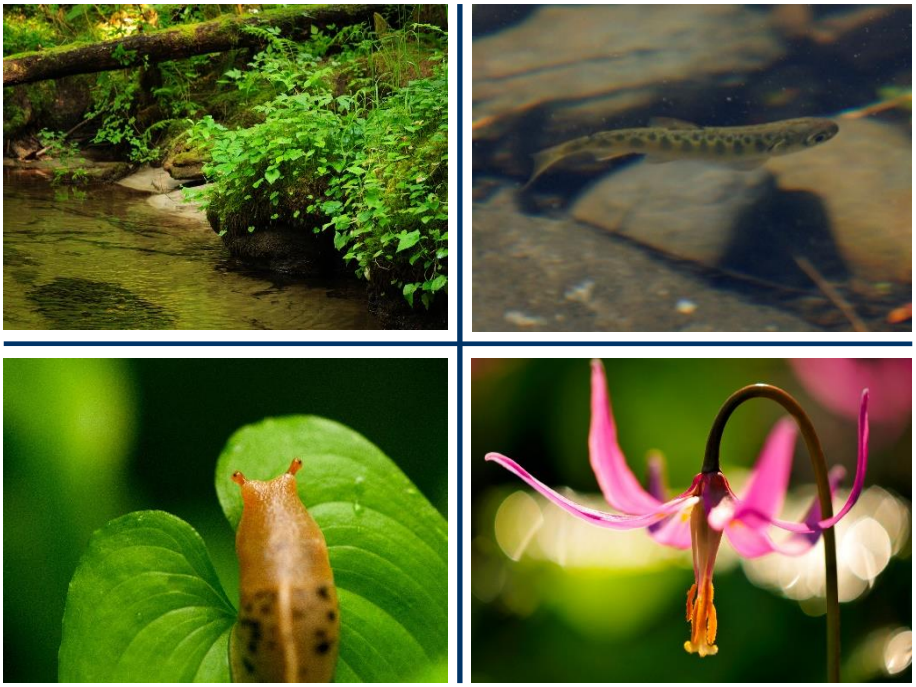
Nunns Creek

Ecological Inventory



Prepared for:

City of Campbell River
301 St. Ann's Road
Campbell River B.C. V9W 4C7

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Prepared by:

Ecofish Research Ltd.[1],

Latitude Conservation Solutions Company[2] &

A-Tlegay Fisheries Society[3]

Latitude Conservation Solutions Company

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For inquiries contact: Technical Lead documentcontrol@ecofishresearch.com 250-334-3042

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Certification: *stamped version on file*

Senior Reviewer

Andrew Harwood, Ph.D., R.P. Bio. No. 1652

Fisheries Scientist/Project Manager

Technical Lead

Leah Ballin, R.P.F. No. 4873, R.P. Bio. No. 2537

Wildlife Biologist

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EXECUTIVE SUMMARY

Nunns Creek is an ecologically valuable urban salmon stream located in the City of Campbell River on the mid-east coast of Vancouver Island, BC. The City of Campbell River is currently developing a master plan for Nunns Creek Park and its adjacent natural areas (the study area). The natural areas include approximately 15 hectares of the lower reaches of Nunns Creek, including wetlands and riparian floodplain forests, whereas Nunns Creek Park is comprised of baseball fields and recreational infrastructure. The natural areas are owned by the Nature Trust of British Columbia and leased to the City of Campbell River to manage as a nature preserve for their intrinsic natural ecosystem values, as well as for the enjoyment of the public. This report provides a history of the area, current ecological information, a conservation value analysis, and management recommendations in support of the master plan and subsequent management planning processes.

This ecological inventory classified the landscape into discrete Ecological Units by synthesizing background information and field data collected in 2016. The inventory characterizes ecosystems and fish and wildlife habitat, and documents native and invasive species, canopy cover and the locations of stream channels and other features. This information was compared to the historic condition, used to inform management objectives and activities, and can be used for monitoring future change.

The background data and field-based inventory were used to describe the study area in terms of its relative ecological significance and condition, which were subsequently used to determine the relative conservation value of each Ecological Unit within the study area.

Fifteen Ecological Units, covering 15.1 ha, were delineated in the study area. These were grouped into four broad ecosystem types including: marsh/open water complexes (2.7 ha, 18%), swamp/open water complexes (4.6 ha, 30%), deciduous forest (1.9 ha, 12%) and mixed deciduous and coniferous riparian and upland floodplain forest (6.2 ha, 40%). Provincially Blue-listed ecosystems occupied 9.8 ha (63%) of the study area, followed by Red-listed (4.9 ha, 32%), Yellow-listed (0.7 ha, 5%) and exotic (0.04 ha, 0.2%) ecosystems.

The forests are recovering from mid-century selective logging and maintain some old growth characteristics including old growth trees, large coarse woody debris and canopy openings. The open water and marsh wetlands are newer components of the ecosystem that are expanding with increased beaver activity. Data were collected within representative Wildlife Habitat Plots in each of the four ecosystem types to characterize the site, substrate, vegetation and wildlife habitat attributes. Cumulative animal and plant species lists from the plots, inventory work and background information review confirmed the presence of 48 animal and 111 plant species in the study area. Two of the wildlife species and 43 of the plant species are not native to BC.

The fish habitat values of 2,336 m of Nunns Creek were mapped. Riffles were the dominant habitat unit (97%) broken up by a few pools. The stream gradient is very low and the stream lacked surface

turbulence typical of riffle habitat. The steepest reach at the northern end of the study area was 0.5% and the average gradient was 0.08%. The stream bed was dominated by silts and fines that embedded small patches of gravel that would otherwise provide suitable anadromous and resident salmonid spawning habitat. Functional large woody debris was located in all stream sections. The number of pieces of large wood recorded is similar to that prescribed for a restoration project 14 years ago (Komori Wong 2002). The largest wood was located in the more defined mid-northern section of the creek and was placed there as part of a restoration project. The primary channel in the mid-southern portion of the property has shifted west over the past two decades and now flows through a network of low gradient and poorly defined channels that bisect the large forested swamp in the middle of the property. No barriers were confirmed although beaver dams may restrict fry and smolt migration. However, the greatest temporal restriction to fish movement is low to no flows.

Several invasive plant species were detected in the study area or on adjacent lands within Nunns Creek Park. This includes four provincially Noxious species (*Weed Control Act*), four species listed as "contain" and nine species listed as "control" by the Coastal Invasive Species Committee (CISC 2016), as well as seven of the top ten invasive plant species identified by the Greenways Land Trust for management (CISC 2015).

Anthropogenic features, including 1,803 m of trails, 190 m of unauthorized trail, eleven bridges, and culverts, storm drains, signage and beaver baffles were mapped and described. The condition of this infrastructure ranged from good to poor.

An assessment of the relative sensitivity of each Ecological Unit to human disturbance was also completed. The sensitivity analysis and conservation values were then used to determine the overall management importance of each Ecological Unit. In this manner, the areas with highest conservation values and highest sensitivity to human disturbance are identified such that incompatible human uses within this important natural area can be limited.

Active management of the study area is recommended to achieve the City of Campbell River's objectives for Nunns Creek specifically, and for parks and natural environments in the municipality. The background information synthesis, ecological inventory, conservation assessment and management recommendations provided herein should be used as a guide to inform management planning and implementation, and facilitate achievement of the City's broader goals to protect and restore environmentally sensitive areas, preserve ecological function, and support a community with awareness and understanding of ecological principles.

Management recommendations are provided for issues and challenges concerning Nunns Creek, beavers, urban forest canopy, invasive species, anthropogenic features and access, educational opportunities and watershed planning. These recommendations focus on ensuring the long-term viability of natural values and opportunities for the public to enjoy these values and engage in nature-based education within the City of Campbell River.

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1. INTRODUCTION AND OBJECTIVES

Nunns Creek is an urban stream located in the City of Campbell River (the City) on the mid-eastern coast of Vancouver Island, BC, that flows into the Campbell River estuary and out to Discovery Passage. The stream is surrounded by urban development, as well as greenspaces that include conservation lands and Nunns Creek Park. The City of Campbell River is currently developing a master plan for Nunns Creek Park and the adjacent conservation lands and requires an ecological inventory to inform the planning process. The Nunns Creek Ecological Inventory (the Project) is the subject of this report.

1.1. Study Area

The study area for the Nunns Creek Ecological Inventory is bounded by 16th Avenue to the north and Homewood Rd. to the south (Map 1). It is comprised of three parcels of private land and an undeveloped road right of way (Table 1). Two of these parcels are owned by The Nature Trust of British Columbia (TNTBC) and are under lease to the City of Campbell River. The third parcel is owned by the Province of British Columbia and administered by the Ministry of Transportation and Infrastructure (MoTI). No management agreement is currently in place between the Province and the City regarding its use. The road right of way extends from the end of 12th Avenue into the study area. It is owned by the City of Campbell River.

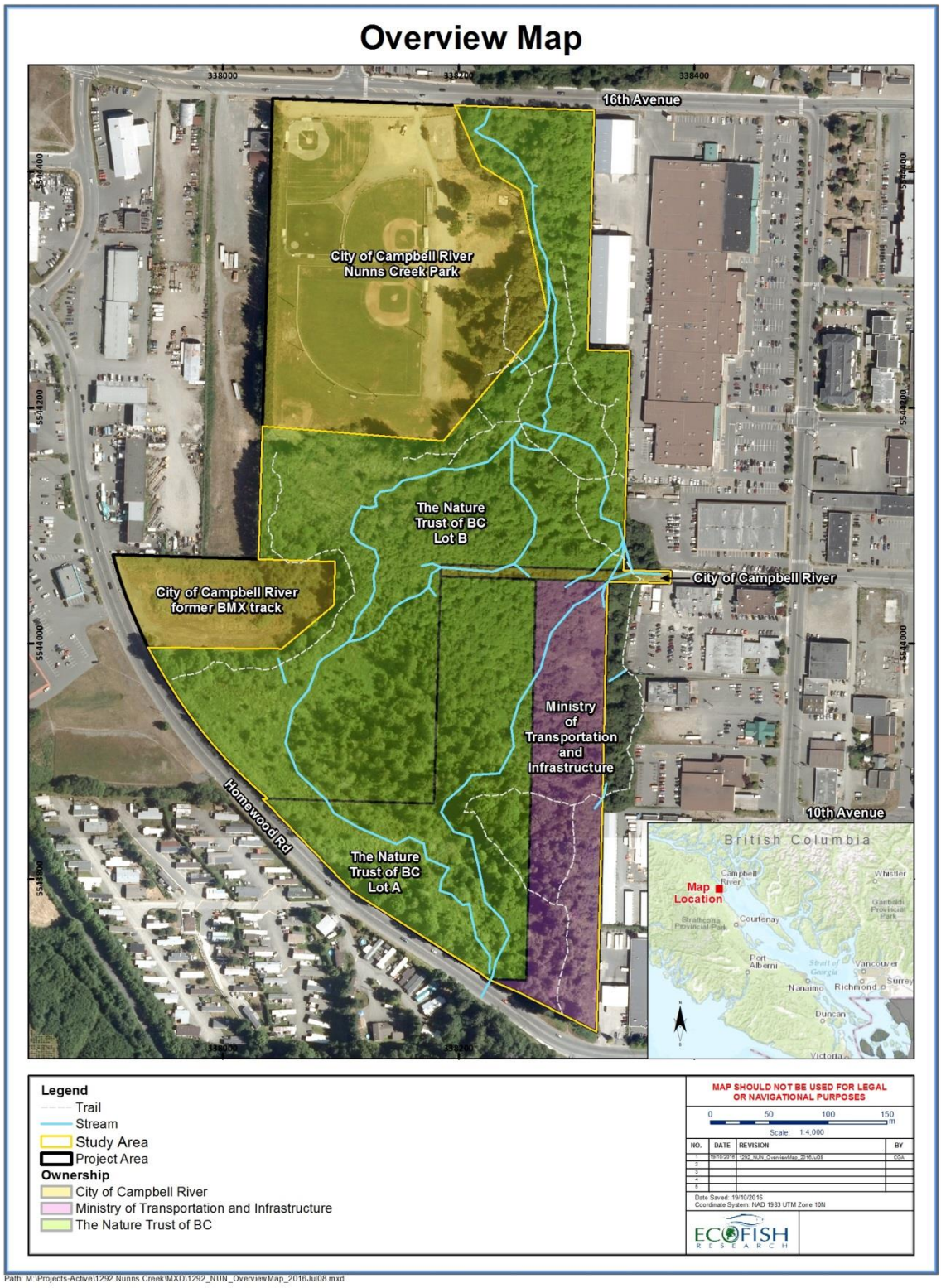
Table 1. Study area parcel descriptions.

PID	Legal Description	Area (ha)	Owner	Zoning
017-753-201	Lot B DL 1417 & DL 1420 & DL 1421, Sayward Land District, Plan VIP53635	8.92	The Nature Trust of BC	PA-2
002-112-272	Lot A of DL 1416 & DL 1418, Sayward Land District, Plan 27478	3.61	The Nature Trust of BC	PA-2
009-678-255	DL 1418 & DL 1416, Sayward Land District, Plan 37764 part shown in red O-I-C 1167	2.25	Crown Provincial	PA-2

A master planning process for the study area is underway, which will include two adjacent lots which are not included in this ecological inventory. The first, Nunns Creek Park, is primarily comprised of baseball fields, logger sports facilities, a skateboard park and associated amenities (Map 1). The

second is a cleared, undeveloped lot which was formerly the site of a BMX bike track. Both are owned by the City of Campbell River.

Map 1. Overview map.



1.2. Project Objectives

The City of Campbell River's Sustainable Official Community Plan (2012) includes the following desired outcomes for parks and natural environments:

a. Environmentally sensitive areas such as streams, wetlands, estuaries and the foreshore and their supporting upland riparian habitats are preserved, protected and restored where possible;

b. The ecological function of terrestrial, freshwater and marine ecosystems is preserved and restored; and

c. Citizens have awareness and understanding of ecological principles that govern the health and functioning of the bioregion.

Management of the study area can support these higher-level objectives by: protecting and restoring streams, wetlands and riparian areas, improving the ecological functions of its terrestrial and freshwater ecosystems, improving access to nature and enhancing educational opportunities available to citizens regarding ecological principles. The purpose of the Project is to provide background information, ecological data and recommendations that lay the foundation for subsequent management planning and implementation actions in support of these higher-level objectives.

The objectives of the Nunns Creek Ecological Inventory are to:

1. Conduct a comprehensive review of background ecological and human use information of the study area;
2. Conduct an ecological inventory of the study area;
3. Complete an analysis of the conservation values and sensitivity to human uses within the study area; and
4. Provide recommendations to support higher-level management objectives of the study area.

2. METHODS

2.1. Background Information

Nunns Creek has a unique history of land use, ecological change and conservation action. The first step of this project was to conduct a comprehensive review of available background information relating to the ecological, human-use and development history of the study area. This review informed the ecological inventory and assessment of conservation value, and provided information relating to changes that have occurred over time and the success of earlier management actions, and insight and support to management recommendations. The background review included a literature review, an assessment of historic air photos, and interviews with local knowledge holders.

2.1.1.Literature Review

Background literature pertaining to the study area was obtained from a variety of sources including:

1. Published reports and publically available online data (e.g., EcoCat, DataBC and the BC Species and Ecosystem Explorer (CDC 2016));
2. Unpublished "grey literature" reports and data obtained from project collaborators including the City of Campbell River, Greenways Land Trust (GLT), and Fisheries and Oceans Canada (DFO); and
3. Historical resources accessed at the Campbell River Museum's archives.

2.1.2.Historic Air Photo Interpretation

Natural area managers often seek a reference benchmark in time, prior to significant European influence, against which ecological change can be measured and ecosystem restoration goals set. Historical photographs are typical sources of data for such analyses (Gayton 2001). A qualitative visual analysis of ecological changes over time was completed using a chronological series of historical air photographs ranging from 1938 to 2016 (1950, 1965, 1976, 2002, 2005, 2007, 2014 and 2016). Ecological changes were noted between each interval where these changes were visible at the scale of resolution available by the air photo. For example, macro-scale effects such as logging, flooding by beavers, or land clearing for development were obvious. Micro-scale effects such as small patches of blowdown, the spread of invasive herbaceous species, and the development of unauthorized camping areas were not detectable. Photographs were provided by DFO (Anderson, pers. comm. 2016) and the City of Campbell River (City of Campbell River 2016) and viewed in hardcopy on the City's online iMap tool, and in ArcGIS.

2.1.3.Interviews

Interviews were conducted with experts knowledgeable about the study area (project collaborators) to better understand the history and ecology of the Nunns Creek study area. Interviews included an orientation site tour with key project collaborators on March 10, 2016 as well as telephone and in-person interviews (Table 2).

Interviews followed a project-specific guide developed to bring consistency to the interview process and to support the adoption of best practices associated with this form of social science research (Appendix A). Interviews were recorded using Voice Record Pro 3.1.1, on either an iPad or iPhone as .m4a files. Interviews were conducted by either Tim Ennis for the purposes of this Project and/or by Kelsey Campbell (A-Tlegay Fisheries Society) for a concurrent ecological inventory and background data collection project focused on the downstream sections of Nunns Creek for the Campbell River Indian Band (CRIB). Interview notes (Appendix B) are summaries from audio recordings and not verbatim transcriptions. Interview notes were sent to the interviewees for their review and approval prior to being included in this report.

Table 2. Project collaborators and interview details.

Name	Title & Affiliation	Role	Date (2016)	Interview Format(s)
Ross Milnthorp	General Manager, Parks, Recreation and Culture, City of Campbell River	Project Director	March 10	site visit
Tim O'Brien	Principal, Outlook Engineering and Landscape Architecture	Project Manager	March 10	site visit
Tim Ennis	President, Latitude Conservation Solutions Company	Project Lead/Interviewer	March 10, May 5, May 6, June 2, June 6	site visit, phone, in-person
Leah Ballin	Wildlife Biologist, Ecofish Research Ltd	Project Lead	March 10	site visit
Christa Rusel	Biologist, A-Tlegay Fisheries Society	Project Associate	March 10	site visit
Barbara Phipps	Volunteer, Nunns Creek Stewards	Project Collaborator	March 10	site visit
Tyson Birkenstock	Volunteer, Nunns Creek Stewards	Project Collaborator	March 10	site visit
Cynthia Bendickson	Project Coordinator, Greenways Land Trust	Project Collaborator	March 10, May 5	site visit, in-person
Chuck DeSourcey	Director, Greenways Land Trust	Project Collaborator	March 10	site visit
Terri Martin	Environmental Specialist, City of Campbell River	Project Collaborator	March 10, June 2	site visit, phone interview
Shannon Anderson	Resource Restoration Biologist, Fisheries and Oceans Canada	Project Collaborator	March 10, May 6	site visit, in-person
Stacey Larsen	Community Advisor, Fisheries and Oceans Canada	Project Collaborator	March 10	site visit
Kelsey Campbell	Biologist, A-Tlegay Fisheries Society	Project Associate/Interviewer	May 5, May 6, May 30, June 2	phone, in-person
Jason Price	Councilor, Campbell River Indian Band	Project Collaborator	May 5	in-person
Dean Drake	Councilor, Campbell River Indian Band; Director, A-Tlegay Fisheries Society	Project Collaborator	May 30	in-person
Rick Senger	Director, Campbell River Salmon Foundation; Volunteer, Willow Creek Stewards; Habitat Biologist, Fisheries and Ocean Canada (ret.)	Project Collaborator	June 6	phone

2.2. Inventory Surveys - Ecological and Anthropogenic Baseline Inventory

2.2.1. Ecological Unit Mapping and Description

The Nunns Creek watershed supports a distinct and diverse assemblage of ecosystems including riparian and upland forests and multiple wetland types. Ecosystem mapping of the Nunns Creek study area was conducted to record site conditions, delineate sensitive ecosystems and guide selection of management units (RIC 1998, MOFR 2010). Ecosystems were broadly grouped into Ecological Units (EU's) that have similar ecological characteristics and provide a practical means for describing, analyzing, managing and monitoring the landscape. Ecological Units were delineated and ground-truthed by a terrestrial ecologist experienced in air photo interpretation and familiar with ecosystems in the Coastal Western Hemlock, Eastern Very Dry Maritime biogeoclimatic subzone (CWHxm1) at a maximum scale of 1:500. Ecological Units were delineated according to a three step process. First, units were delineated on orthophotographs in ArcGIS using current (2014) and historic photographs (to 1950). Second, the boundaries of EUs and ecosystem classifications were verified in the field. Field verification was completed using an iPad with GISPro and GPSKit software and cached satellite imagery. Third, EU polygons were updated based on field-verification. Mapping attributes and data collection were based on site and vegetation attributes set out in the *Field Manual for Describing Ecosystems in the Field* (MOFR 2010) and guided by the *Standard for Terrestrial Ecosystem Mapping in British Columbia* (TEM) (RIC 1998, RIC 2000). The classification of Ecological Units to the site series level followed the *Field Guide for Site Identification and Interpretation for the Vancouver Forest Region* (MOF 1994). Wetland Ecological Unit complexes were delineated and described according to a similar procedure as described for terrestrial ecosystems, but were classified according to *Wetlands of British Columbia: A Guide to Identification* (Mackenzie and Moran 2004). Ecological Units were verified in the field on May 22-24, 2016. Ecological Unit mapping and description data, plot data, and other mapping were verified for quality assurance purposes by a second biologist familiar with local ecosystems.

2.2.1.1. Plot Data Collection

Fixed area Wildlife Habitat Plots (WHPs) were used to describe Ecological Units and provide baseline data. Data collected within each WHP included: general site description parameters, assessment of forest structural stage, tree mensuration and canopy characteristics, site series classification, vegetation species composition and cover, substrate description, and documentation of specific wildlife habitat characteristics and water attributes (MOF 1994, MOFR 2010, MacKenzie and Moran 2004). Data were collected in 200 m^2 (11.28 m radius) fixed area plots. WHP data were collected on May 23 and 24, 2016.

2.2.2. Aquatic Ecosystems Mapping and Description

The location and characteristics of watercourses, and the quality of aquatic habitat in the study area have changed over time.

Water courses were mapped and assessed by a fisheries biologist and fisheries technician with experience with local ecosystems and fish habitat restoration. A Level 1 Fish Habitat Assessment Procedure (FHAP) (Johnston and Slaney 1996) was used to collect information on channel condition and fish habitat. This level of survey was used to identify current habitat conditions in selected high priority reaches. The main objectives of the assessment were to:

1. Describe fish and aquatic habitat within the current primary channel;
2. Describe channel characteristics; and
3. Quantify the habitat unit composition of each reach, delineating units into pools, glides, runs, riffles, cascades, chutes and falls.

Data collection procedures and survey design were consistent with methods in Johnston and Slaney (1996). Although mapping focused on the primary wetted channel, the locations of ephemeral secondary and tertiary channels were also marked during the survey.

The physical parameters surveyed for the FHAP along with the units of measure and the equipment used are listed in Table 3. Parameters were measured rather than estimated wherever possible. However, estimates were made for dominant and subdominant bed materials, percent cover and amounts of spawning gravel. All field data were collected on FHAP site cards (Johnston and Slaney 1996) on May 22, 2016. Data were collected and verified for quality assurance purposes by an experienced fisheries technician.

Additional secondary stream sections were mapped based on field observations of bridge crossings or opportunistic field observations. These data were compared to previous GPS mapping data (DCGLT 2001a), LiDAR stream channel data (Baksh, pers. comm. 2015) and current orthophotographs to estimate channel locations (Baksh, pers. comm. 2016).

American Beaver (*Castor canadensis*) use and habitats were documented, along with additional aquatic features such as large woody debris (LWD) and the infrastructure components described in Section 2.2.4 and 4.4.

Table 3. Physical parameters, units of measure, and equipment used during the FHAP surveys.

Parameter	Unit	Measured or Estimated	Equipment Used
Bankfull depth	m	Measured	Metre stick (0.05 m increments)
Bankfull width	m	Measured	30 m fibreglass tape
Bed material type	n/a	Visual estimate	Visual
Canopy closure	%	Visual estimate	Visual
Cover proportions	%	Visual estimate	Visual
Cover types	n/a	Visual estimate	Visual
Disturbance indicators	n/a	Visual estimate	Visual
Gradient	%	Measured	Suunto clinometer
Habitat unit length	m	Measured	30 m fibreglass tape/rangefinder
Maximum pool depth (>1.5 m)	m	Visual estimate	Visual
Maximum pool depth (<1.5 m)	m	Measured	Metre stick (0.05 m increments)
Pool crest depth	m	Measured	Metre stick (0.05 m increments)
Reach length	m	Measured	30 m fibreglass tape/rangefinder
Residual pool depth	m	Measured	Metre stick (0.05 m increments)
Riparian structure	n/a	Visual estimate	Visual
Riparian vegetation type	n/a	Visual estimate	Visual
Spawning gravel abundance	n/a	Visual estimate	Visual
Spawning gravel amount	m^2	Measured	Metre stick (0.05 m increments)
Spawning gravel type	n/a	Visual estimate	Visual
Substrate type	n/a	Visual estimate	Visual
Water and air temperature	ºC	Measured	Alcohol thermometer
Wetted depth	m	Measured	Metre stick (0.05 m increments)
Wetted width	m	Measured	30 m fibreglass tape

2.2.3. Invasive Species

Exotic invasive species are species that are not native to a specific region, and have a tendency to spread to a degree that can cause negative impacts to local ecosystem function (IAPP 2010, CISC 2015). It is important to monitor invasive species to understand how they may be dispersing and impacting local site ecology, and to be able to implement control or management measures (IAPP 2010).

An invasive plant inventory was conducted for the Nunns Creek study area guided by the provincial Invasive Alien Plant Program methodology (IAPP 2010). The inventory focused on the study area, however, incidental observations from Nunns Creek Park and adjacent private lots bisected by the current trail were also recorded. Invasive plant data was collected on May 22-24 and July 14, 2016. Invasive plants recorded included those identified as Noxious by the Provincial *Weed Control Act* (1996), as well as species proposed to be added to the list covered under the Act (FLNRO 2016), the Coastal Invasive Species Committee (CISC 2016) and local conservation groups (CISC 2015).

Incidental invasive wildlife observations were also recorded.

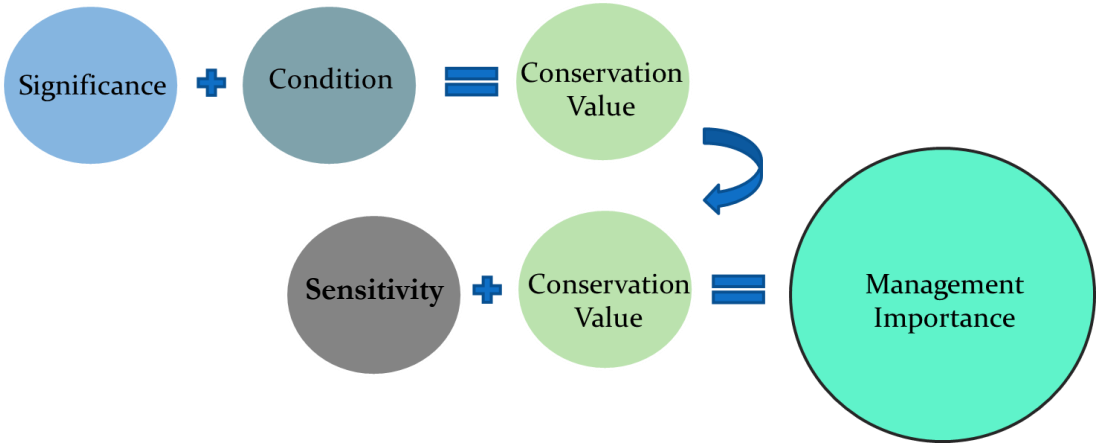
2.2.4. Anthropogenic Features

Anthropogenic features including authorized infrastructure such as bridges, culverts, pipes, trails and signs were documented, along with unauthorized human disturbance such as camps and spur trails. Anthropogenic features in the study area were mapped, photographed and described.

2.3. Conservation Value and Sensitivity Assessment

The significance and condition of each Ecological Unit was assessed and ranked relative to the other Units present (Very High, High, Moderate or Low). These assessments were combined to determine the relative conservation value of each Ecological Unit (Very High to Low) as illustrated in Figure 1. The relative sensitivity of each Ecological Unit to human disturbance was also assessed. The resulting sensitivity ranks were combined with conservation value rankings to determine a management importance rank for each Ecological Unit (Figure 1). A more detailed description of methods associated with determining Ecological Unit significance, condition, conservation value, sensitivity and management importance is presented in sections 2.3.1 to 2.3.5.

Figure 1. Overview of the Conservation Value and Sensitivity Assessment Process.



2.3.1. Ecological Unit Significance

The relative significance of each Ecological Unit was determined by its conservation status (global and sub-national ranks), the ecological services and functions it provides (key ecological attributes), and its role as habitat for species at risk and keystone species. These parameters, for which further description is provided in Table 4, were chosen in consideration of the data available to support an analysis, project requirements, and best management practices associated with conservation planning. For example, fieldwork classified Ecological Units to site series. This enabled a comparison of global and sub-national ranks based on CDC (2016) data. Consideration of ecological services and functions related to estuarine trophic inputs and floodwater storage were project

requirements. Consideration of habitat for species at risk and keystone species are common elements in conservation planning exercises intended to identify areas of conservation importance.

The assessment included attributing a numerical score to each Ecological Unit between 1 and 4 for each parameter assessed, with a higher score indicating greater significance (Table 4). The average significance score for each Ecological Unit was then calculated by dividing each Ecological Unit's summed score by the number of parameters assessed. These average significance scores were graphed, sorted and categorized as Low, Moderate, High and Very High based on the Jenks Natural Breaks algorithm for the categorization of geographical data (Jenks and Caspall 1971). According to this method, the differences between classes are determined based on natural groupings inherent in the data. Class breaks are determined such that groups of data with similar values are captured in the same category (Jenks and Caspall 1971, ESRI 2016) (Table 5).

Table 4. Ecological Unit significance parameters and assessment scores.

Score	G-rank[1]	S-rank[2]	Keystone Species Abundance[3]	Species at-Risk Presence[4]	Floodwater Storage[5]	Estuarine Food Web Contributions[6]	Large Conifer Presence
4	G1	S1	3	Confirmed	N/A	N/A	Presence of coniferous trees >80 years old
3	G2	S2	2	Likely	Major	Major	Presence of coniferous trees 61 - 80 years old
2	G3	S3	1	Possible	Minor	Minor	Presence of coniferous trees <60 years old
1	G4/G5	S4/S5	0	Not Likely	N/A	N/A	Deciduous vegetation only
N/A	GNR/ GNA /Exotic	GNR/ GNA /Exotic	-	-	-	-	-

[1] Refers to the ecological community or species conservation status across its entire range, whereas 'G1' is critically imperiled, 'G2' is imperiled, 'G3' is vulnerable to extirpation or extinction, 'G4' is apparently secure, G5' is demonstrably widespread, abundant, and secure. 'GNR' is unranked, and 'GNA' is not applicable. Where more than one ecological community is present, the most sensitive rating was applied.

[2] Refers to the ecological community or species conservation status in BC, where 'S1' is critically imperilled, 'S2' is imperilled, 'S3' is of special concern, vulnerable to extirpation or extinction, 'S4' is apparently secure and 'S5' is widespread, abundant and secure. 'SNR' is unranked and 'SNA' is not applicable. Where more than one ecological community is present, the most sensitive rating was applied.

[3] Keystone species are species upon which ecosystems and their constituent species largely depend. As such, if they were removed the ecosystem would largely change. On the Nunns Creek property keystone species were considered to be Pacific salmon species, primary cavity nesters (e.g. Pileated woodpecker), and beaver.

[4] Species at-risk include those listed Federally by COSEWIC as 'Endangered', 'Threatened', 'Special Concern' or listed Provincially as 'Red' or 'Blue' within the region.

[5] Areas that flood more frequently and for longer durations, have the topography to store floodwater and have finer soils have greater potential and capacity to store and slowly release water. Areas with relatively high floodwater storage potential are connected to aquatic areas by relatively lower slopes and shorter distances. Note that the role of large conifers in floodwater storage was not considered here as it is accounted for under the 'Large Conifer Presence' metric.

[6] Areas that provide the greatest contributions to estuarine food webs are permanently or temporally hydrologically connected to the Nunns Creek mainstem which provides a direct linkage to the estuary. Thus temporally flooded areas with relatively lower slopes and doser proximity to the mainstem generally provide greater contributions.

Table 5. Ecological Unit significance categories.

Relative Significance Rank	Average Score
Very High	≥2.5
High	2 - <2.5
Moderate	>1.7 - <2
Low	≤1.7

2.3.2.Ecological Unit Condition

Condition refers to the current condition of an Ecological Unit in comparison to the expected reference or benchmark condition based on an evaluation of direct and indirect effects of human activities or disturbances. Parameters used to assess the relative condition of each Ecological Unit include: fragmentation by trails, the relative abundance of invasive plants, the presence of small-scale human disturbances, and the time since medium to large-scale disturbances. The assessment included attributing a numerical score to each Ecological Unit between 1 and 4 for each parameter assessed, with a higher score indicating better condition (Table 6). The average condition score for each Ecological Unit was then calculated by dividing each Ecological Unit's summed score by the number of parameters assessed. The average condition scores were categorized as Low, Moderate, High and Very High based on the Jenks Natural Breaks method (Table 7).

Table 6. Ecological Unit condition parameters and assessment scores.

Score	Fragmentation (trail density)	Invasive Plants	Small-scale Human Disturbances[1]	Time Since Medium to Large-scale Disturbance[2]
4	<30 m/ha	Infrequent	Very Low	>60 years
3	30-99 m/ha	Sub-dominant	Low	60 - 20 years
2	100-200 m/ha	Co-dominant	Moderate	20 - 10 years
1	>200 m/ha	Dominant	High	<10 years

[1]Small-scale disturbances induding camping, personal fires or refuse, based on analysis of mapped disturbances.

[2]Medium to large-scale landscape altering disturbances such as wildfires or logging. Time estimate based on historical air photograph analysis and field observations, breaks correspond to actual disturbance episodes.

Table 7. Ecological Unit condition categories.

Relative Condition Rank	Average Score
Very High	≥3.5
High	3-3.5
Moderate	≥2.5 - <3
Low	<2.5

2.3.3.Ecological Unit Conservation Value

The relative conservation value of a given Ecological Unit is a function of both the significance of the unit and its condition. For example, an Ecological Unit may be highly significant based on it's global-rank and the presence of species at risk, but if that same unit is compromised by high levels of fragmentation and is degraded by high densities of invasive plants, its relative value is less when compared to a unit that shares a similarly high significance value but has not been negatively impacted.

The relative conservation value of each Ecological Unit was calculated as the average of its significance rank and condition rank. Where the result included a decimal greater than or equal to 0.5, it was rounded up.

2.3.4. Ecological Unit Sensitivity

Sensitivity refers to a given Ecological Unit's susceptibility to negative impacts associated with human use and disturbances. In the case of the Nunns Creek study area, sensitivity was assessed in consideration of its existing status as a nature conservation area, and in the context of the restrictions and allowable uses described in the leases in place between the City of Campbell River and the Nature Trust of BC. Therefore, only a limited range of potential impacts were assessed as parameters in the sensitivity analysis. The assessment parameters are primarily associated with the development of trails and associated access infrastructure such as viewing platforms. They included: relative soil moisture, the size of an Ecological Unit and the density of wildlife trees (Table 8).

The sensitivity assessment included attributing a numerical score to each Ecological Unit between 1 and 4 for each parameter assessed, with higher numbers indicating higher susceptibility to negative impacts associated with the development of access infrastructure (Table 9).

Table 8. Ecological Unit sensitivity parameters and assessment scores.

Score	Soil moisture regime[1]	Size/configuration of EU	Density of wildlife trees[3]
4	Subhydric-hydric (7-8)	Very Small patch (<0.2 ha)	High
3	Hygric-subhydric (6-7)	Small patch (0.2 ha – 1 ha)	Medium
2	Subhygric- hygric (5-6)	Medium sized patch (1-3 ha)	Low
1	Submesic- mesic (3-4)	Matrix (>3 ha)	None

[1] MOF 1994, Mackenzie and Moran 2004, MOFR 2010

[3] Based on rapid field assessment. Higher density of wildlife trees is considered more sensitive because they are prone to being cut down for safety reasons if a trail were to bisect them.

Table 9. Ecological Unit sensitivity categories.

Sensitivity Rank	Average Score
Very High	>3
High	3
Moderate	>2 - 3
Low	≤2

2.3.5. Management Importance

Conservation value ranks and sensitivity ranks were combined to derive the *management importance* of each Ecological Unit. Ecological Units with relatively high conservation value and which are relatively more sensitive to negative impacts are of greater importance to managers and land use planners seeking to avoid negative impacts within the study area.

The relative management importance of each Ecological Unit was calculated as the average of its conservation value rank and sensitivity rank, where the result included a decimal greater than or equal to 0.5, it was rounded up.

3. PROPERTY DESCRIPTION

3.1. Historic Character

There are no written descriptions, maps or data describing the historic ecological character of the study area prior to 1998. The first ecological studies of Nunns Creek were completed in 1998 and 2001 (Roth 1999, DCGLT 2001a). By this time, significant anthropogenic impacts had already affected both the study area and the surrounding landscape.

The earliest aerial photo of the study area (1938) indicates that it was dominated by mature-old coniferous forests with some patches of deciduous riparian forest along Nunns Creek. An ecosystem map of the adjacent Campbell River Indian Reserve #11 was completed in 1907. Comparisons between the 1938 air photo and the 1907 ecological map suggest that the coniferous forests within the study area were probably dominated by "large fir and spruce". Remnant old-growth coniferous trees in the study area confirmed by field inventory were Sitka Spruce (*Picea sitchensis*) and Grand fir (*Abies grandis*). Other coniferous species were also likely present historically as sub-dominant elements of the forest based on observations of decaying stumps and contemporary mature trees. These include: Douglas-fir (*Pseudotsuga menziesii*), Western Hemlock (*Tsuga heterophylla*) and Western Redcedar (*Thuja plicata*). Deciduous riparian forests evident on the 1938 air photo were probably dominated by Red Alder (*Alnus rubra*) as described on the adjacent lands in 1907. In consideration of

contemporary site conditions such as terrain and surficial geology that remain unchanged, the historic forest soils were likely moderately rich to rich, with poor to moderate drainage. Therefore, the historic shrub and herbaceous communities were likely similar to those which currently occur in forested units of the study area.

Historic air photos indicate that the study area was partially logged in 1964-65. Logging roads, landings and associated hydrologic disturbances also impacted the site at that time.

In the late 1990s, American Beaver moved into the study area. There is no direct evidence of prior beaver activity. Air photos from 2000-2016 clearly illustrate a series of hydrological and associated ecological changes associated with beaver dam creation throughout the southern half of the study area (Appendix C). Field-based observations confirm that beaver activity is ongoing.

3.2. Historic Use

First Nations have likely utilized, if not occupied, the Nunns Creek watershed for millennia. Early human occupation of the BC coast began at least 13,000 years before present (ybp) (Hakai 2016). Human inhabitation of Quadra Island extends to 7,500 ybp (Fedje *et al.* 2015). Coast Salish fish weirs, fish traps, palisaded fortifications, net fishing stations and village sites throughout the Campbell River and Nunns Creek estuaries were recorded by Admiral Sir George Richards in the early 1860's (Dorricott and Cullon 2012). There are no recorded archaeological sites within the study area, however there is a high potential for unknown/unrecorded archaeological sites (MacLennan 2016). The study area occurs within an area of overlapping First Nations territorial claims including: Wei Wai Kum/Kwiakah First Nation (includes the Campbell River Indian Band), Laich-Kwil-Tach Council of Chiefs (aka Wei Wai Kai/Cape Mudge), K'omoks First Nation, Homalco Indian Band and the Hul'qumi'num (marine areas only) (INAC 2016). The Campbell River Indian Reserve #11 is adjacent to the study area's northern boundary.

Frederick Nunns was the first non-native settler in Campbell River. "Fred" Nunns along with family members John and Laurence Nunns settled on land along the banks of the Campbell River in 1887 and were awarded a pre-emption claim to those lands on May 6, 1889. Their pre-emption was primarily located within the Haig Brown Creek watershed, spanning between what is now Detweiler Rd and Maple St. in the Campbellton neighbourhood. Mr. E. B. Hill pre-empted land immediately thereafter to the southeast of the study area in the current location of the Downtown neighbourhood (Land and Works Department 1889). Although the study area is equidistant between these nodes of early settlement, it does not appear to have been impacted in a material way by early settlers in the region.

In 1970, the City of Campbell River purchased what the local media reported as "swampy bush" land in order to develop Nunns Creek Park. The purchase and subsequent development of park infrastructure was completed by the spring of 1972. This included children's play equipment, equestrian facilities and one baseball diamond (Museum at Campbell River 2015). Nunns Creek Park

was referred to as "the swamp" by the community as a result of the poor drainage during rainfall events. In the early 1990s a park development committee was formed to fundraise for the installation of improved drainage structures and the deposition of fill to raise the elevation of the fields (Campbell River Salmon Festival 2015).

In 1982, negotiations began to expand Nunns Creek Park to protect fish habitat values. In 1986, TNTBC purchased land south of the park from Integrated Developments Ltd. An adjacent eight hectares of City-owned lands were transferred to TNTBC shortly thereafter (January 1987). These two parcels of land were then leased back to the City by TNTBC (in 1986 and 1987 respectively) for a term of 99 years.

The leases specify that these lands are to be:

> "*preserved and/or developed by the Lessee as a site of ecological interest for the use, enjoyment and benefit of the people of British Columbia*".

The leases set out land use requirements in several important ways including but not limited to:

- A restriction against the cutting of timber; and,
- An obligation to protect and preserve the trees and bushes from waste, injury or destruction.

The leases also specify that if:

> "*the Lessee permits activities that on the said premises which in the sole opinion of the Lessor are not conducive to the preservation and/or development of the said premises…*" that the lease "*shall, at the option of the Lessor cease and be void…*".

The leases are on file with both the City of Campbell River and TNTBC, and are available upon request.

Over the past 50 years, the study area has not experienced significant human use. Several project collaborators recalled visiting Nunns Creek occasionally to fish for Pacific salmon when they were children or young adults. Others recalled the site being used as a meeting place for local teenagers (Price, pers. comm. 2016, Anderson, pers. comm. 2016, Phipps, pers. comm. 2016).

The Nunns Creek Stewards formed in 2001 and began to undertake stewardship and enhancement activities on the site. These activities included: invasive species removal, salmon habitat enhancements, and the development/improvement of public access infrastructure (trails and bridges). North Island College, Discovery Coast Greenways Land Trust, Fisheries and Oceans Canada, the City of Campbell River and various affiliated consultants have developed a variety of baseline data sets and monitoring reports, and assisted with the management of the study area since that time.

3.3. Current Use

The naturally forested and wetland dominated study area is rarely visited by Campbell River residents despite the popularity of Nunns Creek Park. The popularity of Ironwood Mall (to the east)

has diminished, resulting in a dramatic decrease in foot traffic through the study area (Price, pers. comm. 2016). The field investigation revealed campsites and regular human inhabitation. This unauthorized use was associated with illegal drug use, refuse accumulation and occasional graffiti. Project collaborators who have visited the park recently mentioned a fear of discarded needles and other biohazards, as well as a sense of being enveloped in a remarkable natural oasis in the heart of the city (Martin, pers. comm. 2016).

3.4. Regional and Watershed Scale Ecology

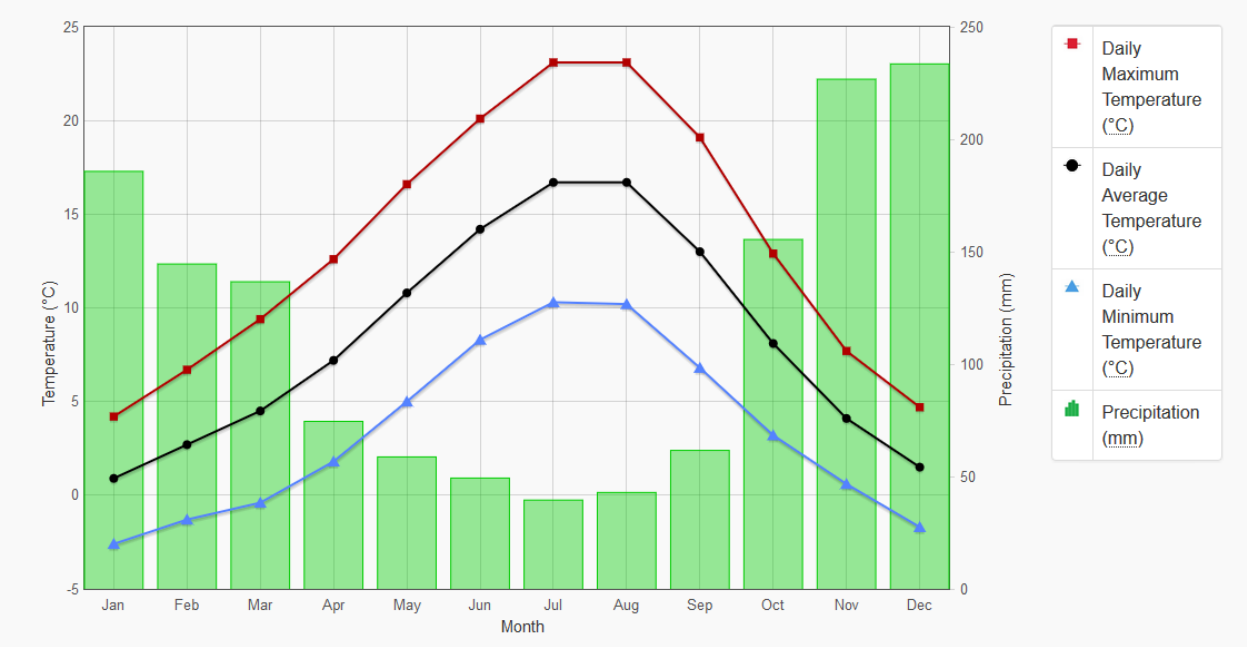
The study area is located in the eastern variant of the very dry maritime subzone of the Coastal Western Hemlock Biogeoclimatic zone (CWHxm1) (DataBC 2016). It is transitional between the temperate rainforests that characterize the majority of the BC Coast, and the sub-Mediterranean "rainshadow" ecosystems of the adjacent Coastal Douglas-fir Biogeoclimatic zone that occupies the majority of the Nanaimo Lowlands Ecosection (Table 10). An orographic effect from the Vancouver Island ranges and adjacency with the temperature moderating marine environment create the region's distinct biogeoclimatic characteristics (MOF 1991).

The regional climate is characterized by four distinct seasons: cool winters with abundant rainfall, warm spring and fall seasons that experience moderate precipitation, and a hot, dry summer (Figure 2). These summer conditions result in a soil moisture deficit for much of July and August. Wildfires cause infrequent, stand-initiating events during summer droughts as a part of the natural disturbance regime (NDT2) (Swift and Ran 2012).

Table 10. Ecological designations of the study area.

Classification	Designation
Ecodomain	Humid Temperate
Ecodivision	Cool Hypermaritime and Highlands
Ecoregion	Eastern Vancouver Island
Ecoprovince	Georgia Depression
Ecosection	Nanaimo Lowlands
Biogeoclimatic (BEC) zone	Coastal Western Hemlock
Subzone (BEC)	Very dry maritime
Variant (BEC)	Eastern
Freshwater Ecoregion	North Pacific Coastal
Ecological Drainage Unit	Vancouver Island

Figure 2. Temperature and Precipitation Graph for 1961 to 1990 Canadian Climate Normals Campbell River, Station A (Environment Canada 2016).



Coniferous Western Hemlock and Douglas-fir dominate the region's landscape. Riparian areas, wetlands and edaphically dry sites add landscape-level heterogeneity. Areas of elevated soil moisture such as depressions or areas with poorly drained soils contain vegetation that is more typical of the wetter parts of coastal BC (MOF 1991).

The Nunns Creek watershed extends from Discovery Passage southwards to a maximum elevation of 100 m (Table 10, Ciruna *et al.* 2007, DataBC 2016, MOE 2012). It is underlain by sedimentary bedrock with a combination of fluvial and marine surficial deposits (DataBC 2016). A shallow aquifer lies beneath the surface at an average depth of 0.61 m. The aquifer is held in a lens of sand and gravel between the bedrock and a cap of marine clay or compacted glacial till. It is recharged by rainwater infiltration where there are permeable gaps in the restricting top layer (MOE 2012, DataBC 2016). Sloping areas are well drained but much of the watershed is low angle with depressions. These areas are prone to ponding surface waters during high rainfall events particularly where the clay restricting layer is near the surface.

Nunns Creek initiates in shallow-gradient headwater tributaries feeding a shallow-gradient mainstem. It experiences naturally high discharge volumes during the rainy winter season, with moderate flows in the spring and fall and very low flows in the summer (Ciruna *et al.* 2007). Under these circumstances, obstacles or constrictions to flow, particularly when discharge is high, regularly lead

to flooding. Well-developed riparian areas, floodplain forests, and off-channel swamps are typical of watersheds affected by this natural disturbance regime.

The estuary and lower floodplain of Nunns Creek is part of the greater Campbell River estuary complex. The Campbell River estuary is known for its diverse, resilient and productive fishery values. Orthophoto analysis indicates that the lower floodplain and estuary of Nunns Creek currently provides a large portion of the natural habitats in the Campbell River estuary.

Table 11. Characteristics of Nunns Creek watershed.

Parameter	Value
Watershed	Nunns Creek
Watershed Area (ha)	<750
Mean Watershed Elevation (masl)	45
Max Watershed Elevation (masl)	100
Min Watershed Elevation (masl)	0
Reverse Stream Order	1
River Ecosystem Type	Sheltered Outer Coast and Island Coastal Rivers (C1b)
Aquatic Nutrient Model Class	N3
Aquatic Temperature Model Class	Warm/high degree days (33)
Stream Gradient Model Class	Shallow gradient mainstem, shallow gradient tributaries (G33)
Mainstem Gradient	100% is <2% grade
K-factor (scale corrected mean annual peak flow)	0.1428 (moderate) (Range = <0.03 - 0.3 for BC)
Flow Regime - winter	High flows
Flow Regime - spring	Moderate flows
Flow Regime - summer	Low flows
Flow Regime - fall	Moderate flows
Glacial Influence	None
Lake Influence	None
Aquifer	Yes
Average Depth of Aquifer Cap	0.61m
Aquifer Cap Material	Clay and glacial till
Aquifer Material	Quadra sands (water bearing sand and gravel lens)
Aquifer Recharge	Rainwater infiltration
Bedrock	Hard sedimentary (Nanaimo Group)
Surficial Geology	Fluvial (and some Marine deposits)
Texture	Gravel (and some sand and silt/ silt)
Surface Material	Fluvial (Marine)
Surface Expression	Fan (blanket / veneer)

Nunns Creek is an urban watershed. Since 1887 agricultural, suburban, urban, commercial and industrial development in the watershed has intensified. The majority of the Nunns Creek watershed (>62%) has been converted to non-natural land cover. Over 16% is now covered by impervious

surfaces such as roads and parking lots. Tree cover has been reduced to less than 33% of pre-contact levels throughout the watershed. Two of the largest tributaries to Nunns Creek, historically located in the vicinity of Maple and Elm streets respectively, have been filled in and developed. Surface waters in the developed areas of the Nunns Creek watershed are directed into a system of storm drains and ditches, then conveyed untreated into Nunns Creek. As of 2002, Nunns Creek and its remaining headwater tributaries spanned over 14 km of natural open channels. Ditches and storm drains within the Nunns Creek watershed extended over 40 km in length. Some of these direct flows into adjacent watersheds, thus reducing the area of the Nunns Creek watershed compared to its historic extent (Urban Systems 2005).

3.5. Property Scale Ecology

The study area is comprised of low lying, hummocky terrain dominated by ephemeral swamps, beaver created wetlands, riparian communities and mixed coniferous-deciduous forests. The study area rises from an elevation of 1.5 m at 16th Ave, to 10.5 m in the southeast corner at Homewood Rd. The majority of the study area occurs at 3-4 m in elevation. Tidal influence extends 74 m south of the northern boundary at 16th Ave (McElhanney and Komori Wong 2004).

Few property-scale ecological inventory projects have occurred, validating the need for improved field-based data addressed by this project. Previous studies have emphasised aquatic habitats and fisheries values (Roth 1999, Komori Wong 2002, DCGLT 2001a), however in April 2001, Discovery Coast Greenways Land Trust (GLT) compiled a plant and animal list for the study area (DCGLT 2001b). GLT recorded 17 bird species, 2 mammals, 1 reptile, and 7 species of tree (all native). They also recorded 17 species of shrubs of which 47% were introduced, and 16 species of herbaceous plants of which 38% were introduced.

Fisheries inventories and historic observations in the study area indicate that Coho Salmon (*Oncorhynchus kisutch*), Coastal Cutthroat Trout (*O. clarkii clarkii*) and Threespine Stickleback (*Gasterosteus aculeatus*) are the dominant fish species in Nunns Creek. Returning adult Coho appear in the system in October, and spawn from November through early December. The main spawning areas for Coho occur upstream of the study area above Otter Rd., but also between Otter and Homewood Rd. (DFO 1991). DFO has annually enhanced the Nunns Creek system with hatchery Coho fry (>150,000 since 1987) (Anderson 2016). Adult returning Coho in Nunns Creek are thought to have numbered in the thousands historically, but have been reduced to approximately 100-300 in recent years (Senger, pers. comm. 2016).

Inventory data and anecdotal observations include historic occurrences of Chinook Salmon (*O. tshawytscha*), Chum Salmon (*O. keta*) and Pink Salmon (*O. gorbuscha*) (Mainstream 2013, Roth 1999, Drake, pers. comm., Senger, pers. comm. 2016). Pink Salmon were observed spawning in Nunns Creek by DFO biologists for the first time in 1990. These fish may have been strays from the

Quinsam River, or returning adults associated with the 177,000 Pink fry that were released into lower Nunns Creek by DFO between 1987 and 1988 (DFO 1990, Anderson 2016).

4. INVENTORY RESULTS

4.1. Ecological Unit Mapping and Description

The study area supports a high diversity of ecological communities relative to its size. Eleven ecological communities (site series or site associations) were documented on the property including three marsh communities, three swamp communities and five forested communities. Four of these communities are Provincially Red-listed, five are Blue-listed, one is Yellow-listed and one is exotic (Table 12).

Ecological Units (EUs) are map units based on ecological community composition, structural stage and management considerations. Fifteen Ecological Units were described on the property including eight wetland EUs composed of marshes and swamps with components of open water habitat, and seven forested types composed of deciduous and mixed coniferous and deciduous upland riparian forest (Table 13, Map 2, Map 3, Appendix D). In total, 15.1 ha were delineated in the study area and a small area of Nunns Creek Park and the BMX track where large conifers and natural ecosystems cross the boundaries. Ecological Units that encompassed the existing trail and continued onto the adjacent private lots to the east were mapped, but their areas not included in this assessment. Mixed coniferous and deciduous riparian floodplain and upland forests and forested and shrub-dominated swamps dominated the landscape, occupying 6.2 (40%) and 4.6 (30%) ha respectively. Marshes and deciduous forest stands occupied 2.7 (18%) and 1.9 (12%) ha respectively. The majority of the EUs were dominated by Provincially Blue-listed ecosystems (9.8 ha, 63%). Red-listed (4.9 ha, 32%), Yellow-listed (0.7 ha, 5%) and exotic (0.04 ha, 0.2%) ecosystems are also present. A detailed description of each EU is provided in Appendix D.

Table 12. Ecological communities documented in the study area.

Type	Scientific Name	English Name	Site Series or Site Association	Ecological Unit Numbers	Global Status[1]	Provincial Status[1]	BC List[2]	Highest Conservation Framework Priority[3]
Marsh/ open water	*Typha latifolia* Marsh	common cattail Marsh	Wm05	1a, 1b	G5	S3	Blue	1
	Phalaris arundinacea	reed canary grass	None (RCG)	1a, 1c, 1e	-	-	Exotic	-
	Schoenoplectus acutus Deep Marsh	hard-stemmed bulrush Deep Marsh	06	1b, 1d	G5	S3	Blue	4
Swamp/ open water	*Spiraea douglasii / Carex sitchensis*	hardhack / Sitka sedge	Ws50	2a	G4	S4	Yellow	4
	Alnus rubra / Lysichiton americanus	red alder - skunk cabbage	Ws52	2b, 2c	GNR	S2	Red	1
	Salix sitchensis - Salix lasiandra var. *lasiandra / Lysichiton americanus*	Sitka willow - Pacific willow/ skunk cabbage	Ws51	2b, 2c	G2	S2	Red	1
Riparian forest	*Thuja plicata / Tiarella trifoliata* Very Dry Maritime	western redcedar / three-leaved foamflower Very Dry Maritime	07	3a, 3b, 4a, 4b, 4c	G3	S2S3	Blue	2
	Picea sitchensis / Rubus spectabilis Very Dry Maritime	Sitka spruce / salmonberry Very Dry Maritime	08	3a, 3c	G3	S2	Red	2
	Thuja plicata / Polystichum munitum - Lysichiton americanus	western redcedar / sword fern - skunk cabbage	Ws53	4a	GNR	S3?	Blue	2
	Thuja plicata / Rubus spectabilis	western redcedar / salmonberry	13	4c	GNR	S1S2	Red	1
	Thuja plicata - Picea sitchensis / Lysichiton americanus	western redcedar - Sitka spruce / skunk cabbage	12	4d	G3?	S3?	Blue	3

[1] Global and Provincial Status Ranks: X = presumed extinct, H = possibly extinct, 1 = critically imperiled, 2 = imperiled, 3 = vulnerable to extirpation or extinction, 4 = apparently secure, 5 = demonstrably widespread, abundant and secure, NA = not applicable, NR = unranked, not yet assessed, U = unrankable.

[2]Ecological communities are assigned to one of four provincial lists based on their Subnational Conservation Status: Red=extirpated, endangered or threatened; Blue=special concern or vulnerable, Yellow=apparently secure or Extinct=no longer exist.

[3] This value represents the highest conservation priority assigned to a Conservation Framework Goal. Values range from 1 (highest) to 6 (lowest).

Table 13. Ecological Unit summary.

Type	Ecological Unit	Site Series or Site Association		General Description	Estimated Maximum Age (years)	Key Wildlife or Wildlife Features	Recent Disturbances
		1°	2°				
Marsh/ open water	1a	RCG	Wm05	Temporally flooded, Reed Canarygrass-dominated marsh bordered by a diversity of shrubs.	41-60	Abundant bird life	Invaded by Reed Canarygrass
	1b	Wm05	Wm06	Marsh and open water communities with floating and emergent vegetation bordered by moisture tolerant trees and shrubs. Beaver pond.	41-60	Great Blue Heron, passerines nesting on edge, wetland birds, amphibian and fish habitat, beaver	-
	1c	RCG	Ws54/ Wm05	Large Reed Canarygrass and Common Cattail dominated marsh with patches of coniferous and deciduous trees and shrubs on hummocks. Floods during wet portion of year and maintains some wetted channels and areas during dry season. Soils have high sand content. Beaver pond.	41-60	Pools and channel for salmon migration, overwintering and rearing, snags with cavity nesters, aerial insectivores, piscivores (birds), small mammals, amphibian habitat, beaver	Invaded by Reed Canarygrass
	1d	Wm05	Wm06	Small pocket Common Cattail marsh adjacent to channel and bordered by swamp.	41-60	-	-
	1e	RCG	RCG	Small open pocket of Reed Canarygrass.	41-60	-	Invaded by Reed Canarygrass

Table 13. Continued.

Type	Ecological Unit	Site Series or Site Association		General Description	Estimated Maximum Age (years)	Key Wildlife or Wildlife Features	Recent Disturbances
		1˚	2˚				
Swamp/ open water	2a	Ws50	-	Open water and shrub dominated swamp that has recently expanded considerably due to beaver activity. Abundant coarse woody debris.	41-60	Abundant wildlife including amphibians, breeding ducks, abundant bird life, small mammals, Coho fry and stickleback, beaver	Extensive flooding, several invasive species at edge of field, potential bullfrog breeding pond
	2b	Ws51	Ws52	Temporally flooded, low-gradient swamp dominated by deciduous trees and shrubs, conifer patches growing on hummocks. Tree regeneration on older decaying large downed wood. Large network of channels.	41-60	Abundant bird life, mammals and amphibians (incl. Red-legged Frog)	-
	2c	Ws51	Ws52	Small swamp within floodplain of main channel with herbs, shrubs, deciduous trees and snags.	41-60	-	Himalayan Blackberry encroaching, flooded by backed up culvert, adjacent to road

Table 13. Continued.

Type	Ecological Unit	Site Series or Site Association		General Description	Estimated Maximum Age (years)	Key Wildlife or Wildlife Features	Recent Disturbances
		1°	2°				
Deciduous riparian forest	3a	07	08	Deciduous forest with abundant snags and some dead young conifers along the edge.	41-60	Snags with cavities	Recent flooding likely leading to conifer mortality, ingress of Himalayan Blackberry, trails
	3b	07	-	Young Red Alder forest with an understory dominated by a thick cover of Salmonberry and some floodplain forest herb cover. Provides a buffer to wetland habitats.	41-60	Will self-thin and recruit wildlife trees in the future. Provides a buffer to wetland habitats.	Thick cover of Himalayan Blackberry ingress on edges, camps, trail
	3c	08	-	Young Red Alder dominated forest with an understory composed of a thick cover of Salmonberry.	41-60	-	Trail, edge has Himalayan Blackberry and other species

Table 13. Continued.

Type	Ecological Unit	Site Series or Site Association		General Description	Estimated Maximum Age (years)	Key Wildlife or Wildlife Features	Recent Disturbances
		1°	2°				
Mixed deciduous / coniferous riparian forest	4a	07	05	Mixed wet to moist to mesic mature riparian forest stand, historically selectively logged however forest maintains old growth forest components and dynamics including canopy gaps, large coniferous CWD in advanced decay classes, understory conifer regeneration. The primary channel of Nunns Creek and multiple channels bisect the EU and temporally flood portions of the EU. Nunns Creek has relatively well defined channel through most of EU with gravels, undercut banks and anchored LWD. Highest cover of herbaceous wildflowers in study area.	61-250	Salmon stream, cavity nesters	Large trees blown down, trails and unauthorized trails and use, garbage in streams, some patches of exotic species
	4b	07	-	Mixed moist to mesic mature riparian forest stand, with moist pockets of Red Alder and Salmonberry with a Sitka Spruce understory and pockets and upslope areas dominated by coniferous forest. Abundant coarse woody debris and snags and stumps. Diverse regenerating tree layer.	61-80	Deciduous (relatively poor quality) snags, coarse woody debris and stumps. Bordered by Nunns Creek	Large trees blown down, trails and unauthorized trails, trampling, hang out spots, some patches of exotic species

Table 13. Continued.

Type	Ecological Unit	Site Series or Site Association		General Description	Estimated Maximum Age (years)	Key Wildlife or Wildlife Features	Recent Disturbances
		1°	2°				
Mixed deciduous/ coniferous riparian forest (continued)	4c	07	13	Narrow band of mixed maturing forest that buffers wetland from road.	61-80	Snags with cavities	Invasive species encroachment, bordered by road and trail
	4d	12	Ws53	Seasonally flooded forest (swamp) that contains channels and hummocky terrain with conifers. Treed area is receding due to flooding of adjacent wetland.	61-80	Snags with cavities, stream	Flooding encroachment

4.1.1.Plot Data Collection

Ecological data was collected at five Wildlife Habitat Plots (WHPs) located in four distinct Ecological Units and three of the four ecosystem categories (i.e., marsh/open water, swamp/open water and mixed coniferous/deciduous riparian forest) (Map 2). Of the two plots that were installed in Ecological Unit 4b, one was placed in a coniferous stand and the other was placed in a deciduous dominated section that is in transition to a coniferous stand and is representative of the adjacent deciduous riparian forest type (EU3c). Plot data and photographs are presented in Appendix E.

A total of 48 animal and 111 plant species were documented in the study area during the field inventory and in previous studies (DFO 1990, DFO 1991, Roth 1999, DCGLT 2001, Komori-Wong 2002, Sellentin 2011, Mainstream 2013, Drake 2016, Martin, pers. comm. 2016, Senger 2016) (Table 14). Two of the wildlife species and 43 of the plant species are not native and have been introduced to BC. A cumulative species list for the study area is presented in Appendix F.

Table 14. Wildlife and plant species documented on the property during the ecological inventory and in background literature.

Kingdom	Species group	Native	Introduced	Total
Animal	Birds	27	1	28
	Mammals	6		6
	Reptiles	1		1
	Amphibians	2	1	3
	Fish	7		7
	Invertebrates	3		3
	Total	*46*	*2*	48
Plants	Trees	11	5	16
	Shrubs	17	8	25
	Herbs	37	30	67
	Moss	3		3
	Total	*68*	*43*	111
Total		**114**	**45**	**159**

4.2. Aquatic Ecosystem Inventory

Nine Fish Habitat Assessment Procedure (FHAP) units were mapped in the study area (Map 4). Two of these were pools, five were riffles in a defined channel, and two were riffles within a wetland

where one had a defined channel during low water, and the other did not. A total length of 2,336 m was mapped, with the majority (97%) of the area being riffles, and the remainder pools. It is important to note that although 'riffles' were the dominant mapped unit, these reaches were frequently characterized by a lack of either gravel and cobble or a lack of surface turbulence which are defining characteristics of riffles (Johnston and Slaney 1996). Data for all units is summarized in Table 15 and Table 16 and presented in full in Appendix F.

FHAP data collection focused on the primary wetted channel that travels through the two beaver ponds (EU's 2a and 1b/1c), and the historic primary channel that parallels the eastern boundary of the study area. The historic channel is now intermittently dry upstream of the storm drain at 12th Ave. Flows ranged from low to intermittent to dry during the survey period. Stream gradients are extremely low and ranged from 0-0.5 % (average 0.08%). Low gradients combined with disruption to natural drainage patterns from logging, adjacent land use (exacerbating sedimentation), and beaver activity has resulted in a complex network of defined and undefined channels with variable flows.

Bankfull depths ranged from 0.4 to 1.05 m and wetted depths from 0.03 to 0.27 m. Bankfull widths ranged from 2.5 to 7.5 m for channelized sections and to over 100 m for wetland sections. Average wetted widths ranged from 1.5 m to 5.3 m. The maximum pool depth was 0.5 m. The bankfull width of several sections of the creek appears to have widened over the past 17 years (Roth 1999, DCGLT 2001a).

Bed materials are dominated by silts and fines deposited over much of the observed gravel that could otherwise provide a low amount of anadromous and resident salmonid spawning habitat. Functional large woody debris (LWD) is present in all segments with defined channels. The majority of natural LWD is comprised of small diameter deciduous tree species that have died following succession to coniferous-dominated stands. Large diameter LWD has been anchored into the channel as per the 2002 Fish Habitat Restoration Prescriptions for Nunns Creek (Komori Wong 2002) and appears to have contributed to maintaining the channel, especially in unit 3 (Appendix G). Placement of two pieces of LWD for each length of stream equal to the average bankfull width is the accepted target density for restoration projects in coastal BC (Komori Wong 2002). The restoration project prescribed adding 28 pieces of wood to the existing 22 mapped pieces (Roth 1999), which would result in 75% achievement of this goal. Fifty-five pieces of LWD were documented during the field inventory. The placed LWD is still present, however, the metal cables anchoring it to the bank are starting to rust and most of the wood is loose to the touch.

The dominant instream cover types were overhanging vegetation followed by LWD, and off-channel habitat was provided by side channels and pools within wetlands. The wetland pools in particular provide excellent rearing habitat for juvenile Coho. Riparian vegetation was mostly mixed coniferous-deciduous forest with a young to mature structure and a canopy closure of 0 to 70%. No

confirmed barriers were observed, although beaver dams may obstruct fry and smolt migration during low flows. The greatest temporal restriction to fish movement is low to no flows.

The primary flow through the mid-southern section has shifted to the west through a low gradient swamp with poorly defined channels. Portions of several of the small and poorly defined channels around the study area were mapped (Map 4).

Table 15. Summary of FHAP data for Nunns Creek (1 of 2).

Dominant Type	Temp. (˚C)		Gradient (%)	Mean Depth		Mean Width (m)		Max Pool Depth (m)	Bed Material Type	
	Water	Air		Bankfull	Wetted	Bankfull[1]	Wetted		Dominant	Sub-dominant
Riffle	13	21	0.08	0.63	0.15	5.73	2.79	0.50	Silts/ fines	Gravel

[1] Unit's 8 and 9 were excluded from this average as their bankful widths spanned the entire wetland area.

Table 16. Summary of FHAP data for Nunns Creek (2 of 2).

Functional LWD Tally				Dominant Cover		Dominant Riparian Vegetation		
Total	10-20 cm	20-50 cm	> 50 cm	Primary Type	Secondary Type	Type	Structure	Canopy Closure (%)
55	37	8	10	Overhanging vegetation	Large Woody Debris	Mixed	Mature/ Young forest	20-40

4.3. Invasive Species

Forty-three non-native plant species have been recorded in the study area (Table 14). Twenty-one species detected during field inventories were considered invasive. These species are presented in the context of provincial and regional priority and management in Section 6.4. The majority of the invasive species detected on the property had been previously recorded in the provincial Invasive Alien Plant Program (IAPP) database (IAPP 2016) (Table 17).

Invasive wildlife species that were observed in the study area included an American Bullfrog tadpole in the wetland adjacent to Nunns Creek Park (EU2a), and nesting European Starlings in the wetland adjacent to Homewood Rd. (EU 2c). Campbell River is the northern extent of known bullfrog distribution on Vancouver Island (BC Frogwatch Program 2016).

Table 17. Invasive species occurrence summary.

Species		Comments	Previously identified
Common name	**Scientific name**		
Knotweed	*Fallopia spp.*	A few patches around the perimeter of EU 1c.	Yes[1]
Daphne/Spurge-laurel	*Daphne laureola*	Distributed throughout drier upland forest types.	No
Common Tansy	*Tanacetum vulgare*	On disturbed edges of natural areas.	
Purple Loosestrife	*Lythrum salicaria*	Sparse occurrence throughout all marshes and edges of open water.	Yes[1]
Himalayan Blackberry	*Rubus armeniacus*	Occasional stems throughout much of the forested area, thicker thickets on edges and developing under gaps in the forest canopy.	Yes[1]
Scotch Broom	*Cytisus scoparius*	A few single stems in forested portions of the study area. Thick patches in disturbed areas adjacent to property.	Yes[1]
Canada Thistle	*Cirsium arvense*	A few patches on border of EU 4a and 2a and Nunns Creek Park.	No[1]
English Ivy	*Hedera helix*	Patchy distribution in drier upland forest, some thick patches.	Yes[1]
English Holly	*Ilex aquifolium*	Patchy distribution in drier upland forest, some thick patches.	Yes[1]
Hairy Cat's Ear	*Hypochaeris radicata*	Occurs occasionally along trail edges.	No
St. Johns Wort	*Hypericum perforatum*	A few patches in disturbed areas on edges of study area.	Yes[1]
Burdock	*Arctium minus.*	Sparsely distributed to small patches at trail edges and stream banks.	Yes[1]
Sulphur Cinquefoil	*Potentilla recta*	Thick patch on private lot bisected by trail adjacent to 3c and 2b.	No
Bull Thistle	*Circium vulgare*	A few stems bordering Nunns Creek Park and	Yes[1]
Reed Canary Grass	*Phalaris arundinacea*	Dominant in marshes1a, c and e and the edges of 1b and 2a.	Yes[2]

[1] IAPP 2016

[2] CISC 2015

Table 17. Invasive species occurrence summary (continued).

Species		Comments	Previously identified
Common name	**Scientific name**		
Reed Canary Grass	*Phalaris arundinacea*	Dominant in marshes1a, c and e and the edges of 1b and 2a.	Yes[2]
Bittersweet/ Climbing Nightshade	*Solanum dulcamara*	Single stem on border of Nunns Creek Park or EU 2a.	No
Wall Lettuce	*Lactuca muralis*	Sparse occurrence along trails.	No
Field Bindweed	*Convolvulus arvensis*	Small patch at edge of EU 3c beside picnic table.	No
Creeping Buttercup	*Ranunculus repens*	Thick in places along trails.	Yes[1]
Oxeye Daisy	*Leucanthemum vulgare*	In disturbed areas along edges of study area.	Yes[1]
Dock	*Rumex spp.*	Sparsely distributed to small patches at trail edges and stream banks.	Yes[1]

[1] IAPP 2016

[2] CISC 2015

4.4. Anthropogenic Features

Anthropogenic features including the trail network, bridges, culverts, signage and other features, as well as aquatic features such as beaver baffles and placed large woody debris are presented in Map 5. The condition and a description of each feature is provided in Appendix H. Photographs of these features are presented in Appendix I.

In total, 1803 meters of trails, and an additional 190 meters of unauthorized trails were mapped. These trails are in various stages of repair.

Eleven bridges were mapped; these cross primary and secondary channels. Most bridges were constructed of wood and surfaced with a wire tread. Four bridges were considered in 'good' condition, five in 'moderate' condition' and three in 'poor' condition. Bridges in poor condition were most often missing some cross planks or a railing and showed signs of rot. Those in moderate condition were starting to show signs of rot, had missing or broken tread or graffiti. The tread on some of the bridges in 'good' condition still had some wear.

General recommendations for management of infrastructure are presented under management considerations (Section 6.5).

5. CONSERVATION VALUES AND SENSITIVITY ANALYSIS

5.1. Ecological Unit Significance

The study area is directly connected to the Campbell River estuary and provides important inputs of detritus and invertebrates that support the estuarine food web. The property supports a diversity of plant and animal life and occurs in a predominantly natural state. The abundance of bird life is notable. It includes a valuable salmon stream, containing Coho and Cutthroat Trout, and occasionally other species of salmon, stickleback and other fish. It provides ecological services such as the storage of floodwater and the conveyance of stormwater, and therefore serves as an important piece of green infrastructure that would be costly to replace with engineered approaches.

The results of the significance assessment for each Ecological Unit are presented in Table 8 and Map 6. Site series and site associations and associated ecological communities are described in Table 12.

Table 18. Ecological Unit significance.

Ecological Unit	Site Series or Site Association	G-rank[1]	S-rank[2]	Keystone Species Abundance[3]	Species at-Risk Presence[4]	Floodwater Storage[5]	Estuarine Food Web Contributions[6]	Large Conifer Presence	Significance Score	Relative Significance Rank
1a	Wm05/RCG	1	2	1	3	3	2	1	1.85	M
1b	Wm05/Wm06	1	2	3	4	3	3	2	2.57	VH
1c	RCG/Ws54	N/A	2	4	4	3	3	2	3.00	VH
1d	Wm05	1	2	1	3	3	2	1	1.86	M
1e	RCG	N/A	1	1	3	3	2	1	1.83	M
2a	Ws50	N/A	1	4	4	3	3	1	2.67	VH
2b	Ws51/Ws52	N/A	3	1	2	3	3	3	2.50	VH
2c	Ws51/Ws52	N/A	3	3	4	3	3	1	2.83	VH
3a	07	1	2	2	1	2	2	1	1.57	L
3b	07	1	2	2	1	2	2	1	1.57	L
3c	08	2	3	1	2	2	2	1	1.86	M
4a	07/05	1	3	3	4	2	3	4	2.86	VH
4b	7	1	2	2	3	2	2	3	2.14	H
4c	07/13	2	4	1	1	2	2	3	2.14	H
4d	12/Ws53	1	2	2	3	2	2	3	2.14	H

[1] Refers to the ecological community or species conservation status across its entire range, whereas 'G1' is critically imperiled, 'G2' is imperiled, 'G3' is vulnerable to extirpation or extinction, 'G4' is apparently secure, G5' is demonstrably widespread, abundant, and secure. 'GNR' is unranked, and 'GNA' is not applicable. Where more than one ecological community is present, the most sensitive rating was applied.

[2]Refers to the ecological community or species conservation status in BC, where 'S1' is critically imperilled, 'S2' is imperilled, 'S3' is of special concern, vulnerable to extirpation or extinction, 'S4' is apparently secure and 'S5' is widespread, abundant and secure. 'SNR' is unranked and 'SNA' is not applicable. Where more than one community is present, the most sensitive rating was applied.

[3]Keystone species are species upon which ecosystems and their constituent species largely depend. As such, if they were removed the ecosystem would largely change. On the Nunns Creek property keystone species were considered to be Pacific salmon species, primary cavity nesters (e.g. Pileated woodpecker), and beaver.

[4] Species at-risk indude those listed Federally by COSEWIC as 'Endangered', 'Threatened', 'Special Concern' or listed Provincially as 'Red' or 'Blue' within the region.

[5] Areas that flood more frequently and for longer durations, have the topography to store floodwater and have finer soils have greater potential and capacity to store and slowly release water. Areas with relatively high floodwater storage potential are connected to aquatic areas by relatively lower slopes and shorter distances. Note that all ecological units provide some floodwater storage

[6]Areas that provide the greatest contributions to estuarine food webs are permanently or temporally hydrologically connected to the Nunns Creek mainstem which provides a direct linkage to the estuary. Thus temporally flooded areas with relatively lower slopes and doser proximity to the mainstem generally provide greater contributions. Note that all ecological units provide some contribution to estuarine food webs.

5.2. Ecological Unit Condition

The condition of the various Ecological Units relative to the expected reference condition are presented in Table 19 and Map 7.

Table 19. Ecological Unit condition.

Ecological Unit	Site Series or Site Association[1]	Fragmentation Score	Invasive Plant Score	Human Disturbances or Use Score	Time Since Disturbance Score	Condition Score	Condition Rank
1a	Wm05/RCG	4	2	3	3	3	H
1b	Wm05/Wm06	4	4	4	2	3.5	VH
1c	RCG/Ws54	4	2	4	2	3	H
1d	Wm05	4	4	3	2	3.25	H
1e	RCG	4	1	4	1	2.5	M
2a	Ws50	4	2	3	1	2.5	M
2b	Ws51/Ws52	4	4	3	3	3.5	VH
2c	Ws51/Ws52	4	3	3	3	3.25	H
3a	07	4	3	2	4	3.25	H
3b	07	1	2	2	3	2	L
3c	08	1	3	3	3	2.5	M
4a	07/05	1	4	2	3	2.5	M
4b	7	1	4	2	4	2.75	M
4c	07/13	4	3	2	4	3.25	H
4d	12/Ws53	4	4	3	4	3.75	VH

[1] Site series and site associations and associated ecological communities are described in Table 12.

5.3. Ecological Unit Conservation Value

The conservation value of each Ecological Unit based on their significance and conditions ranks is presented in Table 20 and Map 8.

Table 20. Ecological Unit conservation value.

Ecological Unit	Site Series or Site Association[1]	Significance Rank	Condition Rank	Conservation Value Rank
1a	Wm05/RCG	M	H	H
1b	Wm05/Wm06	VH	VH	VH
1c	RCG/Ws54	VH	H	VH
1d	Wm05	M	H	H
1e	RCG	M	M	M
2a	Ws50	VH	M	H
2b	Ws51/Ws52	VH	VH	VH
2c	Ws51/Ws52	VH	H	VH
3a	07	L	H	M
3b	07	L	L	L
3c	08	M	M	M
4a	07/05	VH	M	H
4b	07	H	M	H
4c	07/13	H	H	H
4d	12/Ws53	H	VH	VH

[1] Site series and site associations and associated ecological communities are described in Table 12.

5.4. Ecological Unit Sensitivity

The sensitivity of each Ecological Unit is presented below in tabular format. The sensitivity ratings are also presented spatially in Map 9.

Table 21. Ecological Unit sensitivity.

Ecological Unit	Site Series or Site Association[1]	Soil Moisture Regime	Size of EU	Density of Wildlife Trees	Sensitivity Score	Sensitivity Rank
1a	Wm05/RCG	4	3	2	3	H
1b	Wm05/Wm06	4	3	2	3	H
1c	RCG/Ws54	3	2	4	3	H
1d	Wm05	4	4	2	3.33	VH
1e	RCG	3	4	2	3	H
2a	Ws50	4	3	4	3.66	VH
2b	Ws51/Ws52	3	1	2	2	L
2c	Ws51/Ws52	3	3	4	3.33	VH
3a	07	2	3	4	3	H
3b	07	2	2	2	2	L
3c	08	2	3	3	2.66	M
4a	07/05	2	1	4	2.33	M
4b	07	3	2	4	3	H
4c	07/13	2	3	2	2.33	M
4d	12/Ws53	4	2	4	3.33	VH

[1] Site series and site associations and associated ecological communities are described in Table 12.

5.5. Management Importance

Seven Ecological Units scored as Very High with respect to their relative management importance. The analysis results for a given Ecological Unit's sensitivity and conservation value (significance and condition) provide insights to the factors contributing to its ranking. These factors should be used to guide management decisions. For example, EU 2c was assessed as being of Very High conservation value. It was determined to be significant because it includes an ecological community that is at risk, provides habitat for a relatively high number of both keystone species and species at risk, and is a relatively important contributor to floodwater storage and estuarine food webs compared to other EUs. It is not fragmented by trails, has relatively fewer invasive species and is not disturbed by unauthorized uses (High condition). The EU is sensitive to human disturbances because soils are wet and therefore prone to compaction. It is relatively small and therefore any disturbances would have a disproportionally large impact on its total area. It also has a relatively higher density of wildlife trees. From a management perspective, efforts should be made to avoid locating trails or other infrastructure in the EU so as not to displace species at risk or keystone species, or fragment the EU which would require wildlife tree removal due to safety concerns. Invasive species control activities may be focused here to protect the high priority EU.

The management importance of each Ecological Unit based on their conservation and sensitivity ranks is presented in Table 22 and Map 10.

Table 22. Ecological Unit management importance.

Ecological Unit	Site Series or Site Association[1]	Conservation Value Rank	Sensitivity Rank	Management Importance Rank
1a	Wm05/RCG	H	H	H
1b	Wm05/Wm06	VH	H	VH
1c	RCG/Ws54	VH	H	VH
1d	Wm05	H	VH	VH
1e	RCG	M	H	H
2a	Ws50	H	VH	VH
2b	Ws51/Ws52	VH	L	H
2c	Ws51/Ws52	VH	VH	VH
3a	07	M	H	H
3b	07	L	L	L
3c	08	M	M	L
4a	07/05	H	M	H
4b	07	H	H	VH
4c	07/13	H	M	H
4d	12/Ws53	VH	VH	VH

[1] Site series and site associations and associated ecological communities are described in Table 12.

6. MANAGEMENT CONSIDERATIONS

An understanding of the ecosystems within the Nunns Creek study area and their associated key ecological attributes, conservation values, sensitivity and relative management importance can help guide effective management and biodiversity conservation. Key management considerations identified by the City are: Nunns Creek, beavers, forest canopy, invasive species, anthropogenic features (infrastructure), education and watershed planning. Activities pertaining to these management considerations should consider the local ecology and the management importance of Ecological Units and tie together multiple management objectives. For example, a trail route may avoid a sensitive Ecological Unit with lots of danger / wildlife trees, instead winding through a berry patch and over a stream where fish can be observed, across a corner of a swamp with lots of bird life to a viewing platform where beaver activity paired with successful management of beaver dams can be viewed, and then through adjacent land that provides ecologically important linkages. Meanwhile, tree planting activities and invasive plant management can be focused on Ecological Units that are identified as significant ecosystems that are in poor condition, or that are a typically a conifer dominated ecosystem that lacks large conifers.

The following sections address the key management considerations identified by the City in turn by describing the issues and providing recommendations for management.

6.1. Nunns Creek

Nunns Creek has undergone many transitions over the past century as a result of changing land use. Urbanization presents a number of challenges to the ecology of Nunns Creek and the Nunns Creek watershed including:

- Increased peak flows due to increases in impervious surfaces throughout the watershed, the rapid conveyance of stormwater though hard infrastructure (pipes) and a reduction of tree cover in the watershed (Urban Systems 2005);
- Decreased summer base flows due to truncated inter-flow processes of rain water transmission through soils into the creek (impervious surfaces) (Urban Systems 2005);
- Increased summer water temperatures related to reduced tree canopy cover and in-filled natural pools (DFO 2001, McElhanney and Komori Wong 2004, Carter 2005);
- Decreased dissolved oxygen in the water related to increased nutrients from non-point source pollution and associated increases in microbial activity (DFO 2001, Kidd 2011);
- Sedimentation of spawning habitat, channel aggradation and widening resulting from increased sediment loads linked to erosion, upland land uses and downstream culverts (McElhanney and Komori Wong 2004, Senger, pers. comm. 2016, Roth 1999);
- Elevated levels of toxins in aquatic environments from stormwater and other sources (Scholz *et al.* 2011);
- Barriers to fish access from perched culverts, higher peak flows and lower base flows (Senger, pers. comm. 2016); and
- Fragmentation and reduction in size of remnant areas of core terrestrial habitats (Shafer 1990).

In addition, accidents resulting in degradation to the watershed are possible and have happened in the past. For example, in 1990 a structural fire in the Ironwood Mall area resulted in fire retardant entering Nunns Creek by way of the 12th Ave storm drain systems. This effluent affected Nunns Creek from 12th Ave downstream to the ocean killing over 5,000 wild Coho fry and 200 Cutthroat Trout (DFO 1990).

Effective management of the study area must take into account these watershed-scale issues. A review of background data and field inventory data suggest that four factors are of particular concern in the Nunns Creek watershed. These factors require active intervention to ensure the long term viability of wild anadromous salmonids from the watershed.

1. Water temperature: Nunns Creek water temperatures have been recorded to reach 17°C during the summer months (Roth 1999). Studies have shown that 18°C is limiting to

salmonid migration and rearing in lower reaches (Carter 2005). Other studies have indicated that 18-22°C is a threshold whereby fluvial communities switch from salmonid dominance to dominance by other species such as sticklebacks and crayfish (Carter 2005);

2. Water quality: Research in Puget Sound indicates a causal link between untreated stormwater discharge into urban creeks and high levels of mortality (60-100%) of adult Coho returning to spawn. The specific cause remains unknown (Scholz *et al.* 2011);
3. Sedimentation: Studies completed for the lower Nunns Creek watershed (Roth 1999, McElhanney and Komori Wong 2004, Urban Systems 2005), as well as observations from project collaborators (Price, pers. comm. 2016, Drake, pers. comm. 2016, Senger, pers. comm. 2016) and the field inventory, have indicated that the lower reaches of Nunns Creek from the estuary upstream into the study area have experienced severe impacts associated with undersized culverts at each of the four road crossings over lower Nunns Creek. The impacts include: sedimentation, channel aggradation and widening, reduction of spawning habitat, smothering of redds, decreased survival of smolts and reduced canopy cover; and,
4. Barriers to fish: Beaver dams, perched culverts, high peak flows, and low base flows have been identified as problematic to the movement of fish in the Nunns Creek system. Coho fry rear in their natal streams for one to two years prior to out-migrating to sea (Quinn 2005). A smolt migration upstream into optimal winter rearing habitat occurs in the fall. Excessive or sustained peak flows can inhibit this migration, as do obstructions such as beaver dams. In periods of low flow, inadequate base flows combined with aggraded channels may cause the creek to flow subsurface through coarse materials resulting in discontinuous pools of water in the mainstem. Issues with stranding and an inability to migrate upstream to high-quality rearing habitat compromise Coho survival (Senger, pers. comm. 2016).

All of these factors are related to watershed-scale impacts that extend beyond the study area. Nevertheless, effective management of the study area can ameliorate the negative effects of these factors (Table 23).

Table 23. Nunns Creek management recommendations.

Management Objective	Recommended Activity	Timeframe	Other Considerations
Maintain water temperatures within the limits of summer rearing thresholds for Coho (≤18°C) within the study area.	Connect summer rearing habitats within the main channel to the aquifer through the creation of deep water pools.	Following the completion of a detailed restoration prescription prepared by a Qualified Professional (QP) with experience in fisheries biology and hydrology.	Pools may need to be >60 cm to 2 m deep to penetrate the aquifer cap of marine clay "hardpan".
	Maintain high canopy closure along the riparian areas of the main channel by implementing beaver management in these areas and adopting a tree planting prescription.	Following the completion of a planting prescription for the study area that is approved by the landowners.	Planting prescription should be completed by a Registered Professional Forester (RPF) or other QP in consideration of this report and the Campbell River Urban Forest Management Plan.
Maintain water quality within the parameters required for healthy aquatic ecosystems.	Implement recommendation of the Nunns Creek Integrated Stormwater Management Plan with respect to the treatment of stormwater from 12th Ave.	2016 onwards.	Studies from Puget Sound suggest that filtration though ≥1 m of soil is effective in eliminating the lethal effects of urban runoff on returning adult Coho (spawners)(Spromberg *et al.* 2016). Where possible, stormwater treatment should be designed to eliminate existing Reed Canarygrass and/or preculde its development.
	Implement stormwater treatment at Homewood Rd.	2016 onwards.	Identify other potential sources of stormwater from urban or commercial lands upstream of Homewood Rd. and initiate treatment if required.

Table 23. Continued.

Management Objective	Recommended Activity	Timeframe	Other Considerations
Reduce sedimentation and channel aggradation in the lower reaches of the study area.	Support efforts to replace the culverts downstream of the study area with bridges or open bottom crossings as per the Nunns Creek Lower Watershed Management Study (McElhanney 2004)	2016 onwards.	The success of pool and mainstem channel restoration will be constrained unless this action is taken first. Preliminary design work has already been completed by McElhanney. Negotiations with MOTI regarding crossings could be incorporated into discussions regarding management of PID 009-678-255. Coordinating efforts with the Wei Wai Kum First Nation could support negotiations with the Province.
Preserve fish access to spawning areas upstream of the study area.	Restore and maintain the mainstem of Nunns Creek to create one dominant mainstem channel from Homewood to 16th Ave.	Following the completion of a detailed restoration prescription prepared by Qualified Environmental Professionals with experience in fisheries biology and hydrology.	The restored channel should be connected to off-channel beaver wetlands to maximize smolt rearing opportunities. Maintenance of previously installed large woody debris is required. Conifer underplanting in deciduous dominated riparian areas would be beneficial. Deep pool creation connected to the aquifer as above should be incorporated into the design. Conisderation should be given to deepening the channel in places to connect it to the aquifer as with the deep pools above.

Table 23. Continued.

Management Objective	Recommended Activity	Timeframe	Other Considerations
Improve the health of Nunns Creek through community-based partnerships.	Include Nunns Creek within the scope of the existing Estuary Management Group to plan for, fund and implement restoration activities in the Nunns Creek watershed.	2016 onwards.	The Working Group should include representatives from: the City of Campbell River, A-Tlegay Fisheries Society, Nunns Creek Stewards, Greenways Land Trust, DFO, the Province of BC and private landowners.

6.2. Beavers

Beavers have played a large role in shaping the current landscape of Nunns Creek. However, the open water wetlands in the study area that were formed and are maintained by beaver dams are recent modifications to the landscape. There is no evidence that beavers played a role in widespread ecological changes within the study area prior to the mid-1990s, despite infrequently occurring downstream since at least the mid-1980s (Price, pers. comm. 2016, Drake, pers. comm. 2016). It is unlikely that the study area would have provided appropriate habitat for beaver prior to logging in 1965 given the dominance of large-diameter coniferous trees, a consequent lack of a deciduous food source, and absence of pre-existing natural wetlands. It is possible that the logging combined with the dramatic decline of BC's fur industry in the early 1990s (83%) resulted in an increase in beaver populations in BC by the late 1990s (BC Stats 2005).

The immigration of beaver into the study area has likely resulted in several ecological changes including:

- Increased wetland habitat area and decreased forest habitat area;
- Increased species richness (biodiversity) including both species at risk and invasive species;
- Temporarily increased density and distribution of standing dead trees;
- Increased off-channel rearing habitat for Coho and other salmonids;
- Increased stormwater retention and filtration capacity (improved water quality and summer base flows);
- Increased stream temperatures (large areas of shallow water without tree canopy);
- Impaired upstream migration routes for juvenile Coho and Cutthroat Trout;
- Decreased channel confinement of Nunns Creek; and
- Increased incidence and severity of flooding to adjacent properties including Nunns Creek Park.

In response to issues associated with flooding, the City of Campbell River undertook emergency beaver management activities in December 2010. These included: breaching one beaver dam, the installation of drainage pipes within two beaver dams, and the lethal control of approximately five beavers (Martin, pers. comm. 2016). Field observations indicate that the beaver baffles are no longer functioning, and have washed downstream (Figure 3, Figure 4).

Figure 3. Completed installation of a drainage pipe in the beaver dam in EU2a, 2010 (Martin, pers. comm. 2016).

Figure 4. Drainage pipe washed downstream of beaver dam in EU2a, May 24, 2016.

Active beaver improvements to an existing dam were observed during the study period, causing water levels to rise in the wetland adjacent to the ball fields (EU 2a) between May 24 and July 14, 2016. Water levels rose at least 40 cm between the two observation days, flooding the trail on the west edge of the wetland and the mowed fields in Nunns Creek Park to a depth of 15 cm.

Management of the study area should be responsive to both the benefits and challenges associated with beaver (Table 19) and follow Provincial BMP's and permitting processes (FLNRO n.d., Henigman, pers. comm. 2016, MacDermott, pers. comm. 2016).

Table 24. Beaver management recommendations.

Management Objective	Recommended Activity	Timeframe	Other Considerations
Maintain existing wetland habitat with no net increase as a result of beaver activity.	Re-install and adequately maintain water level control structures within existing beaver dams to regulate water levels.	Consistent with Federal and Provincial regulations for instream works.	Ensure notification and permits are in place from Provincial and Federal agencies[1].
	Discourage the expansion of beaver activity by ensuring the riparian corridor along the main stem of Nunns Creek is planted with coniferous tree species ecologically suited to the site.	Following the completion of a planting prescription for the study area that is approved by the landowners.	Planting prescription should be completed by a Registered Professional Forester (RPF) or other QP in consideration of this report and the Campbell River Urban Forest Management Plan.
Maintain the main stem of Nunns Creek as an unobstructed channel to ensure fish access to spawning areas upstream of Homewood Ave.	Designate Ecological Units 1a, 1e, 2c, 3a, 3c, 4a-d and the eastern half of 2b as beaver management zones. Perform beaver control activities as necessary within these zones.	Following the completion of an approved management plan for the study area.	Ensure beaver control activities conform to Provincial regulations and best management practises.
Maximise the nature-based educational opportunities present within the study area.	Install a viewing platform at a beaver-created wetland with interpretive signage that highlights the benefits and challenges associated with beaver activity in an urban context.	Following the completion of an approved management plan for the study area.	

[1] FLNRO n.d.

6.3. Forest Canopy

The Campbell River Urban Forest Management Plan (UFMP) (Penner 2015) recognizes multiple values of urban forests to society. Phase one of the plan provides a forest inventory of Campbell River and sets forest management objectives. Future phases will determine additional strategies, policies and planning initiatives for the urban environment.

The UFMP recognizes that native tree species and canopy cover in Campbell River's urban area is in decline, that most of the City's forests are young, increasingly composed of deciduous species, and in a deteriorating condition (Penner 2015).

The forest canopy cover in the study area appears to be within the range of natural variation for wetland and riparian forest systems on the central east coast of Vancouver Island. The current and future projected canopy of the study area reflect natural disturbance and regeneration patterns alongside human-influenced regeneration from historic logging and changing hydrology. Currently the forests are in a phase of transition. The two greatest changes are that: 1) deciduous stands regenerating after logging in 1965 are now thinning, creating canopy gaps that are being infilled with an understory of conifers with a smaller component of deciduous trees; and 2) coniferous and deciduous trees are dying (decreasing canopy cover) as a result of flooding caused by beaver activity and backwatering culverts. Forest canopy gaps are also being continuously created where larger conifers are falling. Most of these conifers are Western Hemlock trees compromised by Hemlock Dwarf Mistletoe (*Arceuthobium tsugense*). The presence of root rot is also contributing to increased blowdown of trees.

The industrial zone surrounding the study area has a canopy cover of 17%. This is near the minimum recommended cover of 15%. The urban containment area (UCA) currently has an average of 32% canopy cover. The current canopy cover of forested swamps and upland forests in the study area ranges from 50-60%, and the canopy of shrub and herb-dominated wetlands was 1-5%. The current tree density within upland forests of the study area was 875 stems per hectare. This is comparable to the 860 stems per hectare average for City of Campbell River parks (Penner 2015).

The current canopy cover is likely slightly lower than what will be there in 50 years as sub-canopy coniferous regeneration matures. It is also likely lower than prior to logging 70 years ago. The current tree composition is more heavily weighted towards deciduous species than it was in the past and will be in the future.

Tree age in mixed stands was typically around 65 years, with some large veteran trees that were over 160 years old. In younger deciduous stands the average tree age was as low as 25 years.

The Urban Forest Management Plan sets out objectives for management of the City's trees. These objectives are summarized and related to recommended management of trees and forests in the study area in Table 25.

Table 25. Forest canopy management recommendations.

Management Objective	Recommended Activity	Timeframe	Other Considerations
1) Maintain or increase canopy cover.	Develop a forest management plan that sets tree density targets for specific zones based on the current condition, as determined by plot data, and the future desired condition. Key areas to plant coniferous trees may be: 1) Under deciduous trees along urban/ natural boundaries to provide a buffer and ensure regeneration of coniferous trees in areas that are being encroached upon by Himalayan Blackberry; 2) Along the primary stream channel, to stabilize banks and provide other riparian functions with long lived and large coniferous species that beaver prefer not to eat; and 3) In forest gaps where there is strong competition from shade-intolerant species such Himalayan Blackberry.	Planting could occur upon completion of a forest management plan. Planting is best done in fall or early spring.	The forest is regenerating naturally from native seed source. Natural regeneration should be favoured over planting nursery stock unless there is a specific reason for the alternate (e.g. forest health issues). Similarly forest canopy gaps are expected to naturally infill with trees in the absence of other pressures such as invasive species. Determination of the future desired condition should consider ecologically appropriate species and existing and potential Provincially Red- or Blue-listed ecological communities. Consider partnership with Cahari high schools forestry program for planting activities.

Table 25. Continued.

Management Objective	Recommended Activity	Timeframe	Other Considerations
1) Maintain or increase canopy cover (continued).	Other areas that could provide opportunities to plant aesthetically pleasing native tree species are: 1) Along natural edges to provide a buffer and soft transition into the forest; and, 2) As landscaping features around Nunns Creek Park and any future development of the BMX track or associated paths.		
2) Increase composition of conifers, especially older, larger conifers.	See recommended activities from Management Objective 1.		
3) Maintain native tree composition in parks.	Ensure planted stock is composed of native species.		
	Monitor naturally regenerating trees to ensure they are native and not horticultural varieties. Replace non-native trees with native trees where appropriate.	Implement monitoring program upon development of a plan.	Current non-native tree species in the study area are listed in Appendix F. Of these, European Birch has been known to become problematic and dominate the canopy in many areas of the Lower Mainland.
4) Maintain a healthy urban forest.	Develop a plan to monitor tree health and stressors. These may include: pathogens such as root rot, mistletoe, bark beetles or rusts, or other environmental stressors such as drought, excessive heat or flooding.	Implement monitoring program upon development of a plan.	A rough map of the locations of existing pathogens and environmental stressors and the tree species affected could be used to guide future planting prescriptions. (e.g., Don't plant Western Hemlock under a tree with mistletoe or Grand Fir beside a tree with *Laminaria* root rot.)

6.4. Invasive Species

Invasive species threaten biodiversity and degrade ecosystem resilience, as well as impact human health, safety and economics. The City of Campbell River has developed an Invasive Species Policy (City of Campbell River 2013) and Invasive Species Management Plan (CISC 2015) to address these concerns.

Invasive species data and treatment in Campbell River is currently coordinated by the Coastal Invasive Species Committee (CISC). The CISC previously had a North Island subcommittee (the North Island Invasive Species Partnership) that is currently inactive . Within the Nunns Creek watershed invasive species control activities have historically been undertaken by: the City of Campbell River, Greenways Land Trust, Nunns Creek Stewards, Broom Busters, North Island College, the Campbell River Indian Band, and others (CISC 2015, Price, pers. comm. 2016).

Four provincially (and regionally) Noxious species occur in the study area or on adjacent lands within Nunns Creek Park (*Weed Control Act*). Four of the species detected are on CISCs contain list and nine are on their control list. Seven of the top ten invasive plant species identified by the Greenways Land Trust for management (CISC 2015) occur on the property.

Effective invasive species management starts with prevention, followed by early detection and rapid response, then management (CISC 2015). New invaders and small occurrences can be most easily eradicated, while established invasive species must be contained and/or controlled. All but one of the invasive species detected during project-specific inventory of the study area have been previously documented in Campbell River and are considered established (Table 13). The CISC priorities for containment and control of established species are to: (1) protect high value conservation areas, (2) contain existing infestations and prevent the spread to un-infested areas, subject to (3) the likelihood of effective control; and (4) available resources and community interest.

Sulphur cinquefoil (*Potentilla recta*) was identified during the 2016 field inventory. It is a recent arrival to the coastal region, with only ten known occurrences (McElroy, pers. comm. 2016). The species is considered Noxious (*Weed Control Act*) and is a management priority in some interior regions of BC where it is widespread (e.g., SIWMC 2014).

Field inventories have documented 42 non-native plants within the study area and on immediately adjacent lands. Of these, the CISC recommends containment for four species and control for nine other species. Of these 13 species, the CISC has identified five as a management priority for the Nunns Creek study area specifically based on 2015 occurrence data. An additional nine species have been prioritized for management by other partner agencies. One species (Yellow Flag-iris) is included in this report despite not being detected in the study area. It is known to occur directly upstream and downstream of the study area.

The City of Campbell River Invasive Plant Management Plan (CISC 2015) provides management recommendations for treatment of invasive species, as well as budgets and Nunns Creek specific recommendations. These have been strongly considered in the recommendations provided (Table 26). One notable caveat is that herbicides should not be sprayed near watercourses. Instead manual treatments should be used where possible and proven effective. Stem injections of herbicide are also favorable to broadcast spraying methods.

In addition to the specific management recommendations provided there are several documents available that outline best management practices for reducing the spread of invasive species, especially during development (e.g., trail building, infrastructure improvements etc.) (IAPP 2010, CISC 2016).

Table 26. Invasive species management recommendations.

Species		Presence	CISC priority[1,2]	BC Weed Act[3]	Greenways Land Trust Top 10[1]	IMP Nunns Creek Priority List[1]	Management History	Estimated Risk to Conservation Values	Management Recommendation
Common Name	Scientific Name								
Knotweed	*Fallopia spp.*	Current	Contain	Noxious	Yes	Priority treatment	Control by mowing and geomatting by Nunns Creek Stewards pre-2001 by Nunns Creek inflow at Homewood[4]. 2012/2014 herbicide stem injection[1].	Very High in all habitat types other than open water.	Annual control. Use stem injection or backpack sprayer with glyphosate.
Spurge-laurel and European Cherry-laurel	*Daphne laureola* and *Prunus laurocerasus*	Current	Contain	-	-	-	-	Moderate in upland forest areas.	Pull or excavate roots.
Yellow Flag Iris	*Iris pseudacorus*	Upstream/ downstream	Contain	Noxious	-	-	-	High in wetland areas.	Pull or excavate roots.
Common Tansy	*Tanacetum vulgare*	Adjacent	Contain	-	-	-	-	Low in cleared, upland areas and wetland margins.	Spray with herbicide or pull roots.
Purple Loosestrife	*Lythrum salicaria*	Current	Control	Noxious	Yes	Priority treatment	1995-6 biocontrol weevil (*Galarucella pucilla*) released. 2001 removal[4].	High in wetland areas.	Annual control. Pull all rootstock before flowers go to seed. Cut-off flowers before they make seed if pulling not feasible.
Himalayan and Cutleaf Evergreen Blackberry	*Rubus armeniacus and R. laciniatus*	Current	Control	-	Yes	Priority treatment	Historic manual treatment by Nunns Creek Stewards.	High in forest openings, riparian and wetland edges.	Prioritize mechanical removal of fruiting stems in forest openings where there is increased light availability. Excavate as much of root as possible.

[1]CISC 2015

[2]CISC 2016

[3]*BC Weed Control Act,* Weed Control Regulation, Schedule B; note that the provincial noxious species list was updated in 2011

[4]Sellentin 2001

Table 26. Continued.

Species		Presence	CISC priority[1,2]	BC Weed Act[3]	Greenways Land Trust Top 10[1]	IMP Nunns Creek Priority List[1]	Management History	Estimated Risk to Conservation Values	Management Recommendation
Common Name	Scientific Name								
Scotch Broom	*Cytisus scoparius*	Current	Control	Previously noxious	Yes	Priority treatment	Used to mow in BMX area[5].	Moderate in clearings and edges of upland forests.	Prioritize removal of flowering stems from interior of property. Deprioritize removal from open disturbed areas such as adjacent to the BMX area.
Canada Thistle	*Cirsium arvense*	Current	Control	Noxious	-	-	-	Moderate-high in wetland margins.	Spray plants. Secondary treatment method is pulling.
English Ivy	*Hedera helix*	Current	Control	-	-	Priority treatment	Historic manual treatment by Nunns Creek Stewards.	Moderate-high in upland forests and riparian areas.	Cut a segment >60 cm from vines on trees. Hand pull roots and ground stems. Herbicide has been reported as ineffective.
English Holly	*Ilex aquifolium*	Current	Control	-	Yes	-	Historic manual treatment by Nunns Creek Stewards.	Moderate in upland forests and riparian areas.	Cut, pull roots and/ or spray, cut stump or inject herbicide.
Hairy Cat's Ear	*Hypochaeris radicata*	Current	Control	-	-	-	-	Moderate in upland forests and riparian areas.	Monitor and pull in high conservation value areas when possible.
St John's Wort	*Hypericum perforatum*	Current	Control	Previously noxious	-	-	-	Low in upland forests and wetland margins.	Spray with herbicide or pull (ensure roots removed).
Burdock	*Arctium minus*	Current	Control	Noxious in other regions	Yes	-	-	Moderate risk in riparian areas and wetland margins.	Monitor and excavate roots in high conservation value areas when possible.

[1]CISC 2015

[2]CISC 2016

[3]*BC Weed Control Act,* Weed Control Regulation, Schedule B; note that the provincial noxious species list was updated in 2011

[4]Sellentin 2001

[5]Bendickson, pers. comm. 2016

Table 26. Continued.

Species		Presence	CISC priority[1,2]	BC Weed Act[3]	Greenways Land Trust Top 10[1]	IMP Nunns Creek Priority List[1]	Management History	Estimated Risk to Conservation Values	Management Recommendation
Common Name	Scientific Name								
Sulphur Cinquefoil	*Potentilla recta*	Adjacent	-	Noxious in other regions		-	-	Moderate in upland forest clearings and edges, riparian and wetland edges.	Eradicate any plants found on property. Pull or spray all plants before they are able to spread beyond their current location.
Bull Thistle	*Circium vulgare*	Current	-	Previously noxious	-	-	-	Moderate-High in wetland margins.	Pull stems before flowering.
Reed Canarygrass	*Phalaris arundinacea*	Current	-	-	-	-	-	Very High in wetland areas.	Develop wetland restoration plan for affected areas. Control methods are experimental. Consider excavating and creating deep water conditions.
European Bittersweet	*Solanum dulcamara*	Current	-	-	-	-	-	Moderate in riparian areas and wetland margins.	Newer invader. Eradicate if possible by pulling stems.
Wall Lettuce	*Lactuca muralis*	Current	-	-	-	-	-	Low in upland forests.	Monitor. Reported to be aggressive invader in the Kootenays.

[1]CISC 2015

[2]CISC 2016

[3]*BC Weed Control Act,* Weed Control Regulation, Schedule B; note that the provincial noxious species list was updated in 2011

Table 26. Continued.

Species		Presence	CISC priority[1,2]	BC Weed Act[3]	Greenways Land Trust Top 10[1]	IMP Nunns Creek Priority List[1]	Management History	Estimated Risk to Conservation Values	Management Recommendation
Common Name	Scientific Name								
Field Bindweed	*Convolvulus arvensis*	Current	-	-	-	-	-	Moderate in riparian areas, wetland margins, forest edges and openings.	Monitor.
Creeping Buttercup	*Ranunculus repens*	Current	-	-	-	-	-	Low in all habitats.	Monitor.
Oxeye Daisy	*Leucanthemum vulgare*	Current	-	Previously noxious, noxious in other regions	-	-	-	Low in forest openings and wetland margins.	Monitor.
Dock Spp.	*Rumex spp.*	Current	?	-	-	-	-	Low in riparian areas and wetlands.	Monitor.

[1]CISC 2015

[2]CISC 2016

[3]*BC Weed Control Act,* Weed Control Regulation, Schedule B; note that the provincial noxious species list was updated in 2011

6.5. Anthropogenic Features

Human safety within the study area is currently compromised by unauthorized human use, deteriorating infrastructure and danger trees. Unauthorized use includes camping, garbage dumping and littering and engaging in illegal activities. Infrastructure is in various stages of repair. For example some bridges are safe to cross and some are missing railings or cross ties. Similarly some trails are wide, clear and well surfaced, and others are grown over and have blown down trees strewn across them. Trees are in various stages of decay and some have health issues that compromise their stability. Of particular note are the aging deciduous trees that regenerated after logging in the 1960s, and large conifers with pathogens.

General recommendations are provided in Table 27. Infrastructure specific recommendations are provided for most infrastructure and trails. Bridge management will ultimately depend on the final trail route (Appendix H).

In addition to the recommendations provided pertaining to existing infrastructure, there may be opportunities to build additional infrastructure to enhance the user experience such as bird blinds or viewing platforms and interpretive signage.

Table 27. Infrastructure recommendations.

Management Objective	Recommended Activity	Timeframe	Other Considerations
1) Provide a positive user experience and a safe network of trails that:	Create an access management plan that includes designation of a trail route and infrastructure.	2016 onwards.	Consider assessment of trail and infrastructure condition and comments provided in Appendix H.
a. Adhere to sound ecological practices for trail construction.	Access management plan should consider sensitivity analysis, conservation values, management importance and their component factors (Section 5).		Consider other trail construction BMP's regarding drainage and soil compaction, minimizing trail length around wetlands and perpendicular to Ecological Unit boundaries, crossing streams at a perpendicular etc.
b. Free of garbage, camps and other unauthorized use;	Access management plan that designates authorized trails and strategies for dealing with unauthorized use. Increase sanctioned use and the number of visitors to the area for activities such as walking, nature enjoyment and education.	2016 onwards.	Although unauthorized use is expected to decrease with an increase of other users and with implementation of access management plan. Garbage management will always be necessary and could be managed by a combination of garbage cans and clean-up events. Deactivate dead-end trails.
c. Dry year-round;	Manage temporal flooding of trails adjacent to beaver controlled wetlands and during high flows.	Upon completion of an access management plan and concurrent with trail route planning, beaver management plan and Nunns Creek restoration prescription.	This action is related to beaver management (Section 6.2) and the management of Nunns Creek (Section 6.1), as well as strategic placement of the trails away from moist soils (Table 21, Section 5).

Table 27. Continued.

Management Objective	Recommended Activity	Timeframe	Other Considerations
d. Adequately wide to pass through;	Remove Himalayan Blackberry, Salmonberry and other vegetation that is encroaching into trails.	Upon completion of an access management plan and concurrent with trail route planning.	This action is related to invasive species management (Section 6.4).
e. On lands owned by the City of Campbell River or under a lease or other agreement with the City;	Investigate user agreement between the City of Campbell River and MoTI regarding use of PID 009-678-255.	Immediately.	Renewal of lease from TNT in 2085 and 2086.
	Trails that are not on City owned or managed property are removed or relocated.	Upon completion of an access management plan and concurrent with trail route planning.	A thoroughfare through the study area that connects Nunns Creek Park to Homewood Rd. will prove challenging and will likely require a lengthy boardwalk.
f. Well used by the public for nature enjoyment and education (trails continued); and,	Consider patterns of future human use, and nature education in access management plan.	Upon completion of an access management plan and concurrent with trail route planning.	Consider education (Section 6.6) while developing access management plan. Consider thoroughfares and making nature part of peoples daily experience. Tie in's to bike paths. Buffering portions of walking path that must follow a road (such as around Homewood Rd.) with a bike path, fencing or landscaping.

Table 27. Continued.

Management Objective	Recommended Activity	Timeframe	Other Considerations
g. Safe from danger trees (trails continued); and,	Route trail to avoid high densities of decaying and diseased trees. Have the preferred trail route reviewed by a certified Danger Tree Assessor. Develop plan for managing danger trees.	Immediately to upon completion of an access management plan or masterplan and concurrent with trail design.	See Table 20 (Section 5) for relative wildlife tree densities by Ecological Unit. Trail routing and potential management of danger trees (also known as wildlife trees) should consider ecological value of these trees and use. Any danger tree management should be completed outside of the breeding bird period. A biologist should walk the proposed trail route prior to finalizing route selection. Top trees instead of cutting to ground where possible. Use coarse wood onsite to promote biodiversity.
h. Safe from fire.	Work with the City of Campbell River Fire Department to review existing suppression capabilities and identify any gaps.	2016 onwards.	The study area is within 10 minutes of a fire hall (City of Campbell River iMap) and does not have a wildland fire interface[1]. The fire season corresponds to the period when flows in Nunns Creek are lowest. However, wetland on the property may hold enough water in the summer to be useful if the existing hydrant system is behond the reach of the fire location. Wetlands should be used as a last resort.

[1] City of Campbell River, 2012

Table 27. Continued.

Management Objective	Recommended Activity	Timeframe	Other Considerations
2) Provide safe, low maintenance bridges and boardwalks over creeks and areas with sensitive soils.	Repair or remove bridges that pose safety concerns.	2016 onwards.	Consider assessment of bridge condition provided in Appendix H.
	Route trails to reduce number of creek crossings and wet or seasonally flooded areas. Use long lasting materials for bridge repair and construction.	Assess safety of existing bridges. Determine which bridges to keep and which to remove upon completion of an access management plan and concurrent with trail route planning.	
3) Provide functional culverts or alternate passage of Nunns Creek under roads.	Upgrade culverts to adequate size and appropriate style or to bridge to allow adequate flow through culverts, stop flooding of road and backup of creek upstream of 16th and allow fish passage.	2016 onwards.	Review recommendations provided for management of Nunns Creek (Section 6.1).
4) Storm drains effectively manage stormwater runoff without compromising aquatic health.	Filter stormwater through soil by way of a wetland prior to it entering Nunns Creek.	2016 onwards.	Review recommendations provided for management of Nunns Creek (Section 6.1).
5) Beaver baffles on site are effective.	Remove broken and displaced beaver baffles. Maintain, replace or remove existing beaver baffles as per beaver management plan.	Upon completion of beaver management plan.	See beaver management recommendations (Section 6.2).

Table 27. Continued.

Management Objective	Recommended Activity	Timeframe	Other Considerations
6) Provide signage that is visible and useful to the public.	Place signs near trail entrances or roads with long sightlines. Focus on high traffic areas. Ensure view is not obstructed by vegetation such as Himalayan Blackberry thickets.	Following trail design and completion of access management plan or masterplan.	Most people consulted during interviews, the site tour and public meetings reported entering the trails from Nunns Creek Park. Under the current trail design, this entrance would be a good place for a welcoming and informative trail sign and map.
7) Picnic tables are in functional and aesthetically pleasing areas.	Move picnic table to more aesthetically pleasing and accessible area.	Upon completion of access management plan or masterplan and trail design.	-

6.6. Education

The study area provides excellent opportunities for nature-based education to a variety of audiences as it is within a convenient proximity to the city centre and local schools. Both passive and active forms of educational outreach could be successful. Passive forms would include self-guided interpretive trails and associated infrastructure. Active forms would include guided tours and interactive hands-on opportunities for participants to engage directly with natural features. In either case, supporting nature-based education with a dedicated facility such as a Nature House would expand the capacity for nature-base education of all kinds within the City.

Among nature-based education opportunities is the passing on of information about traditional use of the plants and animals in the study area. The study area contains over 75 native species of plants. Many of these species were important to First Nations peoples for food and medicine and/or were used as materials for a variety of purposes such as those in Table 28. Incorporating information about the importance of these natural resources through educational outlets will be of interest to both First Nations people and people from other cultural backgrounds.

Other nature-based education opportunities are summarized in Table 29.

Table 28. Traditional First Nations resources of Nunns Creek.

Common Name	Scientific Name	Traditional Use	Source
Coho	*Oncorhynchus kisutch*	Food	D. Drake 2016
Pink Fawn Lily	*Erythronium revolutum*	Food (bulbs)	F. Boas 1921
Skunk Cabbage	*Lysichiton americanus*	Wax paper (e.g., basket liner), thickening agent	N. Turner 1995
Salmonberry	*Rubus spectabilis*	Food (berries, young shoots)	N. Turner 1995
Sitka Spruce	*Picea sitchensis*	Basketry and cordage (roots), glue (pitch)	N. Turner 1998
Red Alder	*Alnus rubra*	Smoking fish (wood), carving (wood), dye (bark)	N. Turner 1998

Table 29. Summary of educational opportunities.

Educational Infrastructure or Opportunity	Target Audience	Curriculum	Other Considerations
Interpretive trails and signage	All	Traditional First Nations land management techniques and resource use, salmon life cycle, floodplain forest ecology, wetland ecology, invasive species management, wildlife trees.	Install signage on kiosks at main access points, at viewing platforms, and at key interest points. Trail, bridges and access should be wheelchair/ stroller accessible.
Viewing platform / blind	All	Wetland ecology, beaver management, stormwater management/green infrastructure.	Best location is overlooking wetlands adjacent to Nunns Creek Park or proposed Nature House location.
Nature house	All	Varied in subject and educational level. Multi-media, interactive displays.	Best location is outside of conservation area, possible old BMX track area. Combine with GLT office and multi-purpose space.
Community volunteers	General public, stewardship groups, First Nations partners, public service groups, VIHA patients, local businesses (day of service programs).	Invasive plant control, trail maintenance BMPs, ecological succession (tree planting).	Activities linked to approved management plan objectives/ implementation plan, and coordinated with Nunns Creek Stewards and GLT.
Recreation programming	Youth, teens, seniors.	Natural history, art, active living.	TBD
School groups	Pre-school - Grade 12, post secondary.	As per curriculum (e.g., WildBC).	Viewing platforms, rain shelters and other infrastructure should accommodate appropriate group size.

6.7. Watershed Planning

The Theory of Island Biogeography (MacArthur and Wilson 1967) suggests that the smaller an island is, and the farther away it is from the mainland, the fewer species it can sustain. This theory has been applied by conservation biologists to urban parks which exist as islands of habitat in a matrix of non-natural land cover (Shafer 1990). As development occurs, habitat islands become smaller, and increasingly fragmented from one another. This leads to a gradual decrease in the number of native species a given habitat island can sustain in the long term. To overcome this loss of species, it is important to ensure conservation areas are as large as is feasible, to buffer habitat islands with complimentary land uses, and to ensure that natural connectivity corridors link habitat islands together.

There exist several important opportunities to expand the size of the Nunns Creek conservation area. These are summarized in Table 30. Most importantly, ensuring conservation management for the MOTI lands within the study area is recommended.

Currently, there is little opportunity to buffer the study area with complimentary land uses. It is surrounded on all sides by dense urban development including residential, industrial and commercial land uses. Two other nodes of core habitat still remain in the watershed, and strategies to link the study area to these habitat cores is essential in the long term viability of native species within the study area. The first node of core habitat is the estuary of Nunns Creek, and the larger Campbell River estuary complex. It is connected to the study area by Nunns Creek itself downstream of 12th Ave. The Nunns Creek estuary and all lands connecting it to the study area are located on the Campbell River Indian Reserve #11. Strategies to protect this core habitat and the connections to the study area will require partnerships with the Campbell River Indian Band.

A second node of core habitat remains to the south of the study area on either side of the Elk River Trail (ERT) between McPhedran and Petersen Rds. These lands are privately held over multiple titles and are zoned as Residential Multiple One (RM-1). Current bylaws allow for a density of up to 30 units/hectare in this area. Given the zoning, this area of core habitat is at risk of development and could be lost. This habitat core is currently well connected to the study area by lands on either side of the ERT and also helps to protect the conservation values of the ERT. Strategies to protect these lands can be achieved through changes to the OCP and associated bylaws, as well as through partnerships with land trusts.

Table 30. Watershed planning recommendations.

Management Objective	Recommended Activity	Timeframe	Other Considerations
Protect the natural areas within and adjacent to the study area from incompatible development.	Gain clarity of current status of MoTI parcel within the study area. If the parcel is not needed by MoTI, an agreement should be negociated to include the parcel in Nunns Creek Park. This may be through transfer of ownership or other type of agreement.	2016 onwards.	If the title is transfered to the City of Campbell River, it should be done with a conservation covenant held by a land trust. If not possible to transfer the parcel to the city, other options to secure the parcel for conservation should be considered. This could include transfer to MFLNRO for inclusion in the proposed Campbell River estuary Wildlife Managment Area (WMA) or designated by MFLNRO as a map reserve for conservation purposes.
	Protect undeveloped areas of adjacent lots to the east of the study area throughenforcing the General DPA guidelines under the OCP.	2016 onwards.	A segment of the primary access trail connecting Homewood Rd to Nunns Creek Park is located on these private lands and should be re-routed unless easements can be negotiated with each owner.
	Expand the wetland EDPA boundary east of the study area such that it includes the commercial area along Ironwood Rd. Use the EDPA process to encourage re-development that supports the conservation and human use objectives of the study area.	During the next OCP review process.	Improving pedestrian access into the study area from Ironwood through the re-development process would support compliance with human use goals (minimize unauthorized activities)

Table 30. Continued.

Management Objective	Recommended Activity	Timeframe	Other Considerations
Protect the natural areas within and adjacent to the study area from incompatible development (continued).	Redevelop the former BMX track area such that it supports the conservation and education objectives of the study area.	Following the completion of an approved management plan for the study area.	Compatible uses could include developing a multi-purpose Nature House on a portion of the lot, and ecosystem restoration on the remainder.
Protect remaining natural areas within the Nunns Creek watershed.	Protect undeveloped areas within the Nunns Creek watershed for conservation purposes through park acquisition, OCP amendment and EDPA regulations, or through partnerships with ENGOs.	Following the 2018 OCP amendment process.	Priority parcels for protection are listed in the July 2016 DRAFT version of this document.

7. CONCLUSION

The Nunns Creek study area contains high ecological conservation values. It includes a diversity of ecological communities including riparian floodplain forests, swamps, marshes and open water ecosystems that provide important linkages to the Campbell River estuary. Several of the described ecological communities are considered "critically imperiled" in BC. The study area also provides habitat for numerous species of native plants and wildlife, some of which are listed as rare or endangered in BC. Several keystone species are present in the study area including Coho and other salmonids, American Beavers, and primary cavity nesting birds. The study area contributes to ecological services including the retention and conveyance of stormwater and other benefits associated with an urban forest.

Despite being partially logged in 1965, and being surrounded by a growing urban environment, the study area is regenerating naturally to include elements of its pre-disturbance condition. These elements include ecosystem functions, ecosystem dynamics, large trees and species associated with older forests. Elements that differ from the pre-disturbance condition are also developing due to both natural and anthropogenic factors. These factors include flooding associated with beaver dams and the establishment of over 40 non-native plant species, as well as urbanization of the surrounding watershed, climate change, including sea-level rise, and the use of the study area for both unauthorized and accepted public access.

Active management of the study area is recommended to achieve the City of Campbell River's objectives for Nunns Creek specifically, and for parks and natural environments in the municipality. The background information synthesis, ecological inventory, conservation assessment and management recommendations provided herein should be used as a guide to inform management planning and implementation, and facilitate achievement of the City's broader goals to protect and restore environmentally sensitive areas, preserve ecological function and support a community with awareness and understanding of ecological principles.

Recommendations are provided for each management consideration including the development of plans that further detail actions (Section 6). These plans include a Nunns Creek restoration plan, beaver management plan, forest management and planting plan, invasive species management plan and an access management plan or parks masterplan that includes a trail design. Additional ecological investigations are recommended concurrent to development of these plans including:

1. Breeding bird surveys and fine-scale mapping and description of wildlife trees should precede improvements or expansion of the public access routes through the study area to inform site-specific route options;
2. Localized finer-scale mapping and description of Nunns Creek, its existing aquatic habitat features and the underlying aquifer should take place prior to development of site-specific restoration prescriptions for Nunns Creek; and

3. More detailed forest inventory should be completed in candidate tree planting areas to support planting prescriptions that contribute to goals of the City's Urban Forest Management Plan (Penner 2015), including an analysis of current forest health conditions and soils.

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PROJECT MAPS

337600 337800 338000 338200 338400 338600

5544400

5544200

5544000

5543800

16th Avenue

Homewood Road

10th Avenue

1d 2c 3a 4a 2a 3b 2b 1a 1b 1e 4d 3c 1c 4b 4c

Nunns Creek

Ecological Units

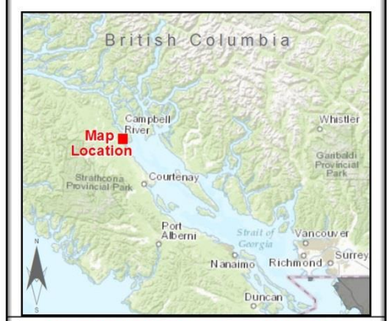
Legend

Ecosystem Type

- Marsh/Open Water
- Swamp/Open Water
- Deciduous
- Mixed Coniferous Deciduous
- Trail
- Stream

Project Areas

- Nunns Creek Park
- Study Area
- Project Area



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Map 2

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16th Avenue

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Homewood Road

10th Avenue

Nunns Creek

BC Listed Ecological Communities

Legend

BC Listed Ecological Communities

- Red
- Blue
- Yellow
- Exotic
- Trail
- Stream

Project Areas

- Nunns Creek Park
- Study Area
- Project Area

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

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ECOFISH RESEARCH

Map 3

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16th Avenue

Unit 1

Unit 2

Unit 3

Unit 4

Unit 5

Unit 6

Unit 7

Unit 8

Unit 9

Homewood Road

10th Avenue

Nunns Creek

Fish Habitat Assessment Procedure

Legend

FHAP Type
- Pool
- Riffle

Ground Truthed Stream
- Yes
- Partial
- No

Aquatic Feature
- Beaver dam
- LWD

Infrastructure
- Bridge
- Culvert
- Storm drain
- Beaver baffle
- Sign
- Picnic table
- Cement pad
- Pipe

Water Attributes
- Wetlands
- Stream

Project Areas
- Nunns Creek Park
- Study Area
- Project Area

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

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ECOFISH RESEARCH

Map 4

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Nunns Creek

Anthropogenic Features

Legend

Infrastructure
- Bridge
- Culvert
- Storm drain
- Beaver baffle
- Sign
- Picnic table
- Cement pad
- Pipe

Aquatic Feature
- Beaver dam
- LWD

Trail Category
- Primary - good condition
- Primary - variable condition
- Primary - degraded
- Secondary - good condition
- Secondary - variable condition
- Secondary - degraded
- Unauthorized

Water Attributes
- Wetlands
- Stream

Project Areas
- Nunns Creek Park
- Study Area
- Project Area

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

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Map 5

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16th Avenue

10th Avenue

Homewood Road

1d 2c 3a 4a 2a 3b 2b 1a 1b 1e 4d 3c 1c 4b 4c

Nunns Creek

Ecological Unit Significance

Legend

Ecological Unit Significance

- Very High
- High
- Moderate
- Low
- Trail
- Stream

Project Areas

- Nunns Creek Park
- Study Area
- Project Area

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

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Scale: 1:3,400

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Date Saved: 19/10/2016
Coordinate System: NAD 1983 UTM Zone 10N

ECOFISH RESEARCH

Map 6

Path: M:\Projects-Active\1292 Nunns Creek\MXD\1292_NUN_Landscape11x17Maps_2016Jul28.mxd

337600 337800 338000 338200 338400 338600

5544400 5544200 5544000 5543800

16th Avenue

10th Avenue

Homewood Road

1d 2c 3a 4a 2a 3b 2b 1a 1b 1e 4d 3c 1c 4b 4c

Nunns Creek

Ecological Unit Condition

Legend

Ecological Unit Condition

- Very High
- High
- Moderate
- Low
- Trail
- Stream

Project Areas

- Nunns Creek Park
- Study Area
- Project Area

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 25 50 100 150 Meters

Scale: 1:3,400

NO.	DATE	REVISION	BY
1	19/10/2016	1292_NUN_Landscape11x17Maps_2016Jul28	CGA
2			
3			
4			
5			

Date Saved: 19/10/2016
Coordinate System: NAD 1983 UTM Zone 10N

ECOFISH RESEARCH

Map 7

Path: M:\Projects-Active\1292 Nunns Creek\MXD\1292_NUN_Landscape11x17Maps_2016Jul28.mxd

337600 337800 338000 338200 338400 338600

5544400 5544200 5544000 5543800

16th Avenue

1d 2c 3a 4a 2a 3b 2b 1a 1b 1e 4d 3c 1c 4b 4c

Homewood Road

10th Avenue

Nunns Creek

Ecological Unit Conservation Value

Legend

Ecological Unit Conservation Value

- Very High
- High
- Moderate
- Low
- Trail
- Stream

Project Areas

- Nunns Creek Park
- Study Area
- Project Area

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 25 50 100 150 Meters

Scale: 1:3,400

NO.	DATE	REVISION	BY
1	19/10/2016	1292_NUN_Landscape11x17Maps_2016Jul28	CGA
2			
3			
4			
5			

Date Saved: 19/10/2016
Coordinate System: NAD 1983 UTM Zone 10N

ECOFISH RESEARCH

Map 8

Path: M:\Projects-Active\1292 Nunns Creek\MXD\1292_NUN_Landscape11x17Maps_2016Jul28.mxd

337600 337800 338000 338200 338400 338600

5544400 5544200 5544000 5543800

16th Avenue

10th Avenue

Homewood Road

1d 2c 3a 4a 2a 3b 2b 1a 1b 1e 4d 3c 1c 4b 4c

Nunns Creek

Ecological Unit Sensitivity

Legend

Ecological Unit Sensitivity

- Very High
- High
- Moderate
- Low
- Trail
- Stream

Project Areas

- Nunns Creek Park
- Study Area
- Project Area

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 25 50 100 150 Meters

Scale: 1:3,400

NO.	DATE	REVISION	BY
1	19/10/2016	1292_NUN_Landscape11x17Maps_2016Jul28	CGA
2			
3			
4			
5			

Date Saved: 19/10/2016
Coordinate System: NAD 1983 UTM Zone 10N

ECOFISH RESEARCH

Map 9

Path: M:\Projects-Active\1292 Nunns Creek\MXD\1292_NUN_Landscape11x17Maps_2016Jul28.mxd

337600 337800 338000 338200 338400 338600

5544400 5544200 5544000 5543800

16th Avenue

10th Avenue

Homewood Road

1d 2c 3a 4a 2a 3b 2b 1a 1b 1e 4d 3c 1c 4b 4c

Nunns Creek

Ecological Unit Management Importance

Legend

Ecological Unit Management Importance

- Very High
- High
- Low
- Trail
- Stream

Project Areas

- Nunns Creek Park
- Study Area
- Project Area

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 25 50 100 150 Meters

Scale: 1:3,400

NO.	DATE	REVISION	BY
1	19/10/2016	1292_NUN_Landscape11x17Maps_2016Jul28	CGA
2			
3			
4			
5			

Date Saved: 19/10/2016
Coordinate System: NAD 1983 UTM Zone 10N

ECOFISH RESEARCH

Map 10

Path: M:\Projects-Active\1292 Nunns Creek\MXD\1292_NUN_Landscape11x17Maps_2016Jul28.mxd

APPENDICES

Appendix A. Interview Guidance Questionnaire

Interview Topic	Sample Questions
Hydrology	Have you noticed changes to the water flows in Nunns Creek over time?
Biodiversity	When you think of the Nunns Creek project area, what kinds of animals and plants come to mind? Or… Tell me about the amphibians you have seen on the site? Or… Are there distinguishing features of the vegetation here that are worth noting?
Beavers	I noticed a beaver dam near the upstream end of the property. How long do you think they have been active in the area?
Salmon/fish	What do you know about the fish in this section of Nunns Creek? Or… What are the current limitations to salmon production in this system, and what if anything could be done to enhance it on the property?
Forests	Have you noticed any changes to the forests on the property over time?
Wetlands	What can you tell me about the wetlands on the property?
Key Ecological Attributes	What do you think are the most important attributes about the ecology of Nunns Creek? What are the key ecological process that are important to maintain the ecological character of the site?
Invasive species	Which non-native species have you encountered on the property? Are there any you think are particularly problematic? What work are you familiar with that has been done to control invasive species, which ones and where?
Food plants	Do you know if this place has been or still is important for gathering wild plant foods? What kinds of traditional plant foods do you think we might find here?
Medicinal plants	I'm very interested in the medicinal plants that may be on the site. Can you tell me about any traditional harvesting activities that may have happened or perhaps that are still happening?
Traditional uses	How have people used this property traditionally in the past?
Name of the site	I know this place as Nunns Creek or Nunns Creek Park. Are you familiar with any other names that have been used to refer to this area?
Stories about the site	What are some of your favourite memories from this place? Have you heard any stories about Nunns Creek from other people?
Personal meaning	Does the Nunns Creek project area hold any special meaning to you? What is important about it?
Wildlife habitats	Dead standing trees, fallen logs, beaver ponds, dense shrub thickets and large logs in the stream are all examples of wildlife habitats. What do you think are the most important kinds of wildlife habitats in the Nunns Creek project area? Are there any missing that used to be there?
Human use	How do people use the site now? I notice there are a number of trails and bridges. Do you think they are in the right places? Are there too many? Not enough?
Future management directions	If you developing a plan for this park, what kinds of things would you want to see promoted or prohibited?
Future studies	If you were studying the property, what would you include?

Appendix B. Interview Notes (Intentionally Omitted)

Appendix C. Historic Chrono- sequence of Ecological Changes

Ecological Unit	Ecosystem Type (1938)	pre-1950	1964	1965	1967	1976	1980	2002	2007	2012	Ecosystem Type (2016)
1a	Conifer forest			logged	regenerating forest			flooded			Wm05/RCG
1b	Conifer forest			logged		impacted by adjacent clearing		flooding starting		flooded	Wm05/Wm06
1c	Conifer forest			minor logging	regenerating forest		conifer regeneration	flooded			RCG/Ws54
1d	Mixed Forest			logged and road built	regenerating forest		conifer regeneration	flooded		partially regenerating with trees	Wm05
1e	Conifer forest		small clearing	landing and road	spur road	regenerating forest				flooded	RCG
2a	Conifer forest		road	logged	gradually getting wetter					flooded	Ws50
2b	Conifer forest			logged	regenerating deciduous swamp with conifers on hummocks						Ws51/wS52
2c	Mixed Forest			logged	regenerating deciduous swamp with conifers on hummocks						Ws51/Ws52
3a	Mixed forest	clearing	development		regenerating mixed forest						07
3b	Conifer forest			selective logging		impacted by adjacent clearing		regenerating mixed forest		partial flooding	07
3c	Conifer forest			logged, road	regenerating mixed forest						08
4a	Mixed Forest			selective logging	conifer regeneration						07/05
4b	Conifer forest	selective logging	regenerating mixed forest with conifer recruitment								7
4c	Conifer forest	selective logging	regenerating mixed forest with conifer recruitment								07/13
4d	Conifer forest	selective logging	regenerating mixed forest with conifer recruitment - receeding as flooding expands								12/Ws53

Appendix D. Ecological Unit Summary Data

LIST OF TABLES

Table 1. Ecological Unit – marsh/ open water summary data.

Type	Ecological Unit	Area (ha)	Ecological Community[1]		Red/Blue Listed Ecosystem	Structural Stage	General Description	Dominant Vegetation	Key Wildlife or Wildlife Features	Recent Disturbances	Public Use	Key Public Use Considerations
			Primary	Secondary								
Marsh/ open water	1a	0.38	Reed Canarygrass	Common Cattail Marsh	Blue/ Exotic	Graminoid	Temporally flooded, Reed Canarygrass-dominated marsh bordered by a diversity of shrubs.	Reed Canarygrass, Rocky Mountain Pond-lily, Common Cattail. Edges with Red-osier Dogwood, European Birch, Pacific Willow, Red Alder, Black Twinberry and other shrubs	Abundant bird life	Invaded by RCG	Low	-
	1b	0.27	Common Cattail Marsh	Hard-stemmed Bulrush Deep Marsh	Blue/ Blue	Graminoid	Marsh and open water communities with floating and emergent vegetation bordered by moisture tolerant trees and shrubs. Beaver pond.	Hard-stemmed Bulrush, Common Cattail, Pondweed sp.	Great Blue Heron, passerines nesting on edge, wetland birds, amphibian and fish habitat, beaver	-	Very Low	-
	1c	2.15	Reed Canarygrass	Western Redcedar / Western Hemlock - Skunk Cabbage/ Common Cattail Marsh	Exotic/ Blue/ Blue	Graminoid / Young forest	Large Reed Canarygrass and Common Cattail dominated marsh with patches of coniferous and deciduous trees and shrubs on hummocks. Floods during wet portion of year and maintains some wetted channels and areas during dry season. Soils have high sand content. Beaver pond.	Reed Canarygrass, Common Cattail, Hard-stemmed Bulrush, Western Hemlock, Red-osier Dogwood, Salmonberry, Skunk Cabbage, other grasses, Common Horsetail	Pools and channel for salmon migration, overwintering and rearing, snags with cavity nesters, aerial insectivores, pescavores (birds), small mammals, amphibian habitat, beaver	Invaded by RCG	Very Low	-
	1d	0.02	Common Cattail Marsh	Hard-stemmed Bulrush Deep Marsh	Blue	Graminoid	Small pocket Common Cattail marsh adjacent to channel and bordered by swamp.	Common Cattail	-	-	Low	-
	1e	0.04	Reed Canarygrass		Exotic	Graminoid	Small open pocket of Reed Canarygrass.	Reed Canarygrass	-	Invaded by RCG	Very Low	-

[1] Ecological community and associated site series and site association conservation status are provided in Table 12 of the body of the report.

Table 2. Ecological Unit - swamp/ open water summary data.

Type	Ecological Unit	Area (ha)	Ecological Community[1]		Red/Blue Listed Ecosystem	Structural Stage	General Description	Dominant Vegetation	Key Wildlife or Wildlife Features	Recent Disturbances	Public Use	Key Public Use Considerations
			Primary	Secondary								
Swamp/ open water	2a	0.74	Hardhack / Sitka Sedge		Yellow	Tall shrub	Open water and shrub dominated swamp that has recently expanded considerably due to beaver activity. Abundant coarse woody debris.	Reed Canarygrass, Hardhack, Pacific Willow, Red-osier Dogwood, dying even-aged Red Alder	Abundant wildlife including amphibians, breeding ducks, abundant bird life, small mammals, Coho fry and stickleback, beaver	Extensive flooding, several invasive species at edge of field, potential bullfrog breeding pond	Low	Flooding into fields
	2b	3.57	Sitka Willow - Pacific Willow / Skunk Cabbage	Red Alder - Skunk Cabbage	Red/ Red	Tall shrub/ Young forest	Temporally flooded, low-gradient swamp dominated by deciduous trees and shrubs with conifer patches growing on hummocks. Tree regeneration on older decaying large downed wood. Large network of channels.	Red Alder, Pacific Willow, Western Hemlock, Cascara, Red Elderberry, Sitka Willow, European Mountain Ash Salmonberry, Red-osier Dogwood, Skunk Cabbage, Reed Canarygrass, Foamflower, Dewey's dedge, False Lily-of-the-Valley, Creeping Buttercup	Abundant bird life, and evidence of use by mammals and amphibians (incl. Red-legged Frog)	-	Low	-
	2c	0.29	Sitka Willow / Pacific Willow - Skunk Cabbage	Red Alder - Skunk Cabbage	Red/ Red	Tall shrub/ Young forest	Small swamp within floodplain of main channel with herbs, shrubs, deciduous trees and snags.	Red-osier Dogwood, Skunk Cabbage, Common Horsetail and some Hardhack patches	-	Himalayan Blackberry encroaching on edges, flooded by backed up culvert, adjacent to road	Low	-

[1] Ecological community and associated site series and site association conservation status are provided in Table 12 of the body of the report.

Table 3. Ecological Unit – deciduous riparian forest summary data.

Type	Ecological Unit	Area (ha)	Ecological Community[1]		Red/Blue Listed Ecosystem	Structural Stage	General Description	Dominant Vegetation	Key Wildlife or Wildlife Features	Recent Disturbances	Public Use	Key Public Use Considerations
			Primary	Secondary								
Deciduous riparian forest	3a	0.32	Western Redcedar / Three-leaved Foamflower	Sitka Spruce / Salmonberry	Blue/Red	Mature forest	Deciduous forest with abundant snags and some dead young conifers along the edge.	Bigleaf Maple, Grand Fir in understory	Snags with cavities	Recent flooding likely leading to conifer mortality, ingress of Himalayan Blackberry, trails	Moderate	Abundant danger trees
	3b	1.13	Western Redcedar / Three-leaved Foamflower		Blue	Young forest	Young Red Alder forest with an understory dominated by a thick cover of Salmonberry and some floodplain forest herb cover. Provides a buffer to wetland habitats.	Red Alder, Salmonberry, Himalayan Blackberry, some herbaceous cover.	Will self-thin and recruit wildlife trees in the future. Provides a buffer to wetland habitats.	Thick cover of Himalayan Blackberry ingress on edges, camps, trail	Moderate	Trail growing over, will develop danger trees within 20 years
	3c	0.48	Sitka Spruce / Salmonberry		Red	Pole/ sapling	Young Red Alder dominated forest with an understory composed of a thick cover of Salmonberry	Red Alder, Salmonberry	-	Trail, edge has Himalayan Blackberry and other species	Low	Danger trees will develop in near future

[1] Ecological community and associated site series and site association conservation status are provided in Table 12 of the body of the report.

Table 4. Ecological Unit - mixed deciduous/ coniferous forest summary data.

Type	Ecological Unit	Area (ha)	Ecological Community[1]		Red/Blue Listed Ecosystem	Structural Stage	General Description	Dominant Vegetation	Key Wildlife or Wildlife Features	Recent Disturbances	Public Use	Key Public Use Considerations
			Primary	Secondary								
Mixed deciduous / coniferous riparian forest	4a	2.93	Western Redcedar / Three-leaved Foamflower	Western Redcedar / Sword Fern	Blue / Blue	Mature forest/ old growth	Mixed wet to moist to mesic mature riparian forest stand, historically selectively logged however forest maintains old growth forest components and dynamics including canopy gaps, large coniferous CWD in advanced decay classes, understory conifer regeneration. The primary channel of Nunns Creek and multiple channels bisect the EU and temporally flood portions of the EU. Nunns Creek has relatively well defined channel through most of EU with gravels, undercut banks and anchored LWD. Highest cover of herbaceous wildflowers in study area.	Western Hemlock, Red Alder, Sitka Spruce, Bigleaf Maple, English Holly, Cultivated Apple, Salmonberry, Balck Twinberry, Elderberry, Sword Fern, Lady Fern, False Lily-of-the-valley, Skunk Cabbage, Common Horsetail, Pink Fawn Lily, Trillium, Pacific Bleeding Heart	Salmon stream, cavity nesters	Large trees blown down, trails and unauthorized trails and use, garbage in streams, some patches of exotic species	Moderate	High blowdown risk
	4b	1.52	Western Redcedar / Three-leaved Foamflower		Blue	Mature forest	Mixed moist to mesic mature riparian forest stand, with moist pockets of Red Alder and Salmonberry with a Sitka Spruce understory and pockets and upslope areas dominated by coniferous forest. Abundant coarse woody debris and snags and stumps. Diverse regenerating tree layer.	Western Hemlock, Grand Fir, Bigleaf Maple, Red Alder, Sitka Spruce, Red Elderberry, Oval-leaved Blueberry, Red Huckleberry, Salmonberry, Sword Fern, Lady Fern, Bracken Fern, False Lily-of-the-Valley, Northern Starflower, Palmate Coltsfoot, Hooker's Fairybells, Western Trillium, Trailing Blackberry.	Deciduous (relatively poor quality) snags, coarse woody debris and stumps. Bordered by Nunns Creek	Large trees blown down, trails and unauthorized trails, trampling, hang out spots, some patches of exotic species	Moderate	Blowdown, abundant deciduous danger trees
	4c	0.60	Western Redcedar / Three-leaved Foamflower	Western Redcedar/ Salmonberry	Blue/ Red	Young forest	Narrow band of mixed maturing forest that buffers wetland from road.	Red Alder, Salmonberry, Sitka Spruce	Snags with cavities	Invasive species encroachment, bordered by road and trail	Moderate	Snags
	4d	1.17	Western Redcedar - Sitka Spruce / Skunk Cabbage		Blue	Mature forest	Seasonally flooded forest (swamp) that contains channels and hummocky terrain with conifers. Treed area is receding due to flooding of adjacent wetland.	Western Redcedar, Sitka Spruce, Skunk Cabbage, Salix sp.	Snags with cavities, stream	Flooding encroachment	Low	High risk of danger trees

[1] Ecological community and associated site series and site association conservation status are provided in Table 12 of the body of the report.

Appendix E. Wildlife Habitat Plot Data

South

North

East

West

Site Characteristics

Forest Region:	DCR
Aspect (degrees):	290
Structural Stage:	6 - Mature Forest
Seral Stage:	3 - Transition
Elevation (m):	16
VRI Stand Age (years):	-
Estimated Age (years):	141-250
Vertical Slope (%):	15
Horizontal Slope (%):	5
Meso Slope Position:	Lower Slope
Site Series	08 (07)

Substrate Description

Rock:	N - Nil
Organic Matter:	D - Dominant
Mineral Soil:	T - Trace
Water:	T - Trace
Bedrock:	N - Nil
Decaying Wood:	SD - Subdominant

Vegetation Characteristics

Layer	Canopy Closure	Comments
Canopy	4 (50-75%)	A:55%
Shrub	2 (5-25%)	B1:12%; B2:3%
Herbs	1 (1-5%)	C:85%
Mosses and Lichens	+ (<1%)	D:5% in flood zone
Other	+ (<1%)	-

Representative Tree Mensuration

Species	dbh (m)	Height (m)
western hemlock	0.92	50
Sitka spruce	0.56	45
red alder	0.31	44
western hemlock	0.08	5

Tree Density

Species	Count
red alder	3
western hemlock	3
Sitka spruce	1
western hemlock	3
Stems /ha	**250**

Vegetation Species

Shrubs	Percent Cover
cultivated apple	4-5%
English holly	2-3%
salmonberry	6-8%
red huckleberry	2-3%
black twinberry	1%
coastal red elderberry	1%

Herbs	Percent Cover
sword fern	6-8%
bracken fern	1%
lady fern	6-8%
false lily-of-the-valley	18-27%
common horsetail	2-3%
creeping buttercup	1%
hedge-nettle	<1%
skunk cabbage	2-3%
Hooker's fairybells	<1%
clasping twistedstalk	<1%
pink fawn lily	1%
Pacific bleeding heart	<1%
western trillium	<1%

Wildlife

Mule Deer, woodpecker

Water Attributes

Type	Flow
Stream	Yes

Report Comments

Mixed mature forest stand that is approximately 160+ years old and was historically selectively logged. The forest maintains old growth forest dynamics including canopy gaps and large coniferous coarse woody debris in advanced decay classes. The plot and nearby forest is intersected by multiple stream channels which seasonally flood portions of the plot and stand, increasing the richness and moisture of this moist forest. The mainstem of Nunns Creek bisects the plot. At this location there are good spawning gravels and undercut banks. Large woody debris has been anchored in the stream channel. Some living trees in the plot show degraded health from pathogens and are being used as woodpecker feeding trees.

City of Campbell River

ECOFISH RESEARCH

Nunns Creek

Survey Date:	2016-05-25
Crew:	LAB, SPP, KC
Date Issued:	2016-08-22

Location NUN-WHP01

BGC Zone CWHxm1

UTM **Zone:** 10U 338283 **E** 5544196 **N** NAD 83

South

North

West

East

Site Characteristics

Forest Region:	DCR
Aspect (degrees):	360
Structural Stage:	5 - Young Forest
Seral Stage:	3 - Transition
Elevation (m):	17
VRI Stand Age (years):	-
Estimated Age (years):	41-60
Vertical Slope (%):	0.5
Horizontal Slope (%):	1
Meso Slope Position:	Depression
Site Series	WS51

Substrate Description

Rock:	N - Nil
Organic Matter:	D - Dominant
Mineral Soil:	T - Trace
Water:	N - Nil
Bedrock:	N - Nil
Decaying Wood:	T - Trace

Vegetation Characteristics

Layer	Canopy Closure	Comments
Canopy	4 (50-75%)	A:55%
Shrub	3 (25-50%)	B1:25%; B2:10%
Herbs	3 (25-50%)	C:30%
Mosses and Lichens	2 (5-25%)	D:20%
Other	2 (5-25%)	-

Representative Tree Mensuration

Species	dbh (m)	Height (m)
Pacific willow	0.12	11
western hemlock	0.57	33
red alder	0.34	27
cascara	0.23	16

Tree Density

Species	Count
red alder	18
western hemlock	1
Pacific willow	1
cascara	3
Stems /ha	**575**

Vegetation Species

Shrubs	Percent Cover
salmonberry	9-13%
coastal red elderberry	2-3%
red huckleberry	1%
English holly	1%
Himalayan blackberry	1%
European mountain-ash	2-3%

Herbs	Percent Cover
skunk cabbage	18-27%
reed canarygrass	4-5%
creeping buttercup	2-3%
Alaska oniongrass	2-3%
sword fern	1%
foamflower	2-3%
common horsetail	1%
Dewey's sedge	2-3%
coltsfoot	1%
salal	1%
false lily-of-the-valley	2-3%

Wildlife

Mule Deer, Red Squirrel, Racoon

Water Attributes

Type	Flow
Wetland	No

Report Comments

The site is located in a swamp complex composed of site series 12 and site associations WS51, 52 and 53. The site receives annual flooding. The main channel of Nunns Creek currently runs adjacent to the plot, but this has changed over time and may be a relatively new channel. Several other channels run through the polygon outside of the plot. Conifers and other typical moist-mesic forest shrubs grow exclusively on large pieces of well decayed (class 4 and 5) wood of coniferous origin. Older conifers on developed mounds are approximately 65 years old. Conifers are regenerating in the under story on decaying wood. Bird life is abundant and active. New coarse woody is small and deciduous in origin.

City of Campbell River

ECOFISH RESEARCH

Nunns Creek

Survey Date: 2016-05-25
Crew: LAB, SPP, KC
Date Issued: 2016-08-22

Location NUN-WHP02

BGC Zone CWHxm1

UTM Zone: 10U 338230 **E** 5544070 **N** NAD 83

North at 6 feet

Channel south upstream

West

East

Site Characteristics

Forest Region:	DCR
Aspect (degrees):	360
Structural Stage:	2 - Herb
Seral Stage:	3 - Transition
Elevation (m):	17
VRI Stand Age (years):	-
Estimated Age (years):	41-60
Vertical Slope (%):	2
Horizontal Slope (%):	4
Meso Slope Position:	Depression
Site Series	WM05 (WS51)

Substrate Description

Rock:	T - Trace
Organic Matter:	SD - Subdominant
Mineral Soil:	D - Dominant
Water:	T - Trace
Bedrock:	N - Nil
Decaying Wood:	T - Trace

Vegetation Characteristics

Layer	Canopy Closure	Comments
Canopy	+ (<1%)	canopy from outside plot A:<1%
Shrub	1 (1-5%)	B1:1%; B2:2%
Herbs	+ (<1%)	C:96%
Mosses and Lichens	0 (0%)	D:0%
Other	0 (0%)	-

Representative Tree Mensuration

Species	dbh (m)	Height (m)
-	-	-

Tree Density

Species	Count
-	-
Stems /ha	**0**

Vegetation Species

Shrubs	Percent Cover
red-osier dogwood	1%
salmonberry	2-3%
stink currant	<1%
red alder	1%
bigleaf maple	1%

Herbs	Percent Cover
reed canarygrass	83-100%
common cattail	4-5%
hard-stemmed bulrush	2-3%
skunk cabbage	2-3%
common horsetail	1%
creeping buttercup	1%
foamflower	<1%
hedge-nettle	<1%
slough sedge	1%
grass	2-3%
Himalayan blackberry	1%

Wildlife

Turkey Vulture, Great Blue Heron, American Beaver, Common Starling, Racoon, Red-winged Blackbird

Water Attributes

Type	Flow
Wetland	Yes

Report Comments

Plot is located in the upper end of the marsh near Homewood adjacent to the current main channel of Nunns Creek. The area has elements of cattail marsh and soils are largely mineral with a high sand content. There is a thick cover of reed canary grass. Deciduous and coniferous trees of various ages occur on elevated mounds. The abundant snags are in various decay classes and are being used by cavity nesting birds. The north edge of the wetland supports standing open water with some emergent vegetation and a higher cover of cattails and stands of bull rush. Most recent coarse wood inputs into polygon are deciduous. Coho smolt and salmonid fry were observed in creek. Some small patches of Himalayan blackberry were present within the wetland and although there appears to have been recent removal, the invasive species lines most of the boundary between the road and the wetland.

City of Campbell River

ECOFISH RESEARCH

Nunns Creek

Survey Date:	2016-05-25
Crew:	LAB, SPP, KC
Date Issued:	2016-08-22

Location NUN-WHP03

BGC Zone			CWHxm1			
UTM	**Zone:**	10U	338203	**E**	5543776	**N** NAD 83

North

Trail on west edge of plot looking to Homewood Rd

East

South

Site Characteristics

Forest Region:	DCR
Aspect (degrees):	315
Structural Stage:	5 - Young Forest
Seral Stage:	3 - Transition
Elevation (m):	13
VRI Stand Age (years):	-
Estimated Age (years):	61-80
Vertical Slope (%):	0
Horizontal Slope (%):	4
Meso Slope Position:	Mid Slope
Site Series	07 (05)

Substrate Description

Rock:	N - Nil
Organic Matter:	D - Dominant
Mineral Soil:	T - Trace
Water:	N - Nil
Bedrock:	N - Nil
Decaying Wood:	SD - Subdominant

Vegetation Characteristics

Layer	Canopy Closure	Comments
Canopy	4 (50-75%)	A:60%
Shrub	3 (25-50%)	B1:15%; B2:15%
Herbs	4 (50-75%)	C:40%
Mosses and Lichens	1 (1-5%)	D:2%
Other	1 (1-5%)	-

Representative Tree Mensuration

Species	dbh (m)	Height (m)
western hemlock	0.4	25
bigleaf maple	0.6	30
grand fir	0.19	18
Sitka spruce	0.14	7

Tree Density

Species	Count
western hemlock	5
grand fir	6
bigleaf maple	3
Sitka spruce	1
Stems /ha	**375**

Vegetation Species

Shrubs	Percent Cover
grand fir	4-5%
bigleaf maple	2-3%
western hemlock	2-3%
bigleaf maple	2-3%
Sitka spruce	2-3%
English holly	1%
coastal red elderberry	2-3%
oval-leaved blueberry	2-3%
salmonberry	2-3%
red huckleberry	2-3%
saskatoon	1%

Herbs	Percent Cover
sword fern	28-42%
false lily-of-the-valley	18-27%
northern starflower	4-5%
palmate coltsfoot	2-3%
Hooker's fairybells	1%
bracken fern	2-3%
wall lettuce	1%
western trillium	1%
oniongrass	<1%
sedge	<1%

Wildlife

Pileated Woodpecker

Water Attributes

Type	Flow
-	-

Report Comments

Plot represents the more mesic portion of the rich moist-mesic forest at the south end of the property. The plot is 10 m from the property edge. Abundant snags and decaying large coarse wood. Many of the snags are young, small diameter, deciduous in origin and have white rot and appear to be relatively poor wildlife habitat. The area was selectively logged approximately 65 years ago and does not have the large remnant veteran trees symbolic of the forest stand at the north end of the property. The forest floor is covered in a deep layer of leaf litter and is hummocky due to abundant accumulations of large coarse wood over time. Regenerating trees and shrubs predominantly growing on this wood. A trail runs through the edge of the plot. Some other human use is evident in the plot such as garbage and vegetation trampling. Note that tree species listed in shrub layer include those under 10 m and are included in tree density counts.

City of Campbell River

ECOFISH RESEARCH

Nunns Creek

Survey Date: 2016-05-26
Crew: LAB, SPP, KC
Date Issued: 2016-08-22

Location NUN-WHP04

BGC Zone CWHxm1

UTM **Zone:** 10U 338304 **E** 5543813 **N** NAD 83

East at 6 ft

North at 6 ft

West

South

Site Characteristics

Forest Region:	DCR
Aspect (degrees):	315
Structural Stage:	5 - Young Forest
Seral Stage:	3 - Transition
Elevation (m):	12
VRI Stand Age (years):	-
Estimated Age (years):	61-80
Vertical Slope (%):	12
Horizontal Slope (%):	4
Meso Slope Position:	Lower Slope
Site Series	07 (08)

Substrate Description

Rock:	N - Nil
Organic Matter:	D - Dominant
Mineral Soil:	T - Trace
Water:	N - Nil
Bedrock:	N - Nil
Decaying Wood:	SD - Subdominant

Vegetation Characteristics

Layer	Canopy Closure	Comments
Canopy	3 (25-50%)	A:30%
Shrub	4 (50-75%)	B1:45%; B2:15%
Herbs	3 (25-50%)	C:40%
Mosses and Lichens	1 (1-5%)	D:5%
Other	1 (1-5%)	-

Representative Tree Mensuration

Species	dbh (m)	Height (m)
grand fir	0.17	15
Sitka spruce	0.09	5
red alder	0.3	23
western hemlock	0.23	26
bigleaf maple	0.67	30

Tree Density

Species	Count
red alder	8
bigleaf maple	1
western hemlock	3
grand fir	1
spruce hybrid	9
Stems /ha	**550**

Vegetation Species

Shrubs	Percent Cover
Sitka spruce	6-8%
Sitka spruce	2-3%
salmonberry	28-42%
salmonberry	4-5%
English holly	1%
red huckleberry	1%
trailing blackberry	2-3%

Herbs	Percent Cover
sword fern	18-27%
Hooker's fairybells	2-3%
false lily-of-the-valley	14-17%
wall lettuce	1%
palmate coltsfoot	2-3%
sedge	1%
lady fern	2-3%
western trillium	1%

Wildlife

Water Attributes

Type	Flow
-	-

Report Comments

Rich moist-mesic forest. Plot includes a flat area dominated by salmonberry, maturing red alder and regenerating Sitka spruce habitat, and an elevated area dominated by swordfern, western hemlock and grand fir. Abundant deciduous snags in the area. Most coarse wood deciduous and in later decay classes. The main loop trail and an unauthorized spur trail transect the plot. The area was logged approximately 65 years ago. Note that tree species listed in shrub layer include those under 10 m and are included in tree density counts.

City of Campbell River

ECOFISH RESEARCH

Nunns Creek

Survey Date:	2016-05-26
Crew:	LAB, SPP
Date Issued:	2016-08-22

Location NUN-WHP05

BGC Zone CWHxm1

UTM Zone: 10U 338253 **E** 5543855 **N** NAD 83

Appendix F. Wildlife and Plant Species List

LIST OF TABLES

Table 1. Bird, mammal, amphibian and reptile species.

Group	Common name	Scientific name	Native/ Introduced (N/I)	Data Source
Birds	Great Blue Heron[1]	*Ardea herodias*	N	DCGLT 2001, Ennis *et al.* 2016
	Green Heron[1]	*Butorides striatus*	N	DCGLT 2001
	Mallard	*Anas platyrhynchos*	N	DCGLT 2001, Ennis et al. 2016
	Northwestern Crow	*Corvus caurinus*	N	DCGLT 2001, Ennis et al. 2016
	Red-winged Blackbird	*Agelaius phenicieus*	N	DCGLT 2001, Ennis *et al.* 2016
	American Robin	*Turdus migratorius*	N	DCGLT 2001, Ennis *et al.* 2016
	European Starling	*Sturnus vulgaris*	I	Ennis *et al.* 2016
	Pacific-slope Flycatcher	*Empidonax difficilis*	N	Ennis *et al.* 2016
	Spotted Towhee	*Pipilo maculatus*	N	Ennis *et al.* 2016
	Swainson's Thrush	*Catharus ustulatus*	N	Ennis *et al.* 2016
	Chestnut-backed Chickadee	*Parus rufescens*	N	DCGLT 2001, Ennis *et al.* 2016
	Dark-eyed Junco	*Junco hyemalis*	N	DCGLT 2001, Ennis *et al.* 2016
	House Finch	*Carpodacus mexicanus*	N	Ennis *et al.* 2016
	Golden-crowned Kinglet	*Regulus satrapa*	N	DCGLT 2001, Ennis *et al.* 2016
	Ruby-crowned Kinglet	*Regulus calendula*	N	DCGLT 2001
	Golden-crowned Sparrow	*Zonotrichia atricapilla*	N	DCGLT 2001
	Yellow-rumped Warbler	*Setophaga coronata*	N	DCGLT 2001, Ennis et al. 2016
	Western Tanager	*Piranga ludoviciana*	N	Ennis *et al.* 2016
	Huttons Vireo	*Vireo huttoni*	N	DCGLT 2001
	Song Sparrow	*Melospiza melodia*	N	DCGLT 2001
	Swallow	*Hirundinidae sp.*	N	DCGLT 2001, Ennis et al. 2016
	Pacific Wren	*Troglodytes troglodytes*	N	DCGLT 2001, Ennis *et al.* 2016
	Brown Creeper	*Certhia americana*	N	DCGLT 2001
	Northern Flicker	*Colaptes auratus*	N	DCGLT 2001, Ennis *et al.* 2016
	Downy Woodpecker	*Pioides pubescens*	N	DCGLT 2001, Ennis et al. 2016
	Pileated Woodpecker	*Hylatomus pileatus*	N	Ennis *et al.* 2016
	Bald Eagle	*Haliaeetus leucocephalus*	N	Ennis *et al.* 2016
	Turkey Vulture	*Cathartes aura*	N	Ennis *et al.* 2016
Mammals	Racoon	*Procylon lotor*	N	DCGLT 2001, Ennis *et al.* 2016
	Beaver	*Castor canadensis*	N	DCGLT 2001, Ennis *et al.* 2016
	American Black Bear	*Ursus americanus*	N	Ennis *et al.* 2016
	Columbian Black-tailed Dee	*Odocoileus hemionus columbiani*	N	Ennis *et al.* 2016
	Red Squirrel	*Tamiasciurus hudsonicus*	N	Ennis *et al.* 2016
	Shrew	*Sorex sp.*	N	Ennis *et al.* 2016
Reptiles	Common Garter Snake	*Thamnophis sirtalis*	N	DCGLT 2001, Ennis *et al.* 2016
Amphibians	Northern Red-legged Frog[1]	*Rana aurora*	N	Ennis *et al.* 2016
	Pacific Chorus Frog	*Pseudacris regilla*	N	Ennis *et al.* 2016
	American Bullfrog	*Lithobates catesbeiana*	I	Ennis *et al.* 2016

[1]Species at risk in British Columbia.

Table 2. Fish and invertebrate species.

Group	Common name	Scientific name	Native/ Introduced (N/I)	Data Source
Fish	Coho Salmon	*Oncorhynchus kisutch*	N	DFO 1990, DFO 1991, Roth 1999, Ennis *et al.* 2016
	Chum Salmon	*Oncorhynchus keta*	N	Drake 2016, Senger 2016
	Pink Salmon	*Oncorhynchus gorbuscha*	N	DFO 1991, Drake 2016
	Chinook Salmon	*Oncorhynchus tshawytscha*	N	Drake 2016
	Cutthroat Trout[1]	*Oncorhynchus clarkii*	N	DFO 1990, Roth 1999, Ennis *et al*.
	Steelhead	*Oncorhynchus mykiss*	N	Komori-Wong 2002
	Stickleback sp.	*Gasterosteus sp.*	N	Roth 1999, Ennis *et al.* 2016
	Threespine stickleback	*Gasterosteus aculeatus*	N	Mainstream 2013
Invertebrates	Signal Crayfish	*Pacifastacus leniusculus*	N	Ennis *et al.* 2016
	Pacific Bananaslug	*Ariolimax columbianus*	N	Ennis *et al.* 2016
	Kayak Pond Skater	*Limnoporus notabilis*	N	Ennis *et al.* 2016

[1]Species at risk in British Columbia.

Table 3. Tree and shrub species.

Group	Common name	Scientific name	Native/ Introduced (N/I)	Data Source
Trees	Western Hemlock	*Tsuga heterophylla*	N	DCGLT 2001, Ennis *et al.* 2016
	Western Redcedar	*Thuja plicata*	N	DCGLT 2001, Ennis *et al.* 2016
	Douglas-fir	*Pseudotsuga menziesii*	N	DCGLT 2001, Ennis *et al.* 2016
	Grand Fir	*Abies grandis*	N	Ennis *et al.* 2016
	Sitka Spruce	*Picea sitchensis*	N	DCGLT 2001, Ennis *et al.* 2016
	Red Alder	*Alnus rubra*	N	DCGLT 2001, Ennis *et al.* 2016
	Bigleaf Maple	*Acer macrophyllum*	N	Ennis *et al.* 2016
	Black Hawthorn	*Crataegus douglasii*	N	Ennis *et al.* 2016
	Bitter Cherry	*Prunus emarginata*	N	DCGLT 2001, Ennis *et al.* 2016
	Cascara	*Rhamnus purshiana*	N	DCGLT 2001, Ennis *et al.* 2016
	Pacific Willow	*Salix lucida ssp. Lasiandra*	N	Ennis *et al.* 2016
	Domestic apple	*Malus pumila*	I	Ennis *et al.* 2016
	Plum	*Prunus sp.*	I	Ennis *et al.* 2016
	English Oak	*Quercus robur*	I	DCGLT 2001, Ennis *et al.* 2016
	European Birch	*Betula pundula*	I	Ennis *et al.* 2016
	European Mountain-ash	*Sorbus aucuparia*	I	Ennis *et al.* 2016
Shrubs	Black Twinberry	*Lonicera involucrata*	N	DCGLT 2001, Ennis *et al.* 2016
	Nootka Rose	*Rosa nutkana*	N	DCGLT 2001, Ennis *et al.* 2016
	Hardhack	*Spirea douglasii*	N	DCGLT 2001, Ennis *et al.* 2016
	Saskatoon	*Amelanchier alnifolia*	N	Ennis *et al.* 2016
	Pacific Ninebark	*Physocarpus capitatus*	N	Ennis *et al.* 2016
	Oceanspray	*Holodiscus discolor*	N	Ennis *et al.* 2016
	Red Elderberry	*Sambucus racemosa*	N	DCGLT 2001, Ennis *et al.* 2016
	Red-osier Dogwood	*Cornus stolonifera*	N	DCGLT 2001, Ennis *et al.* 2016
	Salmonberry	*Rubus spectabilis*	N	DCGLT 2001, Ennis *et al.* 2016
	Common Snowberry	*Symphoricarpos albus*	N	DCGLT 2001, Ennis *et al.* 2016
	Stink Currant	*Ribes bracteosum*	N	Ennis *et al.* 2016
	Huckleberry sp.	*Vaccinium sp.*	N	DCGLT 2001
	Red Huckleberry	*Vaccinium parvifolium*	N	Ennis *et al.* 2016
	Oval-leaved Blueberry	*Vaccinium ovalifolium*	N	Ennis *et al.* 2016
	Trailing Blackberry	*Rubus ursinus*	N	Ennis *et al.* 2016
	Willow sp.	*Salix sp.*	N	DCGLT 2001
	Scouler's Willow	*Salix scouleriana*	N	Ennis *et al.* 2016
	Japanese Knotweed	*Fallopia japonica*	I	Ennis *et al.* 2016
	Salal	*Gaultheria shallon*	N	Ennis *et al.* 2016
	English Holly	*Ilex aquifolium*	I	DCGLT 2001, Ennis *et al.* 2016
	English Ivy	*Hedera helix*	I	DCGLT 2001, Ennis *et al.* 2016
	Himalayan Blackberry	*Rubus discolor*	I	DCGLT 2001, Ennis *et al.* 2016
	Cutleaf Evergreen Blackberr	*Rubus laciniatus*	I	Ennis *et al.* 2016
	Scotch Broom	*Cytisus scoparius*	I	DCGLT 2001, Ennis *et al.* 2016
	Cherry-laurel	*Prunus laurocerasus*	I	Ennis *et al.* 2016
	Privet sp.	*Ligustrum sp.*	I	DCGLT 2001

Table 4. Herb and moss species.

Group	Common name	Scientific name	Native/ Introduced (N/I)	Data Source
Herbs	False Lily-of-the-valley	*Maianthemum dilatatum*	N	DCGLT 2001
	Pink Fawn Lily	*Erythronium revolutum*	N	DCGLT 2001
	Western Trillium	*Trillium ovatum*	N	DCGLT 2001
	Vanilla Leaf	*Achlys triphylla*	N	Ennis *et al.* 2016
	Pacific Bleeding Heart	*Dicentra formosa*	N	DCGLT 2001
	Fringecup	*Tellima grandiflora*	N	Ennis *et al.* 2016
	Foamflower	*Tiarella trifoliata*	N	Ennis *et al.* 2016
	False Bugbane	*Trautvetteria caroliniensis*	N	Ennis *et al.* 2016
	Northern Starflower	*Trientalis latifolia*	N	Ennis *et al.* 2016
	Sweet-scented Bedstraw	*Galium triflorum*	N	Ennis *et al.* 2016
	Mitrewort sp.	*Mitella sp.*	N	Ennis *et al.* 2016
	American Brooklime	*Veronica beccabunga ssp. ameri*	N	Ennis *et al.* 2016
	Pacific Water-parsely	*Oenanthe sarmentosa*	N	DCGLT 2001
	Little Buttercup	*Ranunculus uncinatuo*	N	DCGLT 2001
	Hooker's Fairybells	*Prosartes hookeri*	N	Ennis *et al.* 2016
	Clasping Twistedstalk	*Streptopus amplexifolius*	N	Ennis *et al.* 2016
	Mexican Hedge-nettle	*Stachys mexicana*	N	Ennis *et al.* 2016
	Siberian Miner's Lettuce	*Claytonia sibirica*	N	DCGLT 2001
	Mountain Sweet-cicely	*Osmorhiza berteroi*	N	Ennis *et al.* 2016
	Violet sp.	*Viola sp.*	N	Ennis *et al.* 2016
	Palmate Coltsfoot	*Petasites frigidus*	N	Ennis *et al.* 2016
	Skunk Cabbage	*Lysichiton americanum*	N	DCGLT 2001
	Sword Fern	*Polystichum munitum*	N	DCGLT 2001
	Lady Fern	*Athyrium filix-femina*	N	Ennis *et al.* 2016
	Bracken Fern	*Pteridium aquilinum*	N	Ennis *et al.* 2016
	Small-flowered Bulrush	*Scirpus microcarpus*	N	Ennis *et al.* 2016
	Hard-stemmed bulrush	*Schoenoplectus acutus*	N	Ennis *et al.* 2016
	Small-flowered Woodrush	*Luzula parviflora*	N	Ennis *et al.* 2016
	Common Cattail	*Typha latifolia*	N	Ennis *et al.* 2016
	Slough Sedge	*Carex obnupta*	N	Ennis *et al.* 2016
	Dewey's Sedge	*Carex deweyana*	N	Ennis *et al.* 2016
	Alaska Oniongrass	*Melica subulata*	N	Ennis *et al.* 2016
	Blue Wildrye	*Elymus glaucus*	N	Ennis *et al.* 2016
	Tall Mannagrass	*Glyceria elata*	N	Ennis *et al.* 2016
	Nodding Trisetum	*Trisetum cernuum*	N	Ennis *et al.* 2016
	Common Horsetail	*Equisetum arvense*	N	Ennis *et al.* 2016
	Rocky Mountain Pond-lily	*Nuphar polysepala*	N	Ennis *et al.* 2016
	Burdock	*Arctium minus*	I	DCGLT 2001, Ennis *et al.* 2016
	Purple Loosestrife	*Lythrum salicaria*	I	Sellentin 2011, Ennis *et al.* 2016

Table 4. Herb and moss species (continued).

Group	Common name	Scientific name	Native/ Introduced (N/I)	Data Source
	Yellow Flag-iris	*Iris pseudoacorus*	I	Martin, 2016
	Creeping Buttercup	*Ranunculus repens*	I	DCGLT 2001, Ennis *et al.* 2016
	Black Medic	*Medicago lupulina*	I	Ennis *et al.* 2016
	Field Bindweed	*Convolvulus arvensis*	I	Ennis *et al.* 2016
	Periwinkle sp.	*Vinca sp.*	I	DCGLT 2001
	Dandelion	*Taraxicum officinale*	I	DCGLT 2001
	Hairy Cat's-ear	*Hypochaeris radicata*	I	Ennis *et al.* 2016
	Common Plantain	*Plantago major*	I	Ennis *et al.* 2016
Herbs	Ribwort Plantain	*Plantago lanceolata*	I	Ennis *et al.* 2016
	Wooly Vetch	*Vicia villosa*	I	Ennis *et al.* 2016
	Alsike clover	*Trifolium hybridum*	I	Ennis *et al.* 2016
	Oxeye Daisy	*Leucanthemum vulgare*	I	Ennis *et al.* 2016
	Robert's Geranium	*Geranium robertianum*	I	Ennis *et al.* 2016
	Deadnettle var.	*Lamium maculatum var. unk.*	I	Ennis *et al.* 2016
	Common St. John's Wort	*Hypericum perforatum*	I	Ennis *et al.* 2016
	Common Grape-hyacinth	*Muscari botryoides*	I	DCGLT 2001
	Thistle sp.	*Cirsium sp.*	I	DCGLT 2001
	Bull Thistle	*Cirsium vulgare*	I	Ennis *et al.* 2016
	Canada Thistle	*Cirsium arvense*	I	Ennis *et al.* 2016
	Sulphur Cinquefoil	*Potentilla recta*	I	Ennis *et al.* 2016
	Wall Lettuce	*Lactuca muralis*	I	DCGLT 2001, Ennis *et al.* 2016
	Nipplewort	*Lapsana communis*	I	Ennis *et al.* 2016
	Reed Canarygrass	*Phalaris arundinacea*	N/I	Ennis *et al.* 2016
	Orchardgrass	*Dactylis glomerata*	I	Ennis *et al.* 2016
	Early Hairgrass	*Aira praecox*	I	Ennis *et al.* 2016
	Velvetgrass	*Holcus lanatus*	I	Ennis *et al.* 2016
	Kentucky Bluegrass	*Poa pratensis*	I	Ennis *et al.* 2016
	Quackgrass	*Elymus repens*	I	Ennis *et al.* 2016
Moss	Oregon Beaked Moss	*Kindbergia oregana*	N	Ennis *et al.* 2016
	Wavy-leaved Cotton Moss	*Plagiothecium undulatum*	N	Ennis *et al.* 2016
	Electrified Cat's-tail Moss	*Rhytidiadelphus triquetrus*	N	Ennis *et al.* 2016

Appendix G. Fish Habitat Assessment Procedure Data

LIST OF TABLES

Table 1. Fish Habitat Assessment Procedure data for Nunns Creek.

Habitat Unit					Channel measurements							
Unit Number	Type[1]	Channel Category	Unit Length (m)	Gradient (%)	Mean Depth (m)		Mean Width (m)		Pool Type	Pool Depth (m)		
					Bankfull	Wetted	Bankfull	Wetted		Maximum	Crest	Residual
1	Riffle	Primary	153	0.5	0.65	0.06	9	2				
2	Pool	Primary	50	0	0.9	0.24	7.5	5.3	SC	0.28	0.01	0.27
3	Riffle	Primary	237	0.05	0.85	0.16	6	4				
4	Pool	Primary	16	0	1.05	0.21	6.1	5	SC	0.5	0.01	0.49
5	Riffle	Secondary	339	0.05	0.45	0.13	2.5	2				
6	Riffle	Secondary	435	0.05	0.4	0.11	4.5	1.8				
7	Riffle	Primary	219	0.05	0.4	0.11	4.5	1.8				
8	Riffle/ wetland	Primary	667	0	0.5	0.15	100	1.5				
9	Riffle/ wetland	Primary	220	0.05	0.45	0.22	100	1.7				

[1] Although 'riffles' were the dominant mapped unit, these reaches were frequently characterized by a lack of either gravel and cobble or a lack of surface turbulence which are defining characteristics of riffles (Johnston and Slaney 1996).

Table 1. Fish Habitat Assessment Procedure data for Nunns Creek (continued).

Unit Number	Type	Bed Material Type		Spawning Gravel		Functional LWD Tally (dbh)				Cover			
		Dominant	Sub Dominant	Type	Presence	Total	10-20 cm	20-50 cm	> 50 cm	Primary Type	%	Secondary Type	%
1	Riffle	S/FI	Cobble	Anadromous / resident[1]	L	13	13			Overhanging vegetation	20	Cobble	5
2	Pool	S/FI	Gravel	AR	L	4	2	1	1	Deep pool	10	Large Woody	5
3	Riffle	S/FI	Gravel	AR	L	14	7	4	3	Large Woody Debris	5	Overhanging vegetation	5
4	Pool	S/FI	Gravel	AR	L	1	1			Deep pool	10	Overhanging	5
5	Riffle	S/FI	Gravel	AR	L	5	5			Overhanging	10	Large Woody	5
6	Riffle	S/FI	S/FI		N	6	5		1	Overhanging	15	Large Woody	1
7	Riffle	S/FI	S/FI		N	2			2	Overhanging	15	Large Woody	1
8	Riffle/ wetland	S/FI			N	0				Overhanging vegetation	15	CU	10
9	Riffle/ wetland	S/FI	Gravel	AR	L	10	4	3	3	Overhanging vegetation	10	CU	10

[1] Suitable for both anadromous salmon and resident fish (10-150 mm size sediment, at least 1.5 m^2 patch size)

Table 1. Fish Habitat Assessment Procedure data for Nunns Creek (continued).

Unit Number	Type	Offchannel Habitat			Riparian Vegetation			Barriers
		Type	Access	Length (m)	Type	Structure	Canopy Closure (%)	
1	Riffle				Deciduous	Young Forest	20-40	None
2	Pool				Mixed	Young Forest	0-20	None
3	Riffle	Side channels	NA		Mixed	Mature Forest	20-40	None
4	Pool				Mixed	Young Forest	40-70	None
5	Riffle	Side	NA		Mixed	Young Forest	40-70	None
6	Riffle	Side	NA	15	Mixed	Young Forest	20-40	None
7	Riffle				Mixed	Young Forest	20-40	None
8	Riffle/ wetland	Side channels	G		Mixed	Mature Forest	0-20	Potential
9	Riffle/ wetland				Mixed	Mature Forest	0-20	None

Appendix H. Infrastructure Data and Recommendations

LIST OF TABLES

Table 1. Condition of bridges in the study area.

Map label	Condition	Comment[1]
B01	Good	Bridge with metal handles and wood support, placed LWD at base, maybe some dry rot.
B02	Poor	Over tributary, some planks missing and some rot, main stringers OK.
B03	Moderate	Graffiti.
B04	Poor	Missing half of cross planks.
B05	Moderate	Wire tread needs work.
B06	Moderate	Missing railing.
B07	Moderate	Simple, tread a little worn.
B08	Moderate	Sturdy, needs tread, crosses small creek.
B09	Poor	Needs repair.
B10	Good	Generally good condition, tread good condition.
B11	Good	Generally good, tread a little broken, over primary channel.

[1]No recommendation is provided for bridges as bridge placement depends on final trail route.

Table 2. Condition and recommendations for infrastructure in the study area.

Feature	Map label	Condition	Comment	Recommendation
Beaver baffle	BB01	Poor	Two baffles, the PVC one washed out, the cement one appears to be blocked.	Function should be verified and baffle maintained or replaced as relevant to higher management objectives. Remove PVC baffle.
	BB02	Poor	Washed out.	Baffle should be maintained or replaced as relevant to higher management objectives. Remove existing baffle.
Culvert	C01	Good	Double concrete box culvert, appears in good condition, however this could not be fully confirmed.	Culvert is too small and high for stream flows and substrate elevation and results in annual road flooding and the creek backing up. Culvert replacement with a clear span bridge should be considered.
	C02	Moderate	Double metal cylinder culvert from Homewood into marsh 1c. Partially filled with sediment	Function should be verified at high flows and management actions planned according to observations.
Storm drain	SD01	Moderate	From 12th which is an industrial area into previous primary channel of Nunns Creek. No functional stormwater treatment. Stickleback observed.	Stormwater should be treated prior to flowing directly into Nunns Creek. For example, water could be diverted into a sump or settling pond that provides similar functions to wetlands in cleaning water.
	SD02	Moderate	Runoff from Homewood, enters stream at same location as culvert. Coho smolts and stickleback in pool at base of pipe.	Stormwater should be treated prior to flowing directly into Nunns Creek.
Sign	S01	Moderate	Salmon habitat sign on Nunns Creek and Homewood.	-
	S02	Moderate	Greenways interpretive sign on Homewood, some graffiti, set back from road and many people are unaware of presence. Partially blocked by Himalayan Blackberry thickets.	Move so visible, potentially to road or to Nunns Creek Park. Update trail information as per trail and access updates.
Picnic table	T01	Moderate	Picnic table with undesirable use. Against fence, off property. Adjacent to wetland and Himalayan Blackberry thickets.	Depending on ownership, and pending final trail route, move table.
Cement pad	CP01	Moderate	Unknown purpose.	-
Pipe	P01	Unknown	Trail drain.	-
	P02	Unknown	Trail drain.	-

Table 3. Condition of trails in the study area.

Map Label	Condition	Comment
1	Primary - good condition	Connects loop over bridge.
2	Primary - good condition	Connects to loop trail through moist Salmonberry forest, trail on non-sensitive soils, some blackberry and holly, skirts swamp/creek.
3	Primary - good condition	Traverses mesic to moist soil, abuts wetland, good location, the herbs in some adjacent areas under trees have been trampled, some English Holly and Himalayan Blackberry, ends at road.
4	Primary - variable condition	Main trail. Trail approximately 1-1.5 m wide, dirt surface, good location, diverted around felled tree, needs vegetation maintenance to widen through bushes, ends at 12th Ave., broken bridge near trail end, some invasive species and garbage.
5	Primary - variable condition	Some vegetation trampling and undesired use adjacent to trail, mesic forest type, borders stream at end, trails 1 m wide, a few snags, potentially larger danger trees.
6	Primary - variable condition	Grown over with Salmonberry, less sensitive due to drier soils and vegetation types, some large windfall, not as aesthetically pleasing as alternate trail routes.
7	Primary - variable condition	Not sensitive soils, through mesic to moist forest, some downed trees across trail.
8	Primary - degraded	Beside industrial land, grown over with Himalayan Blackberry, abuts old channel, stop at fence, gets better in forest, resurface, landscape posts or fence, may still be best route.
9	Primary - degraded	Overgrown and degraded, infilling with Salmonberry and Himalayan Blackberry, follows wetland edge and connects Homewood Rd. to park, some undesirable use, runs adjacent (3-10 m) to wetland and associated wet soils.
10	Secondary - good	Connects to Nunns Creek Park.
11	Secondary - good	Connects to Nunns Creek Park.

Table 3. Condition of trails in the study area (continued).

Map Label	Condition	Comment
11	Secondary - good	Connects to Nunns Creek Park.
12	Secondary - variable condition	Some adjacent vegetation trampling and undesired use, mesic forest type, borders stream at end, trail is 1 m wide, a few snags, potentially larger danger trees.
13	Secondary - variable condition	Leads to wetland (EU 2a), Western Hemlock fallen over trail, also leads to Nunns Creek Park.
14	Secondary - variable condition	Passes over bridge B11 to fence then stops at fence and Himalayan Blackberry, some undesirable use.
15	Secondary - degraded	Leads to and skirts wetland (EU 2a), overgrown with Himalayan Blackberry and Salmonberry, moderately sensitive soils, Red Alder snags in wetland currently unlikely to be a threat even though close.

Table 4. Unauthorized trails in the study area.

Map Label	Condition	Comment
16	Unauthorized	Leads to creek, less defined on opposite side of creek.
17	Unauthorized	Narrow trail that is grown over, some adjacent vegetation trampling, defined trail ends at swamp but some tracks continue to 16th Ave. fence.
18	Unauthorized	-
19	Unauthorized	Spur to campsite on creek, needles.
20	Unauthorized	To injection site, ends at swamp
21	Unauthorized	Some garbage and trampling, ends at creek and edge of swamp (EU 2b).
22	Unauthorized	Goes to injection site and camp site currently occupied.
23	Unauthorized	-
24	Unauthorized	-

Appendix I. Photographs

LIST OF FIGURE

Figure 1. Ecological Units in the Nunns Creek Study Area.

a). Representative photograph of EU 1a on May 25, 2016

b.) Representative photograph of EU 1b on May 25, 2016.

c). Representative photograph of EU 1d on May 26, 2016.

d). Representative photograph of EU 2a on May 25, 2016.

e). Representative photograph of EU 2c on May 26, 2016.

f). Last dying conifers in EU 3a on May 26, 2016.

g). Corner of EU 3a with thick Himalayan Blackberry, dying deciduous trees, exotic deciduous trees and Grand Fir regeneration on May 26, 2016.

h). Representative photograph of EU 3b on May 25, 2016.

i). Representative photograph of EU 3b on May 26, 2016.

j). Rich understory herb layer in EU 4a on May 24, 2016.

k). Representative photograph of EU 4b on May 26, 2016.

Figure 2. Ecological features in the Nunns Creek study area.

a). Channelized portion of stream in EU 2c on May 24, 2016.

b). Old growth spruce and hemlock in EU 4a on May 24, 2016.

c). Stumps supporting tree regeneration in EU 4b on May 24, 2016.

d). Regenerating deciduous bigleaf maple tree in gap in EU 4b on May 25, 2016.

e). Western hemlock blowdown in EU 4b on May 26, 2016.

f). Downed bigleaf maple tree in EU 4c on May 24, 2016.

g). Downed western hemlock tree in EU 4c on May 25, 2016.

h). Conifer snag/wildlife tree on May 24, 2016.

i). Mistletoe in canopy of western hemlock tree on July 14, 2016.

Figure 3. FHAP Units in the Nunns Creek study area.

a). FHAP Unit 1 on May 24, 2016.

j). Red-legged frog on May 24, 2016.

b). FHAP Unit 2 on May 24, 2016.

c). FHAP Unit 3 on May 24, 2016.

d). FHAP Unit 4 on May 24, 2016.

e). FHAP Unit 5 on May 24, 2016.

f). FHAP Unit 6 on May 24, 2016.

g). FHAP Unit 7 on May 24, 2016.

h). FHAP Unit 8 on May 24, 2016.

i). FHAP Unit 9 on May 25, 2016.

Figure 4. Aquatic features in the Nunns Creek study area.

a). Anchored LWD, A01 on May 24, 2016.

b). Anchored LWD on May 24, 2016.

c). Anchored LWD on May 24, 2016.

d). Anchored LWD on May 24, 2016.

Figure 5. Beaver dams located in the Nunns Creek study area.

a). Outflow of marsh 1b, BD01, on May 24, 2016.

b). Outflow of swamp 2a, BD02, on May 26, 2016.

c). Outflow of swamp 2a, BD02, on May 24, 2016.

d). Beaver baffle at outflow of swamp 2a, BD02, BB01, on May 24, 2016.

e). Beaver baffle, BB01, on May 24, 2016.

f). BD03 on May 24, 2016.

Figure 6. Invasive species in the Nunns Creek study area.

a). Purple Loosestrife in EU1a on July 14, 2016.

b). European Bittersweet bordering EU 2a and field on May 25, 2016.

c). Bull Thistle bordering EU 2a and field on May 25, 2016.

d). Burdock in EU 2c on May 24, 2016.

e). Spurge-laurel in EU 4a on May 24, 2016.

f). English Holly in EU 4b on May 26, 2016.

g). English Ivy in EU 4a on May 24, 2016.

h). Severe infestation of English Ivy smothering a grand fir tree on July 14, 2016.

i). Himalayan Blackberry treatment in EU 4c on May 24, 2016.

j). Conifer planting in Himalayan Blackberry treatment area in EU 4c on May 24, 2016.

k). Himalayan Blackberry growing under canopy opening on July 14, 2016.

l). Young Himalayan Blackberry under the canopy in EU 4a on May 24, 2016.

m). Recently mowed Himalayan Blackberry by Homewood entrance on July 14, 2016.

n). Sulfur cinquefoil in adjacent lot at 11th on May 26, 2016.

o). Burdock along the trail on July 14, 2016.

Figure 7. Bridges located in the Nunns Creek study area.

a). Bridge in good repair, side view, B01, on May 24, 2016.

b). Bridge in good repair, top view, B01, on May 24, 2016.

c). Bridge in poor repair, side view, B02, on May 24, 2016.

d). Bridge in poor repair, top view, B02, on May 24, 2016.

e). Bridge in moderate repair, top view, B03, on May 24, 2016.

f). Bridge in poor repair, top view, B04, on May 24, 2016.

g). Bridge in poor repair, graffiti, top view, B04, on May 24, 2016.

h). Bridge repairs, top view, B04, on July 14, 2016.

i). Bridge in good repair, top view, B05, on May 24, 2016.

j). Bridge in moderate repair, top view, B06, on May 24, 2016.

k). Bridge in moderate repair, top view, B07, on May 26, 2016.

l). Bridge in moderate repair, top view, B08, on May 26, 2016.

m). Bridge in poor repair, top view, B09, on May 24, 2016.

n). Bridge in moderate repair, good condition but grown over and requires new tread, top view, B11, on July 14, 2016.

Figure 8. Trails located in the Nunns Creek study area.

a). Trail 1 in EU 4a on May 26, 2016.

h). Trail 2 in EU 3c on May 26, 2016.

c). Trail 3 in EU 4a on May 26, 2016.

d). Trail 4 in EU4a on May 26, 2016.

e). Trail 4 in EU 4b on May 26, 2016.

f). Trail 5 in EU 4a on May 26, 2016.

g). Trail 7 in EU 4b on May 26, 2016.

h). Trail 8 on private property along boundary of study area.

i). Trail 9 in EU 3b on May 25, 2016.

j) Trail 19 in EU 4a on May 26, 2016.

k). Trail 14 in EU 4a on May 26, 2016.

l) Trail 22 in EU 2b on May 26, 2016.

m) Trail 23 in EU 2b on May 26, 2016.

Figure 9. Culverts and storm drains located in the Nunns Creek study area.

a). 16th double box culvert, C01, on May 24, 2016.

b). 16th double box culvert, C01, on May 24, 2016.

c). Culvert from Homewood, C02, on May 24, 2016.

d). Storm drain from 12th, SD01, on May 24, 2016.

e). Storm drain from Homewood, SD02, on May 26, 2016.

f). Cement block on May 24, 2016.

g). Trail pipe, P01, on July 14, 2016.

h). Trail pipe, P02, July 14, 2016.

Figure 10. Signage in the Nunns Creek study area.

a). Salmon habitat sign at Nunns Creek on Homewood, S01, on May 24, 2016.

b). Interpretive sign at Homewood entrance, S02, on May 24, 2016.

c). Sign at Homewood entrance, S02, on May 24, 2016.

Figure 11. Other anthropogenic features in the Nunns Creek study area.

a). Picnic table at edge of EU 1a and 2b and industrial area, T01, on May 25, 2016.

b). Cement Pad, CP01, on May 24, 2016.

Figure 12. Undesirable use in the Nunns Creek study area.

a). Burnt graffiti stump on May 26, 2016.

b). Refuse in EU 4b on May 26, 2016.

c). Previous camping area in EU 4b on May 26, 2016.

d). Previous camping area on May 26, 2016.

e). Previous camping area on May 26, 2016.

f). Largest camp in study area, in EU 3b, on May 26, 2016.