EA1839

INTEGRATED WILDLIFE HABITAT RESTORATION PLAN FOR THE JORDAN RIVER WATERSHED, SOUTHERN VANCOUVER ISLAND, BRITISH COLUMBIA

Prepared for

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Bridge Coastal Restoration Program
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BC HYDRO FISH & WILDLIFE BRIDGE COASTAL RESTORATION PROGRAM

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EXECUTIVE SUMMARY

The strategic plans developed for the 15 watersheds within the Bridge Coastal Generation Area provide general direction for habitat restoration, but are too general to direct specific restoration activities in a particular watershed and do not provide designs for habitat replacement or enhancement projects. For all 15 watersheds in the Bridge Coastal Generation Area, the loss of terrestrial wildlife habitat has been quantified, approximated, or acknowledged, yet surprisingly few restoration projects have occurred to mitigate for the impacts of hydroelectric activities on wildlife.

To avoid a "band-aid" approach to habitat restoration, an integrated wildlife habitat restoration plan (IWHRP) was developed for the Jordan River watershed on southern Vancouver Island. The concept of the IWHRP was born out of the need to develop an ecologically-based restoration plan that considered the habitat needs of the species that do, or that are expected to occur in watersheds affected by hydroelectric development. Because the strategic plans developed for the 15 watersheds within the Bridge Coastal Generation Area do not provide direction for habit restoration, it is anticipated that the development of an IWHRP will have value for all watersheds in the Bridge Coastal Generation Area and for all watersheds in BC where BC Hydro operates. Specifically, the IWHRP developed for the Jordan River watershed could be used to guide and prioritize restoration opportunities in watersheds affected by hydroelectric development.

The restoration plan for the Jordan River watershed is premised on the three actions that benefit the greatest number of species: 1) habitat protection, 2) riparian habitat conservation and enhancement, and 3) habitat creation. Of these actions, habitat creation has been deemed as the action with the greatest potential to mitigate footprint impacts resulting from impoundment of the Jordan River. This is because habitat creation can be implemented on a larger scale more quickly than habitat enhancement. Furthermore, we are not interested in converting habitat types into those that did not previously exist in the Jordan River watershed. Our goal is to create habitats that did previously exist, which is why habitat creation is being favoured over habitat enhancement, despite the slightly greater number of species benefiting from enhancement versus creation.

A constructed wetland design was developed concurrently with the IWHRP. This was done because it is recognized that wetland habitat was directly impacted by river impoundment and because habitat creation is an attainable mitigation strategy that could be undertaken in the Jordan River watershed. Furthermore, the addition of wetland habitats would benefit many species of wildlife, thereby creating an integrated approach to restoration. Related to this was the desire to determine if wetland construction was feasible on the edge of a reservoir, where water level fluctuations present a unique problem for wetland construction.

The wetland designed for lands adjacent to Diversion Reservoir in the Jordan River watershed should be considered a proof of concept build. When completed, approximately 6,000 m^2 of wetted surface area and 610 m of wetted perimeter habitat in five ponds ranging in depth from 30 – 50 cm will be created. The proof of concept build is a necessary step in the refinement of the habitat creation restoration strategy that could eventually be implemented in any impounded watershed in the Bridge Coastal system and throughout British Columbia.

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INTRODUCTION

Established in 1999, the goal of the Bridge Coastal Restoration Program (BCRP) is to restore fish and wildlife resources that have been adversely affected by the original footprint development of hydroelectric facilities in the Bridge Coastal Generation Area (Figure 1). These footprint impacts include historical effects on fish and wildlife that have occurred as a result of reservoir creation, watercourse diversions, and the construction of dam structures. The strategic plans developed for the 15 watersheds within the Bridge Coastal Generation Area (BC Hydro 2001; Figure 1) provide general direction for habitat restoration, but are too general to direct specific restoration activities in a particular watershed and do not provide designs for habitat replacement or enhancement projects. For all 15 watersheds in the Bridge Coastal Generation Area, the loss of terrestrial wildlife habitat has been quantified, approximated, or acknowledged, yet surprisingly few restoration projects have occurred to mitigate for the impacts of hydroelectric activities on wildlife.

The goal of many ecological restoration projects is to return ecosystem structures, functions, and processes to “natural” or reference conditions (Block et al. 2003). This is typically accomplished by manipulating vegetation and/or the physical environment to move the system towards pre-defined reference conditions that presumably existed at some point in the past. To date, many of the restoration initiatives that have occurred under the purview of the BCRP have been relevant only to fish and fish habitat. Furthermore, many restoration activities have been ad hoc, site, and situation specific (cf. Hobbs and Norton 1996; Manning et al. 2006), and have not been considered in a broader ecological context. In most cases, these restoration activities have also occurred in the absence of an understanding of the potential effects of those restoration activities on terrestrial wildlife. Moreover, simply providing habitat for wildlife does not infer success; the spatial and temporal component of a given suite of restoration activities must also be considered. For example, creating snags does not ensure that a site will be suitable for use by snag-dependent species. The size, age, and spacing of snags and their juxtaposition to other habitat elements must also be considered (George and Zack 2001; Smallwood 2001).

One of the challenges in mitigating for impacts on terrestrial wildlife is to ensure that the mitigation strategy used does not adversely affect other species. Wildlife species have widely varying and often opposing habitat requirements. For every management option exercised, there will be winners and losers among wildlife populations (Chan-McLeod 2007) and these tradeoffs must be understood and incorporated into integrated prescriptions for habitat restoration. This is particularly true when considering restoration as it relates to conservation. Although restoration can enhance conservation efforts, restoration is always a poor second to the preservation of original (unaltered) habitats (Young 2000).

To avoid a “band-aid” approach to habitat restoration (and possibly conservation; Young 2000), an integrated wildlife habitat restoration plan (IWHRP) was developed for the Jordan River watershed on southern Vancouver Island. The concept of the IWHRP was born out of the need to develop an ecologically-based restoration plan that considered the habitat needs of the species that do, or that are expected to occur in watersheds affected by hydroelectric development. Because the strategic plans developed for the 15 watersheds within the Bridge Coastal Generation Area do not provide direction for habit restoration, it is anticipated that the development of an IWHRP will have value for all watersheds in the Bridge Coastal Generation Area and for all watersheds in BC where BC Hydro operates. Specifically, the IWHRP developed for the Jordan River watershed could be used to guide and prioritize restoration opportunities in watersheds affected by hydroelectric development.

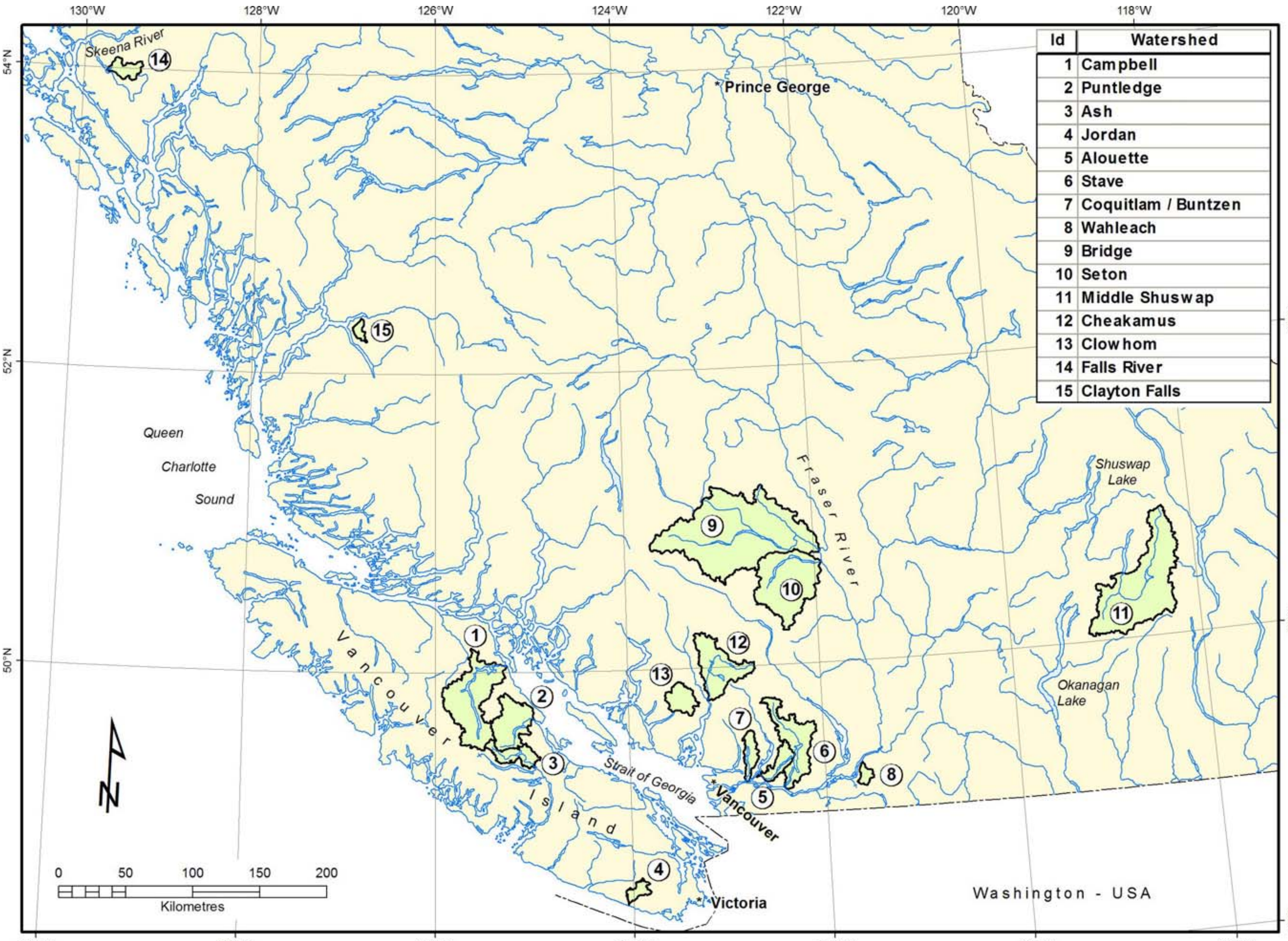

Figure 1. Distribution of hydroelectric facilities in the Bridge Coastal Generation Area.

STUDY OBJECTIVES AND TASKS

The intent of this document is to provide a scientific basis and implementation guidelines for an integrated wildlife habitat restoration program designed to improve ecosystem functions and enhance wildlife habitat in the Jordan River Watershed on southern Vancouver Island. An assessment of existing habitat conditions was combined with fundamental strategies for restoration to create a prioritization process for habitat restoration initiatives in the Jordan River Watershed. The primary area of interest is the area impacted by hydroelectric development, including the lands affected by impoundment, timber removal, road creation, and infrastructure related to the dams, powerhouse, and penstock. This document draws from the fields of restoration ecology, landscape ecology, and conservation biology to offer the most useful restoration strategies for the Jordan River watershed. In Objective 2 below, the focus is on guidelines to implement habitat restoration at the project and program levels. The third and final objective addresses next steps arising from this approach.

The study objectives and associated tasks are:

Objective 1: Establish a scientific basis for ecological restoration of wildlife habitat in the Jordan River Watershed.

- Task 1: Explain the fundamentals of ecosystem-based habitat restoration.
- Task 2: Summarize available data on habitat and ecosystem requirements for wildlife species with provincial or federal conservation status (i.e., species that are red- or blue-listed or that have COSEWIC status).
- Task 3: Describe current conditions and ecological changes over the last century in the Jordan River Watershed.
- Task 4: Identify and prioritize habitat restoration strategies for the Jordan River Watershed, with an emphasis on the area affected by hydroelectric development.
- Task 5: Describe the development of a conceptual wetland design to replace wetland habitat that was lost when Diversion Reservoir was created.

Related to Task 5, are the following sub-tasks:

  - Design and create a healthy, fully-functioning, self-sustaining wetland ecosystem along the shoreline of Diversion Reservoir.
  - Promote the regeneration of native plants and reoccupation by native wildlife species in and near the wetland by providing suitable natural habitat.
  - Maximize plant and wildlife biodiversity in the area based on site-specific conditions and on the species that are present or expected within the watershed.

Objective 2: Develop implementation guidelines for restoration projects in the context of, and consistent with, ongoing efforts.

- Task 1: Describe types of restoration projects for the Jordan River Watershed that are consistent with the goals of the BCRP.
- Task 2: Refine project selection guidelines.
- Task 3: Describe a process to implement habitat restoration projects, including phases for planning, funding, constructing, evaluating, and adaptive management of restoration efforts.

Objective 3: Discuss constraints to implementation and recommend next steps to fulfill the goal of the Jordan River Watershed habitat restoration program.

Study Area

The Jordan River is located within the Capital Regional District, along the southwest coast of Vancouver Island, approximately 72 km by road from Victoria, B.C. The 25 km long river flows southwesterly between the Sooke Hills and the Seymour Mountain range into the Juan De Fuca Strait at the community of Jordan River. The Jordan River watershed is located on southwestern Vancouver Island, British Columbia, approximately 85 km west of Victoria (Figure 1). The watershed drains an area of approximately 165 km^2, flowing westward to empty into the Pacific Ocean along the northern coast of the Strait of Juan de Fuca.

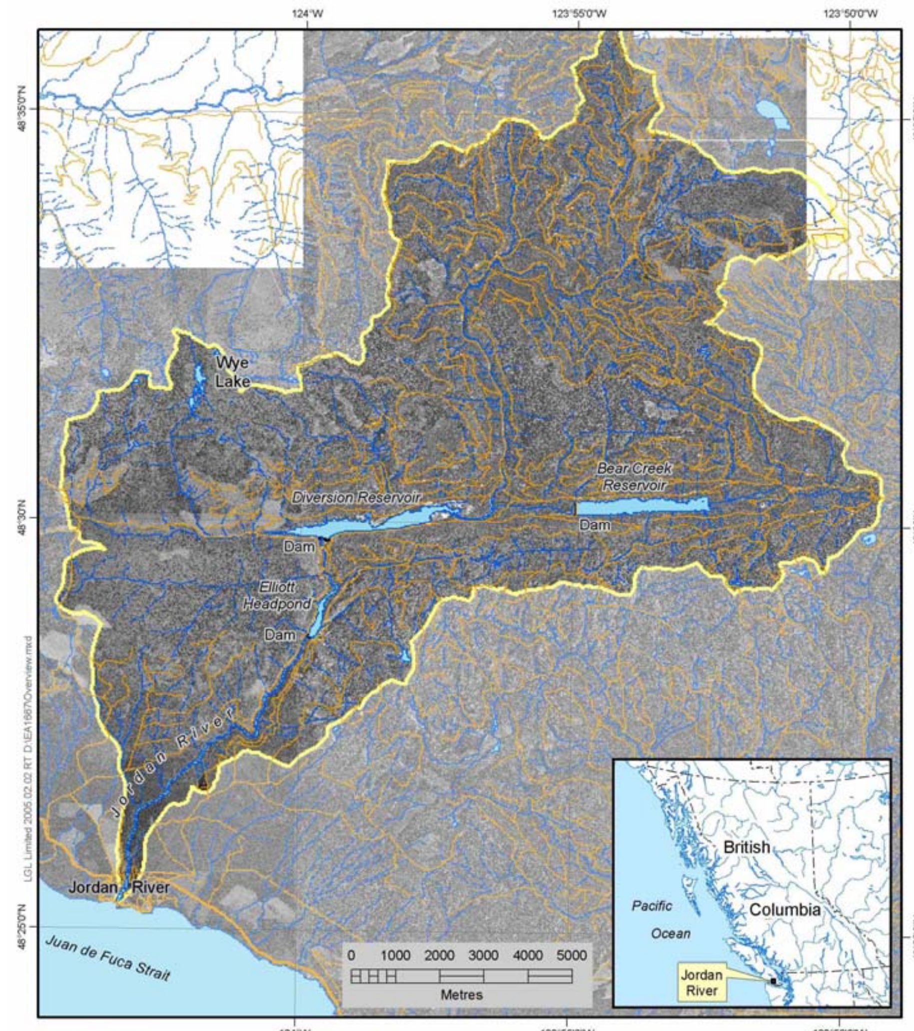

Figure 2. Location of the Jordan River watershed relative to British Columbia and Vancouver Island.

Jordan River is a steep, incised watercourse with several barriers to fish migration, including a series of boulder obstructions 1.2 km from the mouth of the river (Wright and Guimond, 2003). High water inflows from snowmelt occur between May and July, with August and September generally very dry. Heavy rain can cause immediate high flows between October and March. The Jordan River Watershed is part of the Coast and Mountains Ecoprovince, the Western Vancouver Island Ecoregion, and the Windward Island Mountains Ecosection (Demarchi, 1996). Within the

Windward Island Mountains Ecosection, the project area is contained within 4 variants of the Coastal Western Hemlock (CWH) biogeoclimatic zone, which covers much of Vancouver Island:

Table 1. Biogeoclimatic zones, subzones, and variants occurring within the Jordan River Watershed.

Label	Zone	Subzone	Variant
CWHvm1	Coastal Western hemlock	Very wet maritime	submontane
CWHvm2	Coastal Western hemlock	Very wet maritime	montane
CWHmm1	Coastal Western hemlock	Moist maritime	submontane
CWHmm2	Coastal Western hemlock	Moist maritime	montane

The CWH is characterized by cool summers and mild winters and the highest average rainfall of all biogeoclimatic zones (Pojar et al., 1991). Within the CWH, western hemlock is the dominant coniferous tree species with Douglas-fir being widespread. Western redcedar, Amabilis fir and yellow-cedar are also common. Big-leaf maple, red alder and cottonwood species are common in riparian zones throughout the CWH (Pojar et al., 1991). Characteristic floristic features of zonal ecosystems in the CWH are:

a) the prominence of western hemlock;

b) the sparse herb layer;

c) the predominance of several moss species (especially *Hylocomium splendens* [step moss and *Rhytidiadelphus loreus* [lanky moss]).

The riparian zone of Bear Creek between the two reservoirs is dominated by red alder with a well developed understory of shrubs and herbs (V. Hawkes, pers. obs). Riparian vegetation associated with Jordan River includes deciduous and coniferous tree species including red alder, Douglas-fir and western redcedar. In some areas, it appears that riparian vegetation is starting to encroach into floodplain habitats.

THE BASIS FOR ECOLOGICAL RESTORATION

Fundamentals of Ecological Restoration

The long-term goal of restoration projects inside of watersheds is the establishment of a self-sustainable ecosystem that is in equilibrium with the surrounding landscape. Restoration is an effective tool for returning a degraded ecological system close to its pre-disturbed condition. It also serves as a tool for preventing environmental degradation provided that the source of the degradation has been corrected.

Ideally, habitat restoration is intended to restore the habitat value of an area beyond simply "revegetating" or planting vegetation within disturbed areas, but by attempting to create a sustainable and functioning ecosystem. A functioning ecosystem is not restricted to vegetation, but also includes chemical and physical components such as hydrological, soil, wildlife functions, and the interaction of all natural habitat components. Restoration may occur actively or passively. While passive restoration relies exclusively on the forces of nature to enhance and repair disturbed ecosystem functions, active restoration requires anthropogenic actions and physical alterations of the landscape.

Generic Restoration Strategies

The science of ecological restoration has defined strategies (Table 1) that provide guidance for restoration projects (Johnson et al. 2003). Depending on site-specific characteristics and restoration project goals, more than one strategy may be appropriate for a site. In addition, multiple strategies may be employed at a site to maximize the benefit to the ecosystem. Restoration strategies can be categorized as passive (conservation and protection) or active (creation, enhancement, restoration). All strategies try to exploit an ecosystem's capacity to self-adjust to change.

Table 1. Five strategies of restoration ecology.

	Strategy	**Definition**	**Comments**
PASSIVE	Conservation	Maintenance of biodiversity (Meffe et al. 1994).	Conservation biology is a synthetic field that applies the principles of ecology, biogeography, population genetics, economics, sociology, anthropology, philosophy and other theoretically based disciplines to the maintenance of biological diversity. Conservation can allow development to occur as long as biodiversity and the structure and processes to maintain it are not affected. Restricted development is an approach to conservation.
	Creation	Bringing into being a new ecosystem that previously did not exist on the site (NRC 1992).	In contrast to restoration, creation involves the conversion of one habitat type or ecosystem into another.
ACTIVE	Enhancement	Any improvement of a structural or functional ecosystem attribute (NRC 1992).	As noted by Lewis (1990), enhancement and restoration are often confused. The intentional alteration of an existing habitat to provide conditions that previously did not exist and which by consensus increase one or more attributes is enhancement.
	Restoration	Return of an ecosystem to a close approximation of its previously existing condition (e.g., Lewis 1990, NRC 1992).	Includes any form of restoration with the intent of improving habitat to a state closely approximating a historical or pre-disturbance condition.
	Protection	Formal exclusion of activities that may negatively affect the structure and/or functioning of habitats or ecosystems.	Protection can also refer to protection of a species or group of species through management actions such as elimination of harm to a species directly or indirectly through damage of its habitat. Restricted development and land use ordinances can also be used to exclude unwanted activities as an approach to protection.

Six approaches have been described to meet the objectives of the five strategies listed in Table 1. Five approaches involve intervention. The sixth approach is based on the premise that through time, and with control of the sources of disturbance, it is possible for a degraded system to naturally recover. Intervention becomes necessary when a particular habitat type is degraded to the point that it no longer has the capacity for self-maintenance and repair.

1. **No Intervention**: In the no intervention approach, recovery is left to natural processes. The outcome of this approach is unpredictable and may not resemble pre-disturbance condition (Class D restoration, Cairns 1991). The two possible trajectories of the no-intervention

approach are natural recovery or further degradation. Although represented as two distinct trajectories, further degradation may lead to an alternative steady state, which in turn would progress toward natural recovery. Natural recovery is difficult to grasp because it rarely happens within the lifetime of a scientist or manager and can really only be understood in terms of geological time.

2. **Conservation for Natural Recovery**: Conservation can be a practical and effective restoration approach. Conservation biology acknowledges that human-caused disturbances (e.g., logging, road building) has and will continue to occur. However, conservation is based on the premise that disturbances can continue to occur in a way (e.g., using science-based development strategies) that minimizes or avoids damage to the biodiversity of the system. Conservation represents a relevant approach for the Jordan River Watershed because portions of the watershed contain habitat attributes important to the preservation of biodiversity and there will continue to be pressure on the system through natural resource extraction and the maintenance of the reservoirs.
3. **Creation of New Ecosystem**: Creation of a new ecosystem involves the development of a new ecosystem that did not previously exist at the site (NRC 1992; Simenstad and Thom 1992). Creation of a new ecosystem is intended to emulate the present condition of an existing, functioning reference ecosystem. Creation of a new ecosystem involves elaborate reconstruction of both physical (e.g., topographic, hydrologic) as well as biotic (e.g., vascular plants) elements. Although created ecosystems may eventually become self-maintaining, there is considerable uncertainty in the outcome. Created ecosystems typically require ongoing management (Class C restoration, Cairns 1991; Simenstad and Thom 1992).
4. **Enhancement of Selected Attributes**: Attributes are characteristics that are correlated with, and can serve as, indicators of ecosystem structure and function. In general, enhancement refers to any improvement of a structural or functional attribute. Structural (state) and functional (process) attributes need to be considered at the population, community, ecosystem, and landscape levels (as appropriate). Enhancement differs from restoration in that only one or several attributes are improved rather than the whole system. Terrestrial wildlife habitat attributes can be integrated as elements of modified habitats within the Jordan River watershed
5. **Restoration to Improved, Pre-Disturbance, or Historical Condition**: Intervention through restoration is intended to improve existing conditions. Pre-disturbance condition is the condition thought to have previously existed in the watershed prior to the onset of disturbance (of any kind). From a practical standpoint, pre-disturbance condition is difficult to define precisely and is commonly referred to in the literature as the original, undisturbed condition (Jordan et al. 1997; NRC 1992; Cairns 1989). Historic condition is the condition known to have previously existed in the watershed, which for the Jordan River watershed is limited. The goal of restoration to historic condition is to establish a community that is ecologically superior to the present degraded system and resembles the original system in certain carefully defined ways (Cairns 1988). Simenstad and Thom (1992) note that the opportunity for successful restoration to historic condition is high as long as the primary processes delineating the habitat type(s) are still effective at that site (e.g., functional riparian habitat, presence of snags and older forest, habitat corridors providing connectivity between riparian and upland habitat). If some, or all, of these processes have been altered or lost, the prospects for restoration to historic condition are greatly diminished. Furthermore, knowledge of the pre-disturbance condition is essential to successful restoration.
6. **Protection to Maintain a Desirable State**: Although an indirect approach, protection of existing habitat attributes can be an effective intervention tool. Protection helps prevent degradation of existing areas that are presently in a desirable ecosystem state. Protection is

distinct from conservation because protection assumes no further development, whereas conservation does not. Protection could take the form of preserving specific habitat polygons on the landscape to retain specific habitat features that are important to wildlife. Similarly, habitats that have the capability of becoming important to many or sensitive wildlife species can also be considered for protection.

Of the six approaches presented above, creation, enhancement and protection would benefit the structural and/or functional attributes important to wildlife in the Jordan River watershed. Watersheds contain arrays of habitats and sites particularly suited for certain species and many species will be adapted to a unique set of environmental processes or conditions that provide refuge during periods of stress. However, these same species will also likely use sites that provide sub-optimal habitat suitability. Therefore, the importance of a single site for maintaining regional biodiversity is variable – ranging from highly critical during years of high environmental stress, to redundant during years of expanded habitat (NRC 1992). Enhancement actions must be therefore be developed at the landscape scale.

Role of Landscape Ecology

A general goal for ecological restoration is to move the ecosystem from a less desirable condition to a more desirable condition as quickly as possible. A general model for ecosystem state (Figure 3) is one way to visualize the present (disturbed) and historical (undisturbed) “states” of the ecosystem, as well as to identify restoration goals (Thom 1997). First, it is assumed that there is a positive relationship between the structure[1] and function[2] of an ecosystem (Johnson et al. 2003). Next, the system condition on both axes is divided into subjective categories based on existing function and structure to acknowledge two sources of uncertainty: 1) our inability to accurately quantify the relationship between structural and functional ecosystem components; and 2) our inability to accurately predict the dynamic nature of regular periodic and stochastic natural variability associated with structural conditions and functional conditions (Shreffler and Thom 1993; Hobbs and Norton 1996; Johnson et al. 2003). The three levels along each axis are qualitative indicator variables (e.g., square metres) related to the structural condition (e.g., the size of the pond-wetland interface) and the functional conditions (e.g., the number of ducks nesting at this interface). Therefore, an ecosystem under optimal conditions of structure and function can have values that vary over a predictable range because of natural dynamics. This range is the target the restoration project is predicated on, and the project can be considered a success if the structure and function of the restored ecosystem fall within this qualitative range.

[1] Ecosystem structure is defined as the types, distribution, abundances, and physical attributes of the plant and animal species comprising the ecosystem.
[2] Ecosystem function is defined as the role the plant and animal species play in the ecosystem, including primary production, prey production, refuge, water storage, nutrient cycling, etc.

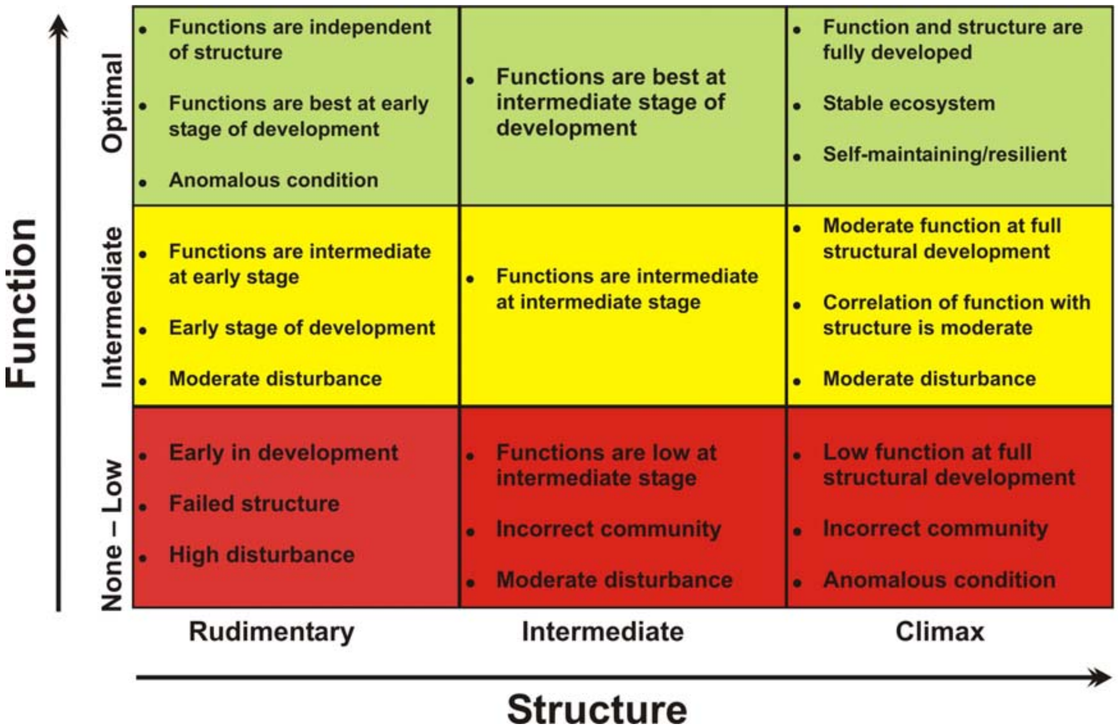

Figure 3. Generalized system-development matrix showing the 9 states a restored ecosystem can occupy during development (modified from Thom 2000). Cells in red represent undesired conditions; yellow – acceptable condition; green – desired condition.

The natural climax structure of an ecosystem, habitat, or community has a corresponding and predictable functional condition (Johnson et al. 2003). The top row in Figure 3 represents systems that can be described as having optimal functionality with varying levels of ecosystem structure, and in general, represents the desired ecosystem condition. The Jordan River watershed system has been altered from prehistorical conditions, and the structure and function of the system differs from that present prior to hydrological modification and other anthropomorphic or natural changes. Although the Jordan River watershed may have reached equilibrium in this altered state, ecological restoration initiatives would benefit wildlife and enhance the ecological condition of the watershed.

WILDLIFE OF THE JORDAN RIVER WATERSHED

Wildlife of the Jordan River Watershed is fairly typical of the forested landscapes of southern Vancouver Island. Certain habitats (e.g. Jordan Meadows) increase the probability of occurrence for rare species of butterflies, dragonflies, and plants. Historical records indicate that marmots may have been present in the Jordan River watershed (Hardy 1946) and species such as the Vancouver Island Wolverine (*Gulo gulo vancouverensis*), Marbled Murrelet (*Brachyramphus marmoratus*), and Roosevelt Elk (*Cervus canadensis roosevelti*) have been reported, or are known to occur in the Jordan River watershed. Red-legged Frogs (*Rana aurora*) occupy riparian and moist forest habitats and breed in Jordan Meadows, and at one time, Western Toads (*Bufo boreas*) were common in the Jordan River watershed (Hardy 1946, Davis and Gregory 2003).

The landscape of southern Vancouver Island is diverse and unique. The convergence of dry climates and wet climates, mountainous areas and lowlands, and terrestrial and marine environments has created one of the most biologically rich regions in Canada, harbouring many species which occur nowhere else in the country or, in some cases, the world. Human development and resource extraction, however, have fragmented the habitats of southern

Vancouver Island and had significant impacts on a number of threatened or endangered species. Indeed, several of these imperiled species have been lost from the region which, for some, represented their only toehold in the country. The combination of biological uniqueness and development pressures has resulted in a particularly high number of species of concern occurring on southern Vancouver Island.

As a result of an increasing awareness of the plight of biodiversity in British Columbia and Canada, ranking schemes have been developed at both the national (Committee on the Status of Endangered Wildlife in Canada [COSEWIC]) and provincial (British Columbia Conservation Data Centre [BC CDC]) levels which assess the current status of threatened or endangered species and provide them with a sensitivity ranking (Table 2). These ranking schemes allow conservationists and biologists to focus their efforts on species that are rare or declining and facilitates further inventory of these species by highlighting their status.

Table 2. Explanation of the ranks used by COSEWIC and the BC CDC when assessing the status of endangered species in Canada and British Columbia, respectively.

National Status (COSEWIC)	
Extinct (X)	No longer known to exist anywhere
Extirpated (XT)	No longer known to exist in the wild in Canada, but known to exist elsewhere
Endangered (E)	Threatened with immediate extinction or extirpation through all or a significant portion of its range, owing to the act of humans
Threatened (T)	Likely to become endangered in Canada if conditions are not reversed
Special Concern (SC)	May become threatened or endangered because of a combination of biological characteristics and identified threats
Data Deficient (DD)	Available information is insufficient (a) to resolve a wildlife species' eligibility for assessment or (b) to permit an assessment of the wildlife species' risk of extinction
Not at Risk (NAR)	Not at risk of extinction given the current circumstances
Provincial Status (BC CDC)	
Red	Species is endangered or threatened under the *Wildlife Act*, is extinct, is extirpated, or is a candidate for these designations
Blue	Species is not immediately threatened, but is of concern because of characteristics that makes it particularly sensitive to human activities or natural events
Yellow	Species is uncommon to common, declining or increasing and but is not a candidate for the red or blue lists

Vertebrate and Invertebrate Animals

The South Island Forest District is home to many species with federal or provincial status as "Species at Risk." Of the approximately 197 mammals, birds, amphibians, reptiles, terrestrial gastropods, butterflies, and dragonflies that likely occur in the Jordan River watershed (Appendix A), 80 are threatened or endangered occurring in 7 species groups. This includes 11 mammals (including marine mammals), 26 birds, 6 reptiles and amphibians, 5 freshwater fish, 15 butterflies, 5 dragonflies, and 12 terrestrial molluscs. Other species groups have not yet been ranked (e.g., most other insects and invertebrates) and it is expected that many more rare or endangered species from these groups occur in this region.

We developed a ranking system to determine the probability of occurrence for each of the threatened or endangered species listed in Appendix A to be present in the Jordan River watershed. This exercise ranked the probability of each species occurring in the watershed as Not Expected, Possible, Probable, or Confirmed. Our ranking was based on the habitats present in the

Jordan River watershed and the species' known distribution on southern Vancouver Island (Figure 4).

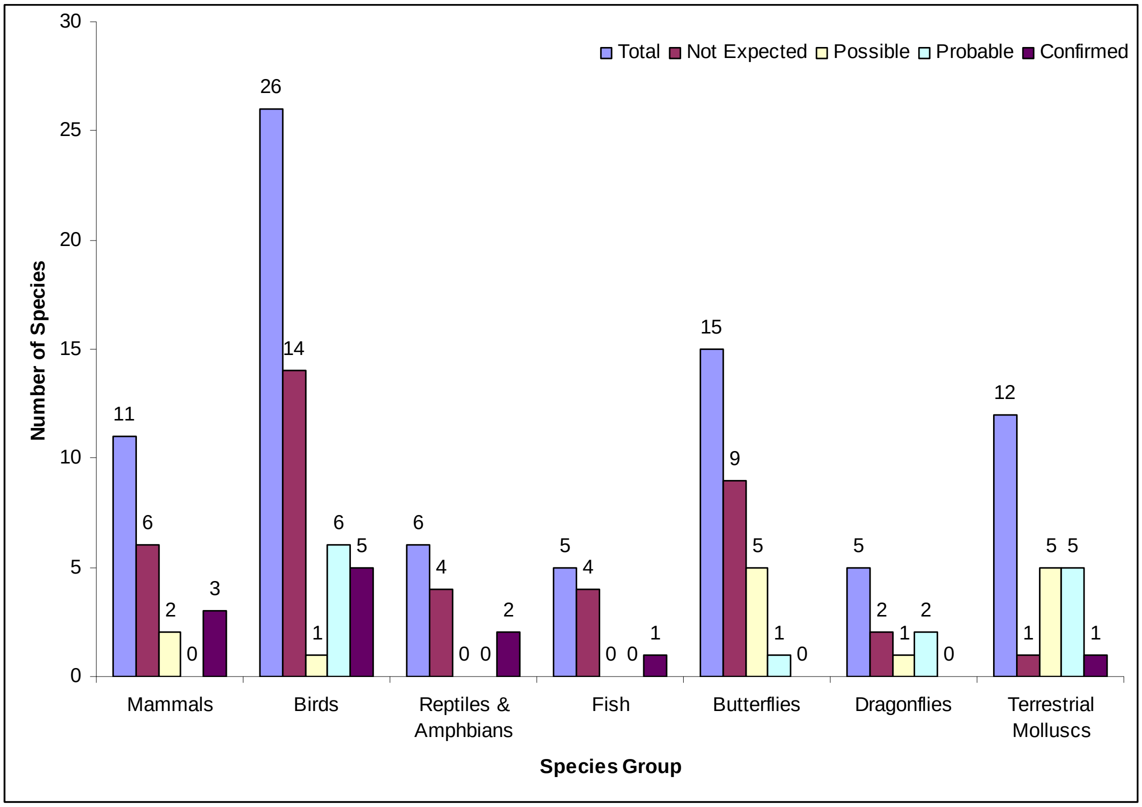

Figure 4. The number of threatened and endangered vertebrate and invertebrate animal species on southern Vancouver Island and their probability of occurring in the Jordan River watershed.

When considering restoration opportunities for the Jordan River watershed, we considered all species present (including those that are considered common and not at risk). However, we also considered the number of confirmed, probable, and possible rare and endangered species that would benefit from each restoration strategy. The number of rare and endangered species that would benefit from a specific restoration initiative had some influence on the overall expected benefit of the restoration strategy. A brief description of habitat associations for rare and endangered species is found in Appendix B.

Existing Conditions

The wetland habitat available around the perimeter of the two reservoirs is typical of that associated with hydroelectric development on the south coast of British Columbia. It consists largely of a mosaic of seasonally flooded shrubby and grassy plant communities which include a large number of exotic or invasive species, with extensive areas of bare soil and mud exposed during the low-water periods in the summer and early fall. Much of the perimeter is covered with a series of grassy meadows, containing a variety of native and introduced grasses, sedges (*Carex* sp.), small-flowered bulrush (*Scirpus microcarpus*), and rushes (*Juncus effusus*, *Juncus ensifolius*), as well as several prominent native and introduced forbs (*Rumex crispus*, etc.). Willows (*Salix* sp.) form a dense transitional habitat between the forested uplands and lower grassy meadows in many areas, with scattered individual willow shrubs also occurring throughout most open, grassy areas. Open water habitats are fairly devoid of vegetation due to the continually fluctuating water levels, although locally-established populations of some emergent and submergent species such as yellow pond-lily (*Nuphar lutea*), watershield (*Brasenia schreberi*), and common cattail (*Typha latifolia*) do occur in sheltered locations. Red alder (*Alnus rubra*) woodlands with a dense understory of salmonberry (*Rubus spectabilis*) typify the riparian habitats at the ends of the reservoirs, as well as those along the Jordan River and its tributaries.

Water quality measurements of Bear Creek Reservoir, which has a surface area of 75 ha, a maximum depth of 15 m, and a mean depth of 6 m, have shown the impoundment to be ultra-oligotrophic. Total dissolved solids are only 18 mg/l and the pH is 6.9; total dissolved phosphorus content is about 3 µg/l, total nitrogen 23 mg/l, ammonia nitrogen 7 µg/l and nitrate/nitrites 2 µg/l (measurements made in 1983, Ministry of Environment, lake survey data). Dissolved oxygen content ranges from 8 to 8.5 mg/l throughout the water column, except near the bottom where the content is only 2.5 mg/l (Ministry of Environment, lake survey data) suggesting the likelihood of stagnation and decomposition in the hypolimnion. The reservoir contains considerable amounts of debris, although the area was apparently logged prior to initial impoundment. This debris accumulates around the perimeter of the reservoir, where it can influence the plant and wildlife diversity and distribution in those wetland habitats. The surrounding coniferous forests have been extensively logged and are currently in an early-mid seral stage of succession. Bear Creek Reservoir only has minor tributaries, most of which dry in late summer (Hirst 1991). Similar data for Diversion Reservoir were not obtained but are likely similar.

Although comprehensive surveys of the flora and fauna of lower Jordan River watershed have not been completed, small-scale surveys (e.g., Beauchesne and Cooper, 2004; Hawkes, 2005), personal site visits, and anecdotal reports, some stretching back to the 1940s (e.g., Hardy, 1949), have partially described the biodiversity of the area. The faunal composition is further augmented through and understanding of the conditions present at the site and the biogeographical setting of the watershed, allowing for a more detailed list of expected species to be constructed for some species groups (Table 3).

Table 3. Comparison of the number of expected and confirmed species of vertebrates and selected invertebrates within the Jordan River watershed based on published reports, site visits, and anecdotal reports.

Life Form	No. of Species (Expected)	No. of Species (Detected)
Mammals	30	16
Birds	118	53
Reptiles	4	2
Amphibians	9	8
Butterflies	43	5
Dragonflies	42	0
Terrestrial Molluscs	60	4

Several species of concern occur within the Jordan River watershed, and a number of others are expected to occur due to their habitat preferences and known distributions (Table 4). The habitats present within the Jordan River watershed allow for the mixing of coastal and montane biota with those that are more typical of the dry southeastern portion of Vancouver Island (Northern Alligator Lizard, Bewick's Wren). The aquatic and riparian habitats also contribute significantly to the biodiversity attracting waterbirds (ducks, geese, swans, loons, herons), amphibians, and aquatic and semi-aquatic mammals (Muskrat, Beaver, River Otter). Little work has been done in the watershed to fully document the biodiversity, particularly for groups other than vertebrates, so many additional species, including some with federal or provincial status, are expected to occur. Wetland construction and habitat restoration within the watershed is expected to enhance populations of a variety of species, including species of concern such as Red-legged Frog and Western Toad (*Bufo boreas*), by providing stable conditions which meet the species needs for breeding, feeding, and resting.

Table 4. Species with provincial (CDC) and/or federal (COSEWIC) status that are known or suspected to occur in the lower Jordan River watershed. Provincial status includes red-listed, or endangered, species (SX, SH, S1, S1S2, S2), blue-listed, or threatened, species (S2S3, S3, S3S4, some S4), and yellow-listed, or secure, species (some S4, S5). Federal status includes Species of Concern (SC), Threatened species (T), Endangered species (E), Extirpated species (XT), and species that are Not at Risk (NAR).

Species	Life Form	Provincial Status (CDC)	Federal Status (COSEWIC)	Documented?
Great Blue Heron, *fannini* subsp.	Bird	Blue (S3B, S4N)	SC (May, 1997)	**Yes**
Northern Goshawk, *laingi* ssp.	Bird	Red (S2B)	T (Nov, 2000)	No
Sandhill Crane	Bird	Blue (S3S4B)	NAR (May, 1979)	**Yes**
Marbled Murrelet	Bird	Red (S2B, S4N)	T (Nov, 2000)	No
Band-tailed Pigeon	Bird	Blue (S3S4B)		No
Western Screech-Owl, *kennicottii* subsp.	Bird	Blue (S3)	SC (May, 2002)	**Yes**
Northern Pygmy-Owl, *swarthi* subsp.	Bird	Blue (S3)		**Yes**
Barn Swallow	Bird	Blue (S3S4B)		No
Common Water Shrew, *brooksi* subsp.	Mammal	Red (S2)		No
Townsend's Big-eared Bat	Mammal	Blue (S3)		**Yes**
Wolverine, *vancouverensis* subsp.	Mammal	Red (SH)	SC (May, 1989)	No
Ermine, *anguinae* subsp.	Mammal	Blue (S3)		**Yes**
Elk, *roosevelti* subsp.	Mammal	Blue (S3)		No
Western Toad[1]	Amphibian	Yellow (S4)	SC (Nov, 2002)	**Yes**
Red-legged Frog	Amphibian	Blue (S3S4)	SC (Nov, 2004)	**Yes**
Western Sulphur	Butterfly	Blue (S4)		No
Johnson's Hairstreak	Butterfly	Red (S1S2)		No
Western Pine Elfin, *sheltonensis* subsp.	Butterfly	Blue (S3)		No
Greenish Blue, *insulanus* subsp.	Butterfly	Red (SH)	E (Nov, 2000)	No
Boisduval's Blue, *blackmorei* subsp.	Butterfly	Blue (S3)		No
Blue Dasher	Dragonfly	Blue (S3S4)		No
Autumn Meadowhawk	Dragonfly	Blue (S3S4)		No
Western Thorn	Mollusc	Blue (S2S3)		No
Threaded Vertigo	Mollusc	Red (S2)		No
Pacific Vertigo	Mollusc	Red (S2)		No
Broadwhorl Tightcoil	Mollusc	Blue (S2S3)		No
Black Gloss	Mollusc	Blue (S3S4)		No
Evening Fieldslug	Mollusc	Red (SH)		No
Dromedary Jumping-slug	Mollusc	Red (S2)	T (May, 2003)	No
Warty Jumping-slug	Mollusc	Blue (S2S3)	SC (May, 2003)	No
Scarletback Taildropper	Mollusc	Blue (S3S4)		No
Blue-gray Taildropper	Mollusc	Red (S1)	E (Apr, 2006)	No
Oregon Forestsnail	Mollusc	Red (S1S2)	E (Nov, 2002)	No
Puget Oregonian	Mollusc	Red (SX)	XT (Nov, 2002)	No
Pacific Sideband	Mollusc	Blue (S3S4)		**Yes**

[1] Western Toad was formerly considered common in the Jordan River watershed but appears to have been extirpated from the watershed sometime during the 1980s or 1990s (Davis and Gregory, 2003).

PURPOSE AND NEED FOR RESTORATION

Background

Impoundment of portions of the Jordan River commenced in 1909 and continued into 1913 with the construction of two dams, creating the Bear and Jordan (=Diversion) Reservoirs (Hawkes, 2005). An additional small reservoir, the Elliot Headpond, was added in 1971 below the Diversion Reservoir. The construction of these dams resulted in the flooding of almost 200 ha of riparian and wetland habitats in the Jordan River watershed, directly affecting over 20 km of the lower Jordan River. In addition, continued input of copper-contaminated water from the legacy of over 80 years of mining activities that took place in the watershed, as well as over 120 years of logging and the associated ecological impacts, have augmented the negative impacts of the hydroelectric developments and had some serious measurable effects on the health of the Jordan River (Wright and Guimond, 2003). For example, the lower portions of the river formerly supported a run of 5,000-10,000 Pink (*Oncorhynchus kisutch*) and Chum (*Oncorhynchus keta*) Salmon, all of which are now extirpated, largely due to the hydroelectric development of the system (Wright and Guimond, 2003). Hawkes (2005) also documented the loss of breeding habitat for pond-breeding amphibians in the Jordan River watershed that has resulted from the flooding of formerly suitable riparian wetlands. This habitat loss is of particular significance for local populations of the Red-legged Frog (*Rana aurora*), which is considered threatened (blue-listed) by the British Columbia Conservation Data Centre and is considered a Species of Concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

Overview of Habitat Impacts

The footprint impacts on wildlife resulting from the construction of Elliot Dam, Jordan River Dam, Bear Creek Dam, the diversion/flume tunnel, and the development of roads all have negative impacts associated with them (BCFWRP). The negative impacts identified in the Jordan River watershed Strategic Plan indicate that there has been an overall loss in old-growth forest and dependent wildlife species. The flooding of Bear Creek resulted in the loss of wetland and riparian areas, and old-growth coniferous forest. Impacts associated with the diversion flume/tunnel include a shift in forest type from old-growth to early successional shrub/tree species and a reduction in flow and altered flow regime, which are indicated as both negative and positive impacts. The impacts caused by impoundment were summarized by BC Hydro and are presented in Table 5**.**

Table 5. Description of footprint impacts on wildlife and their habitat in the Jordan River watershed, southern Vancouver Island (reproduced from the Jordan River Wateruse Plan).

Facility	Description of Hydroelectric Impacts	Neg	Pos	Source
Elliot Dam	1. Dam footprint of __ha: loss of coniferous forest (old-growth?)	X		Hirst 1991
	2. Flooding of narrow river channel and (old-growth?) coniferous forest on steep sided valley.	X		Lee 1914
Diversion (Jordan River) Dam	3. Dam footprint of __ha: presumed loss of old-growth coniferous forest and dependent wildlife species.	X		Lee 1914
	4. Flooding of narrow river channel and old-growth coniferous forest and dependent wildlife on steep-sided valley.	X		Lee 1914
	5. Fluctuating reservoir water levels (18 m) due to annual maintenance operations in August: effects on establishment of aquatic and/or riparian vegetation in drawdown zone.	X		BC Hydro Web page

Facility	Description of Hydroelectric Impacts	Neg	Pos	Source
Bear Creek Dam	6. Dam footprint of 12.1 ha.: loss of old-growth coniferous forest and dependent wildlife species.	X		Lee 1914
	7. Flooding of river channel, some riparian, and wetland areas, and old-growth coniferous forest and dependent species on steep-sided valley.	X		Lee 1914
Diversion Flume / Tunnel	8. Habitat change along 5.3 km flume r-o-w: conversion from old-growth coniferous forest with dependent species to early successional shrub/trees and increased habitat diversity.	X	X	BC Hydro Web page (Lee 1914)
	9. Reduced flows and changed flow regime in 8 km of Jordan River: unknown effects in high-gradient river between diversion and powerhouse and implications for wildlife such as harlequins or American dippers.	X	X	GIS
Roads, etc.	10. Construction of access routes for initial dam construction and ongoing maintenance: habitat loss.	X		Lee 1914

In addition to the impacts identified by BC Hydro (Table 5), Hawkes (2005) estimated that approximately 88.2 ha of suitable pond-breeding amphibian habitat was lost because of impoundment or more recently, because of the removal of the Forebay Pond in 2005. Overall, impoundment of the Jordan River has affected the suitability and connectivity of pond-breeding amphibian breeding habitat in the Jordan River Watershed.

The following are factors that limit current levels of wildlife for species groups associated with the habitats listed in Table 1-2. These also reflect the key issues raised at BCRP regional workshops.

1. **Habitat Changes:** Altered flow regime has changed riverine and riparian habitats. Potential effects on wildlife include changes to habitat quality and quantity for water shrews, harlequins and dippers.
2. **Loss of Habitat:** Loss of wetland habitats in flooded valley bottoms (Bear Creek). Potential effects include availability of habitat for amphibians, water shrews and other small mammals and their predators, browse for ungulates and breeding habitat for some species of neotropical migrants. (Bear Creek).
3. **Reduced Productivity:** Lack of riparian vegetation in drawdown zones; effects on ungulates, furbearers, small mammals and several species of passerines including some neotropical migrants.
4. **Wildlife Migration:** Impediments to wildlife movement (especially large mammals) caused by structures, reservoirs and diversions.
5. **Diversions:** Wildlife (especially mammalian) mortality caused by some diversion structures, through entrainment and drowning. Potential hazards for non aquatic or weak swimming animals.

Goals of Restoration Activities

BC Hydro has identified several restoration goals for wildlife in the Jordan River Watershed. These are:

Objective 1: Reduce erosion or drying of riparian and riverine habitats.

Generally, this goal can be obtained through the avoidance of excessive flood flows or maintenance of drawdowns during the spring and summer growing/breeding season. The Jordan River Consultative Committee made 7 recommendations relating to operational constraints for the Jordan River Hydroelectric system, including the maintenance of maximum and minimum water elevations for Bear Creek and Diversion Reservoirs, and for Elliot Headpond. Water level values were derived primarily to reduce fish stress and were not developed to address the issue of the effects of reservoir water level fluctuations on the development of foreshore riparian habitat.

Objective 2: Rehabilitate reservoir drawdown zones to enhance productivity and wildlife habitat.

To improve vegetation presence and diversity in the drawdown zone, foreshore habitat complexes should be developed at suitable locations. Achieving this goal can only occur through maintenance of water levels in the reservoirs such that foreshore habitats are not consistently scoured or inundated by water. This is particularly relevant to Diversion Reservoir and Elliot Headpond. Water level fluctuations in Bear Creek Reservoir are minimal over much of the year.

The creation of nesting cavities and raptor perches where beneficial have been suggested as possible activities to ameliorate the effects of impoundment on cavity nesting birds and raptors. Similarity, creating artificial nesting platforms may improve nesting opportunities for osprey.

Objective 3: Reduce barrier effects of diversions on wildlife.

The use of overpasses over penstocks and other measures to reduce barriers effects has been suggested as a way to reduce barrier effects created by penstocks. To ensure that overpasses are successful, they would need to be placed in areas that wildlife attempt to cross the penstock on a regular basis.

History of Development in the Jordan River Watershed

The city of Victoria was established by the Hudson's Bay Company in 1843. Between 1849 and 1866, Vancouver Island was a Crown Colony which united with British Columbia (formed in 1858) in 1866. By the mid-1850's the non-aboriginal population of Fort Victoria was approaching 500. At the time of the establishment of the colony (1843), Vancouver Island had a large and varied First Nations population of approximately 30,000, including people from the T'Sou-ke and Pacheedaht First Nations who lived and used the water and lands that included the Jordan River Watershed.

Between 1843 and 1888, there do not appear to be any records of non-aboriginal use of lands in the Jordan River Watershed. However, in 1888, the Weeks family settled in the southern end of the Jordan Meadows in the northeastern portion of the watershed while two individuals settled in the north end of the meadows around the same time. Sometime between 1896 and 1898 the Weeks family moved to Victoria, and it was not until 1907 that there is documentation of exploration of the Jordan River area. The Esquimalt and Nanaimo Railway Company owned the lands and they were officially surveyed in 1910. By 1901, the population of Victoria had reached 23,663 people, including First Nations (source: vihistory.uvic.ca). In 1907, the city of Victoria was powered by a 2000 kilowatt hydroelectric plant at Goldstream and an 800 kilowatt steam plant in Victoria. Over a period of approximately seven years (1900 – 1907) the demand for electricity grew beyond the capacity of both the hydroelectric plant at Goldstream and the steam plant in Victoria, which prompted the Vancouver Island Power Company, a subsidiary of the British Columbia Electric Railway Company, to explore the available water-power possibilities near the city of Victoria, including the Jordan River (Lee, 1914).

Prior to 1907 there appears to have been little exploration of the Jordan River watershed on southern Vancouver Island and preliminary surveys of the Jordan River commenced in 1907. At the time, the country around Victoria was largely unexplored and unmapped, consisting of vast tracts of standing and fallen timber, as well as heavy underbrush (Lee 1914). Based on initial exploratory work, it was determined that a hydroelectric facility could be developed in the Jordan River watershed to supply the City of Victoria with electricity. The Jordan River facility was completed in 1911 and more generators were added and improvements made to the Jordan River plant between 1912 and 1930, bringing its capacity to 26,000 kilowatts - a significant addition to Victoria's energy production that at that time, was also served with a steam generation plant at Brentwood, and supplies of coal, coal gas and wood. By the late sixties, Victoria's growth began to show how inadequate power supplies were becoming and BC Hydro announced an upgrade to the Jordan River plant in 1968, after "brown-outs" in Victoria homes had only been averted the previous winter by carefully managing power going to up-island pulp mills and saw mills. Between 1969 and 1971, much of the system was renovated, with the flume being replaced by a tunnel, connected to a pipe leading down to a new power house. The old generator was replaced by a 170 megawatt Japanese-built turbine and a new reservoir and dam were added to the system just below Diversion Dam.

While the river was harnessed to serve up electric power for generations of Victorians, other resource industries, including logging and mining, were also active in the Jordan River watershed. Logging appears to have been initiated in 1886, when W.P. Sayward leased 12,000 hectares of crown land at Jordan River and Muir Creek. Over time, the logging operation established at Jordan River would evolve into Western Forest Products Inc., a company that is still active in the Jordan River watershed. Another logging company, TimberWest, also has holdings in the Jordan River watershed. While the logging continues today, mining ended in the early to mid 1970's. Interest in mineral exploration reportedly dates back to 1910. From 1962 – 1974 the Sunro Mine operated on the banks of Jordan River, extracting copper. Silver and Gold were also recovered. An additional claim exists approximately 10 km west of Jordan River and appears to be inactive. At present, all mining claims are inactive; however, some people still pan for gold in the river below Diversion dam.

Habitat Change in the Jordan River Watershed

The forests of the Jordan River watershed have been harvested for more than one hundred years, and much of the coniferous forest that exits today exists as young to maturing second-growth stands dominated by Douglas-fir, Western Hemlock, and Western Redcedar. Prior to development, the Jordan River watershed was described as being 'covered by a growth of heavy timber' (Lee 1914). A significant amount of land clearing and flooding was associated with the development of Diversion and Bear Creek Reservoirs. Associated with the development of the hydroelectric facilities was the development of the power line right-of-way, which resulted in the removal of more than 6,000,000 feet B.M of timber (including areas outside of the Jordan River watershed). Concurrent with the development of the Jordan River watershed for hydroelectric power generation was the establishment of a sawmill at the mouth of Jordan River, which would eventually become Western Forest Products.

The Provincial Museum of Natural History and Anthropology produced a document in 1946 (Hardy 1946) that described the lands occupied by the Weeks family. The focus of this document was primarily on Jordan Meadows at the north end of the watershed, but there are several statements regarding the land cover at the time. For example, Hardy (1946) described two distinct forest types in the Jordan River watershed: 1) Hemlock –Cedar Climax and 2) Spruce-Hemlock Climax. The Hemlock-Cedar Climax forest type was typified by dense stands of Western Hemlock that reached heights of greater than 50 m. Where these stands existed, their canopies were closed and little vegetation grew from the forest floor, except in riparian areas or in natural openings. Western Redcedar grew in moist areas and Western White Pine and Douglas-fir were present to a lesser extent. The Spruce-Hemlock Climax forest type occurred at lower elevations and was dominated by Sitka Spruce with Yellow Cedar and true firs also abundant. This forest type was not as common as the Hemlock-Cedar type in the Jordan River Watershed.

In general, habitat change has been associated with logging and road building in the Jordan River watershed. There is evidence of forest fires on the slopes on the north and south sides of Diversion Reservoir (as well as elsewhere in the watershed). Mining activity has had limited impact on the general habitat condition of the Jordan River watershed over the last 100 years. BC Hydro activities, including infrastructure maintenance and deactivation continue to change certain areas of the Jordan River watershed. For example, in 2005 the old Forebay pond was drained. Water levels in the Forebay pond had been stable for 34 years, creating a pond with a surface area of approximately 7 hectares.

The earthen dam at the east end of Bear Creek Reservoir is frequently used by campers and the area is littered with garbage, shotgun shells, and discarded clothing. Of all the areas within BC Hydro's area of operation, this area has been impacted the most through human misuse.

RESTORATION PLAN FOR THE JORDAN RIVER WATERSHED

While there are many restoration activities that can be applied to modify habitat within the Jordan River watershed ranging from minor actions such as installing nest boxes to major modifications such as prescribed burns, an integrated plan must consider all species and, we believe, should have a goal of improved biodiversity rather than single species management. Therefore, we have chosen the approach of identifying restoration opportunities for rare, endangered or threatened species that could potentially reside in the Jordan River watershed if habitats were created or improved and to assess the effect of those restoration activities on other, more common, resident species. This approach allowed us to focus restoration activities on those actions that have the greatest opportunity to improve biodiversity and identifies the ancillary benefits/impacts on non-target species in the watershed. This approach also departs radically in principle from the a la carte menu of restoration activities with each restoration action implemented justified on the basis of its benefit to one or more species.

To prioritize restoration initiatives for the Jordan River watershed it was necessary to assess the benefit that each restoration initiative would have on wildlife and wildlife habitat. Restoration initiatives that were beneficial to a larger number of species, including rare and endangered species, were considered higher priority than those that benefited one or few species. Additionally, the relationship between restoration initiative and likelihood of mitigating for the impacts of river impoundment on wildlife was considered. Those restoration initiatives that benefited many species and directly addressed the footprint impacts associated with reservoir creation received higher prioritization than those activities that benefited one or few species and only indirectly addressed footprint impacts.

Because we did not want to evaluate the potential benefit of restoration strategies on species with conservation status in isolation from those species that are abundant, we examined the habitat requirements and restoration opportunities for 162 of the 197 species listed in Appendix A (we did not include butterflies, dragonflies, or gastropods), including 16 species with provincial or federal conservation designation.

Restoration Strategy Prioritization

We first assigned a numerical rank of species occurrence in the Jordan River watershed using the following *Probability of Occurrence* scale: 1 = not likely; 2 = possible; 3 = occurs. We assigned a rank of 0 for non-native species. Using the five strategies for restoration ecology listed in Table 1 we then used a similar scale to rank the benefit of each restoration strategy for each of the 162 species where 1 = limited to no benefit, 2 = some benefit, and 3 = maximum benefit. Again, 0 was used for non-native species.

When ranking each restoration strategy, we considered the habitats used by each species that would ensure survival and population persistence in the Jordan River watershed during the most limiting season of the year. For example, habitats used by songbirds during the breeding / nesting period were considered. This process was repeated for each species and four of the five possible restoration strategies. A strategy including restoration was not considered for the Jordan River watershed because there is no possibility of creating habitat that approximates the pre-disturbance condition (no data are available to determine what the pre-disturbance condition was). The maximum benefit rank (0, 1, 2, or 3) assigned to each of the restoration activities listed in Table 6 was used to for each species to derive an *Overall Potential to Benefit* score. This value was then multiplied by the *Probability of Occurrence* score to derive an *Overall Benefit from Restoration* score for each species.

Table 6. Activities for consideration under each of the four potential restoration strategies that could be used in the Jordan River watershed on southern Vancouver Island.

Strategy	Example Activities
Conservation	Maintenance of Water Level
Habitat Creation	Snag Creation Islands Wetland Creation Nest Boxes
Enhancement	Coarse Woody Debris Prescribed Burn Manual Clearing Revegetation (including Submergent/Emergent Vegetation)
Protection	Sensitive Habitat Retention

To further refine the wildlife habitat restoration plan for the Jordan River watershed, we determined the proportion of species within each strategy that would have little to no benefit, some benefit, or maximum benefit from each restoration strategy (Table 7). The conservation strategy of maintaining water levels in Diversion and Bear Creek reservoirs benefited the least number of species. Furthermore, seasonal water level maintenance has been previously addressed by the BC Hydro Project Team and the Jordan River Water Use Plan Consultative Committee so we chose not to not to reconsider this conservation activity. Instead, we elected to focus on Habitat Creation, Enhancement, and Protection, as the greatest proportion of species benefited from these three strategies (Table 7).

Table 7. Summary of the level of benefit for each of the 162 species considered in the integrated wildlife habitat restoration plan for the Jordan River watershed on southern Vancouver Island.

	Conservation		Habitat Creation		Enhancement		Protection	
Level of Benefit	No. Spp.[1]	Prop.[2]	No. Spp.	Prop.	No. Spp.	Prop.	No. Spp.	Prop.
No Benefit	2	0.01	2	0.01	2	0.01	2	0.01
Little to No benefit	95	0.59	19	0.12	16	0.10	68	0.42
Moderate Benefit	13	0.08	62	0.38	43	0.27	16	0.10
Maximum benefit	52	0.32	79	0.49	101	0.62	76	0.47
Sum (Moderate + Maximum)*	65	0.40	141	0.87	144	0.89	92	0.57

[1] No. Spp. = number of species; [2] Prop. = proportion of total considered (n = 162)

* Sum (Moderate + Maximum) includes only those species that were assessed as having a moderate or maximum benefit from the restoration strategy.

Restoration Strategies

The restoration plan is limited by the modest extent of land under BC Hydro control and the adjacency of forest company lands that receive repeated treatments of clear-cut logging. Impacts of clear-cut logging on wildlife assemblages have been well-studied, and will not be discussed here. Suffice it to say, restoration actions on BC Hydro property in the Jordan River watershed would be greatly enhanced by implementation of greatly improved ecological forest practices in the adjacent lands to retain and maintain the structure and function of the upland forest habitats.

The restoration plan for the Jordan River watershed is premised on the three actions that benefit the greatest number of species: 1) habitat protection, 2) riparian habitat conservation and enhancement, and 3) habitat creation. Of these actions, habitat creation has been deemed as the action with the greatest potential to mitigate footprint impacts resulting from impoundment of the Jordan River. This is because habitat creation can be implemented on a larger scale more quickly than habitat enhancement. Furthermore, we are not interested in converting habitat types into those that did not previously exist in the Jordan River watershed. Our goal is to create habitats that did previously exist, which is why habitat creation is being favoured over habitat enhancement, despite the slightly greater number of species benefiting from enhancement versus creation (Table 7). A more detailed discussion of habitat creation is provided in the Proof of Concept section, below.

Habitat Protection

The difference between conservation and protection was discussed above and will not be restated here. Bear in mind that conservation measures discussed below have a significant overlap with protective measures. We limit protection to specific, identifiable habitat features within the landscapes rather than to entire habitats. While we espouse the protection of riparian habitats throughout the province, we acknowledge that various activities necessarily take place within riparian zones. Moreover, protection of entire riparian areas is not necessary in the Jordan River watershed because biodiversity goals can be met through the conservation measures described in the next section. However, it is essential to protect certain components within the riparian environment if we are to achieve the level of biodiversity envisioned in this plan.

Several features of the habitat are relatively unique and need to be protected to provide habitat to a number of rare, endangered or threatened species and associated common species. These features include the tallest trees within the BC Hydro property, seeps and extensive areas of moss mats. Surveys for these features within the area of impact should be completed, and when found these features should be marked in the field, georeferenced, and their extent mapped.

Seeps

Seeps are sources where fresh water from underground reaches the surface and forms small streams or small pools of water. Seeps are typically located along or at the bases of hillsides where groundwater flows to the surface and provide a small, year-round source of water. Seeps are particularly important to wildlife during the summer and fall periods when they may be the only source of fresh water and food in an animal's home range. Also, during the winter, groundwater is typically warmer (a constant 10-13°C) than air and ground temperatures and usually remain unfrozen when other local water sources have turned to ice. At those times, seeps are used heavily by wildlife. During winters with deep snow, seeps provide snow-free travel lanes where wildlife can move and feed. Birds and mammals benefit from the herbaceous vegetation that grows and persists around seeps in the winter when other food is scarce. Insects in and around the seeps provide a year-round source of high-protein food. Small mammals often find abundant forage near seeps. Bears and other berry-eating animals such as Band-tailed pigeons forage on the fruit-producing plants that grow well in moist conditions. Songbirds benefit from the fruit and insects around seeps, often nesting in the dense vegetation surrounding the seep. Amphibians and reptiles benefit from the moist conditions created by seeps. Because seeps generally do not support fish populations, amphibian eggs deposited there survive without losses to fish predation. Amphibians also benefit from plant and insect food near seeps. The most important management practice for seeps is protection from activities that can degrade the seep, such as clear-cutting or pollution. Habitat associated with seeps can be enhanced by releasing or planting beneficial trees and shrubs around the seep and encouraging the growth of herbaceous vegetation around the seep's perimeter.

Moss Mats

Mosses have the ability to grow on sterile substrates, such as bare rock, and by breaking down such surfaces into the precursors of soil, trapping dust and soil blown by the wind and adding their own decay products, mosses are soil builders. Moss also traps of the seeds of other plants which in some cases results in a change of the community from one of mosses to one of higher plants. Mosses provide food for some types of thrips and shelter for many different kinds of organisms; algae, protists, insects, spiders, molluscs and many others may be found in and under moss mats. Some rotifers and tardigrades live only when associated with some mosses.

Tall Trees

Tall trees are important landscape features that are used by various groups of wildlife such as raptors, birds, and mammals, including bats. Of these species groups, there is little to no information available on bat presence in the Jordan River watershed. Bats will use larger, older trees as roost sites, and in some places, tall, old trees are important hibernacula for bats. The presence of large trees does not indicate the presence of bats. Therefore, it was important to determine if bats were present in the Jordan River watershed. The easiest way to determine presence is to survey for bats on warm summer nights at potential foraging areas. Both Diversion and Bear Creek reservoirs are potential foraging sites, as water bodies tend to attract flying insects, which are preyed upon by bats.

In 2006, three nights of bat surveys were completed at Diversion and Bear Creek reservoirs. Using a combination of mist netting and a Pettersson D240X ultrasound detector, we documented the presence of a minimum of five species of bats in the Jordan River watershed:

i. *Myotis*: 40 kHz
ii. *Myotis*: 50 kHz
iii. Hoary Bat: *Lasiurus cinereus*

iv. Big Brown Bat: *Eptesicus fuscus* / Silver-haired Bat*: Lasionycteris noctivagans*
v. Townsend's Big-eared Bat: *Corynorhinus townsendii*

Townsend's Big-eared Bat is blue-listed in British Columbia; all other bats documented are yellow-listed.

In addition to night surveys, a visit was made to Diversion Dam to investigate the inside of the dam as a possible roost site for bats. The dam is ideally situated close to the reservoir and Jordan River is likely a productive foraging area for bats. Our investigation, although cursory, identified the dam as a bat roosting site. Specifically, the east side of the inside of the dam structure is used by roosting bats, presumably in summer. It could also be used as a temporary night roost after feeding (i.e., occupied night for a few hours). The dam may also be used for day roosting and possibly supports a maternity colony. Because our investigation of the dam occurred in September after maternity colonies break down, we were too late to detect any day roosting. Further investigation of the dam should occur and would ideally occur in late July of early August. Other potential roost sites (buildings, large trees, bridges) should also be investigated. If any are found, they should be afforded as much protection from human disturbance as possible. If the roost site is such that it affords narrow limits to the numbers of animals using it, additional roost site should be provided in the form of bat houses at the roost site.

The retention of tall trees within BC Hydro's area of operations may benefit bats through the preservation of roosting sites. Because it can be difficult to determine if tall trees are functioning as bat roost sites, we are assuming that tall trees are being used by bats in the Jordan River watershed. Furthermore, retention of tall trees will continue to benefit other wildlife groups and is an easily obtained restoration goal for the Jordan River watershed.

Riparian Habitat Conservation and Enhancement

Riparian areas are transitional zones that link aquatic and terrestrial habitats. Because of the unique ecology of riparian zones (Pabst and Spies 1999) restoration has proven challenging (Chan et al. 1997; Emmingham et al. 1997a, 1998; Emmingham and Hibbs 1997; Emmingham and Maas (1994). The loss of riparian forests due to flooding of the reservoirs and the re-establishment of upland-type forests in the riparian zone of the reservoirs severely limits effective riparian habitat in the Jordan River watershed. Attributes of riparian forests most needed to be re-established are large diameter trees, dead and dying trees, snags, trees with large live crowns, abundant coarse woody debris, multi- storied and multi-species canopies and increased diversity and cover of understory species (Sedell et al. 1997; Tappeiner et al. 1997). As the current forests in the riparian zone along the Jordan River and associated reservoirs advances toward maturity and ultimately to old-growth, many of those features will develop naturally. However, those characteristics can be maintained, improved or created by using silvicultural techniques, thereby increasing the pace of riparian development and improving habitat suitability for many species. Methods used to achieve the desired characteristics include thinning of hardwood- and conifer-dominated stands (Hibbs et al. 1989; Emmingham 1996; Hibbs and Chan 1997; Tappeiner et al. 1997; Baily and Tappeiner 1998), release of desirable understory trees (Emmingham and Maas 1994; Maas and Emmingham 1995; Emmingham et al. 1997b), recruitment of large woody debris (Mcdade et al. 1990), planting/release of big-leaved maple and fruit-producing shrubs, and establishment of understory riparian shrub communities (Baily et al. 1998).

Riparian development in the majority of the Jordan River watershed will ultimately be achieved through conservation as mature forests advance into the more diverse old-growth stage. However, the silvicultural prescriptions identified above should be applied sparingly and throughout the upper watershed (i.e., above Diversion Dam) to significantly enhance the relatively uniform, closed-canopy forests that currently comprise the riparian habitats. In addition to the silvicultural prescriptions recommended above, a survey of nest sites for Western Screech-owls and Northern

Pygmy-owls should be conducted and if found to be limiting, a supply of snags and nest boxes should be created. While it may be possible to attract tree-nesting ducks and other hole-nesting avian species that may be limited due to nest site availability, establishing that nesting sites are limited needs to be done first and a dedicated group willing to take on the long-term commitment of maintaining nest boxes needs to be conscripted before funds are spent on construction and erection of nest boxes for non-endangered species or the effort will be rewarded with short-term benefits at best. The same goes for snag creation. Because most snags are relatively short-lived, if they are found to be limiting to snag-dependent species, snag creation needs to be done periodically rather than all at once and never again. If snags are liming those species, adequate numbers of snags are not being produced by the forest community which is not likely to change until the community itself matures into old-growth conditions.

Another aspect of riparian habitat enhancement/creation lies with opportunities to revegetate the drawdown zone of the reservoirs, and in particular, Diversion Reservoir. More than likely, revegetation would be restricted to the upper portions of the drawdown zone where flooding would occur for the least extent of time. Revegetation would likely need to be limited to experimental plots at first until the success and medium-term survival of planted species could be ascertained. A wide variety of native species should be tested – especially flood-tolerant species such as sedges, grasses, herbs such as Oregon iris, shrubs such as snowberry, black twinberry, red-osier dogwood and Sitka willow, and trees such as black cottonwood, big-leaf maple and red alder. If successful, planting of suitable plants could be expanded to all suitable portions of the reservoirs. Plant establishment and overall success will be a function of the extremes of reservoir management. If operating boundaries are altered, new species and additional areas may become suitable for revegetating the upper portions of the drawdown zone.

A traditional practice in wildlife management is purchasing habitat for protection and manipulation. In the Jordan River watershed near the headwaters of Alligator Creek there exists a wooded bog. This are provides potential habitat for elk, and many other species of wildlife as well as connective habitat between Alligator Creek and Jordan River. Because it largely consists on non-merchantable timber, it has not been recently logged. This are should be considered for lease or purchase to protect it from potential future logging and to secure this area as wildlife habitat for the long term. Alternatively, easements could be purchased that prevent destruction of the bog habitat and adjacent lands that supply the bog with water. Although easements have some advantages over fee acquisition, they have their own set of problems. The purpose of a conservation easement is to acquire an enforceable interest in real estate to prevent habitat alteration. As time passes, and memories of the easements dim or the property changes ownership, the chance of violating the easement provisions increases, in part because economic pressures encourage more intensive forestry use.

Habitat Creation

To provide habitat for a number of rare, endangered or threatened species and improve habitat for a host of more common species, a greater diversity of habitats are required. Providing increased habitat heterogeneity would require more than simply applying silvicultural prescriptions to the existing forested landscape. There are a number of opportunities to provide more open habitats that, combined with the open water of the reservoirs will enhance habitat for many species. The primary open habitats that will benefit many species are wetlands. Ponds and associated meadows, marshes and even forest ponds are critically important wildlife habitat for a wide variety of species and would mitigate for the loss of functional wetlands caused by river impoundment. Wetland creation in the areas affected by the reservoirs is challenging because of the significant water-level fluctuations and the need for relative stability of water levels in a properly functioning wetland. As a result of potential difficulties and the desire to advance the construction of wetlands in the Jordan River system as well as in other regulated systems in the

Bridge Coastal area, a proof of concept and conceptual design of constructed wetlands is provided in some detail below. While we believe that constructed wetlands are a very important component of the overall restoration plan for the Jordan River, the lengthy discussion and detailed consideration should not construed as diminishing the importance of the other components of this plan. Rather, in order to move the development of constructed wetlands in the Bridge Coastal Generation area forward to the design stage, it is necessary to show that the concept is viable whereas the other components of the plan are more-or-less standard procedures and do not need conceptual validation.

While the following description of a constructed wetland focuses upon a single site which appears to provide the best opportunity for a constructed wetland, there are a number of other opportunities that should be considered for enhancing wetlands within the BC Hydro portion of the Jordan River. These include enhancement of the existing wetland at the east end of Bear Creek Reservoir that is currently dominated by hardhack and restoration of the forested headpond that was recently drained by BC Hydro. The headpond provides an ideal opportunity to (re)create habitat for forest amphibians such as red-legged frogs and western toads as well as a host of other forest biota.

The opportunity for the creation of meadow areas ranging from dry to mesic should be investigated. Although clearcut logging creates meadows of sorts, these are very ephemeral and disappear within a few years. While feasible sites for the creation of dry or mesic meadows have not been investigated, it is likely that such sites exist and could be created by judicious clearing and burning. The major difficulty with the creation of meadows in this region is that maintenance of the area as meadow habitat requires regular restoration through mechanical methods or application of prescribed burns. Nevertheless, the diversity added by the creation of small patches of meadow habitat would likely be considerable.

Restoration Plan Summary

Restoration initiatives in the Jordan River watershed should be considered in one of three categories: 1) habitat protection, 2) riparian habitat conservation and enhancement, and 3) habitat creation. The following lists specific activities to pursue within each of the aforementioned categories along with suggested actions:

Habitat Protection

1. Inspect buildings, dams and bridges for hibernacula and roost sites of bats. Protect from human disturbance if found. Construct bat boxes to supplement roost site if necessary.
2. Identify and protect the tallest trees within the BC Hydro property.
3. Locate and protect seeps.
4. Locate and protect extensive areas of moss mats.

Riparian Habitat Conservation and Enhancement

1. Allow mature forests to advance to “old-growth” conditions.
2. Apply silvicultural prescriptions including thinning, release of desirable understory trees, recruitment of large woody debris, planting/release of big-leaved maple and fruit-producing shrubs, and establishment of understory riparian shrub communities sparingly to uniform stands of second-growth forests.
3. Survey for nest sites of Western Screech-owls and Northern Pygmy-owls and provide snags and/or nest boxes if needed.

4. Provide nest boxes for other hole-nesting birds if needed and a volunteer group is willing to maintain them in the future.
5. Plant experimental plots in the upper draw-down zone with a wide variety of native flood-tolerant plant species and monitor their success. Expand plantings if successful.
6. Acquire or otherwise protect the bog habitat and adjacent buffer in the Alligator Creek area.

Habitat Creation

1. Construct one or more perched wetlands adjacent to Diversion Reservoir.
2. Enhance the existing wetland at the east end of Bear Creek Reservoir that is currently dominated by hardhack.
3. Restore / enhance the recently drained forebay pond.
4. Consider creating one or more small meadows through clearing/burning areas of poor wildlife habitat.

PROOF OF CONCEPT: CONSTRUCTED WETLANDS

Wetland ecosystems, including a wide variety of habitats ranging from forested swamps and bogs to shallow open water, are among the most ecologically important components of the landscape and provide ecosystem services that far outweigh their spatial limitations (MacKenzie and Shaw, 2000; MacKenzie and Moran, 2004). They are of obvious importance to aquatic ecosystems, providing cover and food opportunities for fish and aquatic invertebrates, but their influence also extends broadly into the riparian and upland components of the terrestrial environment by fulfilling food, water, cover, habitat, and rearing requirements for a large component of the terrestrial fauna in most regions (MacKenzie and Moran, 2004). However, despite widespread recognition of the importance of these environments, wetlands are among the most threatened and heavily degraded ecosystems in North America (Lynch-Stewart et al. 1993). Threats to wetland habitats in southwest British Columbia include infilling for urban and industrial development, increased sedimentation from erosion due to agricultural and forestry activities, pollution and eutrophication from agricultural and urban run-off, overgrazing and trampling impacts of cattle and other livestock, disturbance from excessive recreational activities, changes in species composition and abundance resulting from fish stocking programs, and losses associated with impoundment and reservoir creation for hydroelectric production (MacKenzie and Shaw, 2000). Restoration programs have become an important tool in the recovery of biodiversity and are regularly used as a means to restore wetlands that have been degraded or destroyed by these factors in North America (Johnson et al. 2003).

Hydroelectric development in British Columbia has had numerous negative impacts on wetland ecosystems throughout the province. These impacts are not only restricted to the direct flooding and loss of riparian and wetland habitats upstream of the dam, but extend downstream of the dam through disturbance of the annual flooding regimes that are needed to maintain the health of floodplain environments (MacKenzie and Shaw, 2000). Although the negative impacts are most significant with large hydroelectric developments, such as those on the Peace River and Columbia River systems, small-scale developments can still have serious impacts at the local level, particularly in areas such as southern Vancouver Island where wetlands are already under stress from other factors such as forestry and rapidly increasing urban development. The Peace Water Use Plan identifies some of the effects of reservoir drawdown on foreshore habitats and the wildlife that use those habitats (Peace Water Use Plan Committee, 2003). Effects are categorized as primary and secondary, with primary effects related to the unproductive drawdown zone that is exposed annually. The unproductive drawdown zone eliminates effective riparian habitat and associated wildlife at all levels except full pool. Additional primary effects are related to drawdown timing, which may have adverse impacts on foreshore nesting waterfowl. Secondary effects are related to debris scour of the shoreline habitats that inhibits establishment of riparian vegetation and accelerates erosion. While these impacts have been determined for the Williston Reservoir, they are also applicable to Diversion Reservoir, and to a lesser extent, Bear Creek Reservoir in the Jordan River Watershed.

Following the recommendations presented in Hawkes (2005), the development of wetland habitat adjacent to Diversion Reservoir has been commissioned by the Bridge Coastal Fish & Wildlife Restoration Program (BCRP) to provide habitat for wetland-associated wildlife that have been negatively influenced or displaced by the creation of the reservoir and its associated hydroelectric developments. The Integrated Wildlife Habitat Restoration Plan (IWHRP) presented here is intended to maximize the success of the project and ensure that all restoration goals and targets are met, as well as provide the opportunity for adaptive management following the completion of the project. In recognition of the degree of connectedness between components of the ecological landscape, a variety of taxa have been included within the scope of the IWHRP, including plants, invertebrates and vertebrates. This is intended to avoid the pitfalls of single-species restoration and to restore structure and function to the entire ecosystem through an understanding of the holistic and cumulative ecological impacts of development (National Research Council, 1992).

Similarly, integrated restoration projects have been completed in a number of regions of North America, such as California (e.g., Carson et al. 2002; Gevirtz et al., 2004), although these projects have generally focused on habitats such as tidal marshes and vernal wetlands where the dynamics of the ecosystem differ greatly from those in impounded reservoirs. Impoundment restoration projects, based on a perched wetland design have been considered for other impounded watersheds in British Columba [e.g., the Peace-Williston system of northeastern B.C. (Peace Water Use Plan Committee, 2003)]; however, none have been implemented. The strategies presented in this IWHRP are thus novel, particularly within the scope of southwestern British Columbia, and with little direct precedent in the region. There is considerable potential for application of similar restoration projects beyond the boundaries of the Jordan River watershed on Vancouver Island.

Conceptual Wetland Design

The design for the wetland was derived by LGL Limited Biologists and Kerr Wood Leidal Consulting Engineers. The following design brief is provided to identify the criteria used for site selection and for the conceptual design. The preferred conditions are described first, followed by actual site conditions and design details for the selected site. Engineering schematics (plan and profile views) of the constructed wetlands are found in Appendix C.

Site Selection Criteria

Criteria taken into consideration when selecting the project site within the Jordan River Watershed included the following:

- Site topography;
- Soil conditions;
- Construction access;
- Location in reference to the reservoirs;
- Elevation in reference to the reservoir water levels, and;
- Water sources.

Site Topography

The preferred site topography is flat or gently sloping. The wetlands will be created through excavation and construction of berms. In flat areas relatively large wetlands can be created with relatively shallow excavation depths or small berm heights. For steeper areas the excavations would have to be deeper and the berms would have to be higher in order to create wetlands of the same size

Soil Conditions

The preferred site soils are relatively fine grained, yet workable. These soils should have minimal seepage in order to keep the wetland adequately wet even during periods without precipitation. Additionally, the soils should be a material which can be used to construct berms with minimal seepage. The ideal soil is silt.

Construction Access

The preferred site would be easy to access with the necessary construction equipment. If access to the site requires the construction of temporary roads then less of the available funds could be used to construct the wetland habitat. Furthermore, construction access roads will result in damage to the existing vegetation.

Location

The preferred site should be located adjacent to an existing larger body of water (i.e., Bear or Diversion Reservoirs). This would provide habitat near to the reservoirs that have resulted in the loss of riparian and wetland habitat.

Elevation

The preferred elevation of the wetland should be high enough that it is not regularly flooded by the reservoirs. At times the reservoirs have relatively rapid rises and drops in water level. If the wetland is frequently inundated by the reservoir water levels, this would have a negative impact on the wetland vegetation and animals.

Water Source

The preferred site would have a perennial water source. Because of the rapid and frequent change in water levels of the reservoirs, this reservoir water cannot be relied upon to maintain an acceptable amount of water in the created wetland.

Site Selection

In selecting the project site, aerial photography and contour information was used to select potential sites. Sites along Bear Reservoir and Diversion Reservoir were investigated.

All of the potential sites investigated along the shores of Bear Reservoir were steep and had bedrock soils and were therefore unsuitable for wetland construction.

Five potential sites were identified along the shores of Diversion Reservoir. A review of the water levels of Diversion Reservoir showed that three of these sites would be frequently inundated and therefore unacceptable. The two remaining sites were similar in characteristics, with one of the sites significantly easier to access with construction equipment. This is the selected site and the location of this site is shown on the attached detailed design drawings.

Site Topography

The selected site was surveyed in April 2007 and has elevations ranging from approximately 390 m to 384 m. The average slope of the site is approximately 10 %. Although a flatter site would be desirable the selected site is still feasible, especially considering it is much wider than it is long (less change in elevation) and a natural draw in the middle provides an ideal location for a berm for impounding water.

Soil Conditions

The site soils were investigated by KWL and Trow in April 2007. This soil investigation was limited to hand digging of 4 holes across the site and investigating soil conditions in areas of exposed erosion. Soils encountered included organic material at the surfaces, soft silty-sands, densely compacted gravels, silts, and some till. Based on the limited soil investigation program, it is expected that some of the materials excavated will be suitable for the construction of the berms. Additionally, it is anticipated that in some areas there will be more seepage of water out of the wetland than desirable. This may necessitate field changes to the design during construction to provide better water retention characteristics. The ponds still may be drier than desirable for the first year, however this will improve over time as the infiltration begins to bind off as a result of fine material and organics.

Construction Access

The site is located immediately adjacent to an abandoned logging road. In order for construction equipment to gain access to the site the abandoned logging road will require the removal of some fallen wood debris and relatively minor upgrades (likely temporary and small culvert installations and regarding) of two creek crossings. The required length of road requiring upgrades to gain access to the site is approximately 1.5 km.

Location

The selected site location is near to, but not immediately adjacent to the Diversion Reservoir, during average water levels. This location was necessary due to the large fluctuations in water levels of the reservoir. In order to minimize the relative distance to the Diversion Reservoir, selective tree removal is proposed as illustrated on the detailed design drawings.

Elevation

The selected site elevation will have water levels ranging from El. 386.5 to 388.5 m. The Diversion Reservoir dam spillway is at elevation El. 386.2 m and the water level in the reservoir infrequently exceeds this level. A review of the daily water levels from 1994 to 2005 indicates that the water levels exceeded elevation El. 386 m twenty nine times, and elevation El. 387 m nine times. Therefore, for the selected site and water levels will only rarely be impacted by the water levels in the reservoir.

To avoid building a wetland in an area prone to excessive over-topping, we first approximated the ideal height of the outer (reservoir side) berm and/or wetland elevation (i.e., elevation above sea level) to determine the minimum acceptable elevation that would enable wetland function to develop without excess stress. Using historical and current reservoir elevation data, we determined how much of the time the reservoir elevation would exceed our desired or available elevations. Desired and available elevations were determined through topographical surveys of four candidate sites. Of these sites, one was selected as the test wetland location. The normal operating maximum elevation of Diversion Reservoir is 386.2 m ASL, which is occasionally exceeded throughout the year (Table 8). To ensure that the created wetlands were not adversely affected by inflow from the reservoir, a minimum berm elevation of 387.5 m was established. This elevation was selected because for the period 1994 – 2005, the reservoir elevation exceeded 387.5 m ASL on only four occasions. Using this elevation nearly removes the potential for overtopping of the lowest elevation berm and ponds at the test wetland location.

Table 8. Average number of days per month during which the elevation of Diversion Reservoir exceeded a given elevation (m ASL). Monthly averages were developed for the period 1 Jan – 31 Dec, 1994 – 2005. Cells in green represent the elevation at which the frequency of inundation becomes negligible.

	Elevation (m ASL)											
Month	**379**	**380**	**381**	**382**	**383**	**384**	**385**	**386**	**387**	**387.5**	**388**	**389**
Jan	23.4	20.0	16.3	10.4	6.6	3.8	2.3	5.0	0.2	0.1	0.1	0.0
Feb	21.0	17.9	16.0	11.0	4.6	2.0	0.7	3.0	0.3	0.0	0.0	0.0
Mar	25.3	23.5	20.1	13.8	8.5	4.9	3.4	3.0	0.3	0.1	0.0	0.0
Apr	29.5	27.8	23.1	15.8	10.0	5.0	1.9	1.0	0.0	0.0	0.0	0.0
May	26.8	22.9	18.7	13.4	9.3	6.7	1.8	1.0	0.0	0.0	0.0	0.0
Jun	21.8	18.8	14.2	11.8	6.9	3.0	0.4	2.0	0.0	0.0	0.0	0.0
Jul	19.1	17.3	12.0	9.5	8.4	6.9	1.7	0.0	0.0	0.0	0.0	0.0
Aug	14.4	11.3	9.1	7.3	3.5	1.7	0.0	0.0	0.0	0.0	0.0	0.0
Sep	9.6	7.3	5.9	4.3	2.9	0.8	0.0	0.0	0.0	0.0	0.0	0.0
Oct	14.9	11.6	9.0	4.8	3.0	1.6	0.8	7.0	0.2	0.0	0.0	0.0
Nov	20.6	17.3	12.7	8.7	5.4	2.4	1.4	4.0	0.3	0.2	0.1	0.0
Dec	23.7	20.6	17.0	11.4	7.8	4.8	2.2	4.0	0.3	0.0	0.0	0.0

Water Supply

The adjacent creek will be used to provide a water source through an intake structure to the proposed wetland. This stream has been described as perennial (J. Walker pers. comm.) and therefore should greatly assist in keeping water in the wetland during periods of little or no precipitation.

Design Details

The design concept for this project is to maximize target species habitat by preparing a robust design that is efficient to build using native materials to the extent possible.

The proposed design includes the following features:

- Berms designed for water retention;
- Training berm;
- Excavated ponds;
- A water supply system, and;
- Tree removal.

Water Retention Berms

The proposed berms are to be constructed from two types of materials. The majority of the berms will be constructed of a native granular material and the upstream face will be constructed of native silt materials. The granular material will provide the desired ease of constructability and the silt material will provide the necessary water retention characteristics. These berms will have side slopes of three horizontal to one vertical. The entire berm will be keyed into the native soil a minimum of 300 mm. The upper slope to be constructed of less permeable material will be keyed into the native soil 600 mm to reduce seepage. The reservoir side of these berms will be armoured with riprap to protect against wave action (Figure 5).

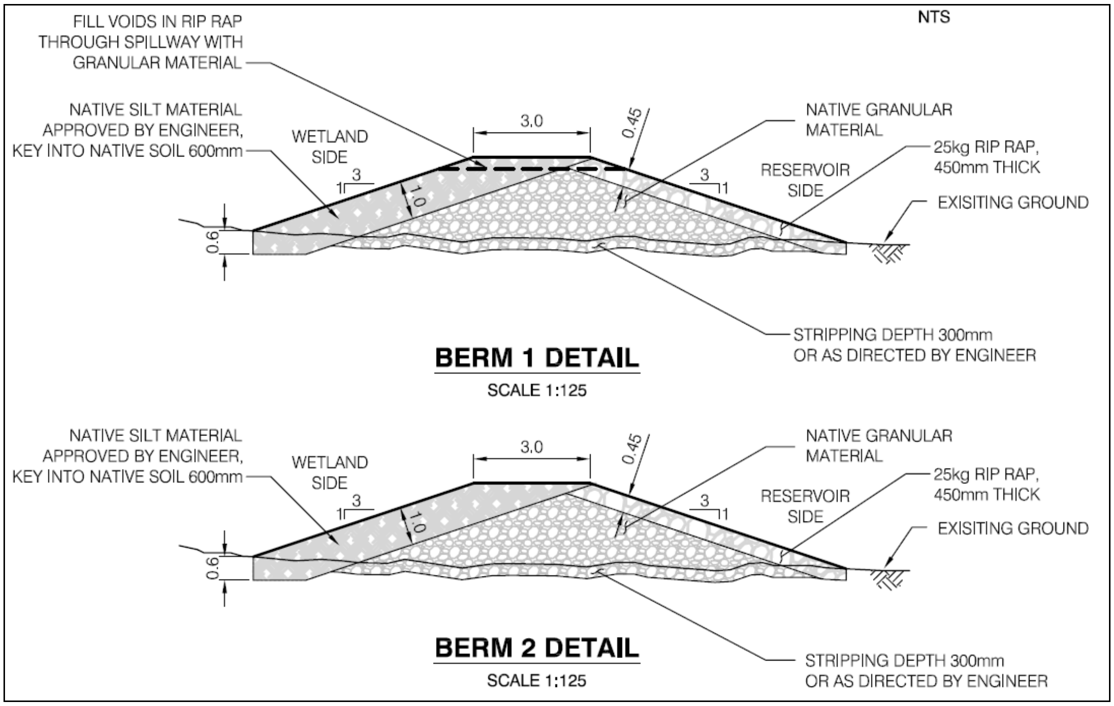

Figure 5. Water retention berm details.

Training Berms

The proposed training berms have been designed to keep the existing stream to the east from entering and damaging the proposed wetland. These berms are located along the east boundary of the proposed site. The upper most training berm is designed to keep the water from flowing down the road, as it currently does (as evident from existing erosion patterns). The second training berm is designed to keep the existing creek from overtopping its banks and flowing through the site. These berms are not required to retain water in the same way as the water retention berms, therefore can be constructed from granular material. The existing watercourse side of these berms will be keyed into the native till 300 mm in order to protect against undercutting from the watercourse (Figure 6).

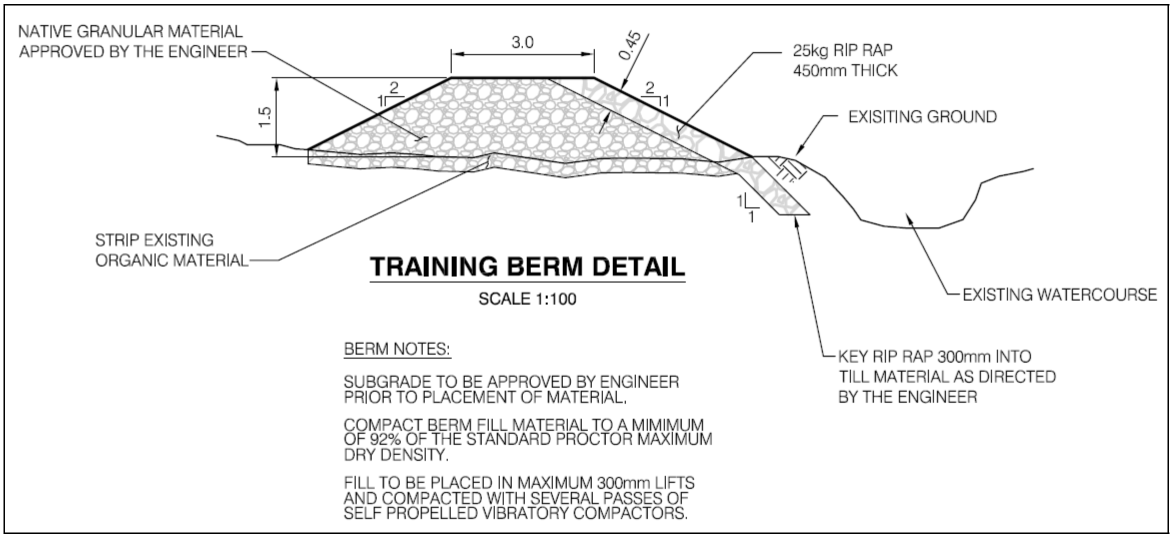

Figure 6. Training berm detail.

Excavated ponds

The ponds within the wetland will be created by impounding water against the berms and through excavation. The ponds will be excavated as shown on the detailed design drawings. These ponds will be typically 300 mm to 500 mm in depth. In order to create ponds of these depths the excavation depths will be greatest at the upland slopes. Similar to the berms, the excavated banks of these ponds are also relatively flat (i.e., 3 horizontal to 1 vertical). The engineer should review these pond excavations in the field (especially those closest to the existing road) to ensure they do not result in slope instability.

The proposed wetland build will produce approximately 6,000 m^2 of wetted surface area in five ponds, which range from 130 – 2,400 m^2.

Table 9. Total surface area and perimeter for each proposed pond of the wetland build. Refer to the attached detailed design drawings for pond location and configuration.

Pond Identifier	Surface Area (m^2)	Wetted Perimeter (m)
Pond 1	130	75
Pond 2	150	50
Pond 3	590	170
Pond 4	200	65
Pond 5	2,400	250

Water Supply

The proposed water supply to the site will be constructed by providing an infiltration pipe below the existing stream adjacent to the site (Figure 7). This infiltration pipe will connect to a solid pipe that will convey the flow to the upper most ponds. Upstream of the upper most pond a valve is designed that can be used to control the amount of flow into the ponds. Although the intake structure is designed to require as little maintenance as possible, over time the capacity of this system may be reduced because of silt build-up.

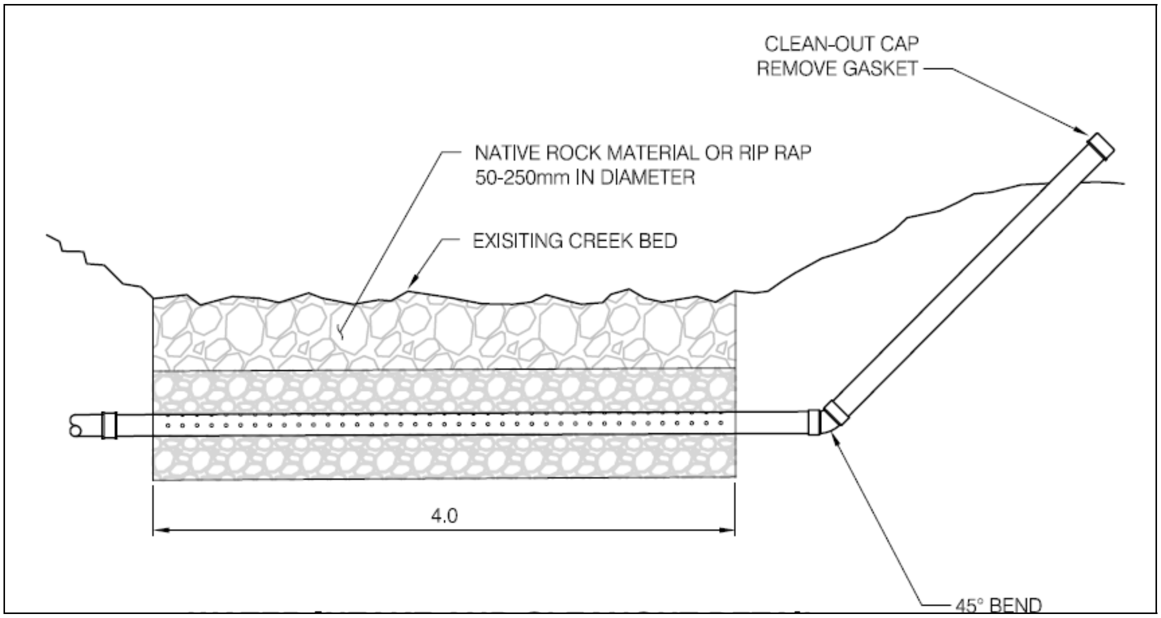

Figure 7. Detail of proposed water intake system.

Tree Removal

The extent of tree removal is illustrated on the design drawings. The site will be cleared in the areas of the proposed ponds. It is expected that slight modifications to the pond locations will be made during construction in order to maintain some existing trees within the wetlands. There is also an area designated for tree removal. This area will provide exposure to the proposed wetlands from the Diversion Reservoir.

Woody Debris

There are areas of significant wood debris through out the site. This wood debris will be used within the existing ponds and wetland to the extent possible. However, it is expected there will be excessive wood debris. This excessive material will be collected and disposed of off-site.

Silt Control

Silt control during construction is required to prevent, to the extent possible, silt from entering the Diversion Reservoir and adjacent watercourse. The proposed silt fencing is shown in Figure 8. This silt fencing is to remain until the vegetation is well established, and will likely remain for 1 year after construction is complete. Depending on field and weather conditions, additional silt protection may be required.

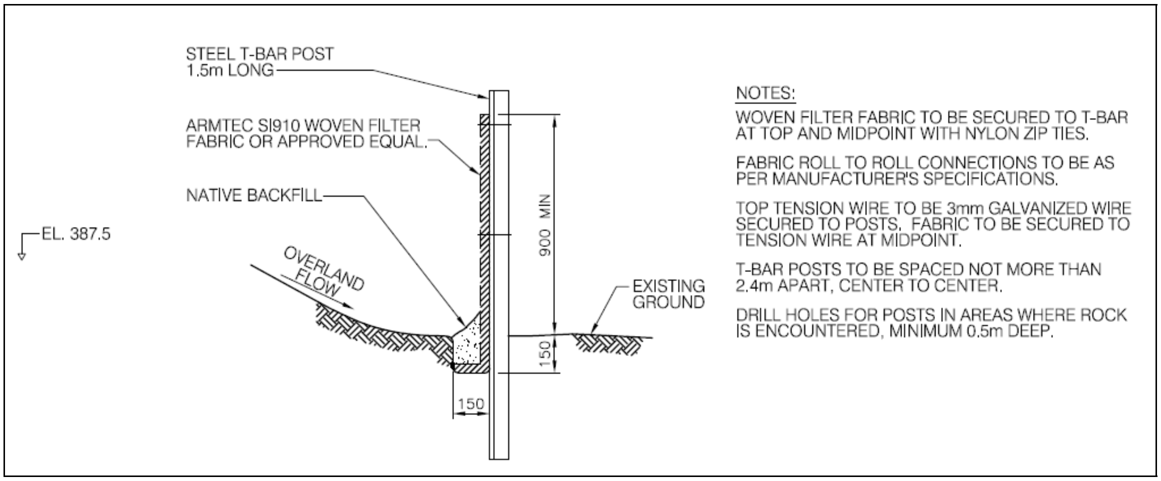

Figure 8. Silt control mechanism proposed for the wetland creation site.

Organic Soils

The areas of proposed excavated ponds will be stripped of organic soils for a depth of approximately 150 mm to 300 mm throughout the site. This material is to be stockpiled during general site grading and then redistributed across the site. Depending on stripping depths, some organic soil may have to be disposed of off-site

Riprap

Riprap will be required for the purposes of erosion protection. The areas this will be required include the creek side of the training berms, the reservoir side of the berms, channel spillways and constructed channels between the ponds. It is anticipated that most of this material will have to be brought to the site from another source.

Site Preparation and Plant Propagation

Site preparation will involve preparing access to the site along existing overgrown roads, coniferous and deciduous tree removal (felled trees will remain on site), shrub removal, pond excavation, and berm construction.

Extensive propagation of native plants will occur within the engineered wetland in order to provide habitat for wildlife and to prevent erosion and its associated problems (water turbidity, etc.) from affecting the wetland. Revegetation and the creation of plant communities will be based on a combination of analysis of the conditions that occur in nearby natural wetlands, a knowledge and understanding of the typical characteristics of wetlands in the Coastal Western Hemlock Biogeoclimatic Zone, and consideration of the goals and objectives of this particular wetland restoration project. Furthermore, the soil and hydrology conditions presented by the reconstructed wetland will limit the type of vegetation communities that can be propagated.

Prior to wetland creation, all exotic plants will be manually removed from the site to reduce their impact on future communities of native species; however, the seed bank within the soil will continue to complicate any invasive species removal programs by providing a continual source of seedlings for years to come. Invasive species removal will be most important around the upper perimeter of the uppermost pond because other areas of the wetland will be permanently inundated following the completion of the berms, which will likely prevent the germination of most or all seeds currently in the seed bank in those areas. Longer-term control programs for introduced species will likely focus on the most aggressive and invasive species because the complete exclusion of all exotics will not be possible without monumental efforts.

The addition of high quality soil to the wetland basins immediately following the construction of the berms will help to increase the nutrient value of the substrate and promote the establishment of the propagated native plant species. Furthermore, if left in place, the organic material provided by the decaying remains of the previously established plants within the wetland will further increase the nutritional value of the substrate. Aside from these methods, though, no additional fertilizing or addition of nutrients will be done in order to prevent the system from becoming nutrient-loaded, leading to phytoplankton blooms that reduce the clarity of the water and affect the condition of the site for native plants (MacKenzie and Moran, 2004).

Plant propagation will be species-specific and will depend on the physiological characteristics of the species (Table 10). All propagation strategies will be based on available literature on wetland restoration. Seeds and/or seedlings will be collected from the immediate vicinity of the Jordan River watershed. Minor differences in genotype often occur between populations of plants, enabling them to be specifically adapted to local conditions. By ensuring that only local populations are used as a source for revegetation, any regional genotypic differences between populations that could negatively affect establishment would be minimized. Whenever possible, native wetland plants will be purchased from local native plant nurseries such as N.A.T.S. Nurseries Ltd. in Surrey and Streamside Native Plants in Courtenay. Species that are not available commercially will be manually collected from the wild, either as seeds, clones, or cuttings. Native species that have the ability to overtake wetlands (i.e., *Typha latifolia*) will be planted in open-bottomed pots, thus curtailing their spread beyond the confines of the pot and limiting them to specific areas of the wetland as chosen by the habitat architects.

Table 10. Primary species for use in wetland restoration at the Diversion Reservoir and the desired method of propagation for each.

Species	Propagation Technique	Collection Season	Planting Season
Typha latifolia	Division	Spring	Summer
Carex utriculata	Division	Spring	Summer
Carex obnupta	Germinated seedlings grown from seed	Fall	Spring
Scirpus microcarpus	Germinated seedlings grown from seed	Fall	Spring
Eleocharis palustris	Division	Spring	Summer
Juncus effusus	Germinated seedlings grown from seed	Summer	Spring
Nuphar lutea	Division	Spring	Spring
Brasenia schreberi	Division	Spring	Spring
Potamogeton spp.	Division	Spring	Spring
Salix spp.	Cuttings	Spring	Spring

Plant communities around the shallow perimeter of the ponds will be a mosaic of *Typha latifolia* (common cattail) and *Carex utriculata* (beaked sedge) communities, which are both frequent in southwestern British Columbia, including southern Vancouver Island, and commonly occur in association with each other (MacKenzie and Moran, 2004). Although these plant communities are typically low in plant species diversity, they are often high in value to wildlife as sources of food and cover. In fact, marsh ecosystems, which include cattail and beaked sedge communities, are the most heavily used wetland type for most wetland-using wildlife species (MacKenzie and Moran, 2004). These ecosystems are characteristic of conditions in which high water in the winter and spring gives way to drawdown and extensive substrate exposure during the summer and early fall (MacKenzie and Moran, 2004) and, as such, will be ideally suited to the hydrology of the restored wetlands. As well, marsh ecosystems are the easiest wetland ecosystems to create artificially and will form naturally in recently created wetland environments (MacKenzie and Moran, 2004); however, to ensure that the desired plant species compositions are achieved and that exotic species are excluded from the wetland we will be artificially propagating *Typha latifolia* and *Carex utriculata* and introducing them manually to the wetland.

Permanently flooded portions of the deeper ponds will be planted with a variety of native submergent plant species such as yellow pond-lily, watershield, and pondweed (*Potamogeton* spp.), all of which are common throughout southern Vancouver Island and have been recorded in the Jordan River watershed. These plant communities are always associated with still or slowly moving water bodies and are highly influenced by the availability of light as it relates to water turbidity and depth (MacKenzie and Moran, 2004). Establishment of a diverse and healthy submergent and emergent community will be of great benefit to pond-breeding amphibians because vegetation structure is required for adherence of egg masses (Hawkes, 2005). Furthermore, these vegetation communities will likely promote high densities of aquatic invertebrates, which are an exceptional food source for developing juveniles (MacKenzie and Moran, 2004).

Low islands will be constructed in the lower two ponds to provide nesting habitat for waterfowl and other wetland-associated birds, as well as to increase the habitat complexity of the site and increase its overall appeal to wildlife. These islands will be planted with a variety of native grasses and semi-aquatic forbs such as creeping spike-rush (*Eleocharis palustris*), sedges (*Carex* spp.), rushes (*Juncus* spp.), small-flowered bulrush (*Scirpus microcarpus*), Pacific water-parsley (*Oenanthe sarmentosa*), and American brooklime (*Veronica beccabunga*), as well as any additional species that are found to be frequent in similar natural conditions within the watershed. These plants will form low, lush, and diverse wet meadow communities across the islands and provide high cover and nesting values. The application of large organic debris to the islands will further augment the habitat.

Plant communities around the perimeter of the upper pond will be similar to the wet meadow ecosystems that will be re-created on the artificial islands, although they will likely be more diverse due to the larger area that is available for planting and the influence of upland habitats. Slough sedge (*Carex obnupta*) and common rush (*Juncus effusus*), both very common in transitional wetland-upland communities on southern Vancouver Island, will provide the backbone of this ecosystem and will be complemented by a diverse assemblage of native grasses and forbs that are representative of that habitat. Thickets of willow (*Salix* spp.) will occur between the wet meadow ecosystem and the upland coniferous forest above the wetland. Because willows are already frequent around the perimeter of the reservoir, including in the vicinity of the proposed wetland, it is unlikely that propagation will be needed for these shrubs.

The berms, which will be used to retain water in the wetlands, will be planted with native grasses and forbs and complemented with thickets of planted willows of several species (including Sitka willow, *Salix sitchensis*, and Pacific willow, *Salix lucida*). Species such as slough sedge, common rush, small-flowered bulrush, creeping spike-rush, and native grasses and forbs will be planted below the willow thickets to provide low cover for wildlife. Additionally, nest boxes for cavity nesting birds (Tree Swallow, Violet-green Swallow, Wood Duck, Western Screech-Owl) will be considered for placement along the berms, on the islands, and between the upper pond and the upland coniferous. The availability of natural nesting sites for these species is an important limiting factor in their distribution.

All of the re-created wetland habitats discussed above will also see the unassisted establishment of additional species through natural recruitment. Exotic species, such as curled dock (*Rumex crispus*) and reed canarygrass[3] (*Phalaris arundinacea*), will be excluded soon after establishment

[3] Although reed canarygrass is native throughout the northern hemisphere, an aggressive genotype has been introduced from Europe and is currently overtaking many wetland and wet meadow ecosystems in British Columbia. It is best to prevent this species from becoming established rather than try to control it once it has invaded a native habitat and reduced it to a dense monoculture with little or no value to wildlife.

through manual removal. Once the native species are established it should prevent the widespread invasion of exotic species, most of which thrive in disturbed habitats with compromised native environments. Control of invasive species will be one of the most crucial components in maintaining a healthy ecosystem for wildlife following construction of the wetland.

Adaptive Management

A critical component of all wetland restoration projects is the ability for adaptive management following the completion of the construction and revegetation phases. Many external factors can contribute to the success or failure of a wetland restoration project, such as poor substrate conditions, changes in water chemistry, poor planting techniques, invasion of exotic species, pathogens, and even weather anomalies. Periodic monitoring of the site following its completion enables the architects of the wetland to follow the maturation of the habitat and, should problems arise such as poor germination of revegetated areas or invasion of exotic plants, the managers are able to identify the problem, quantify the magnitude its impact, and come up with solutions to bring the wetland back to a natural and healthy state. The chances of success of the project drop significantly in the absence of such an adaptive management scheme.

Site photographs, encompassing all portions of the wetland, will be taken during site visits immediately following the completion of the revegetation phase of the project. These photos will be duplicated once a month for the first two years so as to provide a catalogue of the establishment of the vegetation throughout these critical early stages. By comparing photographs of particular areas from different time periods we will be able to ascertain whether the vegetation is establishing itself at an appropriate rate. Additional steps will be taken to remedy any problems that might arise, such as removal of invasive species. After the two year period, the frequency of site visits will be reduced to three per year for the next three years, with the first visit in early spring (April), the second in early summer (June), and the third in late summer/early fall (September). After the five year period, the number of site visits will be reduced to one per year for the next five years. After ten years, assuming that the habitat is considered established, all site visits will cease and the wetland will be considered mature and self-sustaining.

In concert with the monitoring of the progress of the vegetation during the first ten years, the use of the wetland by wildlife will also be closely monitored. Thorough searches of the wetland for evidence of amphibians will be done during all site visits, following the protocols outlined in Hawkes (2005). Detailed notes will also be made of any birds, mammals, reptiles, butterflies, dragonflies, or terrestrial molluscs that are detected in the wetland or in the upland areas immediately adjacent to the wetland. For birds, particular focus will be placed on any breeding activity that is observed, such as swallows nesting in the nest boxes that have been provided or waterfowl nesting on the artificial islands. These efforts will provide a baseline data set for understanding how these wildlife groups are colonizing the wetland and also give managers an opportunity to alter some components of the wetland to enhance its appeal to these species if necessary.

CONSTRAINTS TO IMPLEMENTATION: FUTURE WORK

The development of an integrated wildlife habitat restoration plan requires that the constraints associated with each restoration action be considered and actions taken to mitigate for those constraints. With respect to the three restoration actions proposed for the Jordan River watershed on southern Vancouver Island, most of the identified constraints are easily mitigated while others require additional consideration. For example, land acquisition may require a significant amount of time as well as significant finances. The constraints and associated actions are most easily presented in tabular format:

Restoration Action	Constraint	Action
Habitat Protection		
Townsend's Big-eared Bat protection	Buildings used by bats may be occupied by BC Hydro staff and may not be able to be afforded complete protection.	Additional bat surveys are required Protect roost sites from disturbance
Tall trees protection	Danger trees may need to be removed	Protect tall trees from harvest
Seeps	None	Map locations of seeps as they are found
Moss mats	None	Map locations of extensive moss mats as they are found
Riparian Habitat Conservation and Enhancement		
"Old-growth" succession	None	Protect forest on BC Hydro property from harvest
Silvicultural prescriptions	None	Located suitable areas and develop prescriptions
Owls	None	Survey for nest sites Provide snags and/or nest boxes if needed.
Hole-nesting birds	Willing volunteers are needed to maintain nest boxes if established	Provide nest boxes if needed provided a volunteer group will maintain
Drawdown zone restoration	Water level management may preclude revegetation	Plant experimental plots Expand if successful
Bog habitat acquisition	Owner must be willing to sell or encumber and the cost of protection must be available or raised through collaboration with land trusts.	Acquire/protect bog
Habitat Creation		
Wetland creation	There are engineering constraints to the location and design of constructed wetlands	Build additional wetlands Enhance Bear Creek wetland Restore Forebay Pond
Meadow Creation	There are climatic and permitting constraints to controlled burns	Identify areas of poor wildlife habitat Clear/burn to create meadow habitat

CONCLUSIONS

The concept of the IWHRP was born out of the need to develop an ecologically-based restoration plan that considered the habitat needs of the species that do, or that are expected to occur in watersheds affected by hydroelectric development. Because the strategic plans developed for the 15 watersheds within the Bridge Coastal Generation Area do not provide direction for habit restoration, it is anticipated that the development of an IWHRP will have value for all watersheds in the Bridge Coastal Generation Area and for all watersheds in BC where BC Hydro operates. Specifically, the IWHRP developed for the Jordan River watershed could be used to guide and prioritize restoration opportunities watershed affected by hydroelectric development.

A constructed wetland design was developed concurrently with the IWHRP. This was done because it is recognized that wetland habitat was directly impacted by river impoundment and because habitat creation is an attainable mitigation strategy that could be undertaken in the Jordan River watershed. Furthermore, the addition of wetland habitats would benefit many species of wildlife, thereby creating an integrated approach to restoration. Related to this was the desire to determine if wetland construction was feasible on the edge of a reservoir, where water level fluctuations present a unique problem for wetland construction.

The wetland designed for lands adjacent to Diversion Reservoir in the Jordan River watershed should be considered a proof of concept build. When completed, approximately 6,000 m^2 of wetted surface area and 610 m of wetted perimeter habitat in five ponds ranging in depth from 30 – 50 cm will be created. The proof of concept build is a necessary step in the refinement of the habitat creation restoration strategy that could eventually be implemented in any impounded watershed.

The development of the IWHRP and the wetland concept begin to address the needs of the entire Bridge Coastal Restoration Program and the specific water use plans for each of the 15 watersheds in the BCRP system. The development of the IWHRP provides direction for restoration activities in a particular watershed and provides designs for habitat replacement or enhancement projects. The IWHRP and wetland design can be adapted and implemented in other watersheds in the Bridge Coastal system and throughout British Columbia.

RECOMMENDATIONS

A grant application for the proof of concept wetland build was submitted in November 2006, with funding approved in April 2007. Provided the logistics of the wetland construction (e.g., permitting, land access, engineering availability) can be overcome in 2007, the wetland should be built no later than early October (weather permitting). Associated with the wetland construction, we recommend the following work be undertaken in summer 2007 to expand our knowledge of certain species of wildlife in the Jordan River watershed:

1. Diversion Dam should be investigated for bat presence in July or August 2007.
2. An ultrasound bat detector should be stationed at Diversion Dam for several nights in august to determine bat species presence. The bat detector should be place d at the east end of the dam.

Additional recommendations include:

1. Adapting the IWHRP to another watershed on southern Vancouver Island.
2. Exploring the feasibility of wetland construction in other watershed of the Bridge Coastal system[4].

[4] A wetland feasibility study in the Ash River watershed was funded by the Bridge Coastal Restoration Program for the 2007-08 fiscal year.

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APPENDICES

Appendix A. Mammals, birds, amphibians, reptiles, terrestrial gastropods, butterflies, and dragonflies that likely occur in the Jordan River watershed on southern Vancouver Island, along with their provincial and federal conservation status.

Scientific Name	Common Name	Group	BC CDC Status	COSEWIC
Sorex monticolus	Dusky Shrew	Mammal	Yellow	
Sorex palustris brooksi	Vancouver Island Water Shrew	Mammal	Red	
Sorex vagrans	Vagrant Shrew	Mammal	Yellow	
Myotis californicus	California Myotis	Mammal	Yellow	
Myotis keenii	Keen's Myotis	Mammal	Yellow	
Myotis lucifugus	Little Brown Myotis	Mammal	Yellow	
Myotis volans	Long-legged Myotis	Mammal	Yellow	
Myotis yumanensis	Yuma Myotis	Mammal	Yellow	
Lasiurus cinereus	Hoary Bat	Mammal	Yellow	
Lasionycteris noctivagans	Silver-haired Bat	Mammal	Yellow	
Eptesicus fuscus	Big Brown Bat	Mammal	Yellow	
Corynorhinus townsendii	Townsend's Big-eared Bat	Mammal	Blue	
Sylvilagus floridanus	Eastern Cottontail	Mammal	Exotic	
Microtus townsendii	Townsend's Vole	Mammal	Yellow	
Ondatra zibethicus	Muskrat	Mammal	Yellow	
Permoyscus maniculatus	Deer Mouse	Mammal	Yellow	
Permoyscus keenii	Keen's Mouse	Mammal	Yellow	
Castor canadensis	Beaver	Mammal	Yellow	
Tamiasciurus hudsonicus	Red Squirrel	Mammal	Yellow	
Canis lupus	Gray Wolf	Mammal	Yellow	
Felis concolor	Cougar	Mammal	Yellow	
Gulo gulo vancouverensis	Vancouver Island Wolverine	Mammal	Red	Special Concern
Lutra canadensis	River Otter	Mammal	Yellow	
Martes americana	Marten	Mammal	Yellow	
Mustela vison	Mink	Mammal	Yellow	
Mustela erminea anguinae	Vancouver Island Ermine	Mammal	Blue	
Procyon lotor	Raccoon	Mammal	Yellow	
Ursus americanus	Black Bear	Mammal	Yellow	
Cervus canadensis roosevelti	Roosevelt Elk	Mammal	Blue	
Odocoileus hemonius columbianus	Columbian Black-tailed Deer	Mammal	Yellow	
Branta canadensis	Canada Goose	Bird	Yellow	
Cygnus buccinator	Trumpeter Swan	Bird	Yellow	
Aix sponsa	Wood Duck	Bird	Yellow	
Anas americana	American Wigeon	Bird	Yellow	
Anas platyrhynchos	Mallard	Bird	Yellow	
Anas discors	Blue-winged Teal	Bird	Yellow	
Anas cyanoptera	Cinnamon Teal	Bird	Yellow	
Anas clypeata	Northern Shoveler	Bird	Yellow	
Anas acuta	Northern Pintail	Bird	Yellow	
Anas crecca	Green-winged Teal	Bird	Yellow	
Aythya collaris	Ring-necked Duck	Bird	Yellow	
Aythya affinis	Lesser Scaup	Bird	Yellow	
Bucephala albeola	Bufflehead	Bird	Yellow	
Bucephala clangula	Common Goldeneye	Bird	Yellow	
Bucephala islandica	Barrow's Goldeneye	Bird	Yellow	

Scientific Name	Common Name	Group	BC CDC Status	COSEWIC
Lophodytes cucullatus	Hooded Merganser	Bird	Yellow	
Mergus merganser	Common Merganser	Bird	Yellow	
Bonasa umbellus	Ruffed Grouse	Bird	Yellow	
Dendragopus fuliginosus	Sooty Grouse	Bird	Yellow	
Gavia immer	Common Loon	Bird	Yellow	
Podilymbus podiceps	Pied-billed Grebe	Bird	Yellow	
Ardea herodias fannini	Great Blue Heron, *fannini* ssp.	Bird	Blue	Special Concern
Cathartes aura	Turkey Vulture	Bird	Yellow	
Pandion haliaetus	Osprey	Bird	Yellow	
Haliaeetus leucocephalus	Bald Eagle	Bird	Yellow	
Circus cyaneus	Northern Harrier	Bird	Yellow	
Accipiter striatus	Sharp-shinned Hawk	Bird	Yellow	
Accipiter cooperii	Cooper's Hawk	Bird	Yellow	
Accipiter gentilis laingi	Northern Goshawk, *laingi* ssp.	Bird	Blue	
Buteo jamaicensis	Red-tailed Hawk	Bird	Yellow	
Aquila chrsaetos	Golden Eagle	Bird	Yellow	
Falco sparverius	American Kestrel	Bird	Yellow	
Falco columbarius	Merlin	Bird	Yellow	
Falco peregrinus pealei	Peregrine Falcon, *pealei* ssp.	Bird	Blue	Special Concern
Fulica americana	American Coot	Bird	Yellow	
Grus canadensis	Sandhill Crane	Bird	Blue	
Charadrius vociferus	Killdeer	Bird	Yellow	
Tringa melanoleuca	Greater Yellowlegs	Bird	Yellow	
Tringa flavipes	Lesser Yellowlegs	Bird	Yellow	
Actitis macularia	Spotted Sandpiper	Bird	Yellow	
Calidris minuta	Least Sandpiper	Bird	Yellow	
Limnodromus scolopaceus	Long-billed Dowitcher	Bird	Yellow	
Gallinago delicata	Wilson's Snipe	Bird	Yellow	
Larus canus	Mew Gull	Bird	Yellow	
Larus glaucescens	Glaucous-winged Gull	Bird	Yellow	
Brachyramphus marmoratus	Marbled Murrelet	Bird	Blue	Threatened
Patagioenas fasciatus	Band-tailed Pigeon	Bird	Blue	
Megascops kennicottii kennicottii	Western Screech-Owl, *kennicottii* ssp.	Bird	Blue	Special Concern
Bubo virginianus	Great Horned Owl	Bird	Yellow	
Glaucidium gnoma swarthi	Northern Pygmy-Owl, *swarthi* ssp.	Bird	Blue	
Strix varia	Barred Owl	Bird	Yellow	
Aegolius acadicus	Northern Saw-whet Owl	Bird	Yellow	
Chordeiles minor	Common Nighthawk	Bird	Yellow	
Cypseloides niger	Black Swift	Bird	Yellow	
Chaetura vauxii	Vaux's Swift	Bird	Yellow	
Selasphorus rufus	Rufous Hummingbird	Bird	Yellow	
Ceryle alcyon	Belted Kingfisher	Bird	Yellow	
Sphyrapicus ruber	Red-breasted Sapsucker	Bird	Yellow	
Picoides villosus	Hairy Woodpecker	Bird	Yellow	
Picoides pubescens	Downy Woodpecker	Bird	Yellow	
Colaptes auratus	Northern Flicker	Bird	Yellow	
Dryocopus pileatus	Pileated Woodpecker	Bird	Yellow	
Contopus cooperii	Olive-sided Flycatcher	Bird	Yellow	

Scientific Name	Common Name	Group	BC CDC Status	COSEWIC
Contopus sordidulus	Western Wood-Pewee	Bird	Yellow	
Empidonax traillii	Willow Flycatcher	Bird	Yellow	
Empidonax hammondii	Hammond's Flycatcher	Bird	Yellow	
Empidonax difficilis	Pacific-slope Flycatcher	Bird	Yellow	
Vireo cassinii	Cassin's Vireo	Bird	Yellow	
Vireo huttonii	Hutton's Vireo	Bird	Yellow	
Vireo gilvus	Warbling Vireo	Bird	Yellow	
Perisoreus canadensis	Gray Jay	Bird	Yellow	
Cyanocitta stelleri	Steller's Jay	Bird	Yellow	
Corvus caurinus	Northwestern Crow	Bird	Yellow	
Corvus corax	Common Raven	Bird	Yellow	
Tachycineta thalassina	Violet-green Swallow	Bird	Yellow	
Tachycineta bicolor	Tree Swallow	Bird	Yellow	
Stelgidopteryx serripennis	Northern Rough-winged Swallow	Bird	Yellow	
Petrochelidon pyrrhonota	Cliff Swallow	Bird	Yellow	
Hirundo rustica	Barn Swallow	Bird	Blue	
Poecile rufescens	Chestnut-backed Chickadee	Bird	Yellow	
Sitta canadensis	Red-breasted Nuthatch	Bird	Yellow	
Certhia americana	Brown Creeper	Bird	Yellow	
Thryomanes bewickii	Bewick's Wren	Bird	Yellow	
Troglodytes troglodytes	Winter Wren	Bird	Yellow	
Regulus satrapa	Golden-crowned Kinglet	Bird	Yellow	
Regulus calendula	Ruby-crowned Kinglet	Bird	Yellow	
Myadestes townsendi	Townsend's Solitaire	Bird	Yellow	
Catharus ustulatus	Swainson's Thrush	Bird	Yellow	
Catharus guttatus	Hermit Thrush	Bird	Yellow	
Turdus migratorius	American Robin	Bird	Yellow	
Ixoreus naevius	Varied Thrush	Bird	Yellow	
Anthus rubescens	American Pipit	Bird	Yellow	
Sturnus vulgaris	European Starling	Bird	Yellow	
Bombycilla cedrorum	Cedar Waxwing	Bird	Yellow	
Vermivora celata	Orange-crowned Warbler	Bird	Yellow	
Dendroica petechia	Yellow Warbler	Bird	Yellow	
Dendroica coronata	Yellow-rumped Warbler	Bird	Yellow	
Dendroica townsendii	Townsend's Warbler	Bird	Yellow	
Dendroica nigrescens	Black-throated Gray Warbler	Bird	Yellow	
Oporornis tolmiei	MacGillivray's Warbler	Bird	Yellow	
Geothlypis trichas	Common Yellowthroat	Bird	Yellow	
Wilsonia pusilla	Wilson's Warbler	Bird	Yellow	
Piranga ludoviciana	Western Tanager	Bird	Yellow	
Pipilo maculatus	Spotted Towhee	Bird	Yellow	
Spizella passerina	Chipping Sparrow	Bird	Yellow	
Passerculus sandvicensis	Savannah Sparrow	Bird	Yellow	
Passerella iliaca	Fox Sparrow	Bird	Yellow	
Melospiza melodia	Song Sparrow	Bird	Yellow	
Melospiza lincolnii	Lincoln's Sparrow	Bird	Yellow	
Zonotrichia atricapilla	Golden-crowned Sparrow	Bird	Yellow	
Zonotrichia leucophrys	White-crowned Sparrow	Bird	Yellow	

Scientific Name	Common Name	Group	BC CDC Status	COSEWIC
Junco hyemalis	Dark-eyed Junco	Bird	Yellow	
Pheucticus melanocephalus	Black-headed Grosbeak	Bird	Yellow	
Aglaius phoeniceus	Red-winged Blackbird	Bird	Yellow	
Carpodacus purpureus	Purple Finch	Bird	Yellow	
Loxia curvirostra	Red Crossbill	Bird	Yellow	
Carduelis pinis	Pine Siskin	Bird	Yellow	
Carduelis tristis	American Goldfinch	Bird	Yellow	
Coccothraustes vespertinus	Evening Grosbeak	Bird	Yellow	
Elgaria coerulea	Northern Alligator Lizard	Reptile	Yellow	
Thamnophis elegans	Western Terrestrial Garter Snake	Reptile	Yellow	
Thamnophis ordinoides	Northwestern Garter Snake	Reptile	Yellow	
Thamnophis sirtalis	Common Garter Snake	Reptile	Yellow	
Taricha granulosa	Rough-skinned Newt	Amphibian	Yellow	
Ambystoma gracile	Northwestern Salamander	Amphibian	Yellow	
Ambystoma macrodactylum	Long-toed Salamander	Amphibian	Yellow	
Aneides vagrans	Wandering Salamander	Amphibian	Yellow	
Ensatina eschscholtzii	Ensatina	Amphibian	Yellow	
Plethodon vehiculum	Western Red-backed Salamander	Amphibian	Yellow	
Rana aurora	Red-legged Frog	Amphibian	Blue	
Hyla regilla	Pacific Treefrog	Amphibian	Yellow	
Bufo boreas	Western Toad	Amphibian	Yellow	Special Concern
Allogona townsendiana	Oregon Forestsnail	Mollusc	Red	
Carychium occidentale	Western Thorn	Mollusc	Blue	
Deroceras hesperium	Evening Fieldslug	Mollusc	Red	
Hemphillia dromedarius	Dromedary Jumping-slug	Mollusc	Red	
Hemphillia glandulosa	Warty Jumping-slug	Mollusc	Blue	
Monadenia fidelis	Pacific Sideband	Mollusc	Blue	
Nearctula sp. 1	Threaded Vertigo	Mollusc	Red	
Pristiloma johnsoni	Broadwhorl Tightcoil	Mollusc	Blue	
Prophysaon coeruleum	Blue-grey Taildropper	Mollusc	Red	
Prophysaon vanattae	Scarletback Taildropper	Mollusc	Blue	
Vertigo andrusiana	Pacific Vertigo	Mollusc	Red	
Zonitoides nitidus	Black Gloss	Mollusc	Blue	
Haplotrema vancouvense		Mollusc		
Ariolimax columbiana		Mollusc		
Vespericola columbianus		Mollusc		
Callophrys eryphon sheltonensis	Western Pine Elfin, *sheltonensis* subspecies	Butterfly	Blue	
Callophrys johnsoni	Johnson's Hairstreak	Butterfly	Red	
Callophrys mossii mossii	Moss' Elfin, *mossii* subspecies	Butterfly	Blue	
Cercyonis pegala incana	Common Woodnymph, *incana* subspecies	Butterfly	Red	
Coenonympha tullia insulana	Common Ringlet, *insulana* subspecies	Butterfly	Red	
Colias occidentalis	Western Sulphur	Butterfly	Blue	
Erynnis propertius	Propertius Duskywing	Butterfly	Blue	
Euchloe ausonides insulanus	Island Large Marble	Butterfly	Red	
Euphydryas editha taylori	Edith's Checkerspot, *taylori* subspecies	Butterfly	Red	

Scientific Name	Common Name	Group	BC CDC Status	COSEWIC
Euphyes vestris	Dun Skipper	Butterfly	Blue	
Hesperia colorado oregonia	Common Branded Skipper, *oregonia* subspecies	Butterfly	Blue	
Parnassius smintheus olympianus	Phoebus' Parnassian, *olympianus* subspecies	Butterfly	Red	
Plebejus icarioides blackmorei	Boisduval's Blue, *blackmorei* subspecies	Butterfly	Blue	
Plebejus saepiolus insulanus	Greenish Blue, *insulanus* subspecies	Butterfly	Red	
Speyeria zerene bremnerii	Zerene Fritillary, *bremnerii* subspecies	Butterfly	Blue	
Epitheca canis	Beaverpond Baskettail	Dragonfly	Blue	
Erythemis collocata	Western Pondhawk	Dragonfly	Blue	
Pachydiplax longipennis	Blue Dasher	Dragonfly	Blue	
Sympetrum vicinum	Autumn Meadowhawk	Dragonfly	Blue	
Tramea lacerata	Black Saddlebags	Dragonfly	Red	

Appendix B. Species at Risk Overview.

This appendix summarizes the species expected to occur in the Jordan River watershed that have current provincial or federal conservation status. These species were assessed (in conjunction with common or not at risk species) relative to the benefits of each restoration strategy.

Vertebrates

Vancouver Island Water Shrew (*Sorex palustris brooksi*)

This subspecies of the wide-ranging Water Shrew is endemic to Vancouver Island and occurs nowhere else in the world. It is weakly differentiated from mainland individuals of the species by its darker colour (Nagorsen 1996). This animal is typical of wet habitats, particularly near fast-flowing streams, and is found in areas where there are rocks, boulders, tree roots, and overhanging ledges along the edge of the watercourse. Other habitats that are occupied include wet meadows, riparian thickets, and bogs. This species preys primarily on aquatic insects and terrestrial invertebrates, but has also been known to consume amphibian larvae, carrion, and even small fish which it captures by diving underwater for up to 47 seconds at a time (Nagorsen 1996). The *brooksi* subspecies is extremely poorly known, and up until 2001 was known from only 11 specimens (Craig and Wilson 2001). That year, however, targeted surveys at numerous locations around Vancouver Island documented an additional 27 locations for this enigmatic animal (Craig and Wilson 2001). One of the locations surveyed during that study was the Jordan River watershed and, although no individuals were documented in the watershed, the species may simply have been overlooked because a large amount of suitable habitat is present along the Jordan River system and the animal occurs at very low densities even within appropriate habitat. Additional targeted surveys may indeed demonstrate its presence within the watershed, especially considering that it was documented elsewhere along the west coast of Vancouver Island in areas where it had never been found before, such as Pacific Rim National Park (Craig and Wilson 2001).

Townsend's Big-eared Bat (*Corynorhinus townsendii*)

Although reports of bats in the Jordan River watershed go back as far as the 1940s (Hardy 1949), the only species of bat confirmed in the watershed to date is this species which was captured during nocturnal bat surveys at Diversion Reservoir in 2006 (V.Hawkes, pers. comm.). This small, highly distinctive bat occurs locally in Canada only on southern Vancouver Island and across southern B.C. where it inhabits a wide variety of habitats, from coastal forests to dry interior grasslands (Nagorsen and Brigham 1993). This species roosts colonially during the winter in caves and buildings, with known winter roosts in southwestern British Columbia generally containing between 40-60 animals (Nagorsen and Brigham 1993). The local distribution of the species, coupled with its reliance on relatively few overwintering sites, renders it susceptible to disturbance from human activities and subsequent population reductions.

Vancouver Island Ermine (*Mustela ermina anguinae*)

This endemic, little-known subspecies of the widespread Ermine occurs only on Vancouver Island, where it is scarce and only rarely seen. Despite its current scarcity on Vancouver Island, however, historical records indicate that it has occurred in the Jordan River watershed in the past (Hardy 1949). This species inhabits a broad diversity of landscapes, especially riparian areas, where it searches for the small mammals such as voles, shrews, and mice which it preys on. The relatively low density of potential prey animals on Vancouver Island may be responsible for the overall scarcity of the Vancouver Island Ermine (Cannings et al. 1999). Although habitat fragmentation from urban and agricultural development probably poses the greatest threat to this animal on Vancouver Island, the effects of large-scale timber harvest on prey populations is not known and may be detrimental (Cannings et al. 1999).

Vancouver Island Wolverine (*Gulo gulo vancouverensis*)

Among the scarcest and most mysterious of the terrestrial vertebrates of Vancouver Island, the Vancouver Island Wolverine is known from only a handful of sightings and specimens, with only 4 sight records since 1980. The taxonomic status of this animal has recently been questioned, with some suggesting that it may not be morphologically or genetically distinct from the mainland subspecies *G.g.luscus* (Cannings et al. 1999). The purported habitats utilized by this species on Vancouver Island include alpine tundra, subalpine parkland, and montane coniferous forests, where this solitary animal occupies huge territories and ranges over very large tracts of land (Cannings et al. 1999). This species probably relies largely on carrion as a food source on Vancouver Island (Cannings et al. 1999). It is suspected that human activities negatively influence this species on Vancouver Island and the few recent records suggest that it is now confined to remote, mountainous areas of central Vancouver Island and pristine old growth forests of the west coast (Cannings et al. 1999). Several recent sight records from areas near the Jordan River watershed (ie. Cowichan River watershed) indicate that the species may be present in the Jordan River watershed, at least occasionally.

Roosevelt Elk (*Cervus canadensis roosevelti*)

The Roosevelt Elk numbers only 3400-3500 animals in British Columbia, of which 3000-3200 occur on Vancouver Island with the rest restricted to small, mostly re-introduced herds on the southern mainland coast (Shakleton 1999; Cannings et al. 1999; Blood 2000). These animals inhabit a range of coniferous of deciduous forested habitats, particularly in areas near wetland, riparian habitats, and other moist or brushy sites with an abundance of potential forage and cover plants (Cannings et al. 1999). Populations of this coastal subspecies of Elk have been significantly impacted by a number of factors such as overharvest, poaching, human settlement, and resource extraction activities and have been locally extirpated from a number of areas of southern Vancouver Island (including the Gulf Islands) as well as the Lower Mainland and most of the southern mainland coast (Cannings et al. 1999). Despite their scarcity on southern Vancouver Island, the Jordan River watershed is known to harbour a population of Roosevelt Elk.

Great Blue Heron (*Ardea herodias fannini*)

Although still a common component of the avifauna of Vancouver Island, recent declines coupled with the species' sensitivity to human disturbance at its nesting colonies have resulted in the placement of this coastal subspecies of the Great Blue Heron on the provincial blue list (Gebauer and Moul 2001). This colonial species requires forested groves located near freshwater or marine habitats for nesting, where it places its stick nests high in the branches, usually in well-concealed locations within the trees (Gebauer and Moul 2001). This species has been confirmed as occurring in the Jordan River watershed, at least historically (Hardy 1949), and is occasionally sighted at the mouth of the Jordan River (J.Fenneman, pers. comm.). Although it has not been shown to nest in the watershed, it likely uses the freshwater and estuarine habitats for foraging on frogs, fish, and even small mammals.

Canada Goose (*Branta canadensis occidentalis*)

This dark, north-coastal subspecies of the common and well-known Canada Goose breeds locally in coastal areas of southeast Alaska, including the Copper River delta and some of the islands in the Gulf of Alaska and Prince William Sound, and winters in the Willamette Valley and lower Columbia River valley in southwest Washington and northwest Oregon (Mowbray et al. 2002). Although it doesn't breed in B.C., it does migrate through coastal areas of the province in both spring and fall and is fairly common along the west coast of Vancouver Island at this time. However, because of an overall low global population (fewer than 20,000 individuals as of 2001

[Mowbray et al. 2002]) and the importance of coastal British Columbia as a migration stopover site, it has been given a non-breeding rank on the provincial blue list. During its time in B.C., this subspecies relies heavily on coastal/marine habitats such as mudflats and estuaries and, as such, its occurrence in the Jordan River watershed would likely be peripheral. Nonetheless, the extensive areas of exposed mud, grassy meadows, and open water of the reservoirs could potentially provide stopover habitat for this subspecies during both spring and fall migration.

Northern Goshawk (*Accipiter gentilis laingii*)

This dark subspecies of the Northern Goshawk is restricted as a breeding bird to the Queen Charlotte Islands, Vancouver Island, the central and northern mainland coast of B.C., and some areas of southeastern Alaska (Squires and Reynolds 1997). Recent surveys have documented relatively few nests in B.C., such as surveys in the mid-1990s that documented approximately 30 nests between Vancouver Island and the Queen Charlotte Islands (Fraser et al. 1999). It is a bird of mature and old growth coniferous forests throughout its range (Fraser et al. 1999) and, as a result, often occurs at low densities and widely scattered across the landscape. It ranges far from the nest site during foraging trips, though, and can be found hunting prey such as medium-sized birds and mammals along forest edges and in riparian areas (Fraser et al. 1999). It is likely that this species breeds sporadically in the upper reaches of the Jordan River watershed, particularly in areas of older forest, and would subsequently be found hunting throughout much of the area. In addition, the southwestern portion of Vancouver Island is an important migratory route for raptors in the fall, and migratory Northern Goshawks would also benefit from the prey species that inhabit the Jordan River watershed.

Peregrine Falcon (*Falco peregrinus pealei*)

This subspecies designation refers to the dark forms of Peregrine Falcon that inhabit coastal regions of northwest Washington, British Columbia, and southern Alaska west to the Aleutian Islands (White et al. 2002). This subspecies of Peregrine Falcon is largely a bird of marine areas of the Pacific coast, usually nesting atop steep cliffs in close association with seabird colonies which provide the bulk of its diet (White et al. 2002). Migratory birds, though still largely associated with coastal areas, will range farther inland to areas where shorebirds and waterfowl congregate, such as lakes and agricultural fields. Because these prey species, particularly waterfowl, are known to inhabit the reservoirs of the Jordan River watershed it is likely that the area could provide habitat for the Peregrine Falcon on occasion. As well, as with Northern Goshawk, this species likely participates in the large migration of raptors that passes through southwestern Vancouver Island each fall and would benefit from any concentrations of prey species in the Jordan River watershed.

Sandhill Crane (*Grus canadensis*)

Although not known as a breeding species in the Jordan River watershed, either currently or historically, a large migration of Sandhill Cranes regularly passes through the region in spring and, especially, fall (Campbell et al. 1992; Tacha et al. 1992). During migration most Sandhill Cranes pass through southern Vancouver Island (including the Jordan River region) without stopping, heading instead for large stopover sites in Alaska, Washington, and Oregon (Tache et al. 1992). Occasionally, however, particularly during inclement weather conditions or during the night, small groups of individuals will spend some time on the ground where they require large, open habitats such as meadows, fields, and estuaries for feeding and resting (Tacha et al. 1992). It is suspected that some individuals occasionally roost in the Jordan River watershed during migration, particularly in the fall when water levels are low and there are extensive open areas around the reservoirs which provide the open habitats that these birds require.

Marbled Murrelet (*Brachyramphus marmoratus*)

The Marbled Murrelet is one of the flagship species of old-growth forests in the Pacific Northwest, including in British Columbia. It breeds along much of the coast of the region, from southern Alaska south to central California, where it requires stands of large, mature or old growth trees with an abundance of heavy, moss-laden limbs upon which to nest (Nelson 1997). Although it nests in forests, the Marbled Murrelet is in all other ways a typical seabird and nesting individuals will fly long distances daily to forage on fish in marine waters, returning to the nest site at dusk (Nelson 1997). Because virtually all old growth forests on southern Vancouver Island were harvested over the past 150 years, nesting populations of this species have become highly fragmented and, in many cases, restricted to higher elevation forests which have likely escaped harvest because of the difficulties associated with reaching them. Anecdotal reports exist, however, of breeding Marbled Murrelets in the upper Jordan River watershed and it is possible that San Juan Ridge, in particular, may hold several pairs.

Short-eared Owl (*Asio flammeus*)

Occurring on all continents except Australia and Antarctica, the Short-eared Owl is one of the most cosmopolitan of all bird species (Wiggins et al. 2006). Throughout its vast range it is a bird of open, grassy habitats throughout the year, nesting on the ground in meadows, grasslands, marshes, estuaries, tundra, and recently cleared forests (Wiggins et al. 2006). Its dependency on open habitats has resulted in noticeable population reductions in many regions, including British Columbia, where much of this habitat has been developed or altered in other ways which render it unsuitable for this species (Wiggins et al. 2006). The Short-eared Owl is primarily a fall migrant on southern Vancouver Island, although it occasionally occurs during the winter and spring (Campbell et al. 1992). The open, grassy meadows present around the fringes of the reservoirs in the Jordan River watershed provide suitable, although limited, habitat for this species and may occasionally be utilized by migratory individuals.

Band-tailed Pigeon (*Patagioenas fasciata*)

This shy, forest-dwelling pigeon is widespread along the west coast of Vancouver Island and has been recorded in the Jordan River watershed, where it almost certainly breeds, on many occasions between April and October (J.Fenneman, pers. comm.). It generally frequents low to middle elevation coniferous and mixed forests in our region during the breeding season, especially in areas with an abundance of fruiting shrubs, with some flocks move to higher elevations in late summer and fall in preparation for migration (Keppie and Braun 2000). The depressed populations of this species in the Pacific Northwest, and its subsequent placement on the provincial blue list, is largely the result of overharvest during the 1900s; harvest of this species in British Columbia has been closed since the 1990s as a result of these declines (Keppie and Braun 2000).

Western Screech-Owl (*Megascops kennicottii kennicottii*)

This coastal subspecies of the Western Screech-Owl occurs along the mainland coast of British Columbia, as well as on Vancouver Island and south through much of the western United States and northern Mexico (COSEWIC 2002a). In the Pacific Northwest, this species is associated with a variety of low-elevation forests (coniferous, mixed, deciduous), especially in more open forest types and in riparian woodlands (COSEWIC 2002a). It is dependent on an abundance of snags which provide a suitable location for nest cavities (COSEWIC 2002a). Although it was formerly common throughout Vancouver Island, and historically the most common small owl on the southeast coast of the island, populations of the Western Screech-Owl have plummeted during the past 20 years from Campbell River south to Sooke (COSEWIC 2002a). The species is still relatively common on northern and western Vancouver Island, and near or at historic levels along the mainland coast north of Vancouver Island, but a combination of development, forestry practices, and (most importantly) heavy predation by the recently-arrived Barred Owl (*Strix varia*) have contributed to massive declines throughout the Georgia Depression (COSEWIC

2002a). Nonetheless, this species still occurs in the Jordan River watershed (R.Toochin, pers. comm.) and has been known in the watershed since as early as the 1940s (Hardy 1949).

Northern Pygmy-Owl (*Glaucudium gnoma swarthi*)

This subspecies of the Northern Pygmy-Owl, which is noticeably darker than other subspecies, is endemic to Vancouver Island and occurs nowhere else in the world (Darling 2003). It is generally uncommon throughout the island, from low elevation forests to subalpine areas, and occurs in a wide variety of habitat types including dense old-growth coniferous forests, open woodlands, young regenerating forests, and even recent clearcuts (Darling 2003). The species occasionally ventures into suburban habitats during the winter and is sometimes drawn to bird feeding stations where it preys on the small songbirds that are attracted by the station (J.Fenneman, pers. comm.). Some localized declines of this subspecies have been noted on Vancouver Island, such as in the Comox area, and overall island-wide declines are suspected (Darling 2003). This species has been historically recorded in the Jordan River watershed (Hardy 1949) and undoubtedly still occurs as much suitable habitat for the species remains.

Barn Swallow (*Hirundo rustica*)

One of the most widespread bird species in the world, occurring on all continents except Antarctica, this species is common throughout most of North America (Brown and Brown 1999). This species nests largely on man-made structures such as buildings, barns, and bridges, although it will also place its mud nest in natural locations such as cliffs (Brown and Brown 1999). Foraging birds occur in a wide range of open habitats, including agricultural areas, beaches, meadow, estuaries, ponds, and lakes. Although the species has been increasing in the United States since the 1960s, populations throughout Canada have been declining during the same period (Brown and Brown 1999). Some sources have suggested that these northern populations are more affected by adverse weather conditions and therefore show a greater degree of population fluctuation than populations to the south (Brown and Brown 1999). Nonetheless, the Barn Swallow still remains a common summer inhabitant of southern Vancouver Island and, although it has not been formerly recorded, almost certainly occurs in the Jordan River watershed.

Pine Grosbeak (*Pinicola enucleator carlottae*)

Most individuals of this dark coastal subspecies of the Pine Grosbeak breed on the Queen Charlotte Islands, although localized breeding may occur on the northern mainland coast (Adkisson 1999) and northern Vancouver Island (G.Monty, pers. comm.). This species requires open boreal or montane/subalpine coniferous or mixed forests for breeding, with coastal populations often occurring in areas of alder (*Alnus* sp.), especially above treeline (Adkisson 1999). Wintering individuals wander widely, however, and are often found in parks, wooded suburban areas, lowland forests, and other habitats not frequented by breeding birds, particularly where there is an abundance of food plants such as mountain-ash (*Sorbus* sp.), ash (*Fraxinus* sp.), and maple (*Acer* sp.) (Adkisson 1999). This species is rarely encountered on southern Vancouver Island at any time of year, although the number of individuals or this highly irruptive species recorded in the region does vary significantly from year-to-year. This species has been confirmed in the lower Jordan River reservoir as recently as the winter of 2006-2007 (J.Fenneman, pers. comm.) and is likely present on a semi-regular basis in very small numbers. It is possible that the subspecies recorded in the region was not *carlottae* but instead was a more widespread interior subspecies such as *montanus*, or even the subspecies *flammula* which breeds in southeast Alaska and northwest British Columbia; however, because the subspecific identity of the birds was not determined, they are assumed to have possibly belonged to the subspecies *carlottae*.

Red-legged Frog (*Rana aurora*)

This blue-listed species occurs widely, but locally, in southwestern British Columbia, including all of Vancouver Island (Matsuda et al. 2006). The Red-legged Frog breeds largely in forested habitats such as in shallow forest pools, slow woodland streams, and along the shallow edges of forested lakes and ponds (Matsuda et al. 2006). It wanders widely as an adult, often venturing far from water into moist, forested upland habitats where it feeds on insects and other small invertebrates (Matsuda et al. 2006). This species has been recorded on a number of occasions in the Jordan River watershed (Hardy 1949; Beauchesne and Cooper 2004; BC CDC 2007) and appears to breed in most or all suitable habitat within the watershed.

Western Toad (*Bufo boreas*)

This widespread and formerly common species has recently undergone significant population reductions throughout its Canadian and United States range, and is now classified as a species of Special Concern by COSEWIC (COSEWIC 2002b). Populations on the southwest coast of British Columbia, including Vancouver Island, appear to be experiencing some of the sharpest declines in the country (COSEWIC 2002b). Although a single cause for the decline has not been discovered, a number of causes such as habitat loss and subsequent population fragmentation, disease, and deformities (COSEWIC 2002b). This species requires small pools or ponds, preferably with a sandy bottom, for breeding and wanders widely in upland areas as an adult, returning to traditional breeding ponds to lay their eggs (Matsuda et al. 2006). Recent targeted surveys for this species in the Jordan River watershed have been unsuccessful in locating it, although the species was historically known to be common. For example, Hardy (1949) lists the Western Toad as "by far the commonest amphibian encountered" in upper portions of the watershed. By comparison, Beauchesne and Cooper (2004) failed to find a single individual during amphibian surveys in the watershed, and anecdotal reports from other sources suggest a similar absence of this species (V.Hawkes, pers. comm.).

Cutthroat Trout (*Oncorhynchus clarki clarki*)

This trout is widespread as a native species throughout much of northwestern North America, including western Canada, and occurs in both resident freshwater and migratory anadramous populations (Fishbase 2007). It is restricted to watersheds which drain into the Pacific Ocean from south-central Alaska to northern California (Fishbase 2007; BC CDC 2007), and is usually found within 150 km of the ocean (BC CDC 2007). It typically occurs in small, low gradient coastal streams and estuarine habitats with a water temperature below 18^{0}C (BC CDC 2007). Cutthroat Trout have been documented throughout the Jordan River system, including the mainstem Jordan River, Diversion Reservoir, Bear Creek Reservoir, and Weeks Lake (Westcoast Flyfishers 2007).

Invertebrates

Dun Skipper (*Euphyes vestris*)

This small, dark, provincially blue-listed butterfly is generally scarce wherever it occurs in British Columbia. The larvae of this species rely on stands of sedge (*Carex*) or *Cyperus* as a food plant, while the adults are typically found in nearby moist to mesic, grassy areas such as lawns or meadows (Guppy and Shepard 2001). Records of Dun Skipper on Vancouver Island are restricted to a few areas along the dry southeastern coast from Comox south to Victoria (Guppy and Shepard 2001). However, the larval food plants are also well established within the Jordan River watershed, and the presence of several other butterfly species that are more typical of the east coast of the island in the region (ie. Moss's Elfin) suggests the possibility of this species locally extending its distribution into the Jordan River watershed.

Johnson's Hairstreak (*Callophrys johnsoni*)

This small butterfly is extremely rare in Canada and is known from only a handful of small extant colonies on the Lower Mainland between Vancouver and Hope (Guppy and Shepard 2001). There are at least three historical records from southern Vancouver Island, however, which suggests that this scarce species may still retain a toehold in that region (Guppy and Shepard 2001). The larvae of Johnson's Hairstreak are dependent on dwarf mistletoes (*Arceuthobium*) growing on old or mature hemlock trees (*Tsuga heterophylla*) (Guppy and Shepard 2001). As a result of these extremely narrow ecological requirements, as well as the extensive overharvest of mature coniferous trees across all of southern Vancouver Island and the use of *Bt* spray in the eradication of introduced Gypsy Moths, populations of this already localized species have been substantially reduced in British Columbia (Guppy and Shepard 2001). Johnson's Hairstreak is considered to potentially occur in the Jordan River watershed based on its historical occurrence in adjacent areas areas (Cowichan River watershed) and the presence of scattered remnant mistletoe populations at a number of places on southern Vancouver Island.

Moss's Elfin (*Callophrys mossii mossii*)

This coastal subspecies of Moss's Elfin is restricted in British Columbia to the dry southeastern portion of Vancouver Island and throughout the Gulf Islands (Guppy and Shepard 2001). The larvae of this species are intimately dependent on broad-leaved stonecrop (*Sedum spathulifolium*) as a food plant. This plant, and subsequently the Moss's Elfins that depend on it, are largely restricted to the dry, rocky habitats that abound on southeastern Vancouver Island. There are a few peripheral records away from this zone, however, including at least one which may be within the Jordan River watershed. As a result, Moss's Elfin is considered a potential candidate for occurring in the Jordan River watershed, although spring surveys (April-May) would be needed to detect the presence of this early-flying butterfly.

Western Pine Elfin (*Callophrys eryphon sheltonensis*)

The coastal subspecies of this small butterfly is restricted in Canada to southeastern Vancouver Island, the Gulf Islands, and the Lower Mainland. It is dependent on Shore Pine (*Pinus contorta* var.*contorta*) and, to a lesser extent, introduced ornamental pines as a larval food plant (Guppy and Shepard 2001). Shore Pine has a localized distribution of southern Vancouver Island and, not surprisingly, so does the Western Pine Elfin. This species can occur anywhere where its larval food plant grows, however, and its presence in outer coastal areas of western Washington indicates that it can occur in habitats that are away from the dry, rainshadow zone where it has been documented on Vancouver Island. Should any Shore Pines be found growing in the Jordan River watershed, it is possible that this attractive butterfly could be using them as a host plant.

Boisduval's Blue (*Plebejus icarioides blackmorei*)

Although the interior subspecies of this butterfly are widespread and common in British Columbia, the coastal subspecies *blackmorei* has been significantly impacted by human encroachment on its habitat. The larvae of this butterfly feed on Large-leaved Lupine (*Lupinus polyphyllus*) and, as a result of agricultural and urban development on southeastern Vancouver Island (where the only populations of this subspecies occur in Canada), the distribution of this plant has been severely compromised to the point that no low-elevation populations of Boisduval's Blue have existed since the 1960s (Guppy and Shepard 2001). Away from the effects of development and exotic plants, higher elevation populations of this butterfly still exist between Port Alberni and Victoria, and some populations may potentially occur in the Jordan River watershed, particularly high elevation areas such as San Juan Ridge.

Zerene Fritillary (*Speyeria zerene bremnerii*)

This coastal subspecies of Zerene Fritillary is locally and sporadically distributed in dry to mesic, open meadows on southeastern and northern Vancouver Island, the Gulf Islands (Saltspring Island), and the Lower Mainland, although the latter area likely does not have any sustaining, perennial populations (Guppy and Shepard 2001). The larvae of this species, like other fritillaries, feed on violets (*Viola*) (Guppy and Shepard 2001). This species has been recorded from adjacent watersheds such as the Cowichan River watershed, and as violets are likely widespread and common in the Jordan River watershed, it is possible that this species may occur, at least occasionally, within the boundaries of the Jordan River watershed.

Western Pondhawk (*Erythemis collocata*)

This medium-sized, brightly coloured dragonfly is distributed locally in southern British Columbia, where it is restricted to southeastern Vancouver Island, the southern mainland coast, and one population in the Okanagan Valley (Cannings 2002; Klinkenberg 2006). It is characteristically found in and around ponds and marshy lakes, particularly in association with floating plants (Cannings 2002). Although it is distributed locally within the dry southeastern portion of the island, recently discovered populations away from this region (ie. Courtenay) (J.Fenneman, pers. comm.) suggest the possibility of a wider distribution in moister climates, such as those of the Jordan River watershed.

Blue Dasher (*Pachydiplax longipennis*)

The Blue Dasher, a relatively small dragonfly, is locally distributed in south coastal British Columbia and the Okanagan Valley (Cannings 2002). Although it is most abundant in the drier climates of southeastern Vancouver Island, the species has also been recorded on northern and western portions of the island in decidedly wetter and cooler climates (Klinkenberg 2006). This species inhabits a wide variety of freshwater habitats but is most common in areas with an abundance of emergent vegetation (Canning 2002). The Blue Dasher is considered a potential inhabitant of the Jordan River watershed based on its presence elsewhere along the west coast of Vancouver Island.

Autumn Meadowhawk (*Sympetrum vicinum*)

This small, red dragonfly is uncommon and local across southern British Columbia, including areas of southern Vancouver Island (Cannings 2002; Klinkeberg 2006) where the distribution of populations is closely correlated with the warm, dry southeastern lowlands (Klinkenberg 2006). This species breeds in ponds, slow streams, and lakes where there is prolific emergent vegetation (Cannings 2002). Mapped occurrences of this species approach, if not enter, the Jordan River watershed (Klinkeberg 2006), and as appropriate habitat is known to exist in the watershed, it is suspected that the area may harbour populations of this uncommon dragonfly.

Western Thorn (*Carychium occidentale*)

This tiny land snail is restricted to coastal habitats from southern Vancouver Island and the Lower Mainland south to northern California as well as inland in Washington and Idaho (Forsyth 2004). Within this region it occurs sporadically in the leaf litter of rich, relatively undisturbed low-elevation forests, usually in areas with abundant Bigleaf Maple (*Acer macrophyllum*) in the overstory (Forsyth 2004). The forests inhabited by this snail in British Columbia all contain a deep, rich, moist litter layer and are not subjected to annual flooding (BC CDC 2007). The effects of logging practices and human development on these forests on Vancouver Island has likely impacted populations of Western Thorn on Vancouver Island and this species is on the provincial blue list as a result (BC CDC 2007). Although the nearest known populations are in the Gulf Islands, the Jordan River watershed contains areas where Bigleaf Maple grows in association with other tree species and, as such, the area may contain small populations of this rare snail.

Evening Fieldslug (*Deroceras hesperium*)

This rare slug is known in Canada from only a single historical (1887) specimen from Comox on eastern Vancouver Island (BC CDC 2007). Within its native range, which extends south along the coast to Oregon, it is characteristic of moist forests in the coastal fog-belt as well as mature Douglas-fir forests, the destruction of which may have resulted in significant population reductions on Vancouver Island (BC CDC 2007). Specific habitats inhabited by this species in the Pacific Northwest include low-elevation mixed forests with high humidity and continuous understory cover in Washington, although the general ecology of this localized species is very poorly known throughout its range (Forsyth 2004; BC CDC 2007). Although this species is certainly extremely rare, or possibly extirpated, on Vancouver Island, appropriate habitat remains in the Jordan River watershed. Terrestrial molluscs have not been incompletely surveyed in the area, it is therefore possible that this species occurs in the watershed.

Dromedary Jumping-slug (*Hemphillia dromedarius*)

This globally rare, poorly known slug has a highly restricted geographic range, being confined only to southern Vancouver Island and fewer than 25 known sites in northwestern Washington (COSEWIC 2003a). Within the Vancouver Island portion of its range, it is currently known from only 6 locations from Kennedy Lake south to Shawnigan Lake (COSEWIC 2003a). This species occurs at very low densities in mature and old-growth coniferous forests at low to upper elevations, especially in areas with abundant large woody debris on the forest floor, and is therefore highly impacted by logging practices (Forsyth 2004). The possibility of this species occurring in the Jordan River watershed is based on the presence of some areas of remnant older forests in the upland portion of the watershed, as well as a nearby occurrence of *H. dromedarius* southeast of Port Renfrew which indicates a presence in the region.

Warty Jumping-slug (*Hemphillia glandulosa*)

Like the previous species, this slug is globally rare and is restricted to the Pacific Northwest from southern Vancouver Island south to northwest Oregon (COSEWIC 2003b). It is slightly more abundant in B.C. than *H. dromedarius*, however, and is know from at least 14 sites on southern Vancouver Island from the Nanaimo River south to near Sooke (COSEWIC 2003b). On Vancouver Island, this species occurs sporadically in moist, low-elevation to montane forests (coniferous, deciduous, or mixed) where it tends to frequent riparian areas with abundant woody debris and lush vegetation (COSEWIC 2003b; Forsyth 2004). The Warty Jumping-slug tends to occur at higher densities than the Dromedary Jumping-slug throughout its range, and also inhabits young to middle-aged stands as well as older forests (COSEWIC 2003b). This species is known from at least 4 sites along the coast between Port Renfrew and Sooke and as a result it is considered likely that undiscovered populations occur within the Jordan River watershed.

Pacific Sideband (*Monadenia fidelis*)

This large coastal snail, which occurs in southeast Alaska as well as along the Pacific coast of the Pacific Northwest (Forsyth 2004), is restricted in British Columbia to Vancouver Island, the Gulf Islands, and the Lower Mainland (BC CDC 2007). This species inhabits a wide range of habitat types, including coniferous, mixed, and deciduous forests, open woods, and even open grassy sites (Forsyth 2004). Although fairly common within its BC distribution, this snail occurs largely in areas where there is considerable pressure on its remaining haunts for urban development. This species has been positively recorded in the Jordan River watershed on at least one occasion and likely occurs throughout the lower elevations of the watershed.

Threaded Vertigo (*Nearctula* sp.1)

This species is currently undescribed and, to date, has been found at only 2 locations in southwest BC (eastern Vancouver Island [Union Bay] and the Sunshine Coast [Egmont]) (BC CDC 2007). Elsewhere, this taxon has been recorded south along the Pacific coast to central California (Forsyth 2004). The Threaded Vertigo is restricted to rich, continually moist, mature or old-growth deciduous and mixed forests where it occurs within the leaf litter (Forsyth 2004; BC CDC 2007). Clearcut logging practices have undoubtedly impacted this species because of its dependence on moist, mature forests (BC CDC 2007). Although it has not been detected in the vicinity of the Jordan River watershed, this tiny species is easily overlooked. Furthermore, because targeted surveys have not occurred in the watershed and because appropriate habitats exist, it is considered at least potentially possible that this species inhabits the watershed.

Broadwhorl Tightcoil (*Pristiloma johnsoni*)

This small, rare snail is known from only 3 sites in southwest British Columbia, including 2 locations on Vancouver Island (BC CDC 2007), and also ranges south along the coast to Oregon (Forsyth 2004). This species occurs sporadically throughout its range, where it can be found locally in the leaf litter of mature or old-growth coniferous, mixed, or deciduous forests from low to subalpine elevations (Forsyth 2004; BC CDC 2007). This species may exist in small numbers in remnant older forests within the Jordan River watershed, which has not been adequately surveyed for terrestrial mollusks.

Blue-grey Taildropper (*Prophysaon coeruleum*)

Only discovered in Canada in 2002 on extreme southern Vancouver Island (Metchosin), this small slug has been documented at only 6 sites distributed between the Sooke River and Saanich Peninsula (COSEWIC 2006). The Blue-gray also occurs south along the Pacific coast to extreme northern California, with an isolated population in northern Idaho (COSEWIC 2006). This species characteristically inhabits moist, mature or old-growth mixed forests with a significant proportion of Bigleaf Maple in the overstory (Forsyth 2004) and an abundance of Sword Fern (*Polystichum munitum*) in the understory (COSEWIC 2006). Although unlikely, there is potential for this species to occur within the mature mixed woodlands of the Jordan River watershed, especially considering the relatively close proximity of the Sooke River site.

Scarletback Taildropper (*Prophysaon vanattae*)

More common and widespread than the previous species, the Scarletback Taildropper is restricted in British Columbia to Vancouver Island and the upper Fraser River Valley (Chilliwack) (BC CDC 2007). The species also ranges south along the coast to northwest Oregon (Forsyth 2004). It is largely an arboreal species and is found primarily on the moss-covered branches of trees and shrubs of coastal mixed forests (Forsyth 2004) and is susceptible to being impacted by logging practices (BC CDC 2007). It is considered likely that this slug occurs in the Jordan River watershed based on the species' distribution and the habitats that are present within the watershed.

Pacific Vertigo (*Vertigo andrusiana*)

This very small snail, which ranges south to Oregon and California, is known in British Columbia from only 4 sites, all on the Saanich Peninsula (3 sites) or Gulf Islands (Mayne Island) (BC CDC 2007). It is a species of coastal lowland forests throughout its range, and its localized distribution in British Columbia places it in danger of significant habitat loss (BC CDC 2007). It is possible that populations of this easily overlooked species occur more widely than the few confirmed records indicate, and it is therefore considered a potential candidate for occurring in the Jordan River watershed.

Black Gloss (*Zonitoides nitidus*)

This snail is known in BC from only 8 occurrences in the Okanagan Valley, Lower Mainland, and Vancouver Island (BC CDC 2007), although it ranges widely throughout the northern hemisphere (Forsyth 2004); some authorities have suggested that Pacific coast populations may be introduced (Forsyth 2004). This species lives under wood, rocks, and vegetation in wet, marshy habitats and along rivers, lakes, sloughs, and ponds (Forsyth 2004). The widespread alteration and destruction of wetlands in British Columbia places this species in direct danger of habitat loss (BC CDC 2007). Appropriate habitat exists in much of the Jordan River watershed, however, and it is possible that the species exists there.

Vascular Plants

Due to the limited survey of vascular plants in the watershed, as well as the large number of additional potential species, only the taxa that are known to occur in the watershed will be discussed.

Avalanche Lily (*Erythronium montanum*)

This beautiful montane lily is known on Vancouver Island only from the area of San Juan Ridge along the northern border of the Jordan River watershed (British Columbia Conservation Data Centre 2007). Elsewhere in Canada, it has been found only in the area of Mount Waddington on the southern mainland coast of British Columbia (BC Conservation Data Centre 2007), although anecdotal reports exist for northern Vancouver Island (J.Fenneman, pers. comm.). This species occurs in moist meadows and open forests in montane and subalpine regions (Douglas et al. 2001a) where it flowers soon after the spring snowmelt (Allen and Robertson 2003). Although not expected to occur in the lower elevation portions of the watershed, it may occur elsewhere at higher elevations and, due to its status as a narrow Pacific Northwest endemic (Allen and Robertson 2003), its presence in the region is noteworthy.

Smith's Fairybells (*Prosartes smithii*)

This rare lily is characteristic of moist, shady forests and streambanks at low elevations on southwestern Vancouver Island (Douglas et al. 2001a) and has been documented from several locations in the Jordan River watershed (BC Conservation Data Centre 2007). Aside from a single historical occurrence farther north along the west coast of Vancouver Island at Nootka Sound (BC Conservation Data Centre 2007), this species is known nowhere else in Canada (Ulrech 2003). Its preference for cool, shady coniferous forests and riparian areas makes it particularly sensitive to upland forest harvest and reservoir creation, and as a result has likely decreased significantly in abundance following the extensive landscape alterations that have occurred over the past 100 years in the Jordan River watershed.

Nodding Semaphoregrass (*Pleuropogon refractus*)

This localized grass is found in Canada only along western Vancouver Island, from Cape Scott south to Victoria, and on the southern mainland coast north of Vancouver (BC Conservation Data Centre 2007) where it inhabits cool, moist, shady low elevation habitats such as bogs, streambanks, lakeshores, floodplains, thickets, and forest openings (Douglas et al. 2001b). Like *Prosartes smithii*, its presence in riparian areas and shady lowland habitats places it in direct conflict with timber extraction and reservoir creation activities and, as such, it has likely decreased in abundance in the area over the past 100 years.

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Appendix C. Engineering schematics (plan and profile views) of the constructed wetlands adjacent to Diversion Reservoir.

Appendix D. Financial Statement Form.

BC HYDRO FISH & WILDLIFE BRIDGE COASTAL RESTORATION PROGRAM

BRIDGE COASTAL RESTORATION PROGRAM			**Project No. 06.W.JOR.01**	
	BUDGET		**ACTUAL**	
INCOME	**BCRP**	**Other**	**BCRP**	**Other**
Total Income by Source				
Grand Total Income (BCRP + Other)	$ 82,659.00		$ 82,659.00	
EXPENSES				
Project Personnel				
Wages				$ 47,727.82
Consultant Fees				$ 31,313.53
Technicians				
Materials & Equipment				
Equipment Rental				
Materials Purchased				$ 962.47
Travel Expenses				$ 2,225.09
Permits				
Administration				
Office Supplies				$ 408.29
Photocopies & Printing				$ 21.80
Postage				
Travel & Living				
Total Expenses				
Grand Total Expenses	$ -		$ 82,659.00	
BALANCE (Grand Total Income - Grand Total Expenses)	$ -		$ -	