershed is located in the Coastal Douglas Fir (CDF) biogeoclimatic zone (Green and Kinka, 1994). Due to the rainshadow effect of the mountains of the Olympic Peninsula and the Sooke hills, the CDF zone is characterised by a climate that is substantially drier and Mediterranean-like, compared to the wetter areas farther to the west and on the B.C. mainland coast. The CDF zone is restricted to low elevations along southeastern Vancouver Island, from Bowser to Victoria, the Gulf Islands south of Cortes Island, and a narrow strip along the Sunshine Coast near Halfmoon Bay (Green and Klinka, 1994). Garry oak (*Quercus garryana*) meadows are subcomponent of the CDF ecosystem and were once common throughout the Victoria area and in the Bowker Creek watershed (Figure 5).

Due to substantial urban development in the Bowker Creek watershed, only remnants of native CDF vegetation remain. Some of the species typical of CDF and/or Garry oak ecosystems that are, or were historically, found in the Bowker Creek watershed include:

- Trees such as Douglas fir (*Pseudotsuga menziesii*), western red cedar (*Thuja plicata*), grand fir (*Abies grandis*), red alder (*Alnus rubra*), bigleaf maple (*Acer macrophyllum*), arbutus (*Arbutus menziesii*) and Garry oak (*Quercus garryana*);
- Shrubs such as salal (*Gaultheria shallon*), Nootka rose (*Rosa Nutkana*), Baldhip rose (*Rosa gymnocarpa*), dull Oregon grape (*Mahonia nervosa*), common snowberry (*Symphoricarpos albus*), ocean spray (*Holodiscus discolor*), willows (*Salix* sp.), red-osier dogwood (*Cornus stolonifera*), salmonberry (*Rubus spectabilis*), red flowering currant (*Ribes sanguineum*), huckleberry (*Vaccinium* sp.), kinnikinnick (*Arctostaphylos uva-ursi*), spirea (*Spiraea douglasii* ssp. *douglasii*) and Indian plum (*Oemleria cerasiformis*);
- Herbaceous plants such as sword fern (*Polystichum munitum*), lady fern (*Athyrium filix-femina*), skunk cabbage (*Lysichiton americanum*), sedges (*Carex*, *Scirpus* sp.), rushes (*Juncus* sp.), vanilla leaf (*Achlys triphylla*), devil's club (*Oplopanax horridus*), false lily of the valley (*Maianthemum dilatatum*), lilies (*Erythronium* sp.), nodding onion (*Allium cernuum*), camas (*Camassia* sp.), buttercup (*Ranunculus* sp.), dwarf dogwood (*Cornus canadensis*), shooting stars (*Dodecatheon* sp.), and satin flower (*Sisyrinchium douglasii*).

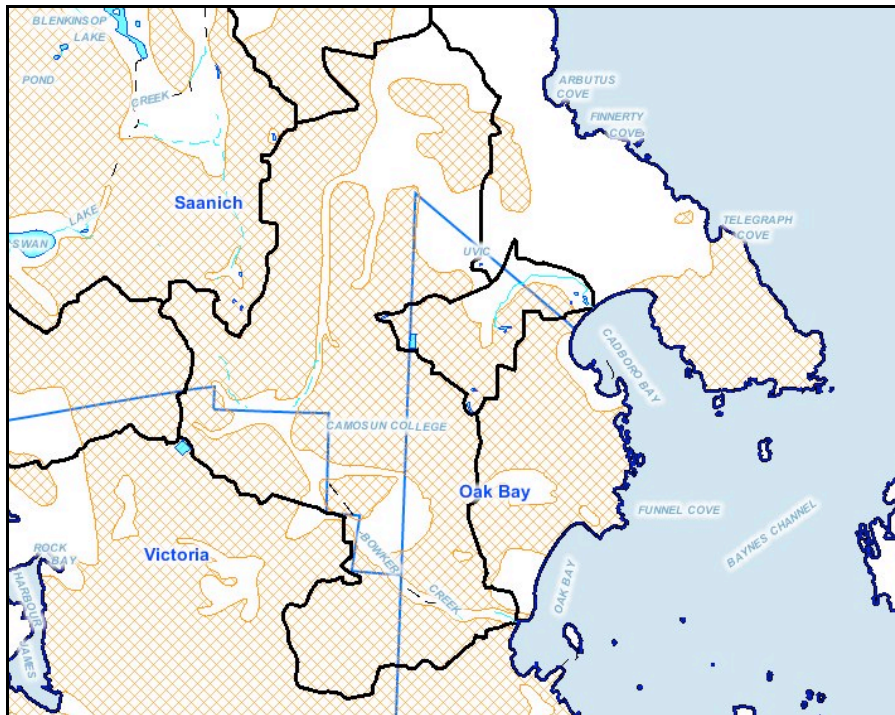


Figure 5. Distribution of Garry oak meadow ecosystems, circa 1800 (yellow hatched area).
 Source: CRD Natural Areas Atlas <http://www.crd.bc.ca/es/natatlas/atlas.htm>.

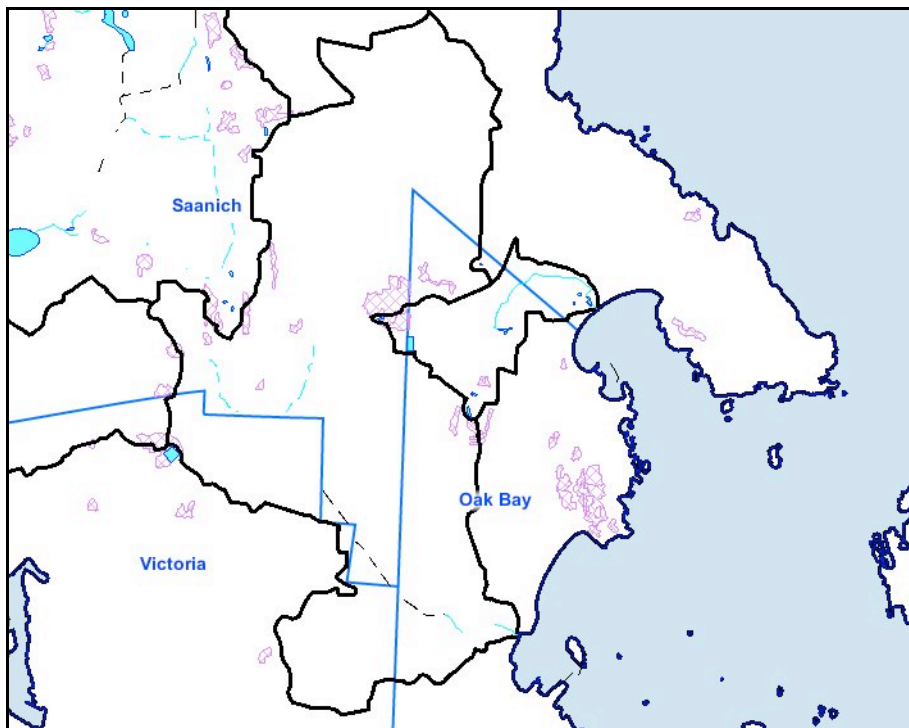


Figure 6. Distribution of Garry oak meadow ecosystems, circa 1997 (purple hatched area)
 Source: CRD Natural Areas Atlas <http://www.crd.bc.ca/es/natatlas/atlas.htm>.

Invasive species that have been introduced deliberately or accidentally in the area include: holly (*Ilex aquifolium*), English ivy (*Hedera helix*), laurel-leaved daphne (*Daphnea laureola*), Scotch broom (*Cytisus scoparius*), Canada thistle (*Cirsium arvense*), Himalayan blackberry (*Rubus discolor*), Japanese knotweed (*Polygonum cuspidatum*) and various lawn and pasture grasses such as Kentucky bluegrass (*Poa pratensis*), common velvet grass (*Holcus lanatus*), Sweet Vernal grass (*Anthoxanthum odoratum*) and orchard grass (*Dactylis glomerata*). In addition, many less invasive but exotic plants are common among the private yards and commercial/institutional grounds in the watershed.

Aquatic Habitat

Although no recent professional fish surveys are recorded for Bowker Creek, local stewardship groups have no recorded observations of fish (RCPL and SHIP, 2000). A survey conducted in 1988 reported the presence of stickleback (*Cottus and Gasterosteus* sp.), but only in Reach 1, between the mouth and Monteith St. (Norris, 1988 in RCPL and SHIP, 2000). Benthic invertebrates observed in the stream consist mostly of pollution-tolerant species such as *Diptera* larvae, freshwater leeches, segmented worms and freshwater snails, although some species considered indicators of fair to good water quality have also been found (RCPL and SHIP, 2000). Frog croaking, once common in certain sections of the stream, is anecdotally reported to have ceased since the mid 1990s (RCPL and SHIP, 2000).

Water quality, in terms of levels of metals, organic contaminants, dissolved oxygen, temperature, pH and conductivity, is generally “acceptable” for aquatic life, however the “first flush” of runoff after a prolonged dry period presents concerns (RCPL and SHIP, 2000).

Methods

PFC Assessment

The Proper Functioning Condition (PFC) assessment involves using a standard checklist to consistently assess the hydrology, soils and vegetation of riparian areas. The checklist and its summarization are used to classify the health or state of physical processes of the riparian-wetland area. The PFC assessment method was chosen because it could provide a quick and defensible method for assessing riparian and stream channel condition. A PFC assessment method is also available for wetland ecosystems. A detailed explanation of the PFC assessment methods and example of the checklist can be found in Appendix 1.

This methodology was originally developed for the US Bureau of Land Management by a team of fifty scientists specializing in hydrology, soils/geology, vegetation, and biology. They developed the Riparian-Wetland Functional Checklist of seventeen hydrology, vegetation, and soils/geology attributes that must be considered when evaluating riparian areas to determine their physical functionality. The assessment is used to identify any significant attributes that may be out of balance with the natural processes necessary for the system to function properly. The PFC teams commonly use Rosgen stream channel typing to determine whether the stream fits the expected landscape setting or is outside the natural range of variability (Rosgen, 1996). Rosgen channel typing is described in Appendix 4.

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

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

To date, the PFC method has been most often applied to “wildland” riparian-wetland systems, *i.e.* those that still retain mostly natural features, even if these have often been influenced by people. The Bowker Creek assessment represents part of a current expansion of the application of the method to urban systems. PFC is wholly applicable to urban streams, however some adaptations are necessary. The pivotal question addressed by the team in the assessment of Bowker Creek was: what is the “potential” condition of the stream? A system’s potential is defined as *the highest ecological status a riparian-wetland area can attain given no political, social, or economical constraints* (Prichard *et al.*, 1998). Often, a picture of the potential condition for an area is given by historical information. For example, if a riparian area has been logged, the potential vegetation might still be a mature forest, since the area can be replanted and/or can regenerate naturally. Bowker Creek is somewhat different. The historical condition of the stream was likely a highly sinuous channel with wide floodplains and wetlands, surrounded by a mature Coastal Douglas Fir ecosystem. Since it is now so far from this condition, and highly unlikely to return to it in the foreseeable future, in effect the system has a new “potential,” in the context of the human-made landscape. This interpretation allows for more realistic recommendations and management options.

In the Bowker Creek Watershed, the assessment area was stratified by defined segments (reaches) of stream that share common processes and attributes. All reaches were numbered sequentially from downstream to upstream and tied to a prominent landmark or road name for map reference (Figure 2). For the purposes of this report, the reaches were defined as those sections that consist of an open channel (as opposed to an underground storm drain). A total of sixteen reaches were defined and assessed.

The assessment started at Reach 1 (Mouth of Stream) and then proceeded upstream to Reach 16 (Tributary from Cedar Hill Golf Course (at Cedar Hill Rec. Centre)). Each reach was classified according to Rosgen’s stream classification system and the team’s estimate of the potential for the reach (Rosgen, 1996). Rosgen channel types are delineated in Appendix 4 (See Table 2 below and individual reach summaries that follow.

Results

Table 2. PFC Summary Determinations

Reach #	Description	Approx. Reach Length (m)	Rosgen Channel Type	Potential Rosgen Channel Type	PFC Determination (PFC/ FAR/ NF)	Trend: Upward/ Not Apparent/ Downward*	Potential Riparian Community Type
1	Outlet to allotment gardens	100	Fg1	B1	NF	*	**
2	Gardens to Monteith St.	75	C2-3b	C2-3b	FAR	Downward	**
3	Monterey to Oak Bay HS	100	Ditch	C	NF	*	**
4	Oak Bay HS to OB Rec tennis bubble	80	Ditch	C	NF	*	**
5	OB Rec to Bee St.	80	G2-3c	B	NF	*	**
6	Bee St. to Cadboro Bay Rd.	40	Ditch	G	NF	*	**
7	Trent to Haultain	250	B4-5/Ditch	C4-5/Lentic	FAR	Upward	**
8	Haultain to Richmond	150	G5-6	C/Lentic	NF	*	**
9	Newton to Pearl	75	G/Ditch	B & C	NF	*	**
10	N Dairy to McRae	180	G4	B4g	NF	*	**
11	McRae to Browning	250	B4g	B4g	PFC	*	**
12	University Club Pond	150	~	~	FAR	Downward	**
13	Pond to McGill Rd	200	C	C	PFC	*	**
14	McKenzie Ave. tributary	200	~	~	PFC	*	**
15	Cedar Hill Rec to bridge	90	G	Gb	PFC	*	**
16	Cedar Hill Golf- bridge to ball diamond	120	C	C	PFC	*	**

*The PFC protocol requires that trend ratings only be given to reaches that are FAR. Reaches that are rated PFC do not receive a trend rating. Trend in the PFC context means to be moving toward or away from reach PFC.

** Mature coniferous and/or deciduous forest.

Mature coniferous forest would include species such as: western red cedar, red alder, big leaf maple, salmon berry, cascara, stink currant, thimble berry, devil's club, salal, skunk cabbage, and slough sedge; Deciduous forest would include species such as: black cottonwood, big leaf maple, red alder, willow, red osier dogwood, Indian plum, red elderberry, bracken fern, hardhack, sedges, and rushes. Without historical vegetation data it is unclear whether deciduous or coniferous would dominate.

~ Reach is a Lentic System. No Channel type applies.

Table 3. Master list of species identified in the riparian zone of Bowker Creek listed alphabetically by common name.

Common name	Scientific name
birch	<i>Betula</i> sp.
black cottonwood	<i>Populus balsamifera</i> ssp. <i>trichocarpa</i>
black hawthorne	<i>Crataegus douglasii</i>
cattail	<i>Typha latifolia</i>
common snowberry	<i>Symphoricarpos albus</i>
conifers (various exotic)*	
Douglas fir	<i>Pseudotsuga menziesii</i>
English hawthorne*	<i>Crataegus laevigata</i>
English holly*	<i>Ilex aquifolium</i>
English ivy*	<i>Hedera helix</i>
European bittersweet	<i>Solanum dulcamara</i>
Garry oak	<i>Quercus garryana</i>
grass species*	
Himalayan blackberry*	<i>Rubus discolor</i>
horsetail	<i>Equisetum</i> spp.
Japanese knotweed*	<i>Polygonum cuspidatum</i>
laurel-leaved daphne*	<i>Daphnea laureola</i>
Maple	<i>Aceraceae</i>
Nootka rose	<i>Rosa nutkana</i>
Pacific water parsley	<i>Oenanthe sarmentosa</i>
poison hemlock	<i>Conium maculatum</i>
Poplar	<i>Populus balsamifera</i>
red alder	<i>Alnus rubra</i>
reed canary grass	<i>Phalaris arundinacea</i>
red-osier dogwood	<i>Cornus stolonifera</i>
rhododendron	<i>Rhododendron</i> spp.
salal	<i>Gaultheria shallon</i>
salmonberry	<i>Rubus spectabilis</i>
Scotch broom*	<i>Cytisus scoparius</i>
Short pine	<i>Pinus contorta</i>
skunk cabbage	<i>Lysichiton americanum</i>
sword fern	<i>Polystichum munitum</i>
weeping willow	<i>Salix babylonica</i>
western red cedar	<i>Thuja plicata</i>
willow (various)	<i>Salix</i> spp.
yellow pond lily	<i>Nuphar polysepalum</i>
yellow willow*	<i>Salix lutea</i>

* denotes invasive species

Physical Watershed Function

Bowker Creek was once a productive and sizeable stream, but over the past 50-100 years it has been transformed into a component of the urban stormwater drainage system. The flows in the watershed are typical of urban systems with a large amount of impervious surfaces in that they increase and decrease sharply in response to runoff from rainstorms; this kind of flow is sometimes called “flashy,” since it is similar to flash floods that occur in desert environments (where the land is also relatively impervious). This hydrology, combined with the current channel shape (straight and deeply entrenched, with no floodplain access) and adjacent land uses, limits the extent of functional recovery possible in this stream. Furthermore, water quality is a concern due to runoff from roads and parking lots. Nevertheless, the function of the stream can be improved, in order to accommodate aesthetic and recreational values and to provide terrestrial habitat.

A riparian-wetland area is considered to be in Proper Functioning Condition when adequate vegetation, landform, or large woody material is present to:

- Dissipate stream energy associated with high water flows, thereby reducing erosion and improving water quality;
- Filter sediment, capture bedload, and aid floodplain development;
- Improve flood-water retention and ground-water recharge;
- Develop root masses that stabilize stream banks against cutting action;
- Develop diverse ponding and channel characteristics to provide the habitat and the water depth, duration, and temperature necessary for fish production, waterfowl breeding, and other uses;
- Support greater biodiversity.

When Bowker Creek was enclosed, straightened and entrenched, several things occurred that dramatically altered the physical function of the stream:

- The energy in the creek channel was concentrated because the creek could not access its floodplain to spread out and dissipate the energy;
- The increased energy caused increased erosion of the banks;
- The flood waters were no longer retained higher up on the land and the water was concentrated in the channel;
- A portion of the water no longer disappeared into the ground to recharge groundwater and reappear in the summer as baseflow- it all went into the channel;
- The imperviousness of the surrounding watershed prevented water from soaking into the ground and it too, ended up in the channel;
- The creek had too much water for the amount of sediment it could carry so it picked up sediment in a phenomenon called “clear water erosion”;
- The width to depth ratio of the channel changed; it became too wide during low flow causing the water to slow down too much and deposit sediment where it should not be;
- The lack of groundwater recharge can lead to lower amounts of future water storage within the floodplain “sponge” which currently provides water to the creek during the summer months (lower recharge rates means future summer flows may not occur);

- Because the creek could not access its floodplain, it could not deposit sediment on it to rebuild the surrounding soils; the fine sediment stayed in the channel and contributed to poor water quality as it could not settle out;
- The ponding and channel characteristics of the stream were reduced and the complex habitat disappeared.

The end result of this is poor water quality, low summer flows, high summer water temperatures; high flood flows and loss of habitat and biodiversity.

Reach Description Summaries (from checklists)

Reach 1 (From the mouth of the stream (ocean) to the community allotment gardens)

Reach 1 is approximately 100 m long and extends from the mouth of the ocean upstream through a residential area, through a culvert under Beach Drive and then to a community gardens/residential area. The stream flows in an armoured channel until it reaches the community gardens. The Rosgen channel type is an Fg1; a concrete armoured meandering channel with some gully characteristics. Erosion has been noted undercutting the right hand bank downstream of the Beach Drive culvert. Additional erosion has been noted under the concrete pad. If this erosion is not handled in a timely manner, there is the potential for the bottom to pull away and thus place more stress on the adjacent walls, causing them to collapse. The surrounding vegetation consists mostly of non-native species such as, English ivy (*Hedera helix*), Himalayan blackberry (*Rubus discolor*), Japanese knotweed (*Polygonum Cuspidatum*), laurel-leaved daphne (*Daphnea laureola*) yellow willow (*Salix lutea*), and some ornamental vegetation. This reach also contains Garry oak (*Quercus garryana*) and) Poplar (*Populus balsamifera*).

As discussed in the Methods section, the potential for Bowker Creek in general is different from its historic condition, since the surrounding property and infrastructure place major limitations on the evolution of the system. The potential for this reach is a Rosgen B type channel with a small amount of sinuosity. The opportunities to narrow the channel would allow the creation of setbacks, and the development of bioengineered terraces with floodplains. This option would be available once the apartment building on Beach Drive is due for either restoration or redevelopment.

Reach 1 was determined to have a rating of Nonfunctional due to the concrete armoured walls and channel bottom. Improvements can only be made once the adjacent land is up for redevelopment.

Reach 2 (From community allotment gardens to Monteith Street)

Reach 2 is approximately 75 m long and extends from the community gardens upstream to Monteith Street. Once leaving the culvert, the stream enters the community gardens in which both sides are soft and vegetated until the last 20 m in which then the downstream right hand side has a hardened face (concrete filled sandbags). The Rosgen channel type is a Cb2-3; a relatively sinuous channel with a slope of less than 2%. Erosion is undercutting the concrete sand bag wall. Furthermore, the left hand side of creek is lined with community gardens and through trampling is causing degradation of the riparian species. The culvert downstream from Fireman's Park is undersized for the amount of volume of water passing through the system, which has resulted in the recent flooding of the park and neighboring houses. Furthermore, recently planted bioengineering was overcome by these high flows resulting in loss of topsoil. It was also noted that a point bar formation has occurred on the right side due to erosion on the outer corners of the soft shore, and there has been the dumping of vegetation and garbage in the reach. There is no notable new growth of vegetation and has insufficient plant communities to withstand high flows. The surrounding vegetation consists of black cottonwood (*Populus balsamifera*, spp. *Trichocarpa*), Common snowberry (*Symphoricarpos albus*), English ivy (*Hedera helix*.), Himalayan blackberry (*Rubus discolor*) laurel-leaved daphne (*Daphnea laureola*), red-osier dogwood (*Cornus stolonifera*), yellow willow (*Salix lutea*), and the surrounding community garden flora and vegetation.

This reach is presently at its potential channel type (Cb 2-3). The potential restoration of the site would include installing an appropriately-sized culvert, performing invasive species removal with replanting of native species, re-planting the bio-engineering, and the installing of rock groynes and weirs for hydraulic diversity (install one 6 m downstream of the culvert, one next to the large group of willows on the downstream left hand side and augment a rock stone line at left outer corner). Exclusion of access to creek is required in order to reduce trampling and dumping of materials. If provided an opportunity to re-develop Fireman's Park (i.e. removal of the baseball diamond), it is recommended that the culverted creek (currently situated underneath the park) be daylighted with a meandering channel and floodplain through constructed terraces and/or adjacent wetlands. During high flows, these ponds would be used to store large amounts of water thus reducing problematic flooding downstream.

Reach 2 was determined to have a rating of Functional-at-Risk, with a downward trend away from PFC. Improvements could be made by creating more floodplain, through constructed terraces and/or adjacent wetlands, as well as by planting more native riparian vegetation. Improving the stormwater management in the watershed, by increasing on-site infiltration of rainwater, would reduce the energy loads placed on this reach and would also improve water quality.

Reach 3 (Between Monterey Avenue and Oak Bay High School)

Reach 3 is approximately 100 m long and extends from Monterey Avenue to Oak Bay High School. The stream flows in an armoured channel throughout the reach. The Rosgen channel type is a ditch; a concrete-armoured straightened channel. The constraint in this reach is that the channel is armoured throughout. The surrounding vegetation is minimal and consists mostly of black cottonwood (*Populus balsamifera*, spp. *Trichocarpa*), grasses, and yellow willow (*Salix lutea*).

The potential for this reach is a Rosgen C type channel with sections of ponds while still keeping the same channel configuration. Restoration would be to redevelop the area as urban park, terracing along the channel with new trails placed above the terraces such that they would not cause the vegetation to be trampled or the bank to collapse. Ideally, to improve the esthetics of the site, the grass should be removed and replanted with natural vegetation including grasses and shrubs.

Reach 3 was determined to have a rating of Nonfunctional due to the concrete armoured walls and channel bottom.

Reach 4 (Oak Bay High School to Oak Bay Recreation Centre tennis bubble)

Reach 4 is approximately 80 m long and extends from Oak Bay High School to the Oak Bay Recreation Centre Tennis Bubble. The Rosgen channel type is a ditch; a concrete armoured straightened channel. The constraint in this reach is that the channel is armoured on the downstream right-hand side throughout, with a steep, vegetated slope on the opposite side. The surrounding vegetation is sparse and consists mostly of black cottonwood (*Populus balsamifera*, spp. *Trichocarpa*), Himalayan blackberry (*Rubus discolor*), grasses, and yellow willow (*Salix lutea*).

The potential for this reach is a Rosgen entrenched C type channel. Restoration would include the redevelopment of this area as an urban park. Such a redevelopment would include building out a planting terrace to the high water mark on the concrete wall side, while lowering the slope by extending the vegetation on the opposite side approx 10 m into the school field with trails alongside above the terrace. Within the channel itself, a meandering thalweg could be created with rocks. Potential for this restoration is likely dependent on redevelopment of the High School and surrounding areas.

Although the system is stable, Reach 3 was determined to have a rating of Nonfunctional due to the concrete armoured wall and channel bottom.

Reach 5 (Oak Bay Recreation Centre tennis bubble to Bee Street)

Reach 5 is approximately 80 m long and extends from the Oak Bay Recreation Centre Tennis Bubble to Bee Street. The stream flows between two adjacent parking lots (Oak Bay Recreation Centre and the Oak Bay High School) and thus receives a considerable amount of stormwater run-off that is resulting in erosion within the reach. The Rosgen channel type is a Gc 2-3; a gully (with some flood plain), entrenched, narrow and deep channel with low sinuosity. Erosion and undercutting has been noted on right side bank upstream of the culvert. This is occurring due to the very high flows from the large impervious area. The common age class and lack of diversity in vegetation, combined with an inappropriate channel width/depth ratio is exacerbating this problem. The surrounding vegetation consists of black cottonwood (*Populus balsamifera*, spp. *Trichocarpa*), Common snowberry (*Symphoricarpos albus*), Douglas fir (*Pseudotsuga menziesii*), English ivy (*Hedera helix*), Himalayan blackberry (*Rubus discolor*), laurel-leaved daphne (*Daphnea laureola*), Maple (*Aceraceae*), red alder (*Alnus rubra*), red-osier dogwood (*Cornus stolonifera*), Scotch Broom (*Cytisus scoparius*), and yellow willow (*Salix lutea*).

The potential for this reach is a channel type “B.” Upon first assessing the reach, it was thought that the potential for this channel was a “G”, but due to erosion, its potential has been classified as a “B.” The long-term recommendation for this reach (if the site was to be redeveloped) is to widen the channel (thus removing some parking stalls and reconfiguring the parking lot (may lose 20 parking stalls)). In the short-term, leave the system as it is and install a series of rock weirs (5 Rosgen weirs spaced appropriately), manage invasive species through removal, terrace the stream channel, replant with riparian species, and install a trail outside the terraced area.

Reach 5 was determined to have a rating of Nonfunctional due to considerable erosion occurring along the banks, the high flows due to impervious area and runoff, and a lack of adequate vegetation.

Reach 6 (Bee Street to Cadboro Bay Road)

Reach 6 is approximately 40 m long and extends from Bee Street to Cadboro Bay Road. This is a highly modified stream that is completely armoured with concrete along the walls and channel bottom. The Rosgen channel type is a ditch. There is no erosion noted due to the structure of the system, nor is there any vegetation within the reach itself.

The potential for this reach is a Rosgen G type channel with a small amount of sinuosity (narrow channel with floodplain terraces). The recommendation for restoration is to leave the channel as is due to nearby road and buildings and install baffles within the channel.

Reach 6 was determined to have a rating of Nonfunctional due to the concrete armoured walls and channel bottom.

Reach 7 (Trent Street to Haultain Road)

Reach 7 is approximately 250 m long and extends from Trent Street to Haultain Road. (St. Patrick’s School and Royal Jubilee Hospital). It passes through a culvert under Haultain Road, crosses two private lots, a vacant property belonging to the Bishop of Victoria, the Royal Jubilee hospital property, and lastly the playing fields of St. Patrick’s School, before re-entering a storm drain under Trent St. The Rosgen channel type is a B4-5 / Ditch; a moderately entrenched and straightened channel closely resembling the functionality of a ditch. There is notable erosion along the concrete wall and banks along the corridor. Some bank slumping was observed next to St. Patrick’s school. Such slumping is the result of the stream trying to dissipate energy by re-establishing some sinuosity. The stream banks are composed primarily of clay, and are lacking stabilizing herbaceous vegetation. The channel in this reach is almost perfectly straight and contains no overflow channels, adjacent floodplains, wood or bedrock features, any of which would help to dissipate the energy of high flows.

Students from St. Patrick’s School have removed some invasive species and replanted riparian vegetation along the stream banks, and willow wattles have been used extensively to create terraces and protect the banks in the area adjacent to the bridge, following the recent installation of a new sewer main under the creek channel. The channel is trying to restore itself slowly with the development of new terraces. Restoration work that has occurred upstream of the bridge has created some floodplain, but requires more to handle flows in the system. The single age class and lack of vegetation is exacerbating the problem of erosion. The surrounding vegetation

consists upland and invasive species, such as black cottonwood (*Populus balsamifera*, spp. *Trichocarpa*), English ivy (*Hedera helix*), Himalayan blackberry (*Rubus discolor*), Scotch broom (*Cytisus scoparius*), and yellow willow (*Salix lutea*).

The Rosgen potential channel type is a C4-5 Lentic; a channel with a well-developed floodplain and ponds. Short-term restoration should continue with bank stabilization measures including planting additional willow wattles, and bioengineering. To ensure success, these efforts should be paralleled with the removal of invasive species. Long-term restoration efforts would be to relocate creek along Trent St. and rebuild new channels and wetlands.

Reach 7 was determined to have a rating of Functional-at-Risk, with an upward trend towards PFC. Improvements could be made by creating more floodplain, through constructed terraces and/or adjacent wetlands, as well as by planting more native riparian vegetation. Improving the stormwater management in the watershed, by increasing on-site infiltration of rainwater, would reduce the energy loads placed on this reach and would also improve water quality.

Reach 8 (Haultain Road. to Richmond Road)

Reach 8 is approximately 150 m long and extends from Haultain Road to Richmond Road. The stream flows southeast; after exiting the Richmond Road culvert, it flows through B.C. Hydro reserve land to the east and residential townhouse property to the west and passes through a culvert under Haultain Rd. The Rosgen channel type is a G5-6; a gullied, entrenched, narrow and deep channel with low sinuosity. The stream has been channelized and down cut, straightening the channel and causing serious erosion of banks alongside of the channel. A combination of very high flows and sparse riparian vegetation has led to erosion within the channel. Furthermore, there are no large rocks/wood to help dissipate the energy of the flows. The surrounding vegetation consists of upland and invasive species, such as black cottonwood (*Populus balsamifera*, spp. *Trichocarpa*), Common snowberry (*Symphoricarpos albus*), English Ivy (*Hedera helix*), Himalayan blackberry (*Rubus discolor*), Maple (*Aceraceae*), Scotch broom (*Cytisus scoparius*), and yellow willow (*Salix lutea*).

The Rosgen potential channel type is a C Lentic; a channel with a well-developed floodplain and ponds. Short-term restoration would involve a continuation of bank stabilization measures including planting additional willow wattles, and bioengineering. To ensure success, these efforts should parallel efforts to remove invasive species. Long-term restoration would include restoration of the channel and creation of a series of wetlands/ponds. One problem to note with the restoration is that the large trees lining the path would have to be removed; this would require neighbourhood education.

Reach 8 was determined to have a rating of Non-Functional due to the severity of downcutting, straightening, and erosion of channel.

Reach 9 (Newton Street to Pearl Street)

Reach 9 is approximately 275 m long and extends from Newton St. to Pearl St. The Rosgen channel type is G / Ditch; a gully that closely resembles the functionality of a ditch. There is erosion occurring along stream banks due to high flows and the lack of available floodplain. This erosion has led to the deepening and straightening of the channel. Contributing to the erosion, is a lack of riparian vegetation within the system. Furthermore, there are no large rocks/wood to

help dissipate the energy of the flows. The surrounding vegetation consists of upland and invasive species, such as English hawthorne (*Crataegus laevigata*), English ivy (*Hedera helix*), European bittersweet (*Solanum dulcamara*), Himalayan blackberry (*Rubus discolor*), Scotch broom (*Cytisus scoparius*), and yellow willow (*Salix lutea*).

The Rosgen potential channel type is a B for the School field area; a moderately entrenched and straightened channel, and a C channel thereafter; a well-developed floodplain, with a relatively sinuous channel and a slope of less than 2%. Short-term restoration is to restore the channel and create a series of ponds and wetlands. Long-term restoration would include the relocation of the stream into the playing field and creating a lake to accommodate high flows and absorb energy.

Reach 8 was determined to have a rating of Non-Functional due to the severity of downcutting, straightening, and erosion of channel. Potential restoration for the reach is contingent upon the redevelopment of the site.

Reach 10 (North Dairy Road to McRae Avenue)

Reach 10 is approximately 180 m long and extends from North Dairy Road to McRae Avenue. The Rosgen channel type is G4 (gravel) with some bedrock; a channelized gully that is entrenched and narrow with some step ponds. There is considerable erosion on the outside bend and gabions. The downstream right hand side is heavily armoured and is eroding. There is no available floodplain or large rock / wood to dissipate energy. The width/depth ratios are not appropriate for the channel size and the team noted some bedrock intrusion as well. There is very little vegetation to hold stream banks together and most of the vegetation consists of invasive species. The vegetation consists of black cottonwood (*Populus balsamifera*, spp. *Trichocarpa*), English holly (*Ilex aquifolium*), English ivy (*Hedera helix*), Himalayan blackberry (*Rubus discolor*), red alder (*Alnus rubra*), Scotch broom (*Cytisus scoparius*), western red cedar (*Thuja plicata*), and yellow willow (*Salix lutea*).

The Rosgen potential channel type is a Bg4; a moderately entrenched and straightened channel with some gully characteristics. Short-term restoration would see the placement of spur dikes in the stream (rock weirs), retrofitting the channel with bioengineering and replanting of vegetation. Long-term restoration would be to realign the stream, but unless there is new development of existing residential area, it would be almost impossible to complete such a restoration.

Reach 10 was determined to have a rating of Non-Functional due to the inappropriate width/depth ratio, lack of adequate and diverse vegetation and severity of erosion within the channel.

Reach 11 (McRae Avenue to Browning Park)

Reach 11 is approximately 250 m long and extends from McRae Avenue to Browning Park. After the stream exits the Knight Ave. culvert, it flows south through Browning Park for about 250 m, and passes through a culvert under McRae Ave. The Rosgen channel type is a Bg4; a moderately entrenched and straightened channel with gully elements. The reach is a “G4” to the end of the pond (upstream of the bridge). The remainder of the reach is a B4 with gully elements. The channel is armoured (no lateral movement of channel) with municipal rock (concrete and rock) and has a limited floodplain. There is little wood in the system likely because it has been removed to prevent plugging up the culvert. There is an adequate amount of vegetation, but the

overall system could use more riparian plants. The vegetation consists of black cottonwood (*Populus balsamifera*, spp. *Trichocarpa*), English holly (*Ilex aquifolium*), English ivy (*Hedera helix*), Himalayan blackberry (*Rubus discolor*), red alder (*Alnus rubra*), Scotch broom (*Cytisus scoparius*), western red cedar (*Thuja plicata*), and yellow willow (*Salix lutea*).

The Rosgen potential channel type is a Bg4; a moderately entrenched and straightened channel with some gully characteristics which has an enhanced floodplain/in-stream elements. Short-term restoration is to do nothing. The system is functioning due to the armoured channel. The long-term restoration would be to widen the stream channel and install a series of small rock weirs (1 weir every 5 full bank widths). Floodplains and planting terraces should be built in wherever possible and all this work should be incorporated into planning and construction of the regional trail that is anticipated in the near future. Care must be taken not to locate the trail within the riparian area.

Reach 11 was determined to have a rating of Proper Functioning Condition. The focus for this reach should be on in stream complexity and enhanced vegetation.

Reach 12 (Pond behind UVic University Club)

Reach 12 is approximately 150 m long and consists of the Pond behind the UVic University Club and its outlet. The pond is artificial, with a mix of drainage and ground water entering in. The pond has three soft sides and one hard side (concrete adjacent to the clubhouse). The age class variation of the surrounding vegetation has been limited by landscaping. Furthermore, the drop-log style weir downstream of the pond is failing because the stop log is rotting. It needs to be replaced immediately. The surrounding vegetation consists of birch (*Betula* sp), black cottonwood (*Populus balsamifera*, spp. *Trichocarpa*), Douglas fir (*Pseudotsuga menziesii*), Garry oak (*Quercus garryana*), Maple (*Aceraceae*), Pacific water parsley (*Oenanthe sarmentosa*), red alder (*Alnus rubra*), rhododendron (*Rhododendron* spp.), salal (*Gaultheria shallon*), sword fern (*Polystichum munitum*), and yellow pond lily (*Nuphar polysepalum*).

No serious restoration effort is required within this reach. Placing large wood in the pond would create habitat for various bird species. Additional planting of riparian vegetation in the banks and planting of willows (*Salix* spp.) and red-osier dogwood (*Cornus stolonifera*) in the grassy areas would improve vegetation and cover. The stop log in the outlet weir requires immediate replacement.

Reach 12 was determined to have a rating of Functional at Risk with a downward trend due to the failing of the dam. Replacing the stop-log in the weir would allow the system to be classified as Proper Functioning Condition.

Reach 13 (University Club to McGill Road)

Reach 13 is approximately 200 m long and extends from behind the University Clubhouse to a small wetland (McKenzie field). A large forested area with gravel paths surrounds the stream. The Rosgen channel type is a C; a channel with a well-developed floodplain. There is a higher than expected sediment load. This is likely due to the large storms in the prior weeks washing off road sand and other sediments into the stream. The surrounding vegetation consists of black cottonwood (*Populus balsamifera*, spp. *Trichocarpa*), Common snowberry (*Symphoricarpos*

albus), Douglas fir (*Pseudotsuga menziesii*), English hawthorne (*Crataegus laevigata*), English holly (*Ilex aquifolium*), English ivy (*Hedera helix*), Himalayan blackberry (*Rubus discolor*), Maple (*Aceraceae*), Nootka rose (*Rosa nutkana*), red alder (*Alnus rubra*), salmonberry (*Rubus spectabilis*), skunk cabbage (*Lysichiton americanum*), and sword fern (*Polystichum munitum*).

The Rosgen potential channel type does not change from its present C channel classification. UVic is presently planning to replace the bridge. They should consider removing invasive species at the same time and ensuring that trampling during construction is minimized to avoid harming existing native vegetation.

Reach 13 was determined to have a rating of Proper Functioning Condition.

Reach 14 (Tributary- McKenzie Avenue and Stadium)

Reach 14 is approximately 200 m long and extends to McKenzie Avenue. This tributary is a wetland, surrounded by two large maintained (mowed) fields. There is a higher than expected sediment load in these wetlands. This is likely due to the lack of a sediment-trapping component with the system and due to the large storms that occurred in the prior weeks carrying road sand and other sediments into the wetlands. It was noted that the bridge and culvert are not appropriate for this type of system and should be replaced. The surrounding vegetation consists of black cottonwood (*Populus balsamifera*, spp. *Trichocarpa*), cattail (*Typha latifolia*), European bittersweet (*Solanum dulcamara*), Himalayan blackberry (*Rubus discolor*), Nootka rose (*Rosa nutkana*), Pacific water parsley (*Oenanthe sarmentosa*), red alder (*Alnus rubra*), and yellow willow (*Salix lutea*).

Restoration efforts should include building a sediment pond/trap to catch and retain the sediment from McKenzie Avenue and nearby residential areas. Furthermore, the bridge and culvert need to be removed and replaced with a more appropriately-sized system. With regard to vegetation, more conifers should be planted and the riparian areas allowed to naturally expand (stop mowing so close to riparian area).

Reach 14 was determined to have a rating of Proper Functioning Condition.

Reach 15 (Tributary at Cedar Hill Road (Cedar Hill Recreation Centre) to the bridge at Cedar Hill Golf Course)

Reach 15 is approximately 90 m long and extends from Cedar Hill Golf Course to approx 40 m upstream of the bridge. This tributary is contained between a golf course and a parking lot (Cedar Hill Recreation Centre). The Rosgen channel type is an artificial G; a non-natural narrow and deep gully. Due to the depth of the channel there is no available floodplain. Furthermore, the species within the system are not diverse in age class, and presently have the potential to become a complete monoculture of Reed Canary Grass due to the lack of large trees and riparian vegetation (large trees would shade the grass out). The surrounding vegetation consists of black cottonwood (*Populus balsamifera*, spp. *Trichocarpa*), Common snowberry (*Symphoricarpos albus*), Douglas fir (*Pseudotsuga menziesii*), Himalayan blackberry (*Rubus discolor*), Nootka rose (*Rosa nutkana*), poison hemlock (*Conium maculatum*), red alder (*Alnus rubra*), reed canary grass (*Phalaris arundinacea*) and western red cedar (*Thuja plicata*).

The Rosgen potential channel type is a Gb; a gully with some enhanced floodplain/in-stream characteristics. Restoration would include widening the stream channel, terracing with bioengineering and planting with riparian species.

Reach 15 is in Proper Functioning Condition (low end rating). Though functional, the reach is not in desired condition. Ideally, if there was enough land available, both Reaches 15 and 16 should be redeveloped to become Rosgen “C” type channels.

Reach 16 (Tributary at Cedar Hill Road- foot bridge to baseball diamond)

Reach 16 is approximately 120 m long and extends from 40 m upstream of the bridge to the Cedar Hill Recreation Centre baseball diamond. This tributary is contained between a golf course and a manicured field (baseball diamond). The Rosgen channel type is a C; a channel with a well-developed floodplain. There is some floodplain available within the reach, but not enough due to the constraints of the berms. No point bars have developed in system due to the growth of the reed canary grass. Furthermore, the reed canary grass and lack of large wood in the system do not allow the tributary to build point bars and achieve its full potential sinuosity. The surrounding vegetation consists of black cottonwood (*Populus balsamifera* ssp. *Trichocarpa*), cattail (*Typha latifolia*), Douglas fir (*Pseudotsuga menziesii*), Himalayan blackberry (*Rubus discolor*), Pacific water parsley (*Oenanthe sarmentosa*), red alder (*Alnus rubra*), red-osier dogwood (*Cornus stolonifera*), reed canary grass (*Phalaris arundinacea*), Short pine (*Pinus contorta*), and yellow willow (*Salix lutea*).

The Rosgen potential channel type is a C; a channel with a well-developed floodplain. Restoration would include building more floodplain areas and adding large pieces of wood to the system.. To effectively remove the reed canary grass without damaging the current ecological function of the system, willow or other fast growing species, that will grow large enough to shade the reed canary grass out, should be planted. Furthermore, other invasive species should be removed and be replaced with native species.

Reach 16 is in Proper Functioning Condition. Ideally, if there was enough land available, both Reaches 15 and 16 should be redeveloped to become Rosgen “C” type channels.

Conclusions

Sixteen reaches of Bowker Creek were assessed according to the Proper Functioning Condition methodology. See Table 2. PFC Summary Determinations for results.

Reach 1 (From the mouth of the stream (ocean) to the community allotment gardens)

The potential for this reach is a Rosgen B type channel with a small amount of sinuosity. The opportunities to narrow the channel would allow the creation of setbacks, and the development of bioengineered terraces with floodplains. This option would be available once the apartment building on Beach Drive is due for either restoration or redevelopment. Improvements can only be made once the adjacent land is up for redevelopment. There is opportunity upstream of Beach Drive to restore a narrow floodplain using terraces and for replanting the riparian area with native vegetation. This would however require the agreement of the homeowners who live adjacent to the creek.

Reach 2 (From community allotment gardens to Monteith Street)

This reach is at its current potential channel type right now (Cb 2-3). The potential restoration of the site would include installing an appropriately-sized culvert, performing invasive species removal with replanting of native species, re-planting the bio-engineering, and the installing of rock groynes and weirs for hydraulic diversity (install one 6 m downstream of the culvert, one next to the large group of willows on the downstream left hand side and augment a rock stone line at left outer corner). Exclusion of access to creek is required in order to reduce trampling and dumping of materials. If provided an opportunity to re-develop Fireman's Park (i.e. removal of the baseball diamond), we recommend that the culverted creek (currently situated underneath the park) be daylighted with a meandering channel and floodplain through constructed terraces and/or adjacent wetlands. These ponds would be used to store large amounts of water thus reducing the high flows and flooding downstream. Improving the stormwater management in the watershed, by increasing on-site infiltration of rainwater, would reduce the energy loads placed on this reach and would also improve water quality.

Reach 3 (Between Monterey Avenue and Oak Bay High School)

The potential for this reach is a Rosgen C type channel with sections of ponds while still keeping the same channel configuration. It could be redeveloped as an urban landscape and park, with some terraces and trails along side the creek outside of the floodplain. Ideally, to improve the esthetics of the site, the grass should be removed and the area replanted with natural vegetation.

Reach 4 (Oak Bay High School to Oak Bay Recreation Centre tennis bubble)

The potential for this reach is a Rosgen entrenched C type channel. Restoration would include the redevelopment of this area as an urban landscape and park. Such a redevelopment would include building out a planting terrace to the high water mark on the concrete wall side, while extending the vegetation on the opposite side approx 10 m into the school field with trails alongside outside of the floodplain. Within the channel itself, a meandering channel could be created with rocks. Potential for this restoration is dependant on the redevelopment of the high school property and surrounding area.

Reach 5 (Oak Bay Recreation Centre tennis bubble to Bee Street)

The long-term recommendation for this reach is to widen the channel (thus removing some parking stalls – reconfiguration may reduce parking by up to 20 parking stalls) if site was to be redeveloped. For the short-term, the system can be left as it is and a series of rock weirs installed (5 Rosgen weirs spaced appropriately), invasive species removed, banks terraced, replanted with riparian species, and a trail installed to direct people away from the stream bank edge.

Reach 6 (Bee Street to Cadboro Bay Road)

The potential for this reach is a Rosgen G type channel with a small amount of sinuosity (narrow channel with floodplain terraces). The channel is likely to remain in its present location due to the presence of the adjacent road and buildings. Offset baffles could be installed within the reach to slow flows and enhance habitat.

Reach 7 (Trent Street to Haultain Road)

The Rosgen potential channel type is a C4-5 Lentic; a channel with a well-developed floodplain and ponds. Short-term restoration efforts should continue with bank stabilization measures including planting additional willow wattles, and bioengineering. To ensure success, these efforts should be paralleled with the removal of invasive species. Long-term restoration efforts would be to relocate the creek along Trent St. and rebuild new a channel and wetlands. Improvements could be made by creating more floodplain through constructed terraces and/or adjacent wetlands, as well as by planting more native riparian vegetation.

Reach 8 (Haultain Road. to Richmond Road)

The Rosgen potential channel type is a C Lentic; a channel with a well-developed floodplain and ponds. Short-term restoration should continue with bank stabilization measures including planting additional willow wattles, and bio-engineering. To ensure success, this effort should be combined with the removal of invasive species. Long-term restoration would be to restore the channel and create a series of wetlands/ponds. One problem to note with the restoration is that the large trees lining the path would have to be removed.

Reach 9 (Newton Street to Pearl Street)

The Rosgen potential channel type is a B for the School field; a moderately entrenched and straightened channel, and a C channel thereafter; a well-developed floodplain, with a relatively sinuous channel and a slope of less than 2%. Short-term restoration is to restore the channel and create a series of ponds and wetlands. Long-term restoration would include the relocation of the stream into the playing field and creation of a lake. Potential restoration for the reach is contingent upon the redevelopment of the site.

Reach 10 (North Dairy Road to McRae Avenue)

The Rosgen potential channel type is a Bg4; a moderately entrenched and straightened channel with some gully characteristics. Short-term restoration is to place spur dikes in stream (rock weirs), retrofit channel with bioengineering, and replant vegetation. Long-term restoration would be to redevelop the stream, but unless there is redevelopment of the surrounding residential area, it would be almost impossible to complete such a restoration.

Reach 11 (McRae Avenue to Browning Park)

The Rosgen potential channel type is a Bg4; a moderately entrenched and straightened channel with some gully characteristics that has enhanced floodplain/in-stream elements. Currently, the system is functioning due to the armoured channel. Therefore, in the short-term, the Bowker Creek UWRI should begin working with Saanich on re-development plans for the park to achieve the long-term restoration goals of the reach. This should include incremental habitat improvement such as planting. The long-term restoration goal would be to widen the stream channel and install a series of small rock weirs (1 weir every 5 full bank widths). Floodplains and planting terraces should be built in wherever possible. This restoration work should coincide with the planning and construction of a regional trail anticipated in the near future. Care must be taken not to locate the trail within the riparian area.

Reach 12 (Pond behind UVic University Club)

No serious restoration effort is required within this reach. Placing large wood in the pond would create habitat for various bird species. Additional planting of riparian vegetation in the banks and planting of willows (*Salix* spp.) and red-osier dogwood (*Cornus stolonifera*) in the grassy areas would improve vegetation and cover. The stop log in the outlet weir requires immediate replacement. Replacing stop-log in the weir would allow the system to be classified as Proper Functioning Condition.

Reach 13 (University Club to McGill Road)

The Rosgen potential channel type does not change from its present C channel classification. UVic is presently planning to replace the bridge. They should consider removing invasive species at the same time and ensuring that trampling during construction is minimized to avoid harming existing native vegetation. Reach 13 is in PFC.

Reach 14 (Tributary- McKenzie Avenue and Stadium)

Restoration efforts should include building a sediment pond/trap to catch and retain the sediment from McKenzie Avenue and nearby residential areas. Furthermore, the bridge and culvert need to be removed and replaced with a more appropriately sized system. With regard to vegetation, more conifers should be planted and the riparian areas allowed to naturally expand (stop mowing so close to riparian area). Reach 14 is in PFC.

Reach 15 (Tributary at Cedar Hill Road (Cedar Hill Recreation Centre) to the bridge at Cedar Hill Golf Course)

The Rosgen potential channel type is a Gb a gully with some enhanced floodplain/in-stream characteristics. Restoration would include widening the stream channel, terracing with bioengineering and planting with riparian species. Ideally, if there was enough land available, both Reaches 15 and 16 should be redeveloped to become Rosgen “C” type channels.

Reach 16 (Tributary at Cedar Hill Road- foot bridge to baseball diamond)

The Rosgen potential channel type is a C; a channel with a well-developed floodplain. Restoration would include building more floodplain areas and adding large pieces of wood to the system. In addition, removing invasive species and planting native species of vegetation is

advisable. Ideally, if there was enough land available, both Reaches 15 and 16 should be redeveloped to become Rosgen “C” type channels.

Physical conditions

The physical and hydrological function of Bowker Creek are severely limited, due to the surrounding urban land uses and the fact that 70% of the stream is contained within underground storm drains. The remaining open channel has been modified into a ditch in order to prevent flooding of adjacent land. Even given these limitations, there is room for improvement that could increase the value of the creek as a public green space amenity and as a provider of terrestrial habitat and reduce flooding in developed areas while releasing energy in “safe” flood zones.

Water Storage and Flows

Very little water is stored in the narrow riparian zone adjacent to the creek. Consequently, flows peak quickly during rainstorms, and also fall quickly afterwards. Since there are few features in the stream channel to dissipate the energy of high flows, erosion often results. In the long-term, hydrological storage in the watershed could be increased, and stormwater runoff reduced. For example, if land adjacent to the creek can be acquired by the municipal government(s), additional floodplains and/or wetlands could be constructed. Better on-site management of stormwater should be undertaken by residential and commercial property owners and developers, in order to reduce the volume of water flowing into Bowker Creek, and to improve water quality.

Water Temperature and River Bank Conditions

Summer water temperatures are in the “moderate” range, therefore are not a serious concern (RCPL and SHIP, 2000). Erosion was observed throughout the channel. Native riparian plantings, and, where possible, reconfiguration of the channel to accommodate vegetated terraces, could help stabilize stream banks.

Riparian Plant Communities

Native riparian plant species are lacking in the all of the reaches assessed, and invasive plant species are prevalent. Invasive species generally provide lower-quality habitat and food sources for wildlife and often do not as effectively stabilize stream banks due to poor root structure.

Native Fish and Wildlife Habitat

Although Bowker Creek historically supported salmon, it is unlikely to do so again in the immediate future, due primarily to the physical limitations of the stream. However, restoration measures could feasibly be expected to improve habitat for invertebrates, amphibians, birds and small mammals. With stormwater management and elimination of barriers (both physical and physiological) salmon could return to the system.

Future Studies, Information Needs, and Management Opportunities

The following elements could facilitate the transition from this preliminary Proper Functioning Condition assessment of Bowker Creek to a more thorough understanding of the stream, and to implementation of the recommendations of this report.

Data Needs

- More recent biological information could be gathered, for example, by community stewardship groups, to document the animal and plant species present.
- Stream flow data could be gathered, in order to construct a hydrograph of the stream. Although general trends are fairly well understood, more detailed information could help convey to the public and involved parties how runoff from impervious surfaces affects the stream. This hydrograph could be compared with one for a more natural watershed.

Education Needs and Public Involvement

- Runoff from impervious surfaces has a major effect on the stream. Education should be designed to increase awareness of this concern and to encourage its mitigation through on-site infiltration methods such as rain barrels, infiltration trenches/galleries, vegetated swales and green roofs.
- Many people in the surrounding area remain unaware of Bowker Creek's existence, and of restoration efforts undertaken to-date. Community outreach, such as the events coordinated by the Friends of Bowker Creek group, helps to increase this awareness. These activities should be continued, and, if possible, expanded.
- School groups have already been involved in restoration projects in the creek, including students from St. Patrick's School and St. Michaels University School. More education programs could be implemented to involve students in stewardship activities.

Restoration Needs

Recommendations for restoration are detailed in the following section. Briefly, they focus on:

- Native riparian plantings, to mitigate erosion and provide food and habitat for wildlife;
- Increasing hydrological storage, with constructed wetlands and/or widened floodplains;
- Decreasing runoff, with on-site infiltration technologies;
- "Soft" bioengineering techniques, implemented where possible, to mitigate erosion and increase the abundance of native plants.

Recommendations

The following recommendations represent opportunities to ensure Bowker Creek maintains its current function, and progresses toward its potential condition.

General Recommendations:

- 1. There is an opportunity to reassess the land use needs of the institutions in the area of Bowker Creek between Fort Street and Richmond Elementary School and restore this portion of the stream cost-effectively.** Many of the lands in this area are owned by institutions that are faced with issues of expansion of their building programs. There is the potential to take a watershed-scale approach to stream restoration based upon linking specific parcels of land and integrating their land-use. These parcels include, but are not limited to, St. Patrick's School, the triangle of land immediately upstream of the school, Royal Jubilee Hospital, the B.C. Hydro property and the Richmond School property, in addition to several municipal rights-of-way and easements. The feasibility of integrating the future development of these properties with the restoration of the stream and alleviation of flooding issues, should be reviewed. There may be an opportunity for a Restoration Economy approach to the long-term ownership of these lands that would benefit the land owners, neighbouring residents and the creek. Such a review should include other properties in the immediate area and examine the opportunity to create a series of connected ponds and small lakes / wetlands.
- 2. Where possible, reconfigure the stream channel by creating/widening floodplains, and/or constructing adjacent wetlands and stormwater detention ponds.**
 - a. Although the potential for "natural" floodplains is limited, some benefit could be achieved by creating rock-reinforced terraces (with riparian vegetation) along the channel that would allow some energy dissipation.
 - b. Some detailed proposals for detention pond locations and sizes already exist (*e.g.* RCPL and SHIP, 2000).
 - c. The feasibility of this kind of work depends to a large degree on land ownership. If the city/municipality can buy properties alongside the channel, over time this option will become more realistic. One of the most likely sites for adjacent ponds or wetlands is the B.C. Hydro property. Education and public involvement would be required to ensure the support of the local community.
- 3. Plant more native riparian and upland species on and near stream banks, control invasive species and use bioengineering techniques to mitigate erosion.**
 - a. Native plants will help to mitigate erosion, increase the available wildlife habitat, and improve hydrological function of the stream. Volunteers have been, and can continue to be, an important force in replanting efforts.
 - b. Bioengineering techniques, such as wattle fences and live staking with willow cuttings, can provide effective erosion control, while restoring a natural appearance and function. Where feasible, this method is generally preferred to hard bank armouring, for example with riprap (angular rock) or concrete.

- c. Invasive plants are currently a concern along Bowker Creek. They out-compete native plants and do not usually provide valuable food or habitat for wildlife. Where they are removed, care should be taken not to excessively disturb soil and cause erosion of the stream banks, and the area should be immediately replanted with native species in order to prevent re-colonization with invasives.
- 4. Encourage on-site infiltration of stormwater in order to reduce the volume of rainwater that flows into the stream.**
- a. Bylaws, codes of practice and best management principles can be used to encourage businesses and developers to use proven and available technologies to keep runoff from their sites to a minimum. Tools such as the Water Balance Model (<http://www.waterbalance.ca/waterbalance/home/wbnIndex.asp>) can provide guidance to developers.
 - b. Education materials can be designed for individual property owners and residents in the watershed, in order to increase awareness about the effects of urban runoff, and to provide options to reduce it.
 - c. Examples of possible technologies include infiltration trenches, pervious pavement, vegetated swales, rain barrels, green roofs, detention ponds and constructed wetlands (which can also be features of public green space).
 - d. Consideration should be given to undertaking a first order assessment of the volumes of stormwater that move through the system. This type of first order modeling has been conducted, by the CRD, on other stream systems in the region and should be conducted on Bowker Creek.
 - e. There should be a standardization of stormwater management practices between the three municipal jurisdictions (Victoria, Saanich and Oak Bay), as well as the largest institution within the watershed (University of Victoria).
- 5. Continue the community education program,** to inform residents and users of public areas in the watershed about physical and ecological processes in Bowker Creek, and how their impacts can be reduced.
- a. The resource entitled “On the Living Edge” is an excellent example of an educational publication aimed at streamside and shoreline property owners. This publication, or another similar one, could be distributed to people living along Bowker Creek. It can be ordered online from:
<http://www.livingbywater.ca/main.html>
 - b. Municipal staff, stewardship group coordinators and other spokespeople should continue to make presentations and lead outings for school groups, in order to highlight the importance of streams in an urban setting.
 - c. Signage can be installed along public trails that are located near Bowker Creek, explaining key stream processes and characteristics, such as the function of riparian vegetation, the importance of floodplains, and fish/wildlife habitat requirements. The history of Bowker Creek could also be highlighted.

6. **Develop a monitoring program for Bowker Creek**, in order to more thoroughly assess its current condition, and to measure the effects of restoration and development.
 - a. Photo point monitoring can be used to visually document human-caused and natural changes that occur in and around the stream.
 - b. PFC assessments can be conducted periodically, to determine whether the condition of the system is static, improving or declining.
 - c. Plant, fish and wildlife inventories can be conducted in order to get a better understanding of the local ecosystems. Sampling can focus on presence/absence and/or population or coverage estimates.
 - d. Water quality should be measured at a number of locations along the creek, testing for the most likely contaminants such as heavy metals, hydrocarbons, pesticides, coliforms and nutrients (nitrates/phosphates).

Recommendations by Reach

Reach 1 (Ocean to Community Gardens)

In the short-term, the erosion behind the concrete retaining wall on the west side of the creek should be re-stabilized (*e.g.* bioengineering, extending the retaining wall).

In the long-term, we recommend that when the properties adjacent to the creek are redeveloped that the morphology of the creek be restored to an appropriate configuration and proper riparian vegetation be established.

Reach 2 (Community Gardens to Monteith St.)

In the community gardens, invasive species control should be implemented, the bioengineering project should be repaired, and riparian vegetation re-established.

The portion of the creek that is buried consists of an undersized culvert that periodically floods overland. This reach should be reviewed for the opportunity to day-light the channel and restore the riparian/wetland one, as well as create fisheries habitat.

Reach 3 (Monterey Avenue to Oak Bay High School)

In the long-term, the hardened banks and bottom should be converted to an appropriate channel morphology and complexity, and riparian vegetation should be re-established.

Reach 4 (Oak Bay High To Oak Bay Recreation Centre)

The north bank of the creek should be re-sloped to provide floodplain and planting terraces, invasive species control and the addition of riparian vegetation.

Reach 5 (Oak Bay Recreation Centre to Bee St.)

Behind Oak Bay Recreation Centre the parking areas on both sides of the creek should be reconfigured to allow resloping and stabilization of the banks, provision of planting terraces and planting of riparian vegetation. Bioengineering may be required to stabilize banks due to space constraints. The parking could be reconfigured by creating a two-tiered structure that would retain an equivalent number of parking stalls but be confined to a smaller footprint.

Reach 6 (Bee Street to Cadboro Bay Road)

In the long-term, the hardened banks and bottom should be converted to an appropriate channel morphology and complexity, and riparian vegetation should be re-established.

Reach 7 (Trent Street to Haultain Road)

The program of bank stabilization should be continued in the short term using bioengineering in this reach, in addition to controlling invasive species and re-establishing riparian vegetation.

In the long-term, this site should be investigated for the potential to realign the creek, restore appropriate channel morphology and complexity, and plant riparian vegetation. Opportunities to detain and treat surface runoff at this site should also be explored.

Reach 8 and 9 (BC Hydro and Richmond Elementary)

In the short-term, a program of bank stabilization using bioengineering is recommended for this reach, in addition to controlling invasive species and re-establishing riparian vegetation.

In the long-term, this site should be investigated for the potential to realign the creek, restore appropriate channel morphology and complexity, and plant riparian vegetation. Opportunities to detain and treat surface runoff at this site should also be explored.

Reach 10 (North Dairy Road to McRae Avenue)

In the short-term we recommend spot placement of bank stabilization measures (bioengineering) and in stream measures to reduce erosion (e.g. weirs).

In the long-term, as the area is redeveloped the channel should be restored, banks stabilized and riparian vegetation re-established.

Reach 11 (McRae Avenue to Browning Park)

As Browning Park is redeveloped in the near future, invasive species should be controlled, the riparian area widened by planting native riparian species and small rock weirs installed within the channel to improve complexity.

Reach 12 (Pond behind UVic University Club)

Riparian vegetation around the perimeter of the pond should be increased and complexity pond habitat improved by adding large wood. The stop log on the outlet weir is rotting and should be replaced immediately.

Reach 13 (University Club to McGill Road)

This reach is very stable and undergoing a significant vegetation change resulting from an increase in surface water. The large floodplain in this reach is now maintained in a wetted condition for prolonged periods of the winter, a condition that is affecting the vegetation. There are numerous mature trees that are subject to blow-down and many individuals are dying as a result of increased soil moisture. There is a new under-story of shrubs that are providing a dense, and diverse, composition of riparian species.

While this reach has been stable, it would be valuable to conduct a thorough review of the channel and the need for additional plant species that could accelerate riparian stability.

Reach 14 (Tributary (McKenzie Avenue and Stadium))

This short reach requires a review to determine the extent to which stormwater is causing channel aggradation; there is a significant blackberry invasion that is resulting in channel bank erosion. The reach would benefit from the addition of large wood to increase channel sinuosity.

Reach 15 and 16 (Tributary - Cedar Hill Recreation Centre and Golf Course)

Invasive species should be controlled, the banks should be resloped to create appropriate channel morphology, riparian vegetation should be planted and large wood should be added for complexity.

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Appendix 1. PFC Assessment Method

PFC: What It Is- What It Isn't

PFC is: A methodology for assessing the physical functioning of riparian-wetland areas. The term PFC is used to describe both the **assessment** process, and a defined, on-the-ground **condition** of a riparian-wetland area. In either case, PFC defines a minimum level or starting point for assessing riparian-wetland areas.

The PFC **assessment** provides a consistent approach for assessing the physical functioning of riparian-wetland areas through consideration of hydrology, vegetation, and soil/landform attributes. The PFC assessment synthesizes information that is foundational to determining the overall health of a riparian-wetland area.

The on-the-ground **condition** termed PFC refers to *how well* the physical processes are functioning. PFC is a state of resiliency that will allow a riparian-wetland area to hold together during a wind action, wave action, or overland flow event, sustaining that system's ability to produce values related to both physical and biological attributes.

PFC isn't: The sole methodology for assessing the health of the aquatic or terrestrial components of a riparian-wetland area.

PFC isn't: A replacement for inventory or monitoring protocols designed to yield information on the "biology" of the plants and animals dependent on the riparian-wetland area.

PFC can: Provide information on whether a riparian-wetland area is physically functioning in a manner that will allow the maintenance or recovery of desired values (e.g., fish habitat, neotropical birds, or forage) over time.

PFC isn't: Desired condition. It is a prerequisite to achieving desired condition.

PFC can't: Provide more than strong clues as to the actual condition of habitat for plants and animals. Generally a riparian-wetland area in a physically nonfunctioning condition will not provide quality habitat conditions. A riparian-wetland area that has recovered to *proper functioning condition* would either be providing quality habitat conditions, or would be moving in that direction if recovery is allowed to continue. A riparian-wetland area that is functioning at-risk would likely lose any habitat that exists during a wind action, wave action, or overland flow event.

Therefore: To obtain a complete picture of riparian-wetland area health, including the biological side, one must have information on *both* physical status, provided through the PFC assessment, and biological habitat quality. Neither will provide a complete picture when analyzed in isolation. In most cases, proper functioning condition will be a prerequisite to achieving and maintaining habitat quality.

PFC is: A useful tool for prioritizing restoration activities. By concentrating on the “at-risk” systems, restoration activities can save many riparian-wetland areas from degrading to a nonfunctioning condition. Once a system is nonfunctional, the effort, cost, and time required for recovery is dramatically increased. Restoration of nonfunctional systems should be reserved for those situations where the riparian-wetland has reached a point where recovery *is possible*, when efforts are not at *the expense* of “at-risk” systems, or when unique opportunities exist. At the same time, systems that are properly functioning are not the highest priorities for restoration. Management of these systems should be continued to maintain PFC and further recovery towards desired condition.

PFC is: A useful tool for determining appropriate timing and design of riparian-wetland restoration projects (including structural and management changes). It can identify situations where structures are either entirely inappropriate or premature.

PFC is: A useful tool that can be used in watershed analysis. While the methodology and resultant data is “area based,” the ratings can be aggregated and analyzed at the watershed scale. PFC, along with other watershed and habitat condition information helps provide a good picture of watershed health and the possible causal factors affecting watershed health. Use of PFC will help to identify watershed-scale problems and suggest management remedies and priorities.

PFC isn't: Watershed analysis in and of itself, or a replacement for watershed analysis.

PFC is: A useful tool for designing monitoring plans. By concentrating implementation monitoring efforts on the “no” answers, greater efficiency of resources (people, dollars, time) can be achieved. The limited resources of the local manager in monitoring riparian-wetland parameters can be prioritized to those factors that are currently “out of range” or at risk of going out of range. The role of research may extend to validation monitoring of many of the parameters. *PFC isn't:* Designed to be a long-term monitoring tool, but it may be an appropriate part of a well-designed monitoring program.

PFC isn't: Designed to provide monitoring answers about attaining desired conditions. However, it can be used to provide a thought process on whether a management strategy is likely to allow attainment of desired conditions.

PFC can: Reduce the frequency and sometimes the extent of more data- and labor-intensive inventories. PFC can reduce time and cost by concentrating efforts on the most significant problem areas first, thereby increasing efficiency.

PFC can't: Eliminate the need for more intensive inventory and monitoring protocols. These will often be needed to validate that riparian-wetland area recovery is indeed moving toward or has achieved desired conditions (e.g., good quality habitat) or simply to establish what the existing habitat quality is.

PFC is: A qualitative assessment based on quantitative science. The PFC assessment is intended for individuals with local, on-the-ground experience in the kind of quantitative sampling techniques that support the checklist. These quantitative techniques are encouraged in conjunction with the PFC assessment for individual calibration where answers are uncertain or where experience is limited. PFC is also an appropriate starting point for determining and prioritizing the type and location of the quantitative inventory or monitoring that is necessary.

PFC isn't: A replacement for quantitative inventory or monitoring protocols. PFC is meant to complement more detailed methods by providing a way to synthesize data and communicate results.

PFC Process and Checklist

Proper Functioning Condition (PFC) is a qualitative method for assessing the condition of riparian-wetland areas. The term PFC is used to describe both the assessment process and the condition of a riparian wetland area. The methodology was developed by a national interagency team and documented in a series of Technical References (TR 9 through 16) (Prichard, 1993 through 1999 *et al.*). See the PFC user's guides for more details on the PFC process http://www.or.blm.gov/nrst/Tech_References/tech_references.htm.

The process involves the following steps:

1. Review existing documents--including maps, files and aerial photos.
2. Analyze the PFC definition--assess riparian/wetland based on a riparian area's capability and potential.
3. Assess Functionality--through document and field review. The rating is based on team discussion.
4. Institute the process--incorporate the information collected into a management plan.

The minimum standards are achieved by using a standardized checklist. The PFC assessment, using the checklist, should work for most sites as long as the procedure is followed and definitions understood. This is because the PFC was founded from rigorous science and is performed in an interdisciplinary setting.

The lotic (stream/moving water) checklist contains 17 items, which are qualitatively assessed by the Team (see checklist below). The lentic (lake/wetland) checklist contains 20 items. The appropriate form is used by the ID Team to assess riparian-wetland conditions. Items on the checklist relate to stream channel stability and/or wetland functionality, and receive "yes" or "no" answers. In some cases, "not applicable" is used.

In addition to the checklist it is helpful to fill out the supplemental field form, developed by John Anderson (a copy of the form follows), which includes information on vegetation community type, restoration measures, stream bank conditions, geomorphology/soils, floodplain availability/size, and grazing.

In order to answer specific questions on the PFC checklist, bankfull stage and floodprone area must be determined. Figure 7 below illustrates the method used to determine their position relative to the stream channel.

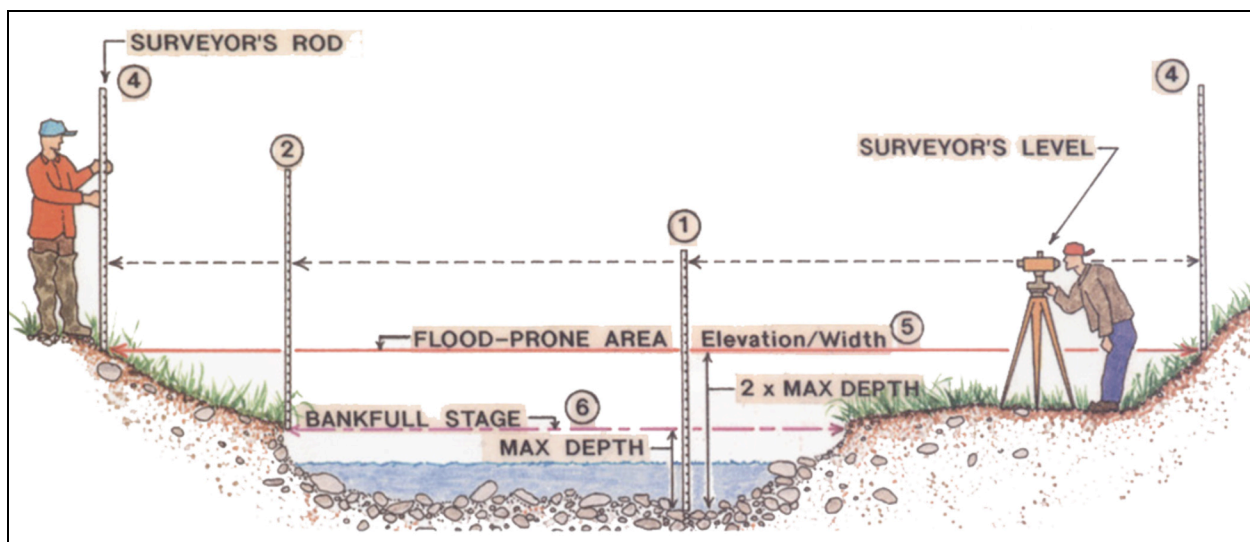


Figure 7. Illustration of the method used to define bankfull stage and flood-prone area for the purposes of calculating the width/depth ratio and entrenchment ratio (Rosgen, 1996).

The checklist and its summarization, which can be done quickly, are used to classify the health or state of physical processes of the riparian-wetland area or reach being studied into one of four categories:

Functional – At Risk (FAR)
 Nonfunctional (NF)
 Proper Functioning Condition (PFC)
 Unknown

The preponderance of “yes” and “no” responses help the ID Team determine the proper classification, however there is no set number of “yes” and “no” answers to determine into which category a water body falls. Team discussion is an important part of classification.

The significance of the classification categories are:

PFC: The stream channel, floodplain, and/or wetland have the physical characteristics that provide stability through various frequency events. This resiliency allows an area to produce desired values such as fish and wildlife habitat over time.

A riparian-wetland area is considered to be in Proper Functioning Condition when adequate vegetation, landform, or large woody material is present to:

- Dissipate stream energy associated with high water flows, thereby reducing erosion and improving water quality;
- Filter sediment, capture bedload, and aid floodplain development;
- Improve flood-water retention and ground-water recharge;
- Develop root masses that stabilize stream banks against cutting action;
- Develop diverse ponding and channel characteristics to provide the habitat and the water depth, duration, and temperature necessary for fish production, waterfowl breeding, and other uses;
- Support greater biodiversity.

FAR: The stream or wetland is functioning but is lacking enough vegetation, soils or landform characteristics to withstand various frequency events without significantly damaging the riparian corridor. FAR is the only category that is further stratified by trend (up, down, not apparent). A downward trend rating indicates deteriorating conditions that could become NF. Deteriorated conditions can be transmitted both up and downstream. Trend that is not apparent requires further study.

NF: The stream or wetland is not stable because it lacks most of the stabilizing physical characteristics and may continue to deteriorate. The degraded area or reach cannot sustain long-term desired values and return to proper-functioning condition without intervention (change in management).

Unknown: Sufficient information to make a rating is lacking. Additional study or data collection is necessary.

The results of the PFC assessment will be analyzed and presented in a written report. The report will outline numbers of streams and wetlands in a particular category *i.e.*, PFC, FAR, NF, or Unknown.

Classification of reaches using the PFC method helps the local planning group establish a common vocabulary for discussing desired conditions to their key riparian-wetland landscape elements. The need, type and location of more detailed inventories (upland methods as well as riparian-wetland corridor methods) can be prioritized once the PFC assessment classifications are known in preparation for developing restoration and management alternatives.

Lotic Checklist

Name of Riparian-Wetland

Area: _____

Date: _____

Segment/Reach

ID: _____

ID Team

Observers: _____

Potential Riparian-Wetland Vegetation.

Potential Channel Characteristics: Rosgen = " " channel type

Yes	No	N/A	HYDROLOGICAL
			1) Floodplain above bankfull is inundated in "relatively frequent" events
			2) Where beaver dams are present are they active and stable
			3) Sinuosity, width/depth ratio, and gradient are in balance with the landscape setting (i.e., landform, geology, and bioclimatic region)
			4) Riparian-wetland area is widening or has achieved potential extent
			5) Upland watershed is not contributing to riparian-wetland degradation

Yes	No	N/A	VEGETATION
			6) Diverse age-class distribution of riparian-wetland vegetation (recruitment for maintenance/recovery)
			7) Diverse composition of riparian-wetland vegetation (for maintenance/recovery) (<i>species present</i>)
			8) Species present indicate maintenance of riparian-wetland soil moisture characteristics
			9) Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high streamflow events (<i>community types present</i>)

			10) Riparian-wetland plants exhibit high vigor
			11) Adequate riparian-wetland vegetative cover present to protect banks and dissipate energy during high flows (<i>enough</i>)
			12) Plant communities are an adequate source of coarse and/or large woody material (for maintenance/recovery)

Yes	No	N/A	EROSION DEPOSITION
			13) Floodplain and channel characteristics (i.e., rocks, overflow channels, coarse and/or large woody material) adequate to dissipate energy
			14) Point bars are revegetating with riparian-wetland vegetation
			15) Lateral stream movement is associated with natural sinuosity s
			16) System is vertically stable (<i>not downcutting</i>)
			17) Stream is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition)

Remarks

SUMMARY DETERMINATION

___ Proper Functioning Condition ___ Functional - At Risk ___ Nonfunctional ___ Unknown Trend for Functional - At Risk: ___ Upward ___ Downward ___ Not Apparent		Are factors contributing to unacceptable conditions outside the control of the manager? Yes ___ No ___ If yes, what are those factors? ___ Flow regulations ___ Mining activities ___ Upstream channel conditions ___ Channelization ___ Road encroachment ___ Oil field water discharge ___ Augmented flows ___ Other (specify)
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(Revised 1998) (7/12/04)

Lentic Checklist

Name of Riparian-Wetland

Area: _____

Date: _____

Segment/Reach

ID: _____

ID Team

Observers: _____

Yes	No	N/A	<i>Hydrology</i>
			1. Riparian-wetland area is saturated at or near the surface or inundated in “relatively frequent” events (1-3 years)
			2. Fluctuation of water levels is not excessive
			3. Riparian-wetland zone is enlarging or has achieved potential extent
			4. Upland watershed not contributing to riparian-wetland degradation
			5. Water quality is sufficient to support riparian-wetland plants
			6. Natural surface or subsurface flow patterns are not altered by disturbance (i.e. hoof action, dams, dikes, trails, roads, rills, gullies, drilling activities)
			7. Structure accommodates safe passage of flows (e.g. no headcut affecting dam or spillway)
			<i>Vegetation</i>
			8. There is diverse age-class distribution of riparian-wetland vegetation (recruitment for maintenance/recovery)
			9. There is diverse composition of vegetation (for maintenance/recovery)
			10. Species present indicate maintenance of riparian-wetland soil moisture characteristics
			11. Vegetation is comprised of those plants or plant communities that have root masses capable of withstanding wind events, wave flow events, or overland flows (e.g. storm events, snowmelt)
			12. Riparian-wetland plants exhibit high vigour
			13. Adequate vegetative cover present to protect shorelines/soil subsurface and dissipate energy during high wind and wave events or overland flows
			14. Frost or abnormal hydrological heaving is not present
			15. Favourable microsite condition (i.e. woody material, water temperature, etc.) is maintained by adjacent site characteristics

			<i>Soils - Erosion / Deposition</i>
			16. Accumulation of chemicals affecting plant productivity/composition is not apparent
			17. Saturation of soils (i.e. ponding, flooding frequency, and duration) is sufficient to compose and maintain hydric soils
			18. Underlying geologic structure/soil material/permafrost is capable of restricting water percolation
			19. Riparian-wetland is in balance with the water and sediment being supplied by the watershed (i.e. no excessive erosion or deposition)
			20. Islands and shoreline characteristics (i.e. rocks, coarse and/or large woody debris) adequate to dissipate wind and wave event energies

Remarks

SUMMARY DETERMINATION

<input type="checkbox"/> Proper Functioning Condition <input type="checkbox"/> Functional - At Risk <input type="checkbox"/> Nonfunctional <input type="checkbox"/> Unknown Trend for Functional - At Risk: <input type="checkbox"/> Upward <input type="checkbox"/> Downward <input type="checkbox"/> Not Apparent	<div style="position: absolute; left: 450px; top: 420px;">PFC</div> <div style="position: absolute; left: 450px; top: 470px;">FAR</div> <div style="position: absolute; left: 450px; top: 520px;">NF</div>	Are factors contributing to unacceptable conditions outside the control of the manager? Yes <input type="checkbox"/> No <input type="checkbox"/> If yes, what are those factors? <input type="checkbox"/> Flow regulations <input type="checkbox"/> Mining activities <input type="checkbox"/> Upstream channel conditions <input type="checkbox"/> Channelization <input type="checkbox"/> Road encroachment <input type="checkbox"/> Oil field water discharge <input type="checkbox"/> Augmented flows <input type="checkbox"/> Other
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**PFC Assessment
(Supplemental Form)**

Reach Findings Field Narrative

Each Reach should have a narrative section in the final PFC report that summarizes the findings. This field form provides a logical sequence of questions that when answered will enable the report writer to quickly and consistently describe each reach assessed.

- 1. Reach Location:** *Begin at GPS Way Point* _____ *end at GPS Way Point* _____
- 2. Verbal description of Reach start and end point:** _____
- 3. Allotment Name:** _____
- 4. Length of Reach (Km to nearest tenth):** _____ . _____
- 5. Rosgen channel type and:** _____, **6. Valley form:** _____
- 7. Potential Rosgen type:** _____, **8. Historic Rosgen type:** _____
- 9. Potential Vegetation Community Type:** _____
- 10. Historic Vegetation Community Type:** _____
- 11. Restoration Projects:** _____
- 12. Vegetation Description:** _____
- 13. Stream Bank Conditions:** _____
- 14. Geomorphology/soils:** _____
- 15. Floodplain Availability/size:** _____
- 16. Grazing:** _____
- 17. PFC Determination:** _____, **18. Trend if FAR** _____

This form was developed by John Anderson, Coldstream Consulting.

FIELD GUIDE FOR THE STANDARD CHECKLIST (LOTIC)

HYDROGEOLOGIC
1) Floodplain above bankfull inundated in “relatively frequent” events
Should this stream type have a floodplain? How wide should it be? How wide is it? Is the stream channel incised or over sized? Has widening begun? Are most terrace walls sloped indicating widening has stopped? Is there an upstream reservoir?
2) Where beaver dams are present they are active and stable
Are beaver dams currently acting as hydraulic modifiers? Are beavers present? Are beavers actively maintaining the dam? Is the dam self-sustaining, e.g., significant vegetation is rooted in the dam? Is the beaver dam a single large dam? Are the beaver dams in a complex?
3) Sinuosity, W/D ratio, and gradient are in balance with the landscape setting (i.e., landform, geology, and bioclimatic region).
Sinuosity —Is the stream actively eroding and building point bars? Are there indications of channel straightening? Does the sinuosity appear to be appropriate for the channel bottom type? Width/depth ratio —Is the stream channel “U” shaped? Are the stream banks undercut and/or sloughing? Is the streambank trapezoidal in shape along straight reaches? Are the stream banks jagged (saw blade)? Is the flood plain the appropriate size? Gradient —Is the channel incised? Does the channel appear straightened? Does the sinuosity appear to be appropriate for the valley bottom type?
4) Riparian wetland area is widening or has achieved potential extent.
Does the stream have the potential or capacity to make a riparian area? Is upland vegetation such as sage brush dying? Is the channel incised? Are riparian species present only because their established roots still reach the water table? Are riparian/wetland species regenerating? Are upland species invading the riparian area? Is the channel narrowing? Are pointbars increasing in size? Is the floodplain fully developed?
5) Upland watershed is not contributing to riparian degradation.
Is there evidence of sediment from the upland degrading the riparian area? Is there evidence of channel degradation because of increased flow from the watershed? Are there major changes in the watershed above this point such as logging, mining, agriculture, high road density, or vegetation manipulation? Is there sufficient precipitation to cause increased flow as a result of these changes?

VEGETATION
6) There is a diverse age-class distribution of riparian-wetland vegetation (recruitment for maintenance/recovery).
Are there two or more age classes of stabilizer (late seral) riparian/wetland species present within the riparian area?
7) There is a diverse composition of riparian-wetland vegetation (for maintenance/recovery).
Are there at least two stabilizer (late seral) riparian/wetland species present within the riparian area?
8) Species present indicate maintenance of riparian soil moisture characteristics.
Are stabilizing riparian/wetland species regenerating? Are upland species encroaching into the riparian/wetland area? Has the channel incised leaving remnant riparian/wetland vegetation on a terrace? Is there a water source independent of the stream?
9) Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high stream flow events.
Are there stabilizing (late seral) riparian species on the streambank?
10) Riparian-wetland plants exhibit high vigour.
Are the herbaceous stabilizer (late seral) species obvious individual plants? Are there new stabilizing herbaceous plants around the perimeter of the mat? Are the leaf blades of the sedges relatively wide? Are non-rhizomatous woody species short with over 10 stems at the base? Do woody species have a club look, multiple branching, at the end of the stems?
11) Adequate riparian-wetland vegetative cover present to protect banks and dissipate energy during high

flows.
Are the stream banks covered with sufficient stabilizing species to protect them from erosion (see Winward 2000, p34)? Is the stabilizing species vigorous (see question 10)?
12) Plant communities are an adequate source of coarse and/or large woody material (for maintenance/recovery).
Is the reach capable of growing trees, <i>e.g.</i> cottonwood, aspen, and conifers? Is large or coarse debris a necessary hydrologic control? Is the site dominated by stabilizing shrub species? Has the site had the trees removed from the site? Are there trees growing within one tree height of the stream channel?

SOILS-EROSION DEPOSITION
13) Floodplain and channel characteristics (<i>i.e.</i>, rocks, overflow channels, coarse and/or large woody material) are adequate to dissipate energy.
Is the floodplain fully developed (see question 1)? Are there sufficient overflow channels, vegetation, rocks, and woody debris to handle high flows without degrading? Is the floodplain capable of growing woody species? Are woody riparian species present on the floodplain and/or stream banks? Is the sinuosity and width/depth ratio appropriate for the site (see question 3)?
14) Point bars are revegetating with riparian/wetland vegetation.
Is there a distinct and relatively continuous line of stabilizing riparian vegetation on the point bar? Are there sprout and/or young woody species on the point bar? Are herbaceous stabilizing riparian species expanding?
15) Lateral stream movement is associated with natural sinuosity.
Do the stream banks have an adequate amount of stabilizing vegetation (see question 9&11)? Is there evidence of rapid point bar growth (see question 3)? Is the channel widening? Is the channel aggrading? Is the channel multi-threaded ("D" channel type)? Is sinuosity appropriate for the valley type (see question 3)?
16) System is vertically stable.
Is there a head cut capable of moving upstream within or below the reach? Are there hydrologic modifiers such as abandoned beaver dams, logs, or structures that have water moving under them? Is sediment or debris accumulation causing the water to flow out of the channel?
17) Stream is in balance with the water and sediment being supplied by the watershed (<i>i.e.</i>, no excessive erosion or deposition).
Is there evidence of increased water flow such as channel degradation or channel erosion (see question 5)? Are there mid-channel bars, sediment-filled pools, sand/silt/clay channel bottoms (see question 3)? Is there channel braiding? Are stream banks stable (see question 11)?

SUMMARY DETERMINATION	
Functioning Rating	Apparent Trend for Functional – At Risk
Are any questions answered "NO"?	Are woody species regenerating?
Are there "NO" attributes or processes important to the proper functioning of this riparian area?	Are herbaceous species reproducing?
Are most of the attributes answered "NO"	Are plants vigorous?
Is the apparent trend upward?	Is the channel degrading?
	Is the channel aggrading?
	Are most stream banks actively eroding?

This form was developed by Erv Cowley- Idaho Riparian Service Team

Appendix 2. Completed PFC Checklists

Lotic Checklist

Name of Riparian-Wetland

Bowker Creek

Area:

Date: **2007-01-19**

Segment/Reach
ID:

Reach 1 – From the mouth of the stream to the community allotment gardens.

ID Team

Patrick Lucey, Lehna Malmkvist, Brian LaCas

Observers:

Daniel Hegg, Lise Townsend

Potential Riparian-Wetland Vegetation: Tidal marsh/estuary species: large coniferous/deciduous trees surrounding

Potential Channel Characteristics: Rosgen = "B" channel type

Yes	No	N/A	HYDROLOGICAL
	✓		1) Floodplain above bankfull is inundated in "relatively frequent" events
		✓	2) Where beaver dams are present are they active and stable
	✓		3) Sinuosity, width/depth ratio, and gradient are in balance with the landscape setting (i.e., landform, geology, and bioclimatic region)
	✓		4) Riparian-wetland area is widening or has achieved potential extent
	✓		5) Upland watershed is not contributing to riparian-wetland degradation

Yes	No	N/A	VEGETATION
	✓		6) Diverse age-class distribution of riparian-wetland vegetation (recruitment for maintenance/recovery)
	✓		7) Diverse composition of riparian-wetland vegetation (for maintenance/recovery) (<i>species present</i>)
	✓		8) Species present indicate maintenance of riparian-wetland soil moisture characteristics
	✓		9) Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high streamflow events (<i>community types present</i>)

	✓		10) Riparian-wetland plants exhibit high vigor
	✓		11) Adequate riparian-wetland vegetative cover present to protect banks and dissipate energy during high flows (<i>enough</i>)
	✓		12) Plant communities are an adequate source of coarse and/or large woody material (for maintenance/recovery)

Yes	No	N/A	EROSION DEPOSITION
	✓		13) Floodplain and channel characteristics (i.e., rocks, overflow channels, coarse and/or large woody material) adequate to dissipate energy
		✓	14) Point bars are revegetating with riparian-wetland vegetation
	✓		15) Lateral stream movement is associated with natural sinuosity s
✓			16) System is vertically stable (<i>not downcutting</i>)
	✓		17) Stream is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition)

Remarks

GPS Way Point #12: N 48° 25.77' W 123° 18.44'

Potential channel type: Rosgen channel type “B” with a small amount of sinuosity (narrower channel with flood plain terraces).

Present channel type: Rosgen channel type “Fg1.” Channel is armoured with a mix of concrete and bedrock.

Constraints:

Erosion is undercutting the right hand bank d/s of the Beach Drive Culvert.

Culvert discharge is causing the erosion below the concrete wall, and eroding underneath the concrete pad (floor), which will consequently pull out the right wall. Very little redevelopment can occur until the apartment building (on right hand side) is replaced in the future.

Potential Restoration:

Redevelopment would include removing the concrete walls, creating a setback, terracing and replanting.

4. Replant. Channel is restrained by concrete walls.

5. Highly urbanized area. Approximately 35% Effective Impervious Area (EIA).

9. System is stable due to concrete walls. (Note: there will be limited stability due to erosion of walls)

11. Not enough vegetation. Concrete walls limit this.

15. Fixed in place b/c of concrete walls.

16. Potential erosion of concrete floor

17. System is eroding walls and floor.

Vegetation:

English ivy (*Hedera helix*)

Garry oak (*Quercus garryana*)

Himalayan blackberry (*Rubus discolor*)

Japanese knotweed (*Polygonum Cuspidatum*)

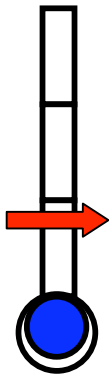
laurel-leaved daphne (*Daphnea laureola*)

Ornamental gardens

Poplar (*Populus balsamifera*)

yellow willow (*Salix lutea*)

SUMMARY DETERMINATION

<input type="checkbox"/> Proper Functioning Condition		Are factors contributing to unacceptable conditions outside the control of the manager?
<input type="checkbox"/> Functional - At Risk		Yes <input checked="" type="checkbox"/>
<input checked="" type="checkbox"/> Nonfunctional		No <input type="checkbox"/>
<input type="checkbox"/> Unknown		
Trend for Functional - At Risk:		If yes, what are those factors?
<input type="checkbox"/> Upward		<input type="checkbox"/> Flow regulations
<input type="checkbox"/> Downward		<input type="checkbox"/> Mining activities
<input type="checkbox"/> Not Apparent		<input type="checkbox"/> Upstream channel conditions
		<input type="checkbox"/> Channelization
		<input type="checkbox"/> Road encroachment
		<input type="checkbox"/> Oil field water discharge
		<input type="checkbox"/> Augmented flows
		<input checked="" type="checkbox"/> Other (Private property and urban run-off)

(Revised 1998) (7/12/04)

Lotic Checklist

Name of Riparian-Wetland

Bowker Creek

Area:

Date: **2007-01-19**

Segment/Reach

Reach 2 – From community allotment gardens to Monteith St.

ID:

ID Team

Patrick Lucey, Lehna Malmkvist, Brian LaCas

Observers:

Daniel Hegg, Lise Townsend

Potential Riparian-Wetland Vegetation: Tidal marsh/estuary species: large coniferous/deciduous trees surrounding

Potential Channel Characteristics: Rosgen = "Cb2-3" channel type

Yes	No	N/A	HYDROLOGICAL
✓			1) Floodplain above bankfull is inundated in "relatively frequent" events
		✓	2) Where beaver dams are present are they active and stable
✓			3) Sinuosity, width/depth ratio, and gradient are in balance with the landscape setting (i.e., landform, geology, and bioclimatic region)
	✓		4) Riparian-wetland area is widening or has achieved potential extent
	✓		5) Upland watershed is not contributing to riparian-wetland degradation

Yes	No	N/A	VEGETATION
	✓		6) Diverse age-class distribution of riparian-wetland vegetation (recruitment for maintenance/recovery)
✓			7) Diverse composition of riparian-wetland vegetation (for maintenance/recovery) (<i>species present</i>)
✓			8) Species present indicate maintenance of riparian-wetland soil moisture characteristics
✓			9) Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high streamflow events (<i>community types present</i>)
✓			10) Riparian-wetland plants exhibit high vigor

	✓		11) Adequate riparian-wetland vegetative cover present to protect banks and dissipate energy during high flows (<i>enough</i>)
	✓		12) Plant communities are an adequate source of coarse and/or large woody material (for maintenance/recovery)

Yes	No	N/A	EROSION DEPOSITION
	✓		13) Floodplain and channel characteristics (i.e., rocks, overflow channels, coarse and/or large woody material) adequate to dissipate energy
✓			14) Point bars are revegetating with riparian-wetland vegetation
✓			15) Lateral stream movement is associated with natural sinuosity s
✓			16) System is vertically stable (<i>not downcutting</i>)
	✓		17) Stream is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition)

Remarks

GPS Way Point #19: N 48° 25.80' W 123° 18.54'

Potential channel type: Rosgen channel type “Cb2-3.”

Present channel type: Rosgen channel type “Cb2-3.”

Constraints:

Erosion is undercutting the right hand concrete sand bag wall. Left hand side of creek is lined with community gardens thus trampling of riparian species has occurred. Culvert is undersized for the amount of volume handled by the creek (Recent flooding in Firemen’s Park and neighboring houses, and bioengineering was overcome by high flows resulting in loss of topsoil). Noted point bar formation on the right side, a soft shoreline, erosion on outer corners and garbage in the reach.

Potential Restoration:

Redevelopment would include installing an appropriately sized culvert, invasive species removal with replanting of native species, bio-engineering, installation of rock groynes and weirs for hydraulic diversity (install one 6 m d/s of culvert, one next to the large group of willows on the left and augment a rock stone line at left outer corner). Exclude access to creek, remove garbage and stop dumping that is occurring. This redevelopment could be tied into the development of Fireman’s Park.

1. Floodplain on inside bend.

2. No beaver presence noted. Site likely had beavers before development occurred.

4. Erosion of left bank has occurred to high flows.
5. Highly urbanized area. Excessive run-off upstream.
6. Trees and shrubs are the same age class. No notable new growth noted.
9. There is some plant communities with root structures able to withstand high flows, but is insufficient (bio-engineering top soils have eroded).
11. Right hand side reasonably ok. Bioengineering on left has failed due to flooding.
12. No large wood in channel.
13. Outside bends are eroding excessively.
14. Point bars are re-vegetating with Lilies which will place pressure on native plants. Suggest removal of Lilies and replant with riparian shrubs.
15. Erosion is excessive.
17. Erosion excessive on outer banks.

Vegetation:

black cottonwood (*Populus balsamifera*, spp. *Trichocarpa*)
 Common snowberry (*Symphoricarpos albus*)
 English ivy (*Hedera helix*)
 Himalayan blackberry (*Rubus discolor*)
 laurel-leaved daphne (*Daphnea laureola*)
 red-osier dogwood (*Cornus stolonifera*)
 yellow willow (*Salix lutea*)

SUMMARY DETERMINATION

<input type="checkbox"/> Proper Functioning Condition <input checked="" type="checkbox"/> Functional - At Risk <input type="checkbox"/> Nonfunctional <input type="checkbox"/> Unknown Trend for Functional - At Risk: <input type="checkbox"/> Upward <input checked="" type="checkbox"/> Downward <input type="checkbox"/> Not Apparent		<p>Are factors contributing to unacceptable conditions outside the control of the manager?</p> <p>Yes <input checked="" type="checkbox"/> No <input type="checkbox"/></p> <p>If yes, what are those factors?</p> <input type="checkbox"/> Flow regulations <input type="checkbox"/> Mining activities <input type="checkbox"/> Upstream channel conditions <input type="checkbox"/> Channelization <input type="checkbox"/> Road encroachment <input type="checkbox"/> Oil field water discharge <input type="checkbox"/> Augmented flows <input checked="" type="checkbox"/> Other (Private property and urban run-off)
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(Revised 1998) (7/12/04)

Lotic Checklist

Name of Riparian-Wetland

Bowker Creek

Area:

Date: **2007-01-19**

Segment/Reach

**Reach 3 – Between Monterey Avenue
and the Oak Bay High School**

ID:

ID Team

Patrick Lucey, Lehna Malmkvist, Brian LaCas

Observers:

Daniel Hegg, Lise Townsend

Potential Riparian-Wetland Vegetation: Natural plants

Potential Channel Characteristics: Rosgen = "C" channel type

Yes	No	N/A	HYDROLOGICAL
	✓		1) Floodplain above bankfull is inundated in "relatively frequent" events
		✓	2) Where beaver dams are present are they active and stable
	✓		3) Sinuosity, width/depth ratio, and gradient are in balance with the landscape setting (i.e., landform, geology, and bioclimatic region)
	✓		4) Riparian-wetland area is widening or has achieved potential extent
	✓		5) Upland watershed is not contributing to riparian-wetland degradation

Yes	No	N/A	VEGETATION
	✓		6) Diverse age-class distribution of riparian-wetland vegetation (recruitment for maintenance/recovery)
	✓		7) Diverse composition of riparian-wetland vegetation (for maintenance/recovery) (<i>species present</i>)
	✓		8) Species present indicate maintenance of riparian-wetland soil moisture characteristics
	✓		9) Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high streamflow events (<i>community types present</i>)
	✓		10) Riparian-wetland plants exhibit high vigor

	✓		11) Adequate riparian-wetland vegetative cover present to protect banks and dissipate energy during high flows (<i>enough</i>)
	✓		12) Plant communities are an adequate source of coarse and/or large woody material (for maintenance/recovery)

Yes	No	N/A	EROSION DEPOSITION
	✓		13) Floodplain and channel characteristics (i.e., rocks, overflow channels, coarse and/or large woody material) adequate to dissipate energy
		✓	14) Point bars are revegetating with riparian-wetland vegetation
	✓		15) Lateral stream movement is associated with natural sinuosity s
✓			16) System is vertically stable (<i>not downcutting</i>)
	✓		17) Stream is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition)

Remarks

Potential channel type: Rosgen channel type “C” with a small amount of sinuosity (narrower channel with flood plain terraces).

Present channel type: Rosgen channel type “Ditch.” Channel is armoured with concrete.

Constraints:

Concrete walls throughout reach.

Potential Restoration:

Redevelopment would entail creating sections of Rosgen type channel “C’s” with various ponds, while still keeping the same configuration. Redevelop as a urban landscape and park, with terraces and trails. Remove grass and plant with natural vegetation.

4. Channel is restrained by concrete walls.

5. Highly urbanized area.

9. System is stable due to concrete walls.

11. Not enough vegetation. Concrete walls limit this. No erosion noted due to armoured channel.

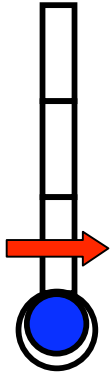
15. Fixed in place b/c of concrete walls.

Vegetation:

black cottonwood (*Populus balsamifera*, spp. *Trichocarpa*)

yellow willow (*Salix lutea*)

SUMMARY DETERMINATION

<input type="checkbox"/> Proper Functioning Condition <input type="checkbox"/> Functional - At Risk <input checked="" type="checkbox"/> Nonfunctional <input type="checkbox"/> Unknown Trend for Functional - At Risk: <input type="checkbox"/> Upward <input type="checkbox"/> Downward <input type="checkbox"/> Not Apparent		Are factors contributing to unacceptable conditions outside the control of the manager? Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> If yes, what are those factors? <input type="checkbox"/> Flow regulations <input type="checkbox"/> Mining activities <input type="checkbox"/> Upstream channel conditions <input type="checkbox"/> Channelization <input type="checkbox"/> Road encroachment <input type="checkbox"/> Oil field water discharge <input type="checkbox"/> Augmented flows <input checked="" type="checkbox"/> Other (Private property and urban run-off)
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(Revised 1998) (7/12/04)

Lotic Checklist

Name of Riparian-Wetland Area:

Bowker Creek

Date:

2007-01-19

Segment/Reach ID:

Reach 4 – Oak Bay High School to Oak Bay Recreation Centre tennis bubble

ID Team

Patrick Lucey, Lehna Malmkvist, Brian LaCas

Observers:

Daniel Hegg, Lise Townsend

Potential Riparian-Wetland Vegetation: large coniferous/deciduous trees surrounding

Potential Channel Characteristics: Rosgen = "Entrenched C" channel type

Yes	No	N/A	HYDROLOGICAL
	✓		1) Floodplain above bankfull is inundated in "relatively frequent" events
		✓	2) Where beaver dams are present are they active and stable
	✓		3) Sinuosity, width/depth ratio, and gradient are in balance with the landscape setting (i.e., landform, geology, and bioclimatic region)
	✓		4) Riparian-wetland area is widening or has achieved potential extent
	✓		5) Upland watershed is not contributing to riparian-wetland degradation

Yes	No	N/A	VEGETATION
	✓		6) Diverse age-class distribution of riparian-wetland vegetation (recruitment for maintenance/recovery)
✓			7) Diverse composition of riparian-wetland vegetation (for maintenance/recovery) (<i>species present</i>)
✓			8) Species present indicate maintenance of riparian-wetland soil moisture characteristics
✓			9) Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high streamflow events (<i>community types present</i>)
✓			10) Riparian-wetland plants exhibit high vigor

✓			11) Adequate riparian-wetland vegetative cover present to protect banks and dissipate energy during high flows (<i>enough</i>)
	✓		12) Plant communities are an adequate source of coarse and/or large woody material (for maintenance/recovery)

Yes	No	N/A	EROSION DEPOSITION
	✓		13) Floodplain and channel characteristics (i.e., rocks, overflow channels, coarse and/or large woody material) adequate to dissipate energy
		✓	14) Point bars are revegetating with riparian-wetland vegetation
	✓		15) Lateral stream movement is associated with natural sinuosity s
✓			16) System is vertically stable (<i>not downcutting</i>)
	✓		17) Stream is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition)

Remarks

GPS Way Point #20: N 48° 25.852' W 123° 19.119'

Potential channel type: Rosgen channel type “Entrenched C”

Present channel type: Rosgen channel type “Ditch.” Channel is armoured with concrete on one the right side. Left side has a steep slope with vegetation.

Constraints:

Concrete wall throughout reach on the right side. Concrete lined channel with silt and gravel in channel.

Potential Restoration:

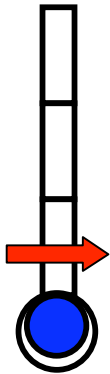
Redevelopment would include building out a planting terrace to the high water mark on the concrete wall side, while expanding the vegetation side approx 10 m. Then create a meandering channel with rocks. Potential for restoration is possible dependant on the sale of the High School.

- 1. Some floodplain available on vegetated left side.**
- 5. Highly urbanized area.**
- 9. System is stable due to concrete wall and vegetation.**

Vegetation:

black cottonwood (*Populus balsamifera*, spp. *Trichocarpa*)
Himalayan blackberry (*Rubus discolor*)
yellow willow (*Salix lutea*)

SUMMARY DETERMINATION

<input type="checkbox"/> Proper Functioning Condition <input type="checkbox"/> Functional - At Risk <input checked="" type="checkbox"/> Nonfunctional <input type="checkbox"/> Unknown		Are factors contributing to unacceptable conditions outside the control of the manager? Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>
Trend for Functional - At Risk: <input type="checkbox"/> Upward <input type="checkbox"/> Downward <input type="checkbox"/> Not Apparent		If yes, what are those factors? <input type="checkbox"/> Flow regulations <input type="checkbox"/> Mining activities <input type="checkbox"/> Upstream channel conditions <input type="checkbox"/> Channelization <input type="checkbox"/> Road encroachment <input type="checkbox"/> Oil field water discharge <input type="checkbox"/> Augmented flows <input checked="" type="checkbox"/> Other (Private property and urban run-off)

(Revised 1998) (7/12/04)

Lotic Checklist

Name of Riparian-Wetland

Bowker Creek

Area:

Date: **2007-01-19**

Segment/Reach

**Reach 5 - Oak Bay Recreation Centre
tennis bubble to Bee Street**

ID:

ID Team

Patrick Lucey, Lehna Malmkvist, Brian LaCas

Observers:

Daniel Hegg, Lise Townsend

Potential Riparian-Wetland Vegetation: large coniferous/deciduous trees surrounding

Potential Channel Characteristics: Rosgen = "B" channel type

Yes	No	N/A	HYDROLOGICAL
	✓		1) Floodplain above bankfull is inundated in "relatively frequent" events
		✓	2) Where beaver dams are present are they active and stable
	✓		3) Sinuosity, width/depth ratio, and gradient are in balance with the landscape setting (i.e., landform, geology, and bioclimatic region)
	✓		4) Riparian-wetland area is widening or has achieved potential extent
	✓		5) Upland watershed is not contributing to riparian-wetland degradation

Yes	No	N/A	VEGETATION
	✓		6) Diverse age-class distribution of riparian-wetland vegetation (recruitment for maintenance/recovery)
✓	✓		7) Diverse composition of riparian-wetland vegetation (for maintenance/recovery) (<i>species present</i>)
	✓		8) Species present indicate maintenance of riparian-wetland soil moisture characteristics
	✓		9) Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high streamflow events (<i>community types present</i>)
	✓		10) Riparian-wetland plants exhibit high vigor

	✓		11) Adequate riparian-wetland vegetative cover present to protect banks and dissipate energy during high flows (<i>enough</i>)
	✓		12) Plant communities are an adequate source of coarse and/or large woody material (for maintenance/recovery)

Yes	No	N/A	EROSION DEPOSITION
	✓		13) Floodplain and channel characteristics (i.e., rocks, overflow channels, coarse and/or large woody material) adequate to dissipate energy
		✓	14) Point bars are revegetating with riparian-wetland vegetation
	✓		15) Lateral stream movement is associated with natural sinuosity s
✓			16) System is vertically stable (<i>not downcutting</i>)
	✓		17) Stream is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition)

Remarks

GPS Way Point #23: N 48° 25.910' W 123° 19.249'

Potential channel type: Rosgen channel type “B.” At first appearance, it was thought that this channel was a “G”, due to erosion its potential has been classified as a “B”

Present channel type: Rosgen channel type “Gc2-3.”

Constraints:

Noted considerable erosion (on right side u/s of culvert) and undercutting in system due to the fact that this reach has very high flows from a large impervious area (High School, Recreation Centre and surrounding parking lots), a common age class and lack of diversity in vegetation, and a width/depth ratio that is not correct.

Potential Restoration:

Redevelopment would allow for the potential to widen the corridor and reconstruct parking lot (may lose 20 parking stalls) if site was to be sold and developed. For redevelopment, leave as a gully, install a series of rock weirs (5 Rosgen weirs should be installed), manage invasive species, terrace back , replant and install a trail alongside.

3. Erosion of right bank. Width/depth ratio not correct

4. Erosion of right bank and undercutting in system.

5. Erosion of right bank. Highly urbanized area. Excessive run-off upstream.

6. Trees and shrubs are the same age class. No notable new growth noted.

7. In the bottom half (d/s) yes there is a diverse collection of species (includes invasive) and

u/s, no, there is not a large/diverse collection of species. There is a large amount of invasive species.

9. There are some large trees holding up the channel (but not enough) and thus erosion has occurred.

10. Few riparian plants, if not none, show high vigor.

11. Not enough vegetation and thus erosion is occurring.

13. Erosion is occurring.

15. Channel is armoured in place

Vegetation:

black cottonwood (*Populus balsamifera*, spp. *Trichocarpa*)

Common snowberry (*Symphoricarpos albus*)

Douglas fir (*Pseudotsuga menziesii*)

English ivy (*Hedera helix*)

Himalayan blackberry (*Rubus discolor*)

laurel-leaved daphne (*Daphnea laureola*)

Maple (*Aceraceae*)

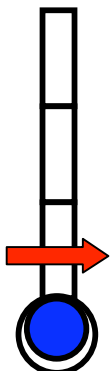
red alder (*Alnus rubra*)

red-osier dogwood (*Cornus stolonifera*.)

Scotch broom (*Cytisus scoparius*)

yellow willow (*Salix lutea*)

SUMMARY DETERMINATION

<input type="checkbox"/> Proper Functioning Condition <input type="checkbox"/> Functional - At Risk <input checked="" type="checkbox"/> Nonfunctional <input type="checkbox"/> Unknown		Are factors contributing to unacceptable conditions outside the control of the manager? Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>
Trend for Functional - At Risk: <input type="checkbox"/> Upward <input type="checkbox"/> Downward <input type="checkbox"/> Not Apparent		If yes, what are those factors? <input type="checkbox"/> Flow regulations <input type="checkbox"/> Mining activities <input type="checkbox"/> Upstream channel conditions <input type="checkbox"/> Channelization <input type="checkbox"/> Road encroachment <input type="checkbox"/> Oil field water discharge <input type="checkbox"/> Augmented flows <input checked="" type="checkbox"/> Other (Private property and urban run-off)

(Revised 1998) (7/12/04)

Lotic Checklist

Name of Riparian-Wetland

Bowker Creek

Area:

Date: **2007-01-19**

Segment/Reach

Reach 6 – Bee Street to Cadboro Bay

ID:

ID Team

Patrick Lucey, Lehna Malmkvist, Brian LaCas

Observers:

Daniel Hegg, Lise Townsend

Potential Riparian-Wetland Vegetation: None.

Potential Channel Characteristics: Rosgen = "G" channel type

Yes	No	N/A	HYDROLOGICAL
	✓		1) Floodplain above bankfull is inundated in "relatively frequent" events
		✓	2) Where beaver dams are present are they active and stable
	✓		3) Sinuosity, width/depth ratio, and gradient are in balance with the landscape setting (i.e., landform, geology, and bioclimatic region)
	✓		4) Riparian-wetland area is widening or has achieved potential extent
	✓		5) Upland watershed is not contributing to riparian-wetland degradation

Yes	No	N/A	VEGETATION
	✓		6) Diverse age-class distribution of riparian-wetland vegetation (recruitment for maintenance/recovery)
	✓		7) Diverse composition of riparian-wetland vegetation (for maintenance/recovery) (<i>species present</i>)
	✓		8) Species present indicate maintenance of riparian-wetland soil moisture characteristics
	✓		9) Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high streamflow events (<i>community types present</i>)
	✓		10) Riparian-wetland plants exhibit high vigor
	✓		11) Adequate riparian-wetland vegetative cover present to protect banks and dissipate energy during high flows (<i>enough</i>)

	✓		12) Plant communities are an adequate source of coarse and/or large woody material (for maintenance/recovery)
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Yes	No	N/A	EROSION DEPOSITION
	✓		13) Floodplain and channel characteristics (i.e., rocks, overflow channels, coarse and/or large woody material) adequate to dissipate energy
		✓	14) Point bars are revegetating with riparian-wetland vegetation
	✓		15) Lateral stream movement is associated with natural sinuosity s
✓			16) System is vertically stable (<i>not downcutting</i>)
	✓		17) Stream is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition)

Remarks

GPS Point: N 48° 25.883' W 123° 19.191'

Potential channel type: Rosgen channel type “G” with a small amount of sinuosity (narrower channel with flood plain terraces).

Present channel type: Rosgen channel type “Ditch.” Channel is armoured with concrete.

Constraints:

Concrete walls throughout reach.

Potential Restoration:

Leave as is due to nearby road and building. Install offset baffles within reach.

4. Channel is restrained by concrete walls.

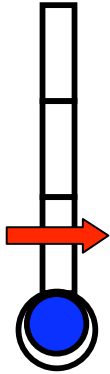
5. Highly urbanized area.

9. System is stable due to concrete walls.

11. Not enough vegetation. Concrete walls limit this. No erosion noted due to armoured channel.

15. Fixed in place b/c of concrete walls.

SUMMARY DETERMINATION

<input type="checkbox"/> Proper Functioning Condition <input type="checkbox"/> Functional - At Risk <input checked="" type="checkbox"/> Nonfunctional <input type="checkbox"/> Unknown		Are factors contributing to unacceptable conditions outside the control of the manager? Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>
Trend for Functional - At Risk: <input type="checkbox"/> Upward <input type="checkbox"/> Downward <input type="checkbox"/> Not Apparent		If yes, what are those factors? <input type="checkbox"/> Flow regulations <input type="checkbox"/> Mining activities <input type="checkbox"/> Upstream channel conditions <input type="checkbox"/> Channelization <input type="checkbox"/> Road encroachment <input type="checkbox"/> Oil field water discharge <input type="checkbox"/> Augmented flows <input checked="" type="checkbox"/> Other (Private property and urban run-off)

(Revised 1998) (7/12/04)

Lotic Checklist

Name of Riparian-Wetland

Bowker Creek

Area:

Date: **2007-01-19**

Segment/Reach
ID:

**Reach 7 – Trent Street to Haultain Rd.
(St. Patrick School & Royal Jubilee
Hospital)**

ID Team

Patrick Lucey, Lehna Malmkvist, Brian LaCas

Observers:

Daniel Hegg, Lise Townsend

Potential Riparian-Wetland Vegetation: large coniferous/deciduous trees surrounding

Potential Channel Characteristics: Rosgen = "C4-5 Lentic" channel type

Yes	No	N/A	HYDROLOGICAL
	✓		1) Floodplain above bankfull is inundated in "relatively frequent" events
		✓	2) Where beaver dams are present are they active and stable
	✓		3) Sinuosity, width/depth ratio, and gradient are in balance with the landscape setting (i.e., landform, geology, and bioclimatic region)
✓			4) Riparian-wetland area is widening or has achieved potential extent
	✓		5) Upland watershed is not contributing to riparian-wetland degradation

Yes	No	N/A	VEGETATION
	✓		6) Diverse age-class distribution of riparian-wetland vegetation (recruitment for maintenance/recovery)
✓			7) Diverse composition of riparian-wetland vegetation (for maintenance/recovery) (<i>species present</i>)
✓			8) Species present indicate maintenance of riparian-wetland soil moisture characteristics
	✓		9) Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high streamflow events (<i>community types present</i>)
✓			10) Riparian-wetland plants exhibit high vigor

	✓		11) Adequate riparian-wetland vegetative cover present to protect banks and dissipate energy during high flows (<i>enough</i>)
	✓		12) Plant communities are an adequate source of coarse and/or large woody material (for maintenance/recovery)

Yes	No	N/A	EROSION DEPOSITION
	✓		13) Floodplain and channel characteristics (i.e., rocks, overflow channels, coarse and/or large woody material) adequate to dissipate energy
		✓	14) Point bars are revegetating with riparian-wetland vegetation
	✓		15) Lateral stream movement is associated with natural sinuosity
✓			16) System is vertically stable (<i>not downcutting</i>)
	✓		17) Stream is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition)

Remarks

GPS Way Point #24: N 48° 26.025' W 123° 19.429'

Potential channel type: Rosgen channel type “C4-5 Lentic.”

Present channel type: Rosgen channel type “B4-5 / Ditch.”

Constraints:

Noted erosion along concrete wall and banks along corridor. Some floodplain access, but not nearly enough. Invasive species present as well.

Potential Restoration:

Short-term restoration to include: install willow wattles, bio-engineering and removal of invasive species. Long-term restoration would be to relocate creek and rebuild to channel and lentic habitat.

- 1. Restoration work that has occurred U/S of bridge has created some floodplain, but more is required.**
- 3. Erosion and deposition occurring. Channel is entrenched and straightened.**
- 4. Vegetation is establishing itself.**
- 5. Erosion is occurring. Highly urbanized area. Excessive run-off upstream.**
- 6. Trees and shrubs are the same age class.**
- 7. Mostly invasive and upland species.**
- 9. There are some large trees holding up the channel (but not enough) and thus erosion has occurred.**

11. Not enough vegetation (riparian species is patchy at most) and thus erosion is occurring.

13. Erosion is occurring.

15. Channel has been straightened and is entrenched.

Vegetation:

black cottonwood (*Populus balsamifera*, spp. *Trichocarpa*)

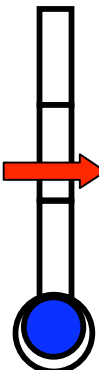
English ivy (*Hedera helix*)

Himalayan blackberry (*Rubus discolor*)

Scotch broom (*Cytisus scoparius*)

yellow willow (*Salix lutea*)

SUMMARY DETERMINATION

<input type="checkbox"/> Proper Functioning Condition		Are factors contributing to unacceptable conditions outside the control of the manager?
<input checked="" type="checkbox"/> Functional - At Risk		Yes <input checked="" type="checkbox"/>
<input type="checkbox"/> Nonfunctional		No <input type="checkbox"/>
<input type="checkbox"/> Unknown		
Trend for Functional - At Risk:		If yes, what are those factors?
<input checked="" type="checkbox"/> Upward		<input type="checkbox"/> Flow regulations
<input type="checkbox"/> Downward		<input type="checkbox"/> Mining activities
<input type="checkbox"/> Not Apparent		<input type="checkbox"/> Upstream channel conditions
		<input type="checkbox"/> Channelization
		<input type="checkbox"/> Road encroachment
		<input type="checkbox"/> Oil field water discharge
		<input type="checkbox"/> Augmented flows
		<input checked="" type="checkbox"/> Other (Private property and urban run-off)

(Revised 1998) (7/12/04)

Lotic Checklist

Name of Riparian-Wetland

Bowker Creek

Area:

Date: **2007-01-19**

Segment/Reach
ID:

**Reach 8 – Haultain Rd. to Richmond
(BC Hydro)**

ID Team

Patrick Lucey, Lehna Malmkvist, Brian LaCas

Observers:

Daniel Hegg, Lise Townsend

Potential Riparian-Wetland Vegetation: large coniferous/deciduous trees surrounding

Potential Channel Characteristics: Rosgen = "C / Lentic" channel type

Yes	No	N/A	HYDROLOGICAL
	✓		1) Floodplain above bankfull is inundated in "relatively frequent" events
		✓	2) Where beaver dams are present are they active and stable
	✓		3) Sinuosity, width/depth ratio, and gradient are in balance with the landscape setting (i.e., landform, geology, and bioclimatic region)
	✓		4) Riparian-wetland area is widening or has achieved potential extent
	✓		5) Upland watershed is not contributing to riparian-wetland degradation

Yes	No	N/A	VEGETATION
	✓		6) Diverse age-class distribution of riparian-wetland vegetation (recruitment for maintenance/recovery)
	✓		7) Diverse composition of riparian-wetland vegetation (for maintenance/recovery) (<i>species present</i>)
	✓		8) Species present indicate maintenance of riparian-wetland soil moisture characteristics
	✓		9) Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high streamflow events (<i>community types present</i>)
	✓		10) Riparian-wetland plants exhibit high vigor

	✓		11) Adequate riparian-wetland vegetative cover present to protect banks and dissipate energy during high flows (<i>enough</i>)
	✓		12) Plant communities are an adequate source of coarse and/or large woody material (for maintenance/recovery)

Yes	No	N/A	EROSION DEPOSITION
	✓		13) Floodplain and channel characteristics (i.e., rocks, overflow channels, coarse and/or large woody material) adequate to dissipate energy
		✓	14) Point bars are revegetating with riparian-wetland vegetation
	✓		15) Lateral stream movement is associated with natural sinuosity s
✓			16) System is vertically stable (<i>not downcutting</i>)
	✓		17) Stream is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition)

Remarks

GPS Way Point #25: N 48° 26.152' W 123° 19.559'

Potential channel type: Rosgen channel type “C Lentic.”

Present channel type: Rosgen channel type “G5-6.”

Constraints:

The stream has channelized and down cut causing serious erosion of entire banks. Very little vegetation holding banks together. Problem with restoration is that the large trees lining the path would have to be removed likely to create animosity with surrounding neighbors.

Potential Restoration:

Restoration includes restoring the channel or creating a series of ponds/wetlands.

1. Steam has channelized and down cut.
3. Erosion and deposition occurring. Channel has deepened and straightened.
4. Severe erosion of banks occurring
5. Erosion is occurring. Highly urbanized area. Excessive run-off upstream.
6. Trees and shrubs are the same age class.
7. Mostly invasive and upland species.
9. There are some large trees holding up the channel (but not enough) and thus erosion has occurred.
10. Few riparian plants, if not none, show high vigor.

11. Not enough vegetation (riparian species is patchy at most) and thus erosion is occurring.

13. No floodplain, nor is there any large wood / rocks to dissipate energy.

15. Channel has been straightened and is entrenched.

Vegetation:

black cottonwood (*Populus balsamifera*, spp. *Trichocarpa*)

Common snowberry (*Symphoricarpos albus*)

English ivy (*Hedera helix*)

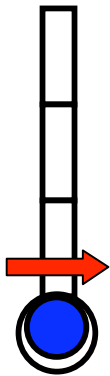
Himalayan blackberry (*Rubus discolor*)

Maple (*Aceraceae*)

Scotch broom (*Cytisus scoparius*)

yellow willow (*Salix lutea*)

SUMMARY DETERMINATION

<input type="checkbox"/> Proper Functioning Condition <input type="checkbox"/> Functional - At Risk <input checked="" type="checkbox"/> Nonfunctional <input type="checkbox"/> Unknown		PFC FAR NF	Are factors contributing to unacceptable conditions outside the control of the manager? Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>
Trend for Functional - At Risk: <input type="checkbox"/> Upward <input type="checkbox"/> Downward <input type="checkbox"/> Not Apparent	If yes, what are those factors? <input type="checkbox"/> Flow regulations <input type="checkbox"/> Mining activities <input type="checkbox"/> Upstream channel conditions <input type="checkbox"/> Channelization <input type="checkbox"/> Road encroachment <input type="checkbox"/> Oil field water discharge <input type="checkbox"/> Augmented flows <input checked="" type="checkbox"/> Other (Private property and urban run-off)		

(Revised 1998) (7/12/04)

Lotic Checklist

Name of Riparian-Wetland

Bowker Creek

Area:

Date: **2007-01-19**

Segment/Reach

Reach 9 – Newton St. to Pearl St.

ID:

ID Team

Patrick Lucey, Lehna Malmkvist, Brian LaCas

Observers:

Daniel Hegg, Lise Townsend

Potential Riparian-Wetland Vegetation: large coniferous/deciduous trees surrounding

Potential Channel Characteristics: Rosgen = "B" channel type (School Field)

Potential Channel Characteristics: Rosgen = "C" channel type (Thereafter)

Yes	No	N/A	HYDROLOGICAL
	✓		1) Floodplain above bankfull is inundated in "relatively frequent" events
		✓	2) Where beaver dams are present are they active and stable
	✓		3) Sinuosity, width/depth ratio, and gradient are in balance with the landscape setting (i.e., landform, geology, and bioclimatic region)
	✓		4) Riparian-wetland area is widening or has achieved potential extent
	✓		5) Upland watershed is not contributing to riparian-wetland degradation

Yes	No	N/A	VEGETATION
	✓		6) Diverse age-class distribution of riparian-wetland vegetation (recruitment for maintenance/recovery)
✓			7) Diverse composition of riparian-wetland vegetation (for maintenance/recovery) (<i>species present</i>)
	✓		8) Species present indicate maintenance of riparian-wetland soil moisture characteristics
	✓		9) Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high streamflow events (<i>community types present</i>)
	✓		10) Riparian-wetland plants exhibit high vigor

	✓		11) Adequate riparian-wetland vegetative cover present to protect banks and dissipate energy during high flows (<i>enough</i>)
	✓		12) Plant communities are an adequate source of coarse and/or large woody material (for maintenance/recovery)

Yes	No	N/A	EROSION DEPOSITION
	✓		13) Floodplain and channel characteristics (i.e., rocks, overflow channels, coarse and/or large woody material) adequate to dissipate energy
		✓	14) Point bars are revegetating with riparian-wetland vegetation
	✓		15) Lateral stream movement is associated with natural sinuosity s
✓			16) System is vertically stable (<i>not downcutting</i>)
	✓		17) Stream is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition)

Remarks

Begin GPS Way Point #27: N 48° 26.332' W 123° 19.747'

End GPS Way Point #28: N 48° 26.51' W 123° 19.95'

Potential channel type: Rosgen channel type “B.” (School Field)

Potential channel type: Rosgen channel type “C.” (Thereafter)

Present channel type: Rosgen channel type “G / Ditch.”

Constraints:

Vertical erosion within stream banks. No floodplain available.

Potential Restoration:

Short-term restoration includes restoring the channel or creating a series of ponds/wetlands. Long-term restoration includes relocating the stream into the playing field and creating a lake.

3. Erosion occurring. Channel has deepened and straightened.

4. Severe erosion of banks occurring

5. Erosion is occurring. Highly urbanized area. Excessive run-off upstream.

6. Trees and shrubs are the same age class.

7. Patches of mostly invasive and upland species.

9. There are some large trees holding up the channel (but not enough) and thus erosion has occurred.

10. Few riparian plants, if not none, show high vigor.

11. Good cover (in patches) wrong species.

Vegetation:

English hawthorne (*Crataegus laevigata*)

English ivy (*Hedera helix*)

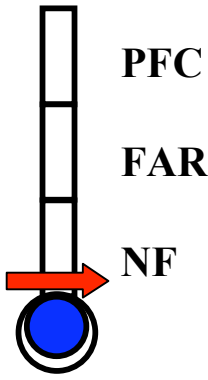
European bittersweet (*Solanum dulcamara*)

Himalayan blackberry (*Rubus discolor*)

Scotch broom (*Cytisus scoparius*)

yellow willow (*Salix lutea*)

SUMMARY DETERMINATION

<input type="checkbox"/> Proper Functioning Condition		Are factors contributing to unacceptable conditions outside the control of the manager?
<input type="checkbox"/> Functional - At Risk		Yes <input checked="" type="checkbox"/>
<input checked="" type="checkbox"/> Nonfunctional		No <input type="checkbox"/>
<input type="checkbox"/> Unknown		
Trend for Functional - At Risk:		If yes, what are those factors?
<input type="checkbox"/> Upward		<input type="checkbox"/> Flow regulations
<input type="checkbox"/> Downward		<input type="checkbox"/> Mining activities
<input type="checkbox"/> Not Apparent		<input type="checkbox"/> Upstream channel conditions
		<input type="checkbox"/> Channelization
		<input type="checkbox"/> Road encroachment
		<input type="checkbox"/> Oil field water discharge
		<input type="checkbox"/> Augmented flows
		<input checked="" type="checkbox"/> Other (Private property and urban run-off)

Lotic Checklist

Name of Riparian-Wetland

Bowker Creek

Area:

Date: **2007-01-19**

Segment/Reach
ID:

Reach 10 – North Dairy Rd. to McRae

ID Team

Patrick Lucey, Lehna Malmkvist, Brian LaCas

Observers:

Daniel Hegg, Lise Townsend

Potential Riparian-Wetland Vegetation: large coniferous/deciduous trees surrounding

Potential Channel Characteristics: Rosgen = "Bg4" channel type

Yes	No	N/A	HYDROLOGICAL
	✓		1) Floodplain above bankfull is inundated in "relatively frequent" events
		✓	2) Where beaver dams are present are they active and stable
	✓		3) Sinuosity, width/depth ratio, and gradient are in balance with the landscape setting (i.e., landform, geology, and bioclimatic region)
	✓		4) Riparian-wetland area is widening or has achieved potential extent
	✓		5) Upland watershed is not contributing to riparian-wetland degradation

Yes	No	N/A	VEGETATION
	✓		6) Diverse age-class distribution of riparian-wetland vegetation (recruitment for maintenance/recovery)
	✓		7) Diverse composition of riparian-wetland vegetation (for maintenance/recovery) (<i>species present</i>)
	✓		8) Species present indicate maintenance of riparian-wetland soil moisture characteristics
	✓		9) Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high streamflow events (<i>community types present</i>)
	✓		10) Riparian-wetland plants exhibit high vigor
	✓		11) Adequate riparian-wetland vegetative cover present to protect banks and dissipate energy during high flows (<i>enough</i>)

	✓		12) Plant communities are an adequate source of coarse and/or large woody material (for maintenance/recovery)
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Yes	No	N/A	EROSION DEPOSITION
	✓		13) Floodplain and channel characteristics (i.e., rocks, overflow channels, coarse and/or large woody material) adequate to dissipate energy
		✓	14) Point bars are revegetating with riparian-wetland vegetation
	✓		15) Lateral stream movement is associated with natural sinuosity s
✓			16) System is vertically stable (<i>not downcutting</i>)
	✓		17) Stream is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition)

Remarks

Begin GPS Way Point #32: N 48° 26.944' W 123° 20.209'

End GPS Way Point #31: N 48° 26.987' W 123° 20.141'

Potential channel type: Rosgen channel type “Bg4.”

Present channel type: Rosgen channel type “G4 with some bedrock”

Constraints:

Unless there is new development of existing residential area, due to location of stream it would be almost impossible to complete a restoration. There is notable erosion on outside bend and gabions. No available floodplain and bedrock intrusion noted as well.

Potential Restoration:

Place spur dikes in stream (rock weirs), and retrofit channel with bio-engineering and vegetation.

- 1. No available floodplain.**
- 3. Right hand side is heavily armoured and is eroding. Width/depth ratio is not appropriate**
- 4. Severe erosion of banks occurring**
- 5. Erosion is occurring. Highly urbanized area. Excessive run-off upstream.**
- 7. Patches of mostly invasive and upland species.**
- 8. Very little vegetation noted.**
- 9. There are some large trees (willows) holding up the channel (but not enough) and thus erosion has occurred.**
- 10. No large community of riparian plants.**
- 11. Banks are falling into the stream.**
- 12. Few large trees. No large wood in system.**

15. One side of channel is armoured.

Vegetation:

black cottonwood (*Populus balsamifera*, spp. *Trichocarpa*)

English holly (*Ilex aquifolium*)

English ivy (*Hedera helix*)

Himalayan blackberry (*Rubus discolor*)

red alder (*Alnus rubra*)

Scotch broom (*Cytisus scoparius*)

western red cedar (*Thuja plicata*)

yellow willow (*Salix lutea*)

SUMMARY DETERMINATION

<input type="checkbox"/> Proper Functioning Condition <input type="checkbox"/> Functional - At Risk <input checked="" type="checkbox"/> Nonfunctional <input type="checkbox"/> Unknown		Are factors contributing to unacceptable conditions outside the control of the manager? Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>
Trend for Functional - At Risk: <input type="checkbox"/> Upward <input type="checkbox"/> Downward <input type="checkbox"/> Not Apparent		If yes, what are those factors? <input type="checkbox"/> Flow regulations <input type="checkbox"/> Mining activities <input type="checkbox"/> Upstream channel conditions <input type="checkbox"/> Channelization <input type="checkbox"/> Road encroachment <input type="checkbox"/> Oil field water discharge <input type="checkbox"/> Augmented flows <input checked="" type="checkbox"/> Other (Private property and urban run-off)

(Revised 1998) (7/12/04)

Lotic Checklist

Name of Riparian-Wetland

Bowker Creek

Area:

Date: **2007-01-19**

Segment/Reach

Reach 11 – McRae to Browning Park

ID:

ID Team

Patrick Lucey, Lehna Malmkvist, Brian LaCas

Observers:

Daniel Hegg, Lise Townsend

Potential Riparian-Wetland Vegetation: large coniferous/deciduous trees surrounding

Potential Channel Characteristics: Rosgen = "Bg4 (with enhanced floodplain/in-stream elements)"
channel type

Yes	No	N/A	HYDROLOGICAL
✓			1) Floodplain above bankfull is inundated in "relatively frequent" events
		✓	2) Where beaver dams are present are they active and stable
✓			3) Sinuosity, width/depth ratio, and gradient are in balance with the landscape setting (i.e., landform, geology, and bioclimatic region)
✓			4) Riparian-wetland area is widening or has achieved potential extent
	✓		5) Upland watershed is not contributing to riparian-wetland degradation

Yes	No	N/A	VEGETATION
✓			6) Diverse age-class distribution of riparian-wetland vegetation (recruitment for maintenance/recovery)
✓			7) Diverse composition of riparian-wetland vegetation (for maintenance/recovery) (<i>species present</i>)
✓			8) Species present indicate maintenance of riparian-wetland soil moisture characteristics
✓			9) Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high streamflow events (<i>community types present</i>)
✓			10) Riparian-wetland plants exhibit high vigor

	✓		11) Adequate riparian-wetland vegetative cover present to protect banks and dissipate energy during high flows (<i>enough</i>)
✓			12) Plant communities are an adequate source of coarse and/or large woody material (for maintenance/recovery)

Yes	No	N/A	EROSION DEPOSITION
✓			13) Floodplain and channel characteristics (i.e., rocks, overflow channels, coarse and/or large woody material) adequate to dissipate energy
		✓	14) Point bars are revegetating with riparian-wetland vegetation
	✓		15) Lateral stream movement is associated with natural sinuosity s
✓			16) System is vertically stable (<i>not downcutting</i>)
✓			17) Stream is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition)

Remarks

Begin GPS Way Point #29: N 48° 27.158 W 123° 20.062'

Potential channel type: Rosgen channel type “Bg4” with an enhanced floodplain/in-stream elements. Widen the stream channel (long-term). In the short-term, do nothing. Watch for potential re-development.

Present channel type: Rosgen channel type “Bg4” with gully elements. “G4” to the end of the pond (U/S of bridge). Remainder is a B4 with gully elements.

Constraints:

Mortared rock walls with municipal rock (concrete and rock) channel. There is a limited floodplain.

Potential Restoration:

Series of small rock weirs (1 weir every 5 full bank widths). A regional trail is expected and planned. Build in floodplains and planting terraces wherever possible. Focus on in stream complexity and designed vegetation.

4. Vegetation is far from what is required (additional shrubs, etc)

5. No evidence within reach (little erosion).

7. Could have a better density of riparian shrubs and removal of invasive species.

11. There is no problem due to concrete and rock channel. There is a large amount of lawn cover and very few riparian plants.

12. Little wood in system, due to fear of culverts downstream.

15. Stream is in its right form, but has no lateral movement due to concrete and rock channel.

Vegetation:

black cottonwood (*Populus balsamifera*, spp. *Trichocarpa*)

English holly (*Ilex aquifolium*)

English ivy (*Hedera helix*)

Himalayan blackberry (*Rubus discolor*)

red alder (*Alnus rubra*)

Scotch broom (*Cytisus scoparius*)

western red cedar (*Thuja plicata*)

yellow willow (*Salix lutea*)

SUMMARY DETERMINATION

<input checked="" type="checkbox"/> Proper Functioning Condition <input type="checkbox"/> Functional - At Risk <input type="checkbox"/> Nonfunctional <input type="checkbox"/> Unknown		Are factors contributing to unacceptable conditions outside the control of the manager? Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>
Trend for Functional - At Risk: <input type="checkbox"/> Upward <input type="checkbox"/> Downward <input type="checkbox"/> Not Apparent		If yes, what are those factors? <input type="checkbox"/> Flow regulations <input type="checkbox"/> Mining activities <input type="checkbox"/> Upstream channel conditions <input type="checkbox"/> Channelization <input type="checkbox"/> Road encroachment <input type="checkbox"/> Oil field water discharge <input type="checkbox"/> Augmented flows <input checked="" type="checkbox"/> Other (Private property and urban run-off)

Lentic Checklist

Name of Riparian-Wetland Area:

Bowker Creek

Date: **2007-01-27**

Segment/Reach ID:

Reach 12 – Pond behind UVic Clubhouse

ID Team

Patrick Lucey, Lehna Malmkvist, Daniel Hegg

Observers:

Yes	No	N/A	<i>Hydrology</i>
✓			1. Riparian-wetland area is saturated at or near the surface or inundated in “relatively frequent” events (1-3 years)
✓			2. Fluctuation of water levels is not excessive
✓			3. Riparian-wetland zone is enlarging or has achieved potential extent
✓			4. Upland watershed not contributing to riparian-wetland degradation
✓			5. Water quality is sufficient to support riparian-wetland plants
✓			6. Natural surface or subsurface flow patterns are not altered by disturbance (i.e. hoof action, dams, dikes, trails, roads, rills, gullies, drilling activities)
✓			7. Structure accommodates safe passage of flows (e.g. no head cut affecting dam or spillway)
			<i>Vegetation</i>
✓	✓		8. There is diverse age-class distribution of riparian-wetland vegetation (recruitment for maintenance/recovery)
✓			9. There is diverse composition of vegetation (for maintenance/recovery)
✓			10. Species present indicate maintenance of riparian-wetland soil moisture characteristics
✓			11. Vegetation is comprised of those plants or plant communities that have root masses capable of withstanding wind events, wave flow events, or overland flows (e.g. storm events, snowmelt)
✓			12. Riparian-wetland plants exhibit high vigour
		✓	13. Adequate vegetative cover present to protect shorelines/soil subsurface and dissipate energy during high wind and wave events or overland flows
		✓	14. Frost or abnormal hydrological heaving is not present
✓			15. Favourable microsite condition (i.e. woody material, water temperature, etc.) is maintained by adjacent site characteristics

✓			<i>Soils - Erosion / Deposition</i>
✓			16. Accumulation of chemicals affecting plant productivity/composition is not apparent
✓			17. Saturation of soils (i.e. ponding, flooding frequency, and duration) is sufficient to compose and maintain hydric soils
✓			18. Underlying geologic structure/soil material/permafrost is capable of restricting water percolation
✓			19. Riparian-wetland is in balance with the water and sediment being supplied by the watershed (i.e. no excessive erosion or deposition)
		✓	20. Islands and shoreline characteristics (i.e. rocks, coarse and/or large woody debris) adequate to dissipate wind and wave event energies

Remarks

Begin GPS Way Point: No GPS measurements taken.

Type: Artificial pond with a mix of drainage and ground water coming in.

Constraints:

Soft edges on 3 sides and a hard edge on the clubhouse side. Dam downstream of pond is failing.

Potential Restoration:

Places pieces of large wood in the system for habitat complexity. Plant willows and Red-osier dogwood (*Cornus stolonifera*) in grassy areas. Plant additional riparian vegetation. Replace Dam.

8. There is just barely enough diverse age class due to landscaping.

9. Could improve on the composition of riparian species.

18. Underlying geologic structure is artificial.

Vegetation:

birch (*Betula* sp)

black cottonwood (*Populus balsamifera*, spp. *Trichocarpa*)

Douglas fir (*Pseudotsuga menziesii*)

Garry oak (*Quercus garryana*)

Maple (*Aceraceae*)

Pacific water parsley (*Oenanthe sarmentosa*)

red alder (*Alnus rubra*)

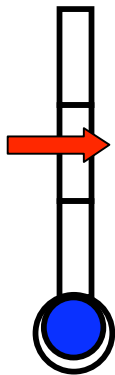
rhododendron (*Rhododendron* spp.)

salal (*Gaultheria shallon*)

sword fern (*Polystichum munitum*)

yellow pond lily (*Nuphar polysepalum*)

SUMMARY DETERMINATION

<input type="checkbox"/> Proper Functioning Condition <input checked="" type="checkbox"/> Functional - At Risk <input type="checkbox"/> Nonfunctional <input type="checkbox"/> Unknown Trend for Functional - At Risk: <input type="checkbox"/> Upward <input checked="" type="checkbox"/> Downward <input type="checkbox"/> Not Apparent		Are factors contributing to unacceptable conditions outside the control of the manager? Yes <input type="checkbox"/> No <input type="checkbox"/> If yes, what are those factors? <input type="checkbox"/> Flow regulations <input type="checkbox"/> Mining activities <input type="checkbox"/> Upstream channel conditions <input type="checkbox"/> Channelization <input type="checkbox"/> Road encroachment <input type="checkbox"/> Oil field water discharge <input type="checkbox"/> Augmented flows <input type="checkbox"/> Other
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Lotic Checklist

Name of Riparian-Wetland

Bowker Creek

Area:

Date: **2007-01-19**

Reach:

Reach 13 – Faculty club to UVic Rd

ID Team

Patrick Lucey, Lehna Malmkvist, Daniel Hegg,

Observers:

Potential Riparian-Wetland Vegetation.

Potential Channel Characteristics: Rosgen = "C" channel type

Yes	No	N/A	HYDROLOGICAL
✓			1) Floodplain above bankfull is inundated in "relatively frequent" events
		✓	2) Where beaver dams are present are they active and stable
✓			3) Sinuosity, width/depth ratio, and gradient are in balance with the landscape setting (i.e., landform, geology, and bioclimatic region)
✓			4) Riparian-wetland area is widening or has achieved potential extent
✓			5) Upland watershed is not contributing to riparian-wetland degradation

Yes	No	N/A	VEGETATION
✓			6) Diverse age-class distribution of riparian-wetland vegetation (recruitment for maintenance/recovery)
✓			7) Diverse composition of riparian-wetland vegetation (for maintenance/recovery) (<i>species present</i>)
✓			8) Species present indicate maintenance of riparian-wetland soil moisture characteristics
✓			9) Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high streamflow events (<i>community types present</i>)
✓			10) Riparian-wetland plants exhibit high vigor
✓			11) Adequate riparian-wetland vegetative cover present to protect banks and dissipate energy during high flows (<i>enough</i>)

✓			12) Plant communities are an adequate source of coarse and/or large woody material (for maintenance/recovery)
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Yes	No	N/A	EROSION DEPOSITION
✓			13) Floodplain and channel characteristics (i.e., rocks, overflow channels, coarse and/or large woody material) adequate to dissipate energy
✓			14) Point bars are revegetating with riparian-wetland vegetation
✓			15) Lateral stream movement is associated with natural sinuosity s
✓			16) System is vertically stable (<i>not downcutting</i>)
✓			17) Stream is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition)

Remarks

Begin GPS Way Point: No GPS measurements taken

Potential channel type: Rosgen channel type “C”

Present channel type: Rosgen channel type “C”

Constraints:

No notable constraints. UVic is replacing old bridge.

Potential Restoration:

Invasive species removal and control is required.

5. Higher sediment load than what is expected.

Vegetation:

black cottonwood (*Populus balsamifera*, spp. *Trichocarpa*)

Common snowberry (*Symphoricarpos albus*)

Douglas fir (*Pseudotsuga menziesii*)

English hawthorne (*Crataegus laevigata*)

English holly (*Ilex aquifolium*)

English ivy (*Hedera helix*)

Himalayan blackberry (*Rubus discolor*)

Maple (*Aceraceae*)

Nootka rose (*Rosa nutkana*)

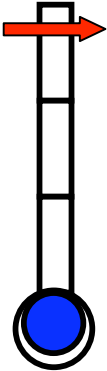
red alder (*Alnus rubra*)

salmonberry (*Rubus spectabilis*)

skunk cabbage (*Lysichiton americanum*)

sword fern (*Polystichum munitum*)

SUMMARY DETERMINATION

<input checked="" type="checkbox"/> Proper Functioning Condition		Are factors contributing to unacceptable conditions outside the control of the manager?
<input type="checkbox"/> Functional - At Risk		Yes <input type="checkbox"/>
<input type="checkbox"/> Nonfunctional		No <input type="checkbox"/>
<input type="checkbox"/> Unknown		
Trend for Functional - At Risk:		If yes, what are those factors?
<input type="checkbox"/> Upward		<input type="checkbox"/> Flow regulations
<input type="checkbox"/> Downward		<input type="checkbox"/> Mining activities
<input type="checkbox"/> Not Apparent		<input type="checkbox"/> Upstream channel conditions
		<input type="checkbox"/> Channelization
		<input type="checkbox"/> Road encroachment
		<input type="checkbox"/> Oil field water discharge
		<input type="checkbox"/> Augmented flows
		<input type="checkbox"/> Other (specify)

(Revised 1998) (7/12/04)

Lentic Checklist

Name of Riparian-Wetland

Bowker Creek

Area:

Date: **2007-01-27**

Segment/Reach
ID:

Reach 14 – Tributary (McKenzie and Stadium)

ID Team

Patrick Lucey, Lehna Malmkvist, Daniel Hegg

Observers:

Yes	No	N/A	<i>Hydrology</i>
✓			1. Riparian-wetland area is saturated at or near the surface or inundated in “relatively frequent” events (1-3 years)
✓			2. Fluctuation of water levels is not excessive
✓			3. Riparian-wetland zone is enlarging or has achieved potential extent
✓			4. Upland watershed not contributing to riparian-wetland degradation
✓			5. Water quality is sufficient to support riparian-wetland plants
✓			6. Natural surface or subsurface flow patterns are not altered by disturbance (i.e. hoof action, dams, dikes, trails, roads, rills, gullies, drilling activities)
✓			7. Structure accommodates safe passage of flows (e.g. no headcut affecting dam or spillway)
			<i>Vegetation</i>
✓			8. There is diverse age-class distribution of riparian-wetland vegetation (recruitment for maintenance/recovery)
✓			9. There is diverse composition of vegetation (for maintenance/recovery)
✓			10. Species present indicate maintenance of riparian-wetland soil moisture characteristics
✓			11. Vegetation is comprised of those plants or plant communities that have root masses capable of withstanding wind events, wave flow events, or overland flows (e.g. storm events, snowmelt)
✓			12. Riparian-wetland plants exhibit high vigour
✓			13. Adequate vegetative cover present to protect shorelines/soil subsurface and dissipate energy during high wind and wave events or overland flows
		✓	14. Frost or abnormal hydrological heaving is not present
✓			15. Favourable microsite condition (i.e. woody material, water temperature, etc.) is maintained by adjacent site characteristics

✓			<i>Soils - Erosion / Deposition</i>
✓			16. Accumulation of chemicals affecting plant productivity/composition is not apparent
✓			17. Saturation of soils (i.e. ponding, flooding frequency, and duration) is sufficient to compose and maintain hydric soils
✓			18. Underlying geologic structure/soil material/permafrost is capable of restricting water percolation
✓			19. Riparian-wetland is in balance with the water and sediment being supplied by the watershed (i.e. no excessive erosion or deposition)
		✓	20. Islands and shoreline characteristics (i.e. rocks, coarse and/or large woody debris) adequate to dissipate wind and wave event energies

Remarks

Begin GPS Way Point: No GPS measurements taken.

Type: Treed wetland.

Constraints:

Bridge and culvert are not appropriate for this system. No sediment pond/bay to trap sediment from McKenzie Ave and nearby residential areas.

Potential Restoration:

Removal of invasive species at the top end (near McKenzie), add more conifers to the system, add more wood to the system to help trap sediment, specifically add a sediment pond/trap to the system. Furthermore, replace the bridge and culvert.

2. McKenzie side of wetland is being maintained by mowing of grasses.

3. System is specifically made for stormwater management.

6. Stormwater management is critical.

7. Artificial system.

16. This is an urban system (water and sediment sampling should be considered).

Vegetation:

black cottonwood (*Populus balsamifera*, spp. *Trichocarpa*)

cattail (*Typha latifolia*)

European bittersweet (*Solanum dulcamara*)

Himalayan blackberry (*Rubus discolor*)

Nootka rose (*Rosa nutkana*)

Pacific water parsley (*Oenanthe sarmentosa*)

red alder (*Alnus rubra*)

yellow willow (*Salix lutea*)

SUMMARY DETERMINATION

<input checked="" type="checkbox"/> Proper Functioning Condition <input type="checkbox"/> Functional - At Risk <input type="checkbox"/> Nonfunctional <input type="checkbox"/> Unknown		PFC FAR NF	Are factors contributing to unacceptable conditions outside the control of the manager?
Trend for Functional - At Risk: <input type="checkbox"/> Upward <input type="checkbox"/> Downward <input type="checkbox"/> Not Apparent		Yes <input type="checkbox"/> No <input type="checkbox"/>	If yes, what are those factors? <input type="checkbox"/> Flow regulations <input type="checkbox"/> Mining activities <input type="checkbox"/> Upstream channel conditions <input type="checkbox"/> Channelization <input type="checkbox"/> Road encroachment <input type="checkbox"/> Oil field water discharge <input type="checkbox"/> Augmented flows <input type="checkbox"/> Other

Lotic Checklist

Name of Riparian-Wetland

Bowker Creek

Area:

Date: **2007-01-27**

Date:

Reach 15 – Tributary from Cedar Hill Golf Course (at Cedar Hill Rec. Centre) – Cedar Hill up past foot bridge.

ID Team

Patrick Lucey, Lehna Malmkvist, Daniel Hegg

Observers:

Potential Riparian-Wetland Vegetation.

Potential Channel Characteristics: Rosgen = "Gb" channel type

Yes	No	N/A	HYDROLOGICAL
		✓	1) Floodplain above bankfull is inundated in "relatively frequent" events
		✓	2) Where beaver dams are present are they active and stable
	✓		3) Sinuosity, width/depth ratio, and gradient are in balance with the landscape setting (i.e., landform, geology, and bioclimatic region)
	✓		4) Riparian-wetland area is widening or has achieved potential extent
✓			5) Upland watershed is not contributing to riparian-wetland degradation

Yes	No	N/A	VEGETATION
	✓		6) Diverse age-class distribution of riparian-wetland vegetation (recruitment for maintenance/recovery)
✓			7) Diverse composition of riparian-wetland vegetation (for maintenance/recovery) (<i>species present</i>)
✓			8) Species present indicate maintenance of riparian-wetland soil moisture characteristics
✓			9) Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high streamflow events (<i>community types present</i>)
✓			10) Riparian-wetland plants exhibit high vigor

✓			11) Adequate riparian-wetland vegetative cover present to protect banks and dissipate energy during high flows (<i>enough</i>)
	✓		12) Plant communities are an adequate source of coarse and/or large woody material (for maintenance/recovery)

Yes	No	N/A	EROSION DEPOSITION
✓			13) Floodplain and channel characteristics (i.e., rocks, overflow channels, coarse and/or large woody material) adequate to dissipate energy
		✓	14) Point bars are revegetating with riparian-wetland vegetation
	✓		15) Lateral stream movement is associated with natural sinuosity s
✓			16) System is vertically stable (<i>not downcutting</i>)
✓			17) Stream is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition)

Remarks

Begin GPS Way Point: No GPS measurements taken.

Potential channel type: Rosgen channel type “Gb”

Present channel type: Rosgen channel type “Artificial G”

Constraints:

No floodplain available.

Potential Restoration:

Cut banks back and terrace with bioengineering and riparian and native species.

5. System is a tributary.

6. Age of species within system is not diverse.

7. Species present are not native to location.

8. System consists of Reed Canary Grass and Red-osier dogwood.

9. Reed Canary Grass tends to form monocultures in systems.

12. No large trees present.

13. No large items in system to dissipate energy (small catchment)

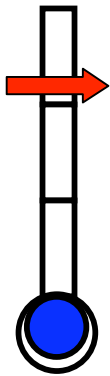
Vegetation:

black cottonwood (*Populus balsamifera*, spp. *Trichocarpa*)

Common snowberry (*Symphoricarpos albus*)

Douglas fir (*Pseudotsuga menziesii*)
Himalayan blackberry (*Rubus discolor*)
Native cedar (*Thuja plicata*)
Nootka rose (*Rosa nutkana*)
poison hemlock (*Conium maculatum*)
red alder (*Alnus rubra*)
reed canary grass (*Phalaris arundinacea*)

SUMMARY DETERMINATION

<input checked="" type="checkbox"/> Proper Functioning Condition <input type="checkbox"/> Functional - At Risk <input type="checkbox"/> Nonfunctional <input type="checkbox"/> Unknown	 <div style="position: absolute; left: 460px; top: 285px;">PFC</div> <div style="position: absolute; left: 460px; top: 335px;">FAR</div> <div style="position: absolute; left: 460px; top: 385px;">NF</div>	<p>Are factors contributing to unacceptable conditions outside the control of the manager?</p> <p>Yes <input type="checkbox"/> No <input type="checkbox"/></p>
<p>Trend for Functional - At Risk:</p> <input type="checkbox"/> Upward <input type="checkbox"/> Downward <input type="checkbox"/> Not Apparent		<p>If yes, what are those factors?</p> <input type="checkbox"/> Flow regulations <input type="checkbox"/> Mining activities <input type="checkbox"/> Upstream channel conditions <input type="checkbox"/> Channelization <input type="checkbox"/> Road encroachment <input type="checkbox"/> Oil field water discharge <input type="checkbox"/> Augmented flows <input type="checkbox"/> Other (specify)

(Revised 1998) (7/12/04)

Lotic Checklist

Name of Riparian-Wetland

Bowker Creek

Area:

Date: **2007-01-27**

Date:

Reach 16 - Tributary from Cedar Hill Golf Course (at Cedar Hill Rec. Centre) – Up past foot bridge to baseball diamond.

ID Team

Patrick Lucey, Lehna Malmkvist, Daniel Hegg

Observers:

Potential Riparian-Wetland Vegetation.

Potential Channel Characteristics: Rosgen = "C" channel type

Yes	No	N/A	HYDROLOGICAL
✓			1) Floodplain above bankfull is inundated in "relatively frequent" events
		✓	2) Where beaver dams are present are they active and stable
✓	✓		3) Sinuosity, width/depth ratio, and gradient are in balance with the landscape setting (i.e., landform, geology, and bioclimatic region)
✓			4) Riparian-wetland area is widening or has achieved potential extent
✓			5) Upland watershed is not contributing to riparian-wetland degradation

Yes	No	N/A	VEGETATION
	✓		6) Diverse age-class distribution of riparian-wetland vegetation (recruitment for maintenance/recovery)
✓			7) Diverse composition of riparian-wetland vegetation (for maintenance/recovery) (<i>species present</i>)
✓			8) Species present indicate maintenance of riparian-wetland soil moisture characteristics
✓			9) Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high streamflow events (<i>community types present</i>)
✓			10) Riparian-wetland plants exhibit high vigor

✓			11) Adequate riparian-wetland vegetative cover present to protect banks and dissipate energy during high flows (<i>enough</i>)
	✓		12) Plant communities are an adequate source of coarse and/or large woody material (for maintenance/recovery)

Yes	No	N/A	EROSION DEPOSITION
✓			13) Floodplain and channel characteristics (i.e., rocks, overflow channels, coarse and/or large woody material) adequate to dissipate energy
	✓		14) Point bars are revegetating with riparian-wetland vegetation
	✓		15) Lateral stream movement is associated with natural sinuosity
✓			16) System is vertically stable (<i>not downcutting</i>)
✓			17) Stream is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition)

Remarks

Begin GPS Way Point: No GPS measurements taken.

Potential channel type: Rosgen channel type “C”

Present channel type: Rosgen channel type “C”

Constraints:

Some floodplain available. System is constrained by berms. No point bars have developed in system due to the growth of the Reed Canary Grasses. Furthermore, the Reed Canary Grass and lack of large wood in the system don’t allow the tributary to achieve its full sinuosity.

Potential Restoration:

More floodplain areas and large pieces of wood in the channels would benefit the system. Remove invasive species and plant native species of vegetation.

3. Reed Canary Grass and lack of large wood in the system don’t allow the tributary to achieve its full sinuosity.

4. System is constrained by berms.

14. Systems should have point bars. Lack of formation is due to Reed Canary Grass.

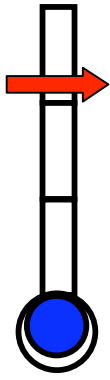
15. System is not reaching full potential due to berms and Reed Canary Grass

black cottonwood (*Populus balsamifera* ssp. *Trichocarpa*)

cattail (*Typha latifolia*)

Douglas fir (*Pseudotsuga menziesii*)
Himalayan blackberry (*Rubus discolor*)
Pacific water parsley (*Oenanthe sarmentosa*)
red alder (*Alnus rubra*)
red-osier dogwood (*Cornus stolonifera*)
reed canary grass (*Phalaris arundinacea*)
Short pine (*Pinus contorta*)
yellow willow (*Salix lutea*)

SUMMARY DETERMINATION

<input checked="" type="checkbox"/> Proper Functioning Condition <input type="checkbox"/> Functional - At Risk <input type="checkbox"/> Nonfunctional <input type="checkbox"/> Unknown	 <div style="position: absolute; left: 460px; top: 300px;">PFC</div> <div style="position: absolute; left: 460px; top: 350px;">FAR</div> <div style="position: absolute; left: 460px; top: 400px;">NF</div>	Are factors contributing to unacceptable conditions outside the control of the manager? Yes <input type="checkbox"/> No <input type="checkbox"/>
Trend for Functional - At Risk: <input type="checkbox"/> Upward <input type="checkbox"/> Downward <input type="checkbox"/> Not Apparent		If yes, what are those factors? <input type="checkbox"/> Flow regulations <input type="checkbox"/> Mining activities <input type="checkbox"/> Upstream channel conditions <input type="checkbox"/> Channelization <input type="checkbox"/> Road encroachment <input type="checkbox"/> Oil field water discharge <input type="checkbox"/> Augmented flows <input type="checkbox"/> Other (specify)

(Revised 1998) (7/12/04)

Appendix 3 Photo Record

Bowker Creek PFC Assessment and January 2007.



Reach 1, Photo 1, 2007-01-19. Bowker Creek – Residential area next to stream. Reach 1 has concrete lined walls and stream bed throughout.



Reach 1, Photo 2, 2007-01-19. Bowker Creek – Concrete lined walls and stream bed downstream of Beach Drive culvert.



Reach 1, Photo 3, 2007-01-19. Bowker Creek - Water is eroding soil behind concrete wall.



Reach 2, Photo 4, 2007-01-19. Bowker Creek – Allotment Gardens. Stream bank erosion due to trampling and high flows.



Reach 2, Photo 5, 2007-01-19. Bowker Creek – Allotment Gardens. Stream bank erosion due to trampling and high flows.



Reach 2, Photo 6, 2007-01-19. Bowker Creek – Allotment Gardens. Erosion of Concrete wall.



Reach 2, Photo 7, 2007-01-19. Bowker Creek – Allotment Gardens. Side bar formation occurring due to deposition and erosion.



Reach 3, Photo 8, 2007-01-19. Bowker Creek – Urban Park.



Reach 3, Photo 9, 2007-01-19. Bowker Creek – Urban Park, channelized and hardened in place.



Reach 3, Photo 10, 2007-01-19. Bowker Creek – Urban Park.



Reach 4, Photo 11, 2007-01-19. Bowker Creek – Oak Bay High School. One armoured side opposite to a steep vegetated side.



Reach 4, Photo 12, 2007-01-19. Bowker Creek – Oak Bay High School.



Reach 5, Photo 13, 2007-01-19. Bowker Creek – Oak Bay Recreation Centre. Site is heavily inundated with stormwater run-off due to surrounding impervious surfaces.



Reach 5, Photo 14, 2007-01-19. Bowker Creek – Oak Bay Recreation Centre. Notable erosion of banks due to high flows and lack of adequate vegetation.



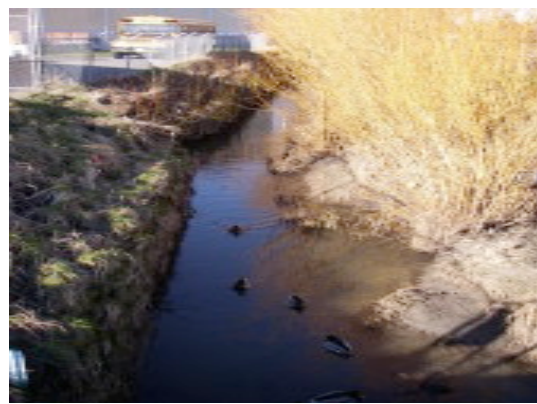
Reach 5, Photo 15, 2007-01-19. Bowker Creek – Oak Bay Recreation Centre. Further down the reach the downstream left-hand side is heavily armored.



Reach 6, Photo 16, 2007-01-22. Bowker Creek – Bee Street. This reach is entirely armoured throughout.



Reach 7, Photo 17, 2007-01-19. Bowker Creek - St. Patrick's Catholic School. Restoration of this part of the reach has occurred with recent terracing of banks and bioengineering.



Reach 7, Photo 18, 2007-01-27. Bowker Creek - St. Patrick's Catholic School. Bio-engineering has occurred on the downstream left-hand side. Erosion and deposition occurring throughout reach.



Reach 8, Photo 19, 2007-01-19. Bowker Creek – BC Hydro Lot. Due to high flows, water has eroded soil from behind the culvert wall.



Reach 8, Photo 20, 2007-01-19. Bowker Creek – BC Hydro Lot. Extensive down cutting and bank erosion leaving tree roots exposed and unable to armor the banks.



Reach 8, Photo 21, 2007-01-19. Bowker Creek – BC Hydro Lot. Bank erosion and slumping.



Reach 8, Photo 22, 2007-01-19. Bowker Creek – BC Hydro Lot. Bank erosion and slumping.



Reach 8, Photo 23, 2007-01-19. Bowker Creek – BC Hydro Lot. Bank erosion and slumping.



Reach 9, Photo 24, 2007-01-19. Bowker Creek – Richmond Elementary. Vertical erosion occurring within stream banks due to high flows and the lack of available floodplain.



Reach 9, Photo 25, 2007-01-19. Bowker Creek – Richmond Elementary. Erosion occurring within stream banks now undercutting fence.



Reach 9, Photo 26, 2007-01-19. Bowker Creek – Richmond Elementary. Due to unstable banks, the fence is losing ground and will soon fall into the creek.



Reach 9, Photo 27, 2007-01-19. Bowker Creek – Richmond Elementary. Unstable banks are weakening the concrete and fence structure above.



Reach 10, Photo 28, 2007-01-19. Bowker Creek – North Dairy Road. Considerable erosion on the outside bend and gabbions, due to inadequate vegetation and width/depth ratio of channel.



Reach 10, Photo 29, 2007-01-17. Bowker Creek – North Dairy Road. Area was recently repaired. A homeowner's driveway was falling into the creek due to unstable banks within the reach.



Reach 11, Photo 30, 2007-01-17. Bowker Creek – Browning Park. Reach is armored with concrete and rock. Some flood plain is available, but the system requires more riparian vegetation.



Reach 11, Photo 31, 2007-01-17. Bowker Creek –Browning Park. Notable erosion underneath bridge due to no riparian vegetation.



Reach 11, Photo 32, 2007-01-17. Bowker Creek Browning Park. Some erosion of banks have left tree roots unable to armor streambanks.



Reach 12, Photo 33, 2007-01-27. Bowker Creek – University of Victoria Pond – Artificial Pond.



Reach 12, Photo 34, 2007-01-27. Bowker Creek – University of Victoria Pond – Artificial Pond.



Reach 12, Photo 35, 2007-01-27. Bowker Creek – University of Victoria Pond – Weir downstream of artificial pond.



Reach 12, Photo 36, 2007-01-27. Bowker Creek – University of Victoria Pond – Weir below artificial pond is failing due to wood rot.



Reach 13, Photo 37, 2007-01-27. Bowker Creek – University of Victoria (University (Faculty) Club to UVic Road). Notable amount of sediment within system.



Reach 13, Photo 38, 2007-01-27. Bowker Creek – University of Victoria (University Club to UVic Road). Notable amount of sediment within system.



Reach 14, Photo 39, 2007-01-27. Bowker Creek – University of Victoria Tributary (McKenzie Avenue). Bridge and path that should be removed and appropriately sized to the system.



Reach 14, Photo 40, 2007-01-27. Bowker Creek – University of Victoria Tributary (McKenzie Avenue). Edge of wetland/manicured field.



Reach 15, Photo 41, 2007-01-27. Bowker Creek – Tributary (Cedar Hill) - Deep channel with large amounts of reed canary grass – facing downstream of bridge



Reach 15, Photo 42, 2007-01-27. Bowker Creek – Tributary (Cedar Hill) - Deep channel with large amounts of reed canary grass – facing upstream of bridge.



Reach 16, Photo 43, 2007-01-27. Bowker Creek – Tributary (Cedar Hill) – Area is endowed with reed canary grass. Some floodplain is available (seen here).



Reach 16, Photo 44, 2007-01-27. Bowker Creek – Tributary (Cedar Hill) – Some floodplain is available. (seen here)

Appendix 4. Rosgen Stream Type Classification

The physical processes that define the geomorphic character of streams and rivers are universally observable. The objective of classifying streams on the basis of channel morphology is to set categories of discrete stream types so that consistent, reproducible descriptions and assessments of condition and potential can be developed. The Rosgen classification scheme is a uses a hierarchical assessment of stream channel morphology to:

1. Predict a river's behavior from its appearance;
2. Develop specific hydraulic and sediment relationships for a given stream type and its state;
3. Provide a mechanism to extrapolate site-specific data to stream reaches having similar characteristics; and
4. Provide a consistent frame of reference for communicating stream morphology and condition among a variety of disciplines and interested parties (Rosgen, 1996).

Level I classification

A Level I classification in the Rosgen system describes the geomorphic characteristics that result from integrating basin relief, landform, and valley morphology. The dimension, pattern, and profile of rivers are used to delineate geomorphic types at a coarse scale (Rosgen, 1996). This procedure is typically conducted through the evaluation of topographic maps, aerial photographs, and field verification. A Level I stream classification serves the following four primary functions:

1. It integrates basin characteristics, valley types, and landforms with respect to the morphology of the stream system;
2. It provides a framework for organizing and communicating river information;
3. It provides the information for prioritizing the need for detailed assessments or companion inventories; and
4. It provides information that can be used to correlate similar general level inventories such as fisheries habitat, boating categories, riparian habitat, etc.

The information derived from a Level I evaluation is the least specific, but it provides a rapidly-obtainable starting point from which a detailed evaluation can be drawn. Through a Level I characterization, valley types and landforms are evaluated, and the study stream is then categorized as one of the following nine stream types: Aa+, A, B, C, D, DA, E, F, and G (Figure 8 and Figure 9). The reader is referred to Rosgen (1996) for a comprehensive treatment of all stream and valley types.

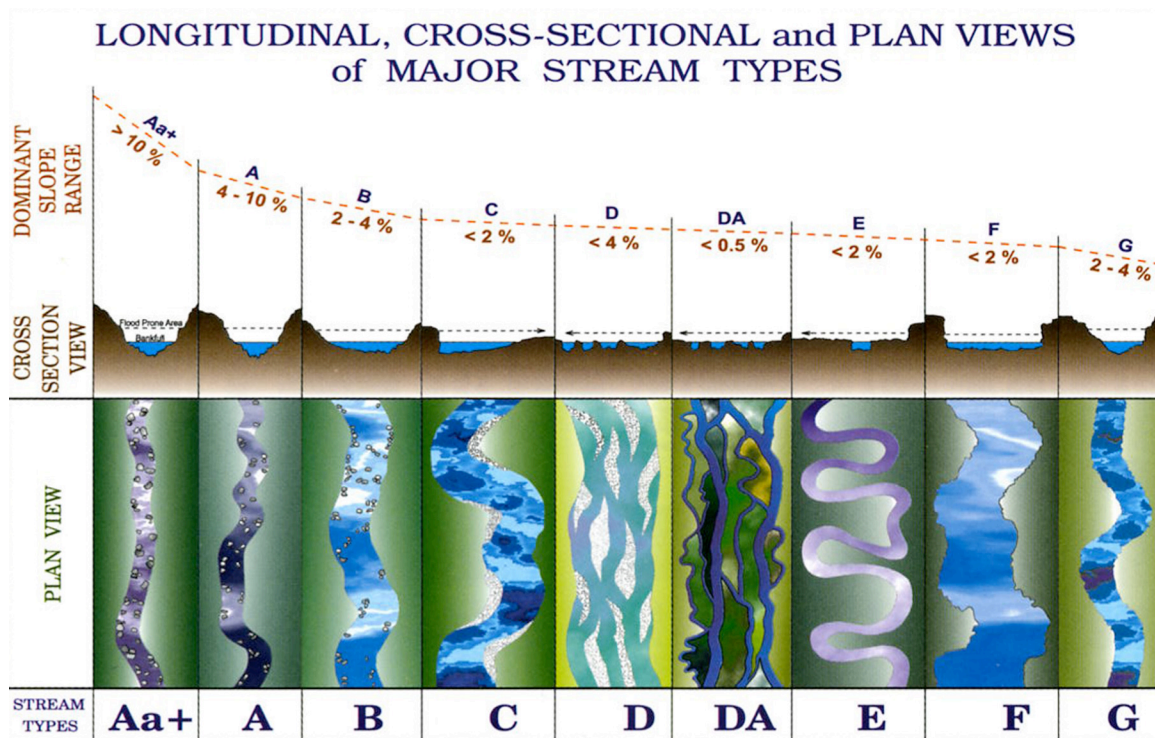


Figure 8. Broad level stream classification delineation showing longitudinal, cross-sectional, and plan views of major stream types (Rosgen and Silvey, 1998).

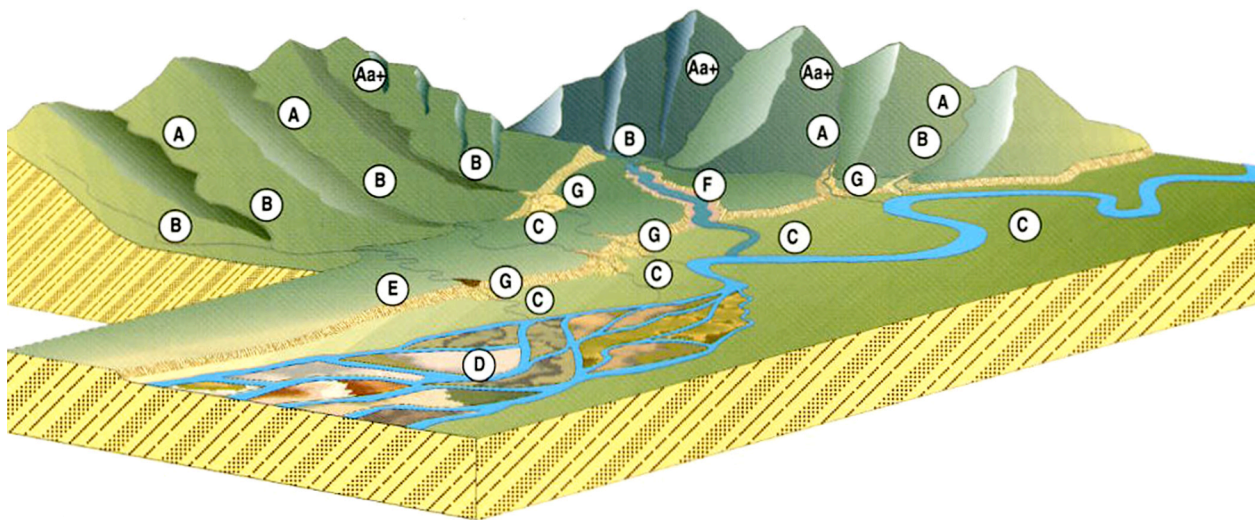


Figure 9. Example of broad level delineation of stream types at Level I (Rosgen and Silvey, 1998)

Level II classification

“River and stream morphology is determined by the interplay of the forces acting to create channel dimensions versus the forces resisting that action. River bed features, dimensions, and patterns for rivers influenced by structural controls are naturally different from those systems influenced by alluvial patterns of deposition. While Level I stream types are distinguished primarily on the basis of the valley landforms and channel dimensions observable on aerial photos and maps, Level II stream types are determined with field measurements from specific channel reaches and fluvial features within the river’s valley” (Rosgen, 1996).

Level II stream type delineation criteria are based on:

Channel cross-section:

- Entrenchment Ratio: A computed index value which is used to describe the degree of vertical containment of a river channel (width of the flood-prone area at an elevation twice the maximum bankfull depth/bankfull width) (see Figure 7).
- Width/Depth Ratio: An index value which indicates the shape of the channel cross-section (ratio of bankfull width/mean bankfull depth)
- Dominant Channel Materials: A selected particle size index value, the D50, representing the most prevalent of one of six channel material types or size categories, as determined from a channel material size distribution analysis.

Longitudinal profile:

- Slope: Slope of the water surface averaged for 20-30 channel widths.
- Bed Features: Secondary delineative criteria describing channel configuration in terms of riffle/pools, rapids, step/pools, cascades and convergence/divergence features which are inferred from channel plan form and gradient.

Plan-form (pattern) features as measured and computed from collected field data:

- Sinuosity: defined as stream length/valley length or valley slope/channel slope.
- Meander width: A secondary delineative criterion defined as meander belt width/bankfull width that describes the degree of lateral channel containment, and is primarily used assisting aerial photo delineation of stream types (Rosgen, 1996).

The Level II classification is summarized in Figure 10.

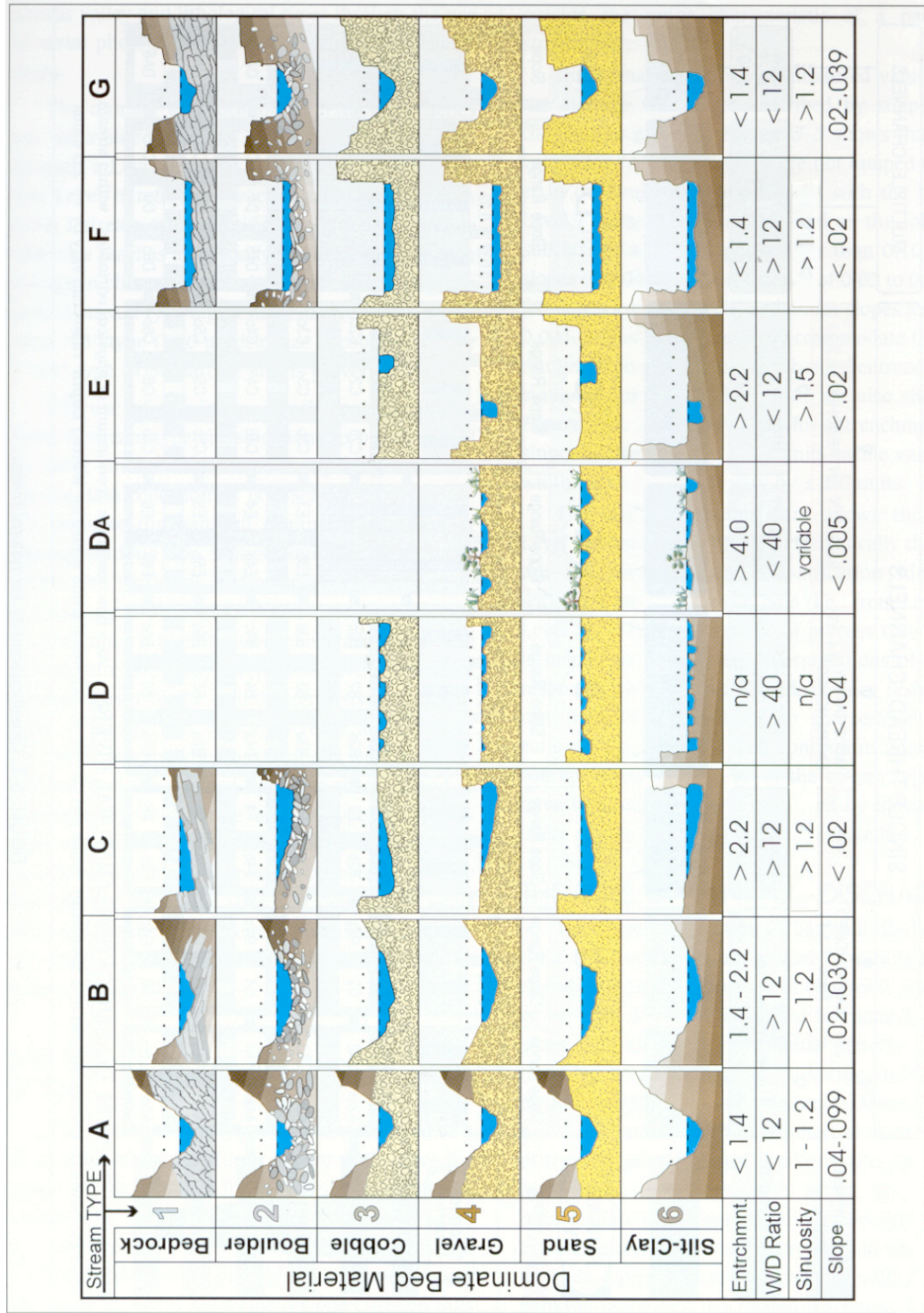


FIGURE 5-2. Primary delineative criteria for the major stream types.

Figure 10. Delineative criteria for the major stream types in Rosgen's stream classification system (Rosgen, 1996).

Appendix 5. Photopoint Monitoring

Photopoint Monitoring Field Procedures

Photopoint Photographs

Photopoint photographs are standardized pictures that are taken of 10 meter transects containing target resources at the selected monitoring site. The prime objective is not to capture every square meter of the sample site on film, but rather to give a representative view of the site conditions and resources of management concern. All photopoint photographs contain a meter board that is placed at a standard distance of 10 meters from the camera point. When possible, the meter board is placed in the center of each picture and the focal point (cross hairs) of the camera is centered on the 1 meter mark (1M) of the meter board (in unique circumstances, the 0M and 2M are also acceptable focal points). The meter board serves three important functions:

1. to embed a standard scale within each photograph so that features in close proximity to the meter board can be measured;
2. to provide a focal point for the camera so that repeat photography can be achieved; and
3. to provide a scale for the purposes of grid sampling analysis.

Both the location of the camera and the meter board are permanently marked so that precise replication of the photopoint can be achieved provided the camera height and focal point are known (Figure 11 and Figure 12). Placing the meter board at a standard distance of 10 meters from a 35 mm camera with a 50 mm lens was established by Hall (2001) to ensure at least 25% of the overall photograph height was captured by the meter board.

It is important to note that although the distance between the camera point and meter board is 10 meters, only approximately 7 meters are depicted on the resulting photograph due to optical limitations of a 35 mm camera with a 50 mm camera lens. To overcome this limitation, a second photopoint can be taken in which the locations of the camera and meter board are swapped. Establishing a second photopoint in the opposite direction of the first photopoint ensures that the entire 10 meter transect between the two permanent marker pins is captured on film. The contents of these photopoints can then be compared with other quantitative data collection techniques that are conducted between the two permanent marker pins (*e.g.* transect profiles and vegetation intercept samples).

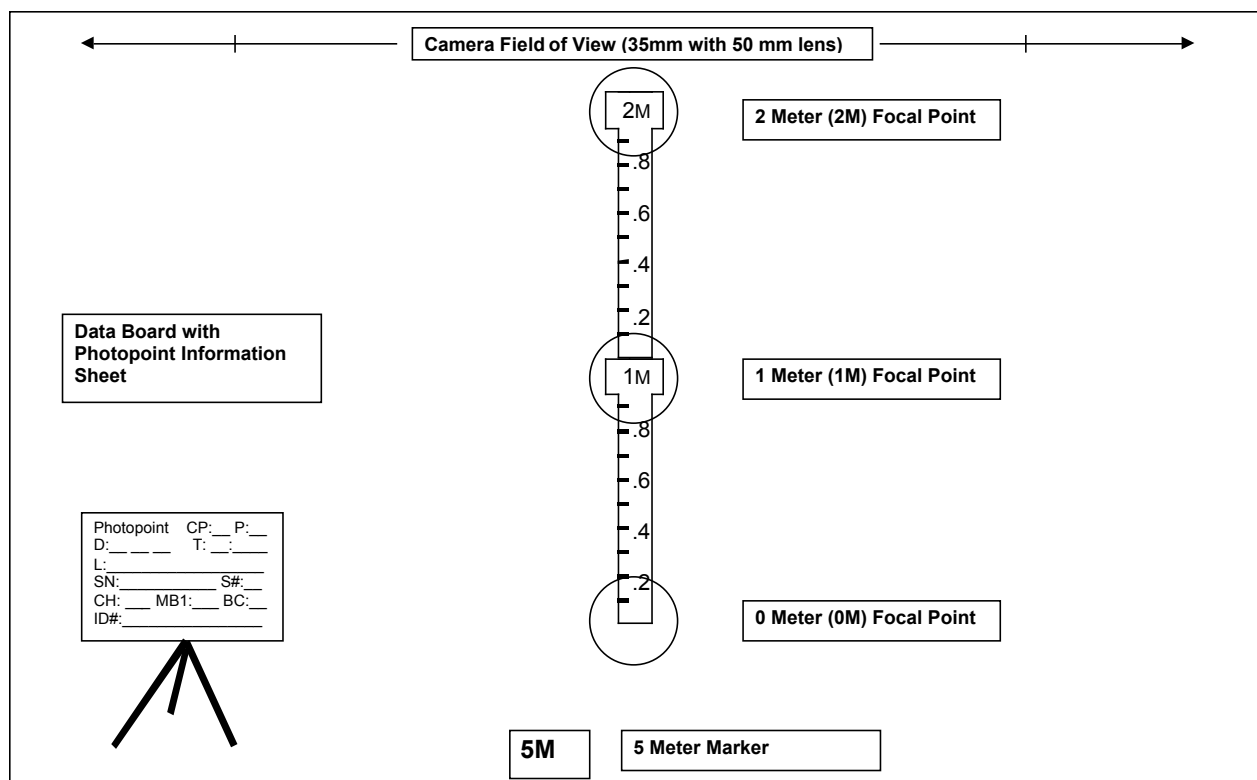


Figure 11. Schematic of meter board, data board and 5 meter marker within a photopoint photograph. 0M, 1M and 2M focal point options are also depicted.

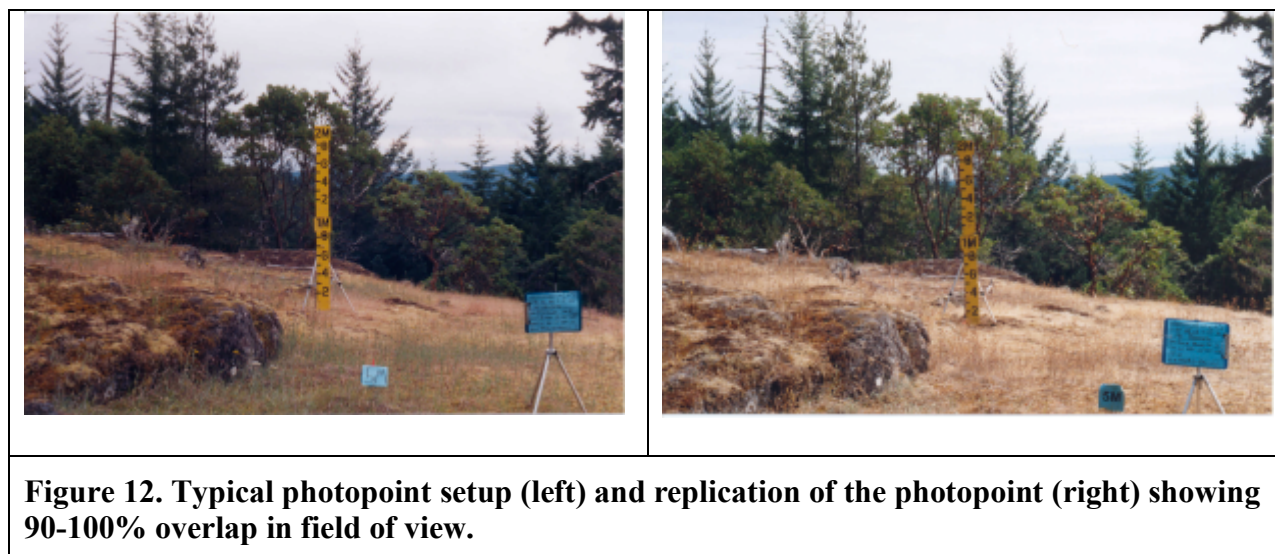


Figure 12. Typical photopoint setup (left) and replication of the photopoint (right) showing 90-100% overlap in field of view.

Technique

The following guidelines outline the procedure for shooting photopoint photographs:

1. Prior to entering the field, determine day-specific field objectives, assemble appropriate field resources (maps, site locations, etc.), check weather reports and assign work positions to crew members. For a three person crew, positions include 1. data recorder 2. meter board, data board and distance measurement technician; and 3. photographer / compass operator.
2. Use maps, aerial photographs and /or GPS to locate study site. Review site monitoring objectives and conduct a site assessment to identify target resources that require monitoring.
3. Identify the location name (broad geographic area), sample site name (specific area) and sample site number. A sample site is defined as not exceeding 1 hectare in total area. Each successive sample site is sequentially numbered (provided that the location name remains constant) and named according to a distinguishable feature contained within or adjacent to the site. If a new location name is selected, site numbering reverts to 1.

Example:

Location Name: Cherry Creek
Site Name: Day use picnic area
Site Number: 1

Location Name: Mark Creek
Site Name: Main bridge
Site Number: 1

Location Name: Cherry Creek
Site Name: Day use picnic area
Site Number: 2

Location Name: Mark Creek
Site Name: Upstream of wetlands
Site Number: 2

4. Identify a representative 10 meter linear transect at the sample site. More than one transect may be required to capture the target resources at a specific site. When selecting an appropriate transect, consideration must also be given to accessibility based on current and future vegetation and soil conditions, and absence of such safety hazards as snags, avalanche chutes and steep slopes. Selecting a representative transect is the most challenging and subjective component of the entire photopoint process. Transect selection is significantly improved by sighting through the camera at each potential transect location. What may appear to be a good transect to the human eye, may prove inadequate when viewed through a camera lens. In general, transect selection cannot be random as the site conditions (slope and vegetation) limit where photopoints can be taken.
5. Measure the selected 10 meter linear transect with a fiberglass measuring tape or a pre-measured piece of string. The measuring tape should be leveled and held approximately 1 meter above the ground. Always ensure that the measuring tape is oriented so that the 0 meter mark is on the end point that is associated with the minimum azimuth (compass

bearing value closest to 0°) and the 10 meter mark is on the end point that is associated with the maximum azimuth (bearing value closest to 360°). Orienting the transect line in this manner standardizes transect orientation and eliminates inconsistencies in labeling camera points. All azimuths are recorded to true north.

6. Load the camera(s) with film. Be sure to check that the film is securely attached to the take up spool: the winder knob should turn as the film advance lever is depressed. Advance the film to frame number 1.
7. Immediately take a photo of the film information sheet. Be sure that the correct information (ASA/ISO and roll #) is recorded for each camera separately as slide and print film will normally be different speeds (ASA).
8. Place the camera on the tripod. A quick release foot is very useful and makes switching to another camera, without disturbing the setup, much easier.
9. Center the camera tripod over the 0 meter mark of the transect line and adjust camera height until transect and target resources are in field of view. Standard camera heights range from 1 to 1.5 meters depending on site topography and configuration of target resources. Designate this camera location as camera point A. When the camera and meter board locations are swapped to do the next photo for the transect, the next position of the camera will be labelled camera point B. These two photos complete one transect. If a second transect is established at the sample site, label the third camera location camera point C (0 meter mark) and the fourth camera point D (10 meter mark). In other words, each unique camera location is given a unique letter. If a camera location is reused it retains its original letter. It is uncommon to install more than 4 camera points at a single sample site. Use the same camera point labeling process at each successive sample site, starting with the letter A.
10. Install a meter board at the 10 meter mark of the transect. The location of the meter board is photopoint 1. Ensure the meter board is level and is centered in the camera field of view. The camera is always oriented in the landscape position (long axis of photo is horizontal). Select 0M, 1M or 2M as the camera focal point (1M is the preferred focal point).
11. On the 10 meter transect between the camera and the meter board, locate the 5 meter mark and place the 5 meter marker 5 cm from the transect line. The 5 meter marker provides a spatial scale within the photopoint and also serves as a focal point for landscape photographs (See Figure 12).
12. Fill out the field data form. Sketch a map and include all bearings and distances. Record the photo number as appropriate for each roll of film (colour print, black & white, slide).
13. Fill out the photopoint information sheet. Photopoint photographs are coded according to the following procedure:
YY MM DD - First 3 letters of site name - camera location and photopoint number.

For example, photopoint 1, taken at the site named Creek Mount, from camera point A on December 31, 1999 would be coded 99 12 31-CRE-A1.

14. Attach photopoint information sheet to the data board and install the data board at 5 meters from the camera (maximum distance of 6 meters if necessary due to obstacles etc.) Ensure that the data board is not obscuring any of the target resources and is evenly illuminated (either total shade or total sunlight, but a mix of illumination should be avoided). The data board is placed in the camera field of view and is used to imbed site information into each photopoint photograph including: date, time, location, site name, site number, camera height, camera point, photopoint, photocode and distance / bearing of meter board from camera location. The information contained on photopoint information sheets is for photographic identification, replication and database storage purposes. Embedding detailed site information into each photograph eliminates the need to maintain a separate site information database.
15. Check to ensure the camera aperture is set to a standardized F-stop of 16 or 22. This standardizes the depth of field to ensure that all features which are beyond the 5 meter marker are in focus. Also check to ensure that the correct film speed (ISO level) has been set.
16. Read the light meter and adjust the shutter speed accordingly. If the shutter speed cannot be set to optimize the lighting conditions, a photographic bracketing procedure may have to be used in which 3 photographs are taken over the appropriate range of shutter speeds. To bracket a photograph, select a shutter speed which represents the ideal light level according to the light meter. Take one photograph at the optimum speed, one photograph at the next highest speed and one photograph at the next lowest speed. Use a cable release at shutter speeds of 1/60 sec. or slower.
17. Focus the camera on the meter board focal point (0M, 1M or 2M) and alert the crew that camera is ready It is important to note that the contents of data board will not necessarily be in focus in the view finder. If the correct f-stop has been used the data board will be in focus in the final photo. In rare circumstances, it may not be possible to capture all of the target resources in a single photopoint photograph. In such situations, 2 photopoint photographs are taken in which the meter board is first aligned on the right hand side of the field of view, and then aligned on the left hand side. Subsequent to developing, the photographs can be overlapped along the meter board to obtain a complete image of all target resources.
18. Shoot the photopoint with all three film types (depending on number of film types being used). Use quick release bases on each camera to increase speed of camera swapping on the tripod. Ensure that the field of view and focal point remain constant between cameras.
19. Install permanent marker pins at the camera and meter board locations (0 meter and 10 meter marks). Use case-hardened sidewalk stakes if locations are on soil (requires a sledge hammer) and use brass survey pins if locations are on bedrock (requires a Hilty rock drill TM, generator and rock grout). Permanently marking the location of the camera and meter board ensures precise photopoint replication provided that the camera height

and focal point are also recorded. In addition, the marker pins can be used for other non-photopoint purposes such as transect profile surveys and point intercept samples. If the possibility exists that the permanent marking pins may be removed by a natural or human caused disturbance, it may be necessary to select a witness point to aid in camera point relocation. If a witness point is designated, then the location and bearing of all camera points must be measured to the witness site. The witness point must also be marked with a permanent marker pin and tagged.

To complete the transect:

20. Swap the location of the camera and the meter board by placing the camera on the 10 meter mark (camera point B) and the meter board on the 0 meter mark (camera point A). Adjust camera height until the transect and target resources are in the field of view. Ensure that the meter board is level and is centered in the camera field of view. Select 0m, 1m or 2m as the camera focal point. Record the true north bearing from the camera location to the meter board (should be original bearing plus 180°).
21. Add the appropriate data to the original field data form and create a new photopoint information sheet.
22. Attach the photopoint information sheet to the data board and install the data board at a maximum distance of 6 meters from the camera. Ensure that the data board is not obscuring any of the target resources.
23. Turn the 5 meter marker to face the camera.
24. Shoot photopoint with all three film types. The first photopoint taken at a camera location is labeled 1. Each successive photopoint taken from the same camera location is incremented by one. (e.g. A-1, A-2, A-3 designates 3 photos all taken with the camera at exactly the same location ("A") but facing three different photopoints or targets ("1", "2" and "3")).
25. Confirm that all the necessary site data has been recorded by means of a check list.

Location: _____ Site Name: _____ Site #: _____

Lat./ Long. or UTM: _____

Date (YYYY/MM/DD) _____ Time (HH:MM) _____ Data Recorder: _____

SLD#: _____

BW#: _____

CLR#: _____

compass declination ____E/W

Map Checklist:

- ☐ North Arrow
- ☐ Camera Locations (A H)
- ☐ Photopoint Locations (#)
- ☐ Landscape Location (L)
- ☐ Site Setup Location (S)
- ☐ Veg. Plot Locations (V)
- ☐ Meter Boards (MB)
- ☐ Direction of Trail
- ☐ Transect
- ☐ Predominant Vegetation
- ☐ Landmarks

PHOTO INFORMATION

CAM LOC	PHOTO POINT#	SLD #	B/W F#	CLR F#	CH (M)	FOCAL POINT

DISTANCE (M)

CAM TO MB1	WIT TO CAM

Bearing (True North –19.35°E in Victoria)

CAM TO MB1	CAM TO MB2	FOCAL BEARING	WIT TO CAM

FILM INFORMATION

ROLL: _____ ISO/ASA: _____

DATE (Y/M/D): _____

CP= CAMERA POINT

P=PHOTOPOINT #

L=LOCATION NAME

CH=CAMERA HEIGHT

MB1/MB2= 1ST/2ND METER BOARD DISTANCE

CB°= COMPASS BEARING FROM CAMERA TO
METER BOARD

FB= FOCAL BEARING

D= DATE (Y/M/D)

T=TIME

SN=SITE NAME

S#=SITE NUMBER

FP=FOCAL POINT

ID= PHOTOGRAPH IDENTIFICATION NUMBER

PHOTOPOINT CP_____P_____

D_____T_____:_____
YEAR (YY) MONTH (MM) DAY (DD) HOUR(HH) MINUTE (MM)

L_____

SN_____S#_____

CH_____MB1_____CB°_____
Camera Height (m) Distance Camera to Meterboard (m) Compass bearing
Camera to Meterboard

ID #

Appendix 6. Glossary

Key Terms

Abiotic— of or related to non-living things; independent of life of living organisms.

Adfluvial—species or populations of fish that do not go to sea, but live in lakes and enter streams to spawn.

Aggradation—a modification of the earth's surface in the direction of uniformity of grade by deposition.

Alluvial— Deposited by running water.

Alluvial fan channel—streams generally located on foot slope landforms in a transitional area between valley floodplains and steep mountain slopes where a fan-shaped deposit of sand, gravel and fine material is formed.

Alluvium— material deposited by rivers and streams including sediment laid down in river beds, flood plains, lakes, and at the foot of mountain slopes and estuaries.

Anadromous— fish that ascend from the sea to breed in freshwater streams.

Bedload— sand, silt and gravel, or soil and rock debris rolled along the bottom of a stream by moving water.

Biotic— of or related to living things; caused or produced by living organisms

Bog— a wetland which has poorly drained, acidic, organic soils materials that support vegetation that can be either sphagnum moss or herbaceous plants or sedges, rushes, and forbs or may be a combination of sphagnum moss and herbaceous plants.

Buffer strip— an area adjacent to a stream or water body that is retained for ecological function.

Capability—the highest ecological status a riparian-wetland area can attain given political, social or economic constraints. These constraints are also referred to as limiting factors.

Channel types— stream section classifications based on physical attributes such as channel gradient, channel pattern, stream bank incision and containment, and riparian plant community composition.

Cirque— A semicircular feature found in glaciated mountains which is characterized by a steep, nearly vertical headwall, a concave floor, and a lip or threshold at the entrance.

Debris torrent—mass erosion process which occurs when a debris avalanche enters a high gradient stream channel, mixes with water, and continues downstream as a slurry of mud, large woody debris and water. Debris torrents are usually confined within the stream channel until they reach the valley floor where the debris spreads out, inundating vegetation and forming a broad surface deposit.

Delta— a nearly flat alluvial deposit between diverging branches of the mouth of a river, often triangular in shape.

Discharge— the volume of water transported by a stream over a given period of time.

Ecosystem— a complete, interacting system of organisms together with their environment (for example a bog, forest, or lake).

Ephemeral—a stream that flows in direct response to rainfall and snowmelt but not during dry seasons. Its channel is above the level of the water table.

Estuarine— deepwater tidal habitats and adjacent tidal wetlands that are usually semi-enclosed by land, but which have open, partly obstructed or sporadic access to the open ocean, and in which ocean water is diluted by freshwater runoff.

Estuary— relatively flat, intertidal, and upland area where saltwater meets freshwater, as at the heads of bays and the mouths of streams.

Fen— a wetland of slow-moving, nutrient rich, often alkaline water with sedge peat forming the substrate.

Floodplain— A relatively flat landform adjacent to a stream that is composed of primarily unconsolidated depositional material derived from the stream and that is subject to periodic flooding.

Glacial till— gravel, boulders, sand, and finer materials transported and deposited by a glacier.

Hydric— of, pertaining, or adapted to a wet or moist environment.

Hydrophytic vegetation— plants typically found in wetlands and dependent upon wetland moisture regimes for growth and reproduction.

Intermittent— A stream or body of water that does not flow continuously.

Interrupted— A stream with discontinuities in *space*.

Karst—A type of topography that develops in areas underlain by soluble rocks, primarily limestone. Features may include sinkholes, collapsed channels or caves.

Large Woody Debris (LWD) – any large piece of relatively stable woody material having a diameter of at least 4 inches and a length greater than 3 feet that intrudes into a stream channel; also called Large Organic Debris (LOD) or Large Woody Material (LWM).

Lentic—pertaining to or living in still water (lakes, ponds, etc.)

Lotic—pertaining to or living in moving water (streams, rivers, etc.)

Mitigation— measures designed to counteract environmental impacts or to make impacts less severe.

Muskeg—a common term used in Southeast Alaska to collectively describe wetlands dominated by sphagnum moss (bogs).

Potential- the highest ecological status a riparian-wetland area can attain given no political, social or economic constraints: it is often referred to as the “potential natural community” (PNC).

Potential Plant Community (PPC) - Represents the seral stage the botanical community would achieve if all successional sequences were completed without human interference under the present environmental conditions.

Potential Natural Community (PNC) - The biotic community that would become established if all successional sequences were completed without interferences under the present environmental conditions.

Perennial stream—A stream that has year round flow.

Process group—broad stream classification groups which describe the interrelationship between watershed runoff, landform relief, geology, and glacial or tidal influences on fluvial erosion and deposition processes.

Proper Functioning Condition- Riparian-wetland areas are functioning properly when adequate vegetation, land form, or large woody debris is present to: dissipate stream energy associated with high waterflows, thereby reducing erosion and improving water quality; filter sediment, capture bedload, and aid floodplain development; improve flood-water retention and ground-water recharge; develop root masses that stabilize stream banks against cutting action; develop diverse ponding and channel characteristics to provide the habitat and the water depth, duration, and temperature necessary for fish production, waterfowl breeding, and other uses; and support greater biodiversity.

Resident fish— non-migratory fish that complete their entire life cycle in freshwater.

Riparian area— the area including a stream channel, lake or estuary bed, the water itself, and the plants that grow in and on the land next to the water.

Riparian ecosystem— land next to water where plants that are dependent upon a perpetual source of water grow.

Riparian-wetland area— An area that is saturated or inundated at a frequency and duration sufficient to produce vegetation typically adapted for life in saturated soil conditions. It is also the transitional area between permanently saturated wetlands and upland areas often referred to as a riparian area. This transition area has vegetation or physical characteristics reflective of permanent surface or subsurface water influence.

Runoff—water which travels over the ground surface, through the upper soil layers and/or within the water table.

Sediment—solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice and has come to rest on the earth's surface either above or below sea level.

Seral stage— One of a series of plant communities that follows another in time on a specific site.

Soil productivity— capacity of a soil, in its normal environment, to produce plant growth, due to the soil's inherent chemical, physical, and biological properties.

Stream order—First order streams are the smallest unbranched tributaries; second order streams are initiated by the point where two first order streams meet; third order streams are initiated by the point where two second order streams meet, and so on.

Sub-basin—area that contributes to a drainage or stream within a watershed.

V-notch—a very steep, deeply incised stream channel which is usually situated on steep mountain slopes or hill slopes. Has a characteristic ``V" shaped cross-section.

Watershed– area that contributes water to a drainage or stream.

Wetlands– areas that are inundated by surface or ground water with a frequency sufficient, under normal circumstances, to support vegetation that requires saturated or seasonally saturated soil conditions for growth and reproduction.

Wind throw– areas where trees are uprooted, blown down, or broken off (windsnap) by storm winds.