RMOW Ecosystems Monitoring Report 2013

Whistler, BC

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CASCADE ENVIRONMENTAL
RESOURCE GROUP LTD

Executive Summary

This report documents ecosystem monitoring efforts for 2013 in the Resort Municipality of Whistler (RMOW). Cascade worked with the RMOW to identify key indicator species and habitats then conducted vegetation, wildlife, fish and amphibian capture and abundance surveys, as well as habitat assessments using Terrestrial Ecosystem Mapping (TEM) based on Biogeoclimatic Ecological Classification (BEC). In an effort to build off existing work commissioned by the RMOW, Cascade relied on the previous study, *A Proposed Framework for the use of Ecological Data in Monitoring and Promoting the Conservation of Biodiversity in Whistler,* as a foundation document (Golder 2008). Cascade also consulted with Snowline Ecological Research (Snowline), using data graciously provided and generated from the Biodiversity Project

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1 Introduction

Cascade Environmental Resource Group (Cascade) respectfully submits this report on the RMOW Ecosystems Monitoring Program for 2013. Cascade has operated in Whistler for over 20 years, and has extensive experience with the local environment and its conditions. Cascade used its expertise in freshwater ecology, fish, wildlife, avian and vegetation surveys, habitat assessment and environmental monitoring and management in the preparation of this report. Cascade drew upon the knowledge of experts in the vegetation and wildlife fields to ensure that methodologies, indicators and reporting mechanisms were properly identified, defined and documented. To meet the identified goals and objectives of the ecosystem monitoring program, Cascade worked with the Resort Municipality of Whistler (RMOW) to identify key indicator species and habitats then conducted vegetation, wildlife, fish and amphibian capture and abundance surveys, as well as habitat assessments using Terrestrial Ecosystem Mapping (TEM) based on Biogeoclimatic Ecological Classification (BEC). In an effort to build off existing work commissioned by the RMOW, Cascade relied on the previous study, *A Proposed Framework for the use of Ecological Data in Monitoring and Promoting the Conservation of Biodiversity in Whistler,* as a foundation document (Golder 2008). Cascade also consulted with Snowline Ecological Research (Snowline), using data graciously provided and generated from the Biodiversity Project (http://www.whistlerbiodiversity.ca/) and numerous studies carried out in the Whistler area. The Sea to Sky Invasive Species Council (SSISC) provided input on invasive species as well as access to their database for the purpose of identification of "hotspots".

This report focuses on development of a standardized terms of reference for an ecological monitoring program for the RMOW (Map 1). With emphasis on identification of biodiversity and ecosystem health indicators, studies attempted to pinpoint measureable and quantified values for the ecological attributes being monitored, so that over time, the records can reveal trends that can be used to interpret ecosystem health.

This study represents a starting point for development of an ongoing program with the capacity to evolve and expand over time, but that will create a baseline record of abundance. Most of the results should be considered as preliminary and as the program is in its early stages the findings are generally insufficient for identification of trends, or risk to ecosystem health. As the program develops and is refined over subsequent years, and as the standardized, replicable inventories generate more depth to the database, it is the authors' belief that trends and conclusions should become evident.

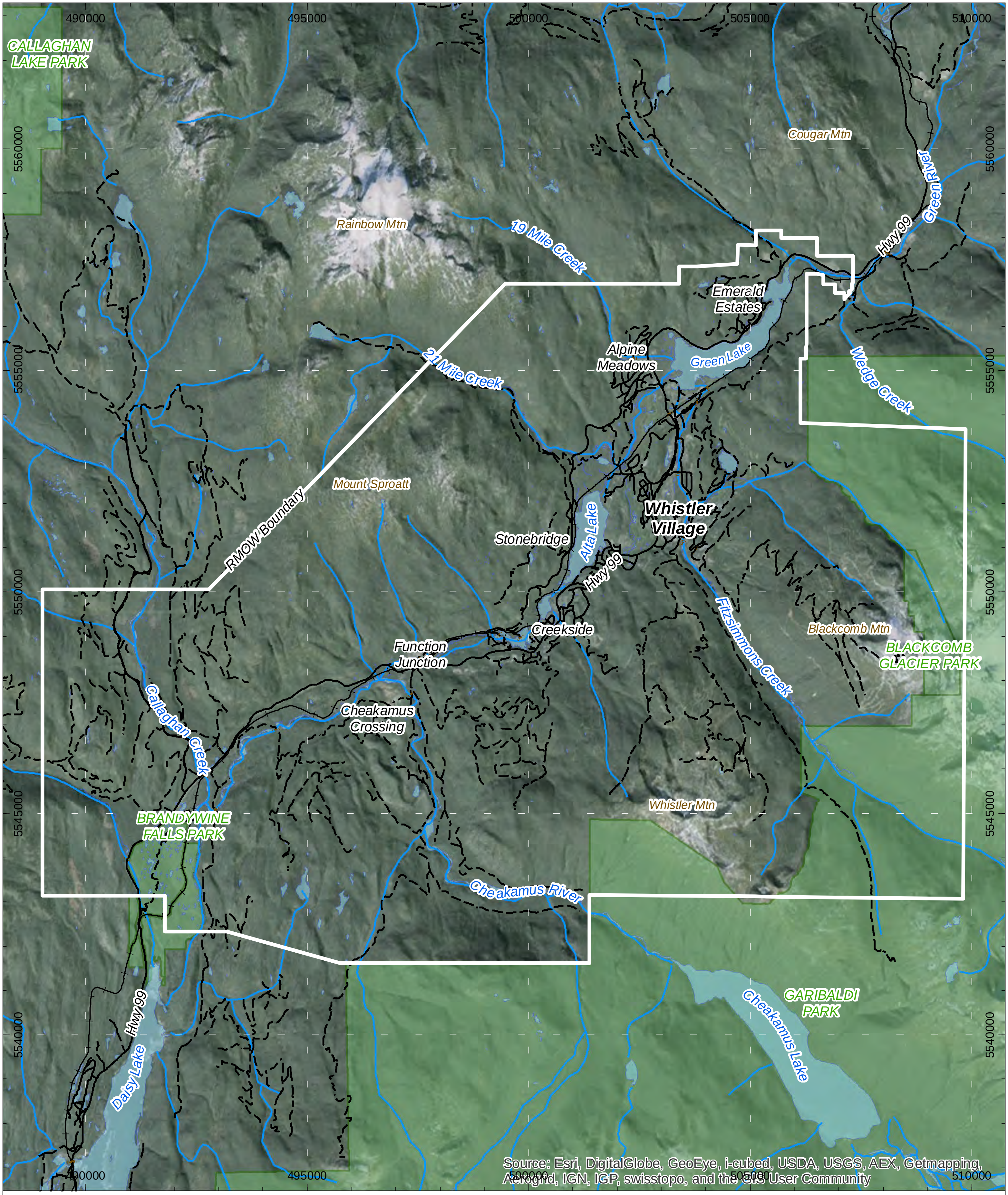
1.1 Terms of Reference and Project Scope

1.1.1 Purpose and Background

In 2008, Golder and Associates with contribution from Snowline Ecological Research prepared *A Proposed Framework for the use of Ecological Data in Monitoring and Promoting the Conservation of Biodiversity in Whistler* which laid out seven priority action items for monitoring and reporting on indicators of biodiversity in the Whistler area. Herein that report is referred to as Phase 1 of the ecosystem monitoring program. This follow-up initiative, herein referred to as Phase 2, identifies priority species indicators, developed and executed a monitoring program, and delivers this report on the program's findings.

From the outset of this project, the terms "monitoring of ecosystem health" and "biodiversity" were used in a manner suggesting an intrinsic connection. A review of currently accepted definitions can assist the reader to understand why this is so. While not considered an academic or citable source, Wikipedia does provide a commonly accepted definition as follows:

Biodiversity is a measure of the health of ecosystems. (http://en.wikipedia.org/wiki/Biodiversity)



GIS Cartographer: Todd Hellinga
Date: February 4, 2014
CERG File#: 013-48-01
Projection: UTM 10N NAD83
Orthophoto: ESRI

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Map 1 - Location

RMOW Biodiversity Monitoring Project
Whistler, British Columbia

Therefore, the RMOW is interested in monitoring ecosystem health recognizing that biodiversity is important. The following rationale in support of biodiversity provided by Failing and Gregory (2003) supports the RMOW's interest:

1. Preserve ecological services (such as carbon sequestration or hydrology regulation) associated with the composition, structure, and function of ecosystems, as well as the resilience to provide these services into the future;
2. Prevent losses to a targeted species or forest attribute (often a vulnerable or keystone species);
3. Prevent aesthetic losses (associated with what have been termed 'charismatic megafauna' or other losses of recreational quality);
4. Uphold ethical principles of ecosystem-based forest management (associated with a belief in the intrinsic value and rights of all species);
5. Protect and enhance social and economic value, both current and future, derived from industrial, medical, and agricultural uses of species and genes.

Biodiversity is characterised by the European Academies Science Advisory Council (2005) according to the following attributes:

1. Variety, the number of different types
   This aspect is well covered by the inventory gathered through the Biodiversity Project.
2. Quantity, the number or total biomass of any type
   This is an objective for this phase of study and is based on indicators and abundance.
3. Distribution, the extent and nature of geographic spread of different types
   Partially completed through existing inventories, development of the geodatabase will provide distribution and geographic context.

For the purpose of this phase of the ecosystem monitoring program the following definition will be used for guidance:

Biodiversity is the number, variety and variability of living organisms (species) for a standard area (ha).

1.1.2 Work Objectives

1. Identify and monitor select indicators of biodiversity
2. Identify ecological "hotspots"
3. Document small and ephemeral wetlands
4. Incorporate inventory data into municipal database/GIS

Cascade has met the following objectives developed from the Proposed Framework's recommendations:

1. Identify priority species for monitoring in order to manage for preservation of biodiversity
2. Monitor species indicators using methodologies and at intervals determined in consultation with the RMOW.
3. Submit a final report with accompanying shape files relating to the program.

A number of people contributed to this study including analysis of the data, development of the monitoring program and execution of the sampling program. The core study team for the project included:

Dave Williamson, B.E.S., ASc.T, QEP
Todd Hellinga, B.Sc., G.I.S.
Candace Rose-Taylor, M.Sc., EP
Mike Nelson, B.Sc., R.P.Bio, QEP
Ruth Begg, M.E.M., EP

Kersti Vaino, B.Sc., R.B.Tech. QEP
Adrien Baudouin, M.Sc.
Paula Zettel, B.Sc.
Natasha Dudley, B.Sc. (cand.)

Additionally, a number of associates and external professionals were consulted during the data gathering and program development stages of the study. Their contributions are greatly appreciated:

Heather Beresford, M.A. (Environmental Stewardship Manager, RMOW)
Leslie Anthony, Ph.D. (herptiles)
Lori Homstol, M.Sc. P.Biol., QEP (large mammals)
Dave Polster, M.Sc. R.P.Bio., QEP (vegetation)
Bob Brett, M.Sc., R.P.Bio., QEP (biodiversity)
Kristina Swerhun, M.Sc. (invasive plants)

2 Work Plan and Methodology

2.1 Assemble and Analyze the Geodatabase

Cascade identified the lack of geographic context as a significant barrier to development of an ecosystem monitoring program for the RMOW. Therefore, the first task involved taking delivery of the existing available ecosystem inventory and the existing GIS information from the RMOW, Snowline and SSISC and articulating it into a comprehensive geodatabase. The data was reviewed and wherever possible, incorporated into the GIS for the purposes of analysis. Once the GIS information was prepared and mapped, the GIS could be used as an analytical tool for each of the tasks associated with the project. For each of these tasks a series of queries were conducted to identify correlation with species occurrences and habitat types. These correlations were then used to extrapolate potential data gaps and to identify sample sites as well as monitoring locations.

Assembling the data from a variety of sources and taking delivery of data in multiple formats on a range of platforms proved to be more time consuming and labour intensive than initially anticipated. As a result, GIS analysis could not commence until late July. This meant that some of the optimal survey windows were missed for this year. Regardless, survey windows were identified for each of the field indicators and are included in this report for future years. Field surveys for some indicators focused on proving out standardized methodologies and sample site locations with an aim to establishing a prescriptive sampling program for next year. Methodologies for each of the tasks are further described in each section of this report.

2.2 Identify Ecological Hotspots

One of the objectives of this phase of the program is identification of biodiversity hotspots at the local scale. Although the following definition is aimed at the more typical regional scale, it was agreed upon as a starting point for identification of hotspot indicator sites:

A biodiversity hotspot is a region with a exceptional levels of endemic *species AND by serious levels of habitat loss.* http://www.conservation.org/where/priority_areas/hotspots/Pages/hotspots_defined.aspx

The RMOW OCP (2013) has identified sensitive ecosystems that should provide candidates for hotspots. Identification of ecological hotspots will be an ongoing process and other than the initial hotspots, should be results-based and directed by the trends revealed by the indicator species monitoring. Building on the theme of scarcity, the RMOW has completed an inventory of terrestrial ecosystem mapping and have identified the rare and special ecosystems of interest. In order to classify specific ecosystems as hotspots, these candidate sites should be at risk of impact by externalities like land development, industrial development, infrastructural development, tourism development or recreational activity. Lands classification that present a potential risk due to development include private lands, provincial and municipal parks and recreation sites, tenured intensive use on Crown land.

Initial identification of hotspots focused on the following conditions (Map 2):

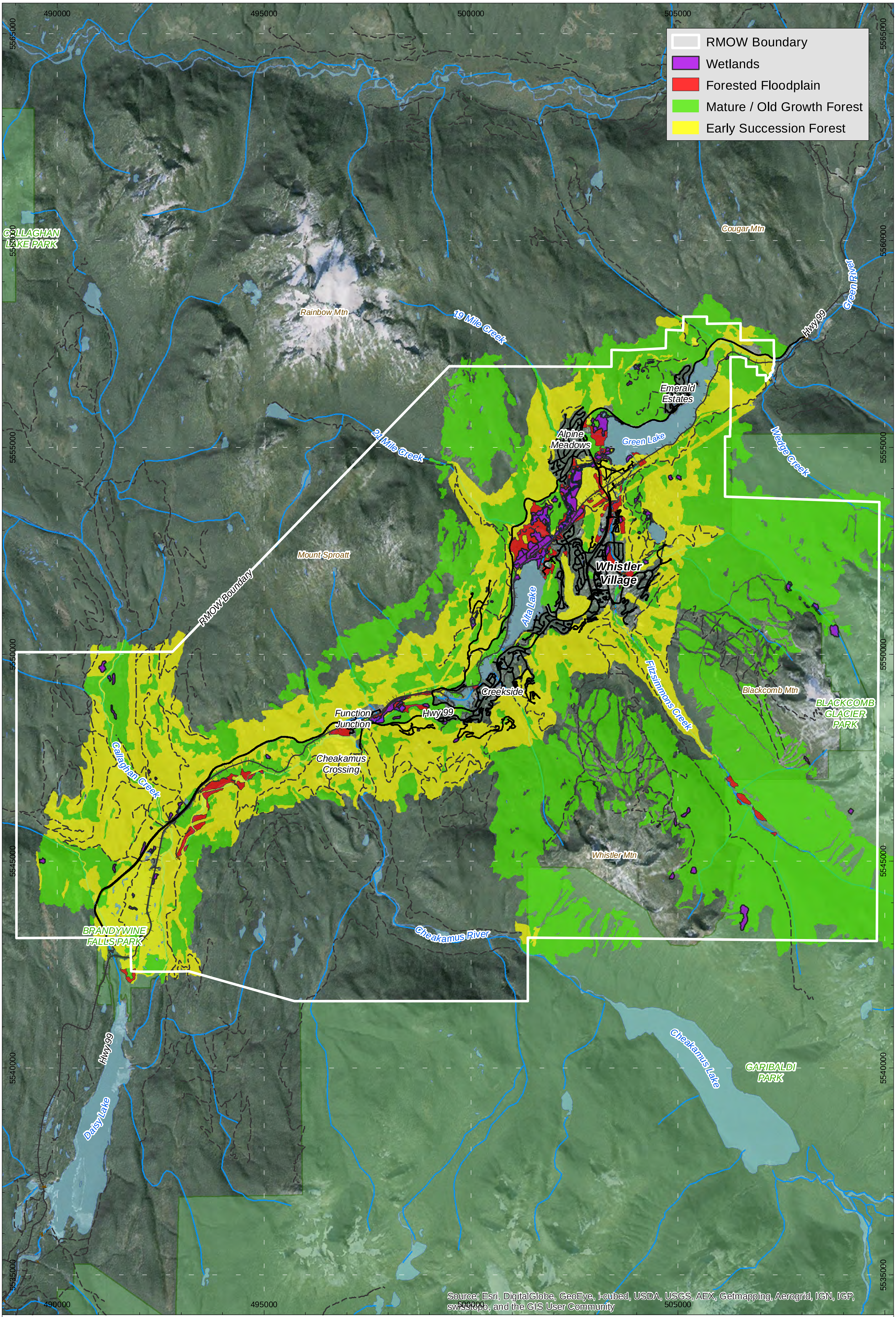
1. Mature/old forest ecosystems
   Renewable, old forests are becoming rare in the RMOW valley bottom due to development pressure and scarcity combined with high biodiversity constitutes qualifying criterion. Mature and old forests are established ecosystems with naturally high levels of species biodiversity due to their age and the lack of disturbance. While not necessarily under threat, they may be considered hotspots meriting protection due to the presence of a wide range of endemic species.

2. Forested floodplain ecosystems
   Valley bottom, forested ecosystems occurring on floodplains are identified s are rare in the RMOW valley bottom due to development pressure from the "boom" period of 1980 to 2000. This scarcity combined with high biodiversity values associated with floodplains and riparian vegetation constitutes qualifying criterion.

3. Early succession ecosystems
   With the exception of a few isolated sites, the entire valley bottom was harvested for timber. The period of extensive harvesting began shortly after the start of the last century, with the introduction of the Pacific Great Eastern Railway and carried on well into the 1980's. As a result, early succession ecosystem are widespread and abundant. However, the high level of biodiversity represented by these successional ecosystems constitutes qualifying criterion.

4. Wetland ecosystems
   Wetlands in the Whistler valley have been subjected to encroachment for mining, agriculture, real estate and recreation development. Wetlands are known to be important for protection of biodiversity because species occupation and utilization may be specific and not represented in other ecosystems. As a result, the remaining wetlands are widely recognized as a valued ecosystem component of the community and qualify as hotspots.

Other sensitive ecosystems of concern identified by the RMOW include high mountain ecosystems and avalanche tracks. At this time, these identified ecosystems are not included in the hotspots list because the threats are not readily articulated at this time. These may be added to the list in subsequent monitoring studies.



GIS Cartographer: Todd Hellinga
Date: April 4, 2014
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Orthophoto: Bing Maps

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Preliminary Hotspots

Biodiversity Monitoring Project
Resort Municipality Of Whistler
British Columbia

2.3 Identify Priority Habitats and Species for Monitoring

Cascade reviewed "A Proposed Framework for the Use of Ecological Monitoring and Promoting the Conservation of Biodiversity in Whistler" (Golder, 2008) and in-house ecological inventory information, as well as species data previously collected through the Whistler Biodiversity Project. The purpose of the review was to identify and select indicators of biodiversity. Biodiversity indicators, and their accompanying metrics, can provide feedback to land mangers and other user groups. Indicators can be used to interpret the effects of change over time, if monitored in a consistent and quantifiable manner. The survey methods for indicators should be repeatable, focusing on providing the sought after information.

Biodiversity indicators can be divided into species indicators, habitat indicators, or landscape, with links between all three. To use species indicators there must be a sufficient baseline inventory, and the inventory methodology must be repeatable. To use a habitat indicator, the link between the applicable species and the habitat unit must be understood, and to use a landscape indicator the relationship between species and habitat patch size and fragmentation should be known. Indicators, therefore, need a sufficient knowledge set to be effective. To be useful and cost efficient, indicators should by definition be able to represent trends affecting a larger group of species.

With reference to the previous report and in consultation with the RMOW, along with the GIS information, a prioritized list of appropriate species, habitat and landscape biodiversity indicators was developed. The list considered inventory information already gathered, regional and local values or priorities, as well as the availability of a cost-effective, standardized and replicable inventory methodology. The list was vetted and refined through a series of meeting with the RMOW. The refined list of indicator species and habitats is as follows:

Aquatic Habitat Indicators

- Water Quality Sampling
    - Full spectrum
- Wetlands survey
    - Small and ephemeral wetlands

Aquatic Species Indicators

- Kokanee salmon (*Oncorhynchus nerka*)
- Bull Trout (*Salvelinus confluentus*)
- Rainbow trout (*Oncorhynchus mykiss*)

Riparian Species Indicators

- Amphibians
    - Tailed frog (*Ascaphus truei*)
- Mammals
    - Beaver (*Castor canadensis*)

Terrestrial Habitat Indicators

- Invertebrates
    - Carabid Beetle (Carabidae)
- Invasive Plants
    - Terrestrial ecosystem plots

Terrestrial Species Indicators

- Avifauna
    - Pileated Woodpecker (*Dryocopus pileatus*)

- Small mammals
    - Red-backed vole (*Clethrionomys gapperi*)

Climate Indicators

- Alta Lake freeze-up and thaw dates

3 Monitoring Program

With the selection of indicators species completed and based on the 2013 monitoring program developed in the initial stage of this project, Cascade monitored the identified species, habitat or landscape feature identified in the previous section.

3.1 Aquatic Habitat Indicators

3.1.1 Water Quality Sampling

Water quality within the Whistler region has been collected on a project by project basis and is therefore decentralized. In 2013 the Resort Municipality of Whistler began compiling this data, but by its nature will take some time to assemble and sort. The RMOW in collaboration with the Ministry of the Environment has been collecting water quality data for all Whistler lakes. This data once compiled will be used as a baseline for future years (Burrows and Tayless pers. comm.).

Water quality data was collected during the fish and amphibian surveys. Basic water quality, including temperature, pH and conductivity was collected at each coastal tailed frog tadpole survey site (Table 1).

Table 1: Basic water quality at each coastal tailed frog tadpole survey site

Site	Date	Time	Area (m^2)	Basic Water Chemistry		
				Water Temp. (^oC)	pH	Cond. (µS)
Alpha Creek #1	2013.08.30	10:16	18	10.5	7.61	90
Alpha Creek #2	2013.08.30	11:50	15	10.5	7.79	88
Alpha Creek #3	2013.08.30	12:26	36	10.5	7.29	88
Scotia Creek #1	2013.08.30	13:38	21	11.8	7.68	57
Scotia Creek #2	2013.08.30	14:23	13	11.5	7.88	31
Scotia Creek #3	2013.08.30	14:50	17	11.4	7.41	29

Prior to electrofishing on Fitzsimmons Creek, Jordan Creek and the River of Golden Dreams, basic water quality measurements were taken. These include temperature, pH, conductivity and turbidity (Table 2).

Table 2: Basic water quality at electrofishing sites

Site	Date	Area (m^2)	Basic Water Chemistry			
			Water Temp. (^oC)	pH	Cond. (µS)	Turbidity. (NTU)
Fitz Creek	2013.08.19	334	6.7	8.8	65	39.6
Jordan Creek #1	2013.09.04	108	16.8	7.81	61	3.90
Jordan Creek #2	2013.09.04	108	16.8	7.81	61	3.90
River of Golden Dreams	2013.09.06	100	16.9	7.66	225	7.26

RMOW Fish Stewardship Group volunteers recoded basic water quality in Crabapple Creek and the River of Golden Dreams during the 2013 kokanee spawning survey (Table 3).

Table 3: RMOW kokanee spawning survey water quality

Site	Date	Time	Weather	Water Temperature (^oC)	Conductivity (µS/s)	pH	TSS (ppm)
Crabapple Creek	2013.09.05	17:45	Cloudy	13.6	227	7.89	113
Crabapple Creek	2013.09.13	17:20	Sunny	14.8	238	7.90	119
Crabapple Creek	2013.09.20	17:45	Cloudy	11.7	236	7.83	118
Crabapple Creek	2013.09.26	17:30	Sunny	7.8	225	7.78	112
River of Golden Dreams	2013.09.05	17:50	Cloudy	13.1	68	7.30	34
River of Golden Dreams	2013.09.12	17:30	Sunny	14.3	64	7.41	32
River of Golden Dreams	2013.09.20	17:45	Cloudy	11.7	67	7.51	34
River of Golden Dreams	2013.09.26	17:30	Sunny	8.1	56	7.61	28

3.1.1.1 Discussion and Recommendations

Water quality data is currently being collected by the RMOW in collaboration with the MOE for all lakes (Burrows and Tayless pers. comm.). That data is being collected in a standard format and held in a centralized database. To date, water quality data for Whistler area creeks was collected on a project by project basis. Establishing permanent monitoring sites and regular monitoring on key Whistler creeks is recommended. Additionally, MOE is establishing water quality objectives for all of the Lakes in Whistler. Permanent and ongoing monitoring will allow the RMOW to identify changes that could impact the health and productivity of aquatic and riparian flora and fauna within Whistler.

3.1.2 Wetlands Survey

Based on the previous report, the RMOW had identified small and ephemeral wetlands as valued ecosystem components, and included them as work objectives within this study. Due to their small size and large numbers of potential wetland occurrences, a focused search was determined to be a critical first step in the survey to narrow the focus of study. A desktop mapping and analysis exercise, utilizing near Infra-red (IR) imagery and digital elevation model (DEM) slope analysis in conjunction with watercourse and Terrestrial Ecosystem Mapping (TEM), allowed the team to quickly identify areas that met the criteria for potential wetland locations.

In order to use the criteria for determining the potential location of small and ephemeral wetlands a model was developed that used 2 m contour data to create a digital elevation model (DEM) and complete a slope analysis classification. The resultant classification identified all areas of less than 10% gradient (Map 3). The slope analysis allowed Cascade to identify flat, low lying areas within the municipality which could then be overlaid with existing watercourse and wetland information as well as Terrestrial Ecosystem Mapping (TEM) data. The GIS analysis queried ecosystems with wetland, riparian or ecosystems with moist to wet soil moisture regimes (Map 4). Next, near Infra-red (IR) ortho-imagery was acquired at 5 m resolution. A supervised classification analysis was applied using the spectral signature of known wetland vegetation types (*Spiraea douglasii* and *Salix glauca*) in the River of Golden Dreams and Millar Creek wetlands. The results of the supervised classification were combined with the slope analysis results and hydrological information to create an intersect identifying 14,997 areas that could potentially contain small and ephemeral wetlands. While it was understood that there would be false positives, such as moss covered flat bedrock outcroppings and urban areas, these were readily identified and discarded. Further, the potential of missed wetlands in forests with high crown closure is also recognized. The remaining identified potential wetlands were grouped into field maps and transferred into the Trimble GPS for field surveys. *A program* of systematic field verification was developed to ground truth the sites. Due to the sheer numbers and geographic extents of the inventory, this survey could be expected to extend over a number of years. For the purpose of the 2013 field season, sites were selected to test the veracity of the pre-screening process.

3.1.2.1 Wetland Survey Methodology

Field teams used the DEM in conjunction with the TEM system to map out areas where small and ephemeral wetlands were suspected to exist. Wetlands encountered in and around Whistler and outside of the valley bottom tend to be bed rock controlled. A positive confirmation of a wetland required the identification of both obligate hydrophytes and facultative wetland and uplands affiliated species (MacKenzie & Moran, 2004). Obligate wetland species are only found in wetlands and are used as an indicator of wetland presence. Facultative wetland species occur in wetlands 66-99 percent of the time, can be found in permanent or seasonal wetlands and can be used to identify seasonal wetlands during dry times of the year. Facultative upland species are usually found in wetlands 33-66 percent of the time, hence wetland identification should not be based on these species as they are the least reliable indicator of wetlands (MacKenzie & Moran, 2004). Identification of wetland obligate species in Whistler valley included *Sphagnum magellanicum* and *Symplocarpus foetidus*. Common wetland facultative species included *Pinus contorta, Spiraea douglasii*, *Rhododendron groenlandicum* and *Salix glauca*. Due to time constraints, wetlands were not classified according to the BC Wetland Classification (MacKenzie and Banner, 2001 or MacKenzie and Moran, 2004) or the Wetlands of Canada (NWWG, 1988).

3.1.2.1.1 Site Selection

In order to test the veracity of the model, two sites were selected for identification of potential wetlands in Whistler. The first site is located in the Lower Callaghan area and the second in Emerald Estates. Sites were chosen on Crown land, in areas where small wetlands are known to exist.

3.1.2.2 Results

A total of 32 potential wetland areas were investigated; 20 were investigated in the Lower Callaghan and 12 were investigated in Emerald Estates. The investigation yielded a prediction success rate of 35 percent at the Callaghan site and 58 percent at the Emerald site. For the two sites combined, a prediction success rate of 44 percent was attained.

A wide range of wetland types were discovered during potential wetland investigation. Three ponds were predicted and confirmed as wetlands using the DEM at the Callaghan site ranging in diameter from approximately 15 to 50 m (Photo 1). As well, a stream wetland (Photo 2) and a seep (Photo 3) were identified at the Callaghan site (Map 5). At the Emerald site, several bogs were detected as well as a wetland area with standing water (Map 6).

Many of the investigated potential wetland sites that were confirmed to not be wetlands were identified as convex rocky outcrops at both Emerald and Callaghan sites (Photo 4).

3.1.2.3 Discussion and Recommendations

The infrared signal emitted by known wetland vegetation types is likely similar to the signal emitted by convexities of bedrock and other types of land which could account for the relatively high occurrence of false positive sites. However, as a prescreening tool aimed at reducing field time, the model proved valuable and can be used to focus subsequent field investigations.

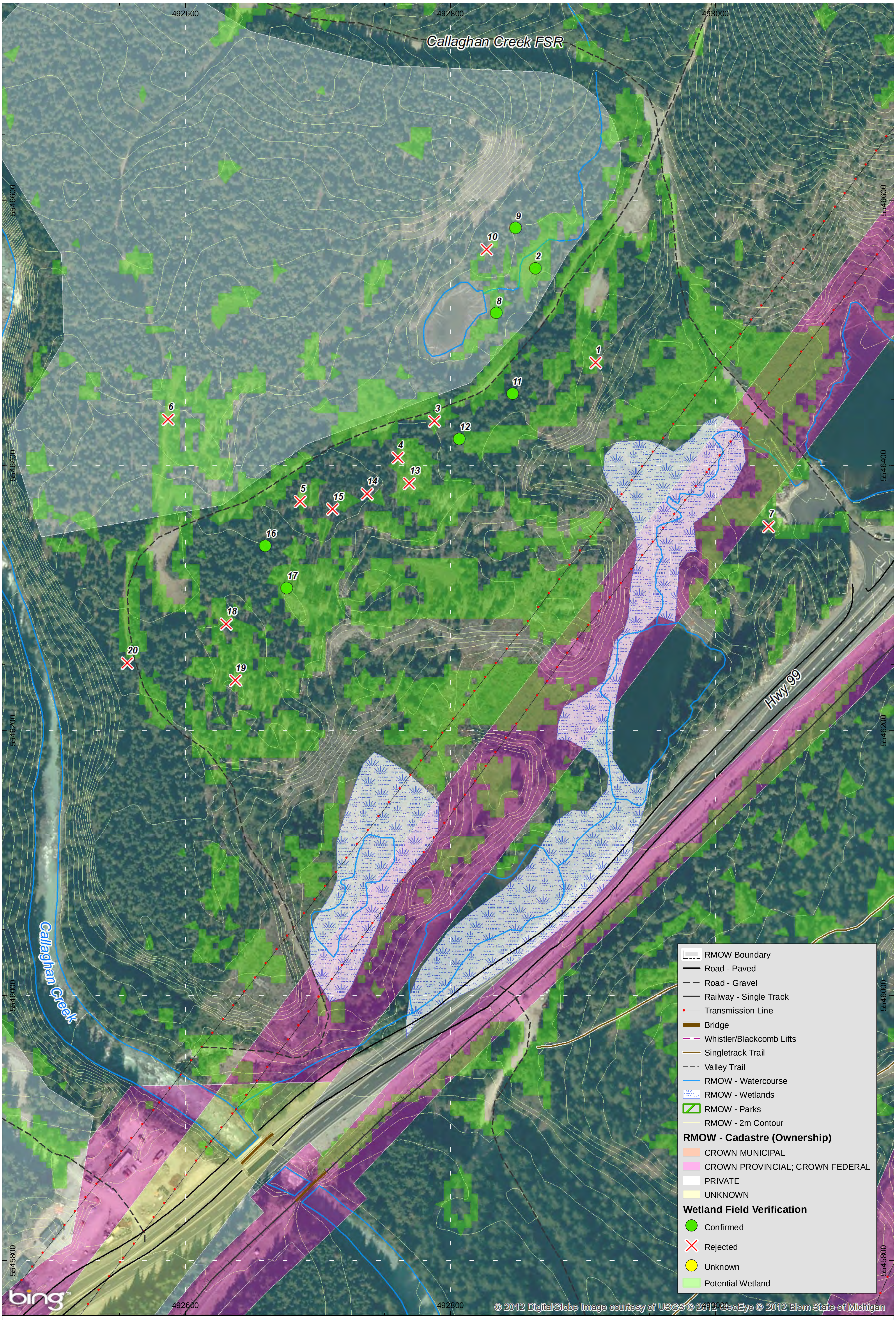
In the future this model could be further refined by using higher resolution imagery, in order to increase the predictive accuracy for potential wetlands occurrence.

However, identification of all small and ephemeral wetlands throughout the valley may not be a high priority for the RMOW given the labour intensive nature of field verification. Given that there are almost 15,000 potential wetland sites and assuming the lower level of predictive accuracy of 35%, there are potentially over 5000 small and ephemeral wetlands within the RMOW. Wetland preservation objectives may be better served by identifying wetland hotspots within the RMOW and focusing on monitoring the health of the hotspot wetlands. The list of hotspot wetlands should be developed in consultation with the RMOW in the next phase of the project. Since one of the main criteria for hotspots is threat, some of the wetlands designated as hotspots will likely fall on or be adjacent to private land. Therefore, any development proposals that could potentially affect wetland hotspots would require assessment through the Development Permit (DP) process.

As with TEM inventories and mapping in the RMOW, so should wetlands be accurately delineated and classified according to the BC Wetland Classification system (MacKenzie and Moran, 2004). This classification system dovetails with the BC Biogeoclimatic Ecological Classification (BEC) system and the National Wetland Classification System (NWWG, 1987).


Wetland Spectral Analysis
Potential Areas for Further Investigation
RMOW Biodiviersity Monitoring Project
Whistler, BC
N
W
E
S
0
1
2
3
Kilometers
1:31,000
Date - July 18, 2013
CERG File# 013-48-01
Projection - UTM Zone 10N NAD83
Ortho/Data - Bing/BC Gov/RMOW
GIS Cartographer - Todd Hellinga
Legend
RMOW Boundary
Road - Paved
Road - Gravel
Railway - Single Track
Transmission Line
Bridge
RMOW - Watercourse
TRIM - Lake
Extents of Slope Analysis (2m Contour Coverage)
RMOW Identified Wetland
Potential Wetland Areas (Spectral Signature)
1 - 44
44 - 49
49 - 54
54 - 59
59 - 64
64 - 69
69 - 74
74 - 79
79 - 84
84 - 89
89 - 94
94 - 99
99 - 104
104 - 160
Percent Slope
0 - 10
10 - 50
50+
Mapping By:
CASCADE ENVIRONMENTAL
RESOURCE GROUP LTD
Rainbow
Emerald Estates
Alpine Meadows
Green Lake
Nicklaus North
Mount Sproatt
Spruce Grove
White Gold
Rainbow Park
Whistler Village
Benchlands
Alta Lake
Stonebridge
Alta Vista
Brio
Nordic Estates
Creekside
Function Junction
Spring Creek
Bayshores
Kadenwood
Cheakamus Crossing
Whistler Mountain
Blackcomb Mountain
bing


Wetland Identification - GIS Analysis Results
RMOW Biodiviersity Monitoring Project
Whistler, British Columbia
Potential Wetland - GIS Analysis
Extent of 2m Contours (DEM extents)
RMOW Boundary
RMOW - Watercourse
RMOW - Wetlands
Road - Paved
Road - Gravel
Railway - Single Track
Transmission Line
Bridge
Singletrack Trail
Valley Trail
Whistler/Blackcomb Lifts
RMOW - Parks
Provincial Park
RMOW - Cadastre (Ownership)
CROWN MUNICIPAL
CROWN PROVINCIAL; CROWN FEDERAL
PRIVATE
UNKNOWN
N
W
E
S
0 500 1,000 1,500 2,000 2,500
Meters
1:31,000
Date - December 17, 2013
CERG File# 013-48-01
Projection - UTM Zone 10N NAD83
Ortho/Data - Bing/BC Gov/RMOW
GIS Cartographer - Todd Hellinga
See Emerald Estates Map
Emerald Estates
Heliport
Rainbow
Alpine Meadows
Nicklaus North
Spruce Grove
White Gold
Mount Sproatt
Rainbow Park
Whistler Village
Benchlands
Stonebridge
Alta Vista
Bmo
Nordic Estates
Creekside
Function Junction
Bayshores
Kadenwood
Spring Creek
Cheakamus Crossing
See Lower Callaghan Map
BLACKCOMB GLACIER PARK
Blackcomb Mountain
Whistler Mountain
GARIBALDI PARK
BRANDYWINE FALLS PARK
Mapping By:
CASCADE ENVIRONMENTAL
RESOURCE GROUP LTD
bing



GIS Cartographer: Todd Hellinga
Date: December 12, 2013
CERG File#: 013-48-01
Projection: UTM 10N NAD83
Orthophoto/Data: Bing Maps, RMOW

CASCADE ENVIRONMENTAL RESOURCE GROUP LTD

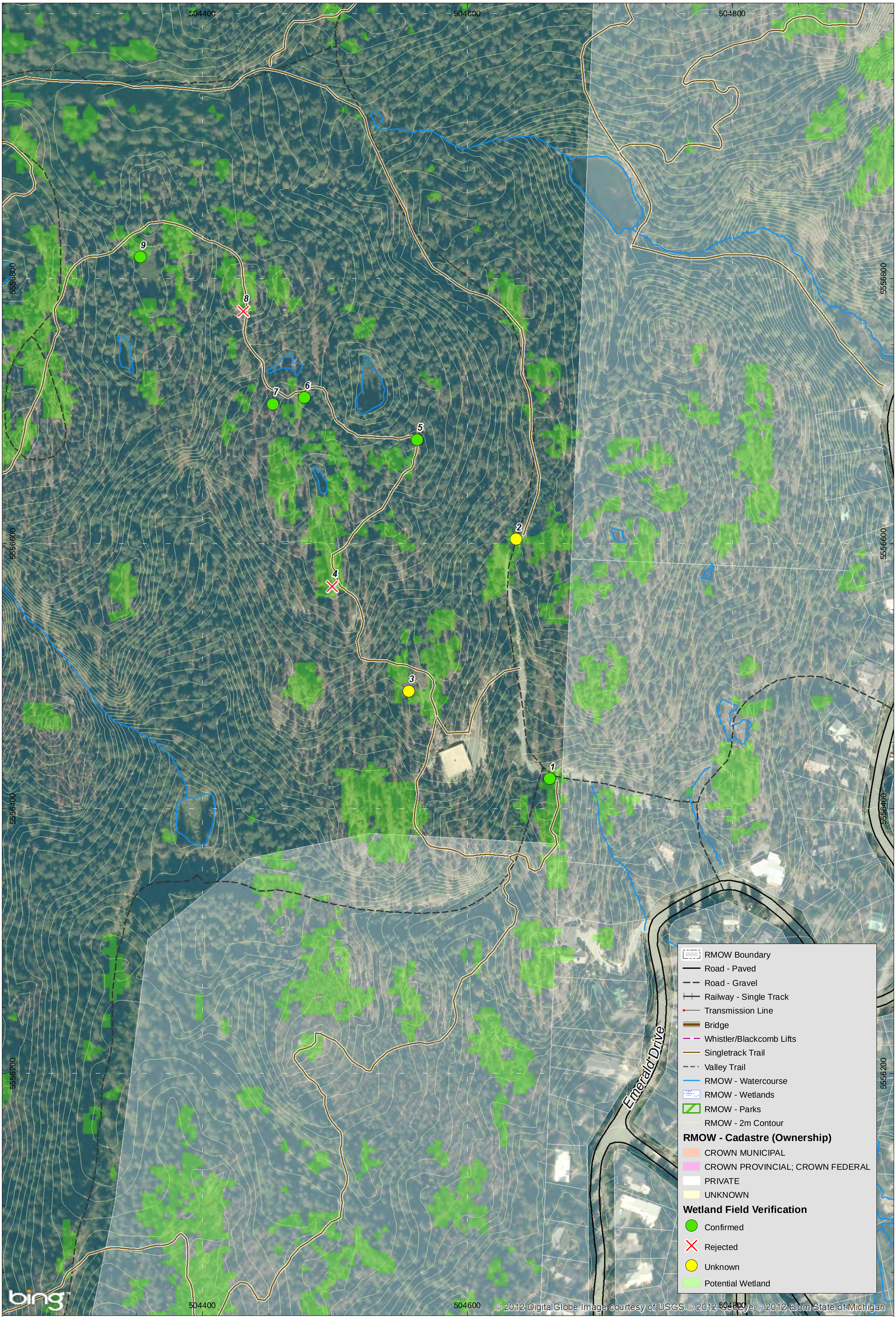
N S E W

0 50 100 150

Meters

Wetland Identification - Lower Callaghan Area Field Map

RMOW Biodiversity Monitoring Project
Whistler, British Columbia



GIS Cartographer: Todd Hellinga
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Projection: UTM 10N NAD83
Orthophoto/Data: Bing Maps, RMOW

CASCADE ENVIRONMENTAL
RESOURCE GROUP LTD

N
W E
S

0 50 100 150

Meters

Wetland Identification - Emerald Estates Area Field Map

RMOW Biodiversity Monitoring Project
Whistler, British Columbia

Photo 1. Ponded marsh wetland discovered at the Lower Callaghan site approximately 30 m in diameter. October 10, 2013.

Photo 2. Confirmed stream wetland identified at the Lower Callaghan site. October 10, 2013.

Photo 3. Wetland seep identified at the Lower Callaghan site. October 10, 2013.

Photo 4. Open bedrock convexity confirmed as a non-wetland area at the Emerald Estates site. September 12, 2013.

3.2 Aquatic Species Indicators

Resident fish spend their entire life cycle in local rivers and lakes and their condition and population size are important indicators of ecosystem health (Raymond et. al 1999). The Fisheries Information Summary System (FISS) database indicates that several species of salmonids have been observed in the water bodies that flow through the Resort Municipality of Whistler. Within the RMOW boundaries historic records include Kokanee, Bull trout, Dolly Varden, Rainbow trout, Cutthroat trout. The Daisy Lake Dam and Nairn Falls provide barriers to fish passage preventing other fish species such as Coho Salmon, Chum Salmon, Pink Salmon, Chinook Salmon, Steelhead, Sockeye Salmon and Brook trout, which are known to occur in Checkamus River and Green River from entering the municipal boundaries. It should also be noted that the FISS records are occurrence only and do not provide population estimates or changes in distribution or time. InStream Research Inc. Recently conducted an evaluation of the Green Lake Bull trout population (Instream 2012). Other than this detailed population study, very little work has been done to estimate salmonid populations within the region. To better understand the resident fish population in Whistler, surveys were conducted by Cascade Environmental during the months of August 2013 and September 2013 in Fitzsimmons Creek, Jordan Creek and the River of Golden Dreams. Information gathered from these surveys may build on the information gathered by the Whistler Fish Stewardship Group (WFSG) over the past 20 years.

3.2.1 Site Selection

Three representative creeks were examined to assess the fish species composition and population in Whistler: Fitzsimmons Creek, Jordan Creek and the River of Golden Dreams were surveyed (Map 7). Fitzsimmons Creek is a glacial stream that flows between Whistler and Blackcomb Mountains, through Whistler Village terminating in Green Lake. The upper reaches are steep and receive regular inputs from steep, unstable land masses along the creek walls. The lower downstream reaches have been dyked and channelized to minimize the flood risk through Whistler Village (Cascade 2010). Jordan Creek is a small, < 500 m connector stream that flows from Nita Lake to Alpha Lake. It is surrounded by The Nita Lake Lodge, houses, roads, the paved valley trail, rail road tracks and municipal park land. The River of Golden Dreams (ROGD), also known as Alta Creek flows from Alta Lake to Green Lake. It is hemmed by houses, roads and the valley trail. The ROGD is also popular for recreational paddlers and is used extensively by individual canoers, kayakers, stand up paddle (SUP) boards as well as commercial tour operators.

3.2.2 Fish Species

In B.C. species and ecological communities are assigned to the Red, Blue or Yellow list depending on their provincial Conservation Status Rank. The Red List included species that are designated as Endangered or Threatened under the *Wildlife Act*, or are extirpated or are candidates for these designations. Blue Listed species are not immediately threatened but are of concern due to factors that make them sensitive to human activates or other environmental change. The Yellow List includes all species not on the Red or Blue Lists. Most fish species that occur within the RMOW boundaries are Yellow Listed except for the Bull Trout and Cutthroat Trout.

During the surveys Cascade captured rainbow trout, Bull trout, cutthroat trout as well as stickle back and sculpin. The Resort Municipality of Whistler (RMOW) also conducted a survey of spawning Kokanee in the River of Golden Dreams.

Bull Trout

Bull trout (*Salvelinus confluentus*) are not true trout, but are in fact char. They are often confused with Dolly Varden (*Salvelinus malma*) which have similar markings, skull morphology and distribution (Hammond, 2004). Through genetic studies, the separation between the two species was recognized by the American Fisheries Society in 1980 (Hammond, 2004). Bull trout are characterized as having a large head and jaw relative to their long, slender body. When compared to Dolly Varden, bull trout have a larger, broader and flatter head and more ventrally flattened body (Hammond, 2004). Their colour ranges from green to greyish blue. Some lake residents have silver sides. The dorsal and peduncle regions are spotted with pale yellowish-orange spots. Bull trout are distinguished from other char and trout species native to western Canada by the absence of black spots on the dorsal fin (Hammond, 2004).

Bull trout are endemic to western Canada and the U.S. Pacific Northwest. In B.C. they are found in all major drainage basins on the mainland. However they are on the provincial *Blue List*. Bull trout populations are declining in abundance in Canada and the U.S. (Hammond, 2004). In B.C. the main threat to bull trout populations is fragmentation due to disruption of the migration patterns by obstructions such as perched culverts, water velocity through culverts and degraded habitats (Hammond, 2004). In B.C. bull trout are protected under the provincial *Wildlife Act*, the provincial *Fish Protection Act* and the federal *Fisheries Act.*

Cutthroat Trout

Coastal cutthroat trout (*Oncorhynchus clarki clarki*) are distinguished by a red or orange streak under their jaw (MOE BC Fish Fact Sheet- Cutthroat). In comparison to other trout, cutthroats have many spots all over the head and sides of the body and occasionally on the belly and fins (MOE BC Fish Fact Sheet-Cutthroat).

Coastal cutthroats range from southern Alaska to the Eel River in California. Their range does not extend very far inland from the coast—usually less than 150 km (MOE BC Fish Fact Sheet- Cutthroat). In B.C. the coastal cutthroat is considered vulnerable and is therefore on the provincial *Blue List*. Their numbers are most notably in decline on the East coast of Vancouver Island and the Lower Mainland. Coastal cutthroat rely on small streams for spawning, however it is these streams that are easily altered or destroyed or simply overlooked during planning for residential, agricultural and industrial development or forest harvesting (MOE BC Fish Fact Sheet- Cutthroat). While there is some debate locally regarding the historic presence of cutthroat in the Whistler area, sterilized cutthroats were introduced to Alta Lake in an effort to control the stickleback population.

Kokanee

Kokanee (*Oncorhynchus nerka*) are morphologically similar to sockeye salmon, however kokanee spend their entire lives in freshwater. Non-breeding kokanee have bright silver sides, dark grey dorsal regions and may have dark markings on the dorsal fin (MOE BC Fish Fact Sheet- Kokanee). Spawning kokanee change colour, becoming bright crimson in the body with a green or black head. The colour change is most notable on the males who also develop long jaws, hooked snouts, large teeth and a slight hump behind the head. The female colour change is not as pronounced and their overall shape does not change (MOE BC Fish Fact Sheet- Kokanee).

Natural resident populations of kokanee range from California to Alaska and northeast Asia. In North America the natural populations of kokanee are most abundant in B.C. (MOE BC Fish Fact Sheet - Kokanee). Kokanee live in mid depths of open lakes but more commonly are found around lake shores or tributaries to spawn (MOE BC Fish Fact Sheet - Kokanee). In BC, kokanee are on the provincial *Yellow List*, which means they are not at risk but their populations can be influenced by industrial, agricultural and urban development. Forestry practices can increase sedimentation and water temperature which can also put kokanee populations at risk (MOE BC Fish Fact Sheet- Kokanee).

Rainbow Trout

Rainbow trout (*Oncorhynchus mykiss*) are generally silvery in colour with an iridescent pink to reddish band along the lateral line (MOE BC Fish Fact Sheet- Rainbow Trout). In B.C. native populations of rainbow trout are descended from two lines and can be divided into two types: the coastal rainbow trout and the interior red-band trout (MOE BC Fish Fact Sheet- Rainbow Trout). Coastal rainbow trout are heavily spotted with irregularly-shaped spots above and below the lateral line with rounded parr marks.

At all stages of the life cycle the lateral line appears rose red in colour (MOE BC Fish Fact Sheet-Rainbow Trout). Red-band rainbow trout have larger spots, they may be yellow or orange tinted through the body and they may have a slight cutthroat mark and faint streak under the lower jaw (MOE BC Fish Fact Sheet- Rainbow Trout).

Native rainbow trout populations range from west of the Rocky Mountains, and from northwest Mexico to the Kuskokwim River in Alaska. In B.C. the native coastal rainbow trout are found throughout the coastal drainage system while the red-band species is found in the interior within the Fraser and the Columbia basins (MOE BC Fish Fact Sheet- Rainbow Trout). Rainbow trout have been widely introduced outside their natural range and are now found across Canada. In B.C. most rainbow trout that are reared in hatcheries and used for stocking are red-band rainbow trout originating from Pennask Lake (MOE BC Fish Fact Sheet- Rainbow Trout).

In B.C. rainbow trout are on the provincial *Yellow List*, therefore they are not considered at risk. However several populations have declined as a result of habitat damage or over-fishing (MOE BC Fish Fact Sheet- Rainbow Trout).

Sculpin

Coast range sculpin (*Cottus aleuticus*) are mottled brown to light blue-grey with dark dorsal and white ventral regions. The head of the coast range sculpin is large and the body tapers from the head to the tail (MOE BC Fish Fact Sheet- Coastrange Sculpin).

Coast range sculpins range from southern California to Bristol Bay, Alaska. In B.C. they occur in streams, rivers, estuaries and lakes along the entire coast as well as Vancouver Island and Haida Gwaii (MOE BC Fish Fact Sheet- Coastrange Sculpin). Coast range sculpins are widely distributed and not considered at risk in B.C.

Stickleback

Threespine stickleback (*Gasteroteus aculeatus*) are small fish that do not tend to grow larger than 7 cm and are named for the three spines that project upward from their back (Hatfield, 1999). Threespine stickleback are commonly found in estuaries, the lower reaches of streams and in lowland lakes throughout the central coast (McPhail and Carveth, 1993). Threespine sticklebacks are on the provincial *Yellow List* and are not at risk.

3.2.3 Methodology

Cascade physically sampled fish using active (electroshocking) gear. The RMOW collected data on spawning Kokanee through visual observations (foot survey).

3.2.3.1 Electrofishing

Electrofishing involves passing electricity through the water to attract or immobilize fish for capture. It is a very efficient method of fish collection when used in contained areas of rivers and streams that are difficult to sample using nets or traps (MELP 1997). Electrofishing is done on foot using a backpack unit (Photo 5). The fish respond to the electrical current in one of three ways: forced swimming (taxis), muscle contraction (tenanus) or muscle relaxation (narcosis). Alternating current (AC) is damaging to fish and cause high mortality therefore only direct current (DC) electrofishers are approved for use in BC. DC is less harmful and causes forced swimming (galvanotaxis) towards the anode. The closer the fish get to the anode they go into narcosis and can be easily captured. The efficiency of electrofishing is affected by fish behaviour which varies between species. Benthic fish such as sculpins swim in short bursts and tend to sink when stunned and can become lost in the substrate. Nectonic fish such as salmonids can be forced to swim longer therefore can be brought into open water where they are easier to catch. Territorial fish are also easier to catch because they tend to stand their ground where as schooling fish have a fright response that causes them to swim away and avoid capture.

Sampling with a portable backpack electrofisher was conducted with a minimum of two individuals, one person to operate the machine and the other to catch the fish with a dip net and hold the bucket for holding the fish. The crew worked from downstream to upstream and vice versa with stop nets/fish fences in place to prevent fish from escaping the sample area (Photo 5).

3.2.3.2 Fish Handling Procedure

Fish are coated with a mucilaginous layer, referred to as 'slime', which acts to protect them against infection, parasitic invasion and the effects of water (MELP, 1997). Handling fish removes their 'slime' layer; making the fish susceptible to infection and disease. When the animal is returned to the water upon being handled it will experience "waterburn" since its protective mucilaginous layer has been removed. Hence, it is important that the fish be handled as little as possible and processed as quickly as possible to avoid stress.

While waiting to be processed, fish were kept in holding buckets filled with water from the creek they were captured from. Since fish viscera is not adequately supported by mesenteries and muscle (MELP, 1997), fish were kept in horizontal positions and processed as quickly as possible to minimize the amount of time the fish spent out of the water.

Photo 5. Team of three electrofishing inside fenced off area on Fitzsimmons Creek. August 19, 2013.

3.2.3.3 Electrofishing Sample Sites

Cascade carried out electrofishing surveys on Fitzsimmons Creek, Jordan Creek and the River of Golden Dreams (Map 8 and Map 9). At the Jordan Creek and River of Golden Dreams sites fish were measured, weighed and the developmental stage was identified. At the Fitzsimmons Creek site fish were measured but not weighed since fishing at this site was part of a time sensitive salvage involving gravel extraction works that preceded electrofishing in the creek.

Length

Length is the most important measurement when collecting information on the size of fish in a population, and it can be used to determine the age of the fish as well as its growth rate. Length measurements are either taken as whole body measurements, or particular body part measurements. Body part measurements are generally taken for a specialized study, whereas whole body measurements as more common for fisheries studies (MELP, 1997). The most common whole body measurements are fork length, total length and standard length (Anderson and Gutreuter, 1983).

Fork length is measured from the extreme anterior part of the head to the median of the caudal fin rays (fork of tail). Measuring the fork length is the most common method used in Canada, but can only be used for fork tailed fish such as salmon, trout and char (Anderson and Gutreuter, 1983). Total length is the distance from the extreme anterior part of the head to the end of the longest caudal fin ray, when the fin lobes are held together. Scientists in B.C. use the total length measurement technique on fish without forked tails, such as sculpins and bulbot (MELP, 1997). Standard length is the measured distance from the extreme anterior part of the upper jaw to the posterior end of the hypural bone of the fish. Since there are a variety of different ways to measure this standard length, this measurement technique is confusing and inconvenient to use. For this study fork length was measured for all salmonid species captured while total length was used to measure all sculpins and stickleback that were captured.

Weight

The whole wet weight of a recently captured fish is usually recorded in grams (g) after the excess water has been drained or blotted off with a paper towel before measurement. There are a variety of scales that can be used to weigh fish in the field; including toploading electronic balances, beam balances and spring scales. It should be noted that one should endeavour to match the accuracy of the scale with the size of fish to be sampled—fry or juvenile fish should not be weighed on a spring scale that is designed to weigh adult fish (MELP, 1997). For this study, fish were weighed to the nearest 1 g using a Cuisinart PerfectWeight kitchen scale.

3.2.3.4 Foot Survey (Spawning fish)

When sampling takes place during the spawning season a foot survey (set interval method) can be used to estimate the spawning population. Spawning grounds should be surveyed several times during the spawning season, which depends on the residency time of the spawners (DFO 1995). The residency time is the turnover time between one spawning group and the next. This varies between 5 and 28 days and is influenced by location, species, season and stream conditions. Counts of live and dead fish are combined to estimate the total number for the season.

Variations on the set interval method may be required depending on stream size, access, size of spawning area, amount of data needed and number of surveyors available. The adapted methods include:

1. Single Count Survey: a count of live fish during spawning done before any fish die, or a count of live and dead fish at or just after the peak of spawning activity
2. Adjusted Frequent Survey: intensive survey of the spawning area to count live and dead fish during the peak of the spawning season
3. Factor Five Method: survey shallow riffle spawning areas to count live fish then apply a formula to estimate population from counts, turnover rate and number of survey days
4. Strip Surveys: spawners are counted along one meter wide transects in the spawning area
5. Carcass Count: remove and count all dead fish within reach of the shore, every three days or less

Kokanee Spawning Survey Sites

Counts of spawning kokanee were carried out by volunteers for the RMOW Fish Stewardship Group. Surveyor experience was low therefore the survey data is an account of presence rather than abundance. Volunteers surveyed the Crabapple Creek, Jordan Creek, the River of Golden Dreams and Whistler Creek between August 25 and September 20, 2013 (Map 9). Cascade also counted kokanee in the River of Golden Dreams on September 4, 2013.

3.2.4 Electrofishing Surveys Results

Fitzsimmons Creek

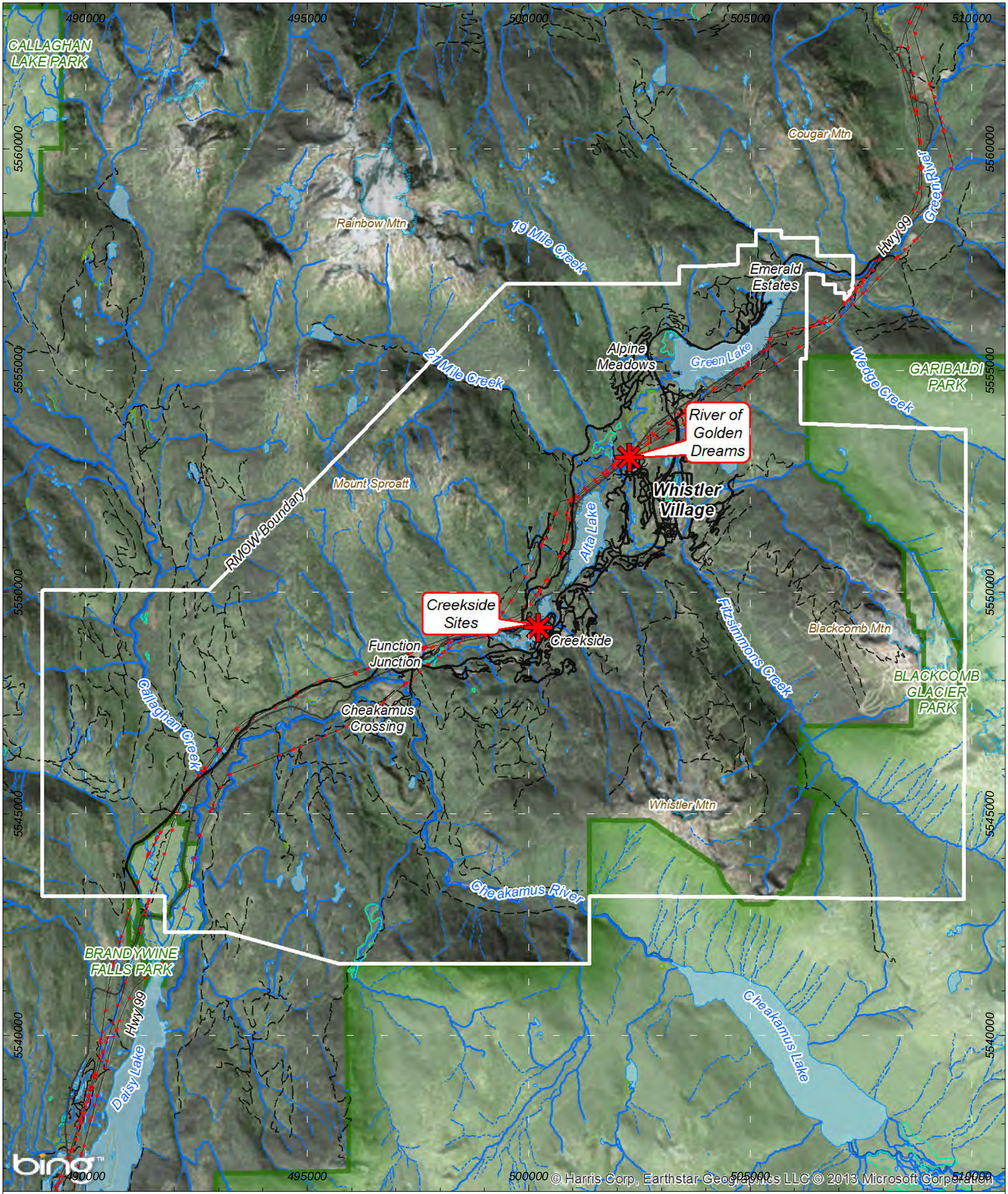
On August 19, 2013 a 334 m^2 area was isolated on Fitzsimmons Creek immediately upstream of the Spruce Grove wood bridge (Photo 6, Map 8). At the time of sampling the water temperature was 6.7 ^oC, the pH was 8.8, conductivity was 65 µS/cm and the turbidity was 36.6 NTU (Table 4). Three passes were made within the isolated area, on the third pass no fish were caught. A total of 81 fish were caught including 10 rainbow trout, four bull trout and 67 sculpin (Table 5). Absolute abundance was calculated for each species and represented as #fish/m^2 (Table 6). The absolute abundance for rainbow trout was 0.03, 0.01 for bull trout and 0.20 for sculpin.

Jordan Creek

Two areas were sampled on Jordan Creek on September 4, 2013. Basic water chemistry was the same at both sites. Water temperature was 16.8 ^oC, the pH was 7.81, conductivity was 61 µS/cm and the turbidity was 3.90 NTU (Table 4). Site #1 was a 108 m^2 glide (Photo 7). A total of 17 fish were caught at this site including four rainbow trout, 10 threespine stickleback and three scuplin (Table 5). Site #2 was a 108 m^2 riffle (Photo 8). A total of nine fish were caught at this site including two rainbow trout, one cutthroat trout, five threespine stickleback and one sculpin (Table 5). At site #1 the absolute abundance for rainbow trout was 0.04, 0.09 for threespine stickleback and 0.03 for sculpin (Table 6). For site #2 the absolute abundance for rainbow trout was 0.02, 0.01 for cutthroat trout, 0.05 for threespine stickleback and 0.01 for sculpin (Table 6).

River of Golden Dreams

On September 4, 2013 a 100 m^2 area was electrofished on the River of Golden Dreams approximately 300 m upstream of the Lormier Road pedestrian bridge (Map 8). At the time of sampling the water temperature was 16.9 ^oC, the pH was 7.66, conductivity was 225 µS/cm and the turbidity was 7.26 NTU (Table 4). One threespine stickleback was captured and the absolute abundance was calculated to be 0.01 (Table 5, Table 6). Details regarding individual fish data at each of these water bodies can be obtained from the Department of Oceans and Fisheries (DFO) forms in Appendix A.



GIS Cartographer: Todd Hellinga
Date: December 17, 2013
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CASCADE ENVIRONMENTAL
RESOURCE GROUP LTD

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Aquatic Species Survey - Location

Biodiversity Monitoring Project
Resort Municipality Of Whistler
British Columbia

GIS Cartographer: Todd Hellinga
Date: December 17, 2013
CERG File#: 013-48-01
Projection: UTM 10N NAD83
Orthophoto/Data: Bing/RMOW

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RESOURCE GROUP LTD

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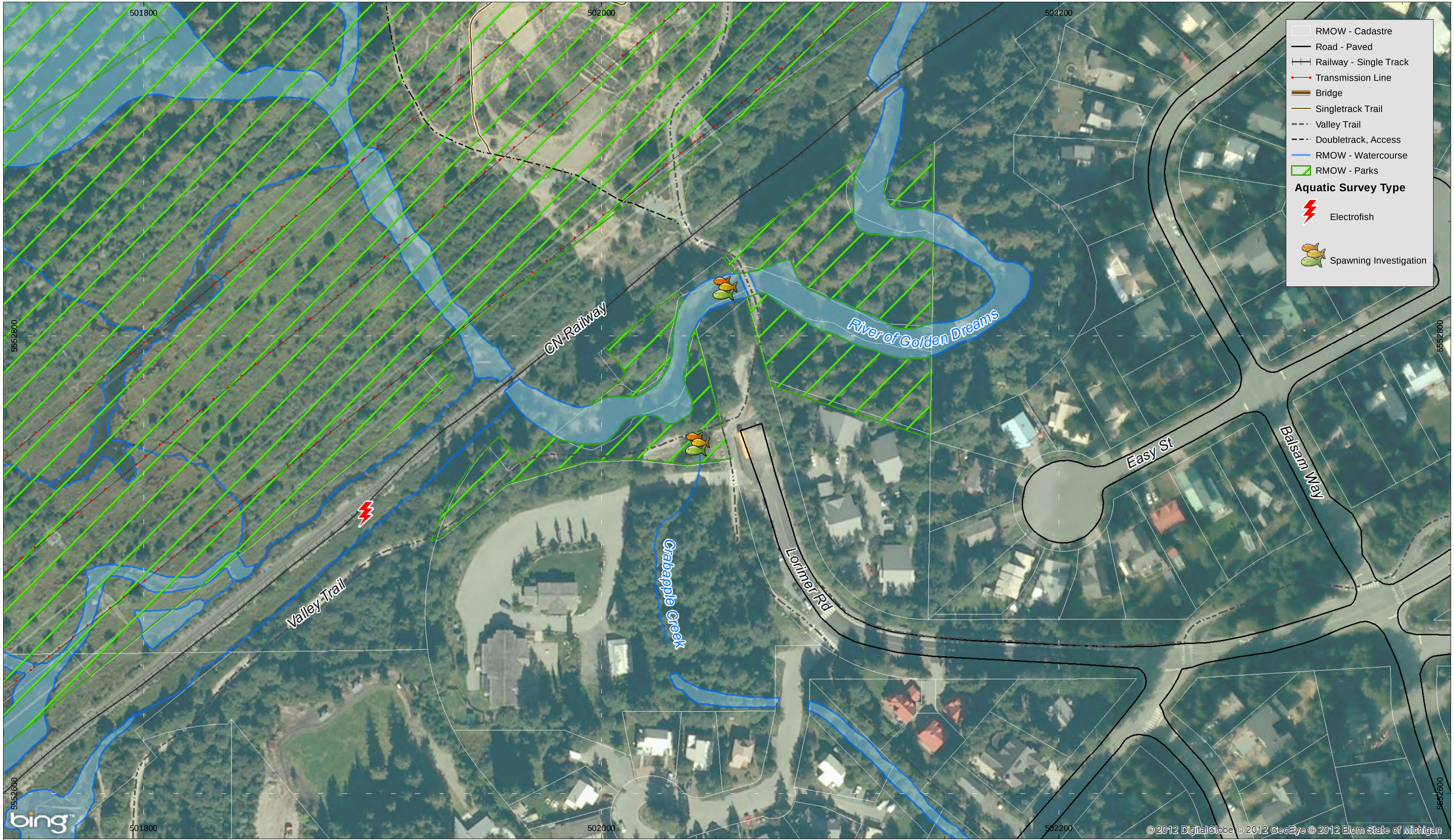
Aquatic Survey Site - Creekside

RMOW Biodiversity Monitoring Project
Whistler, British Columbia



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CASCADE ENVIRONMENTAL
RESOURCE GROUP LTD

Aquatic Survey Site - River of Golden Dreams

RMOW Biodiversity Monitoring Project
Whistler, British Columbia

Photo 6. Fenced off area of Fitzsimmons Creek upstream of Spruce Grove wood bridge.

Photo 7. Jordan Creek site #1 – glide.

Photo 8. Jordan Creek Site #2 – riffle.

Photo 9. Kokanee spawners redding in the River of Golden Dreams upstream of Lorimer Rd. pedestrian bridge.

Table 4: Electrofishing sites and shocker settings

Site	*Date*	*Area (m^2)*	Basic Water Chemistry			Electrofisher Settings			
			Water Temp. (^oC)	pH	Turb. (NTU)	Cond. (µS)	Voltage (V)	Freq.(Hz)	Duty Cycle (%)
Fitz Creek	2013.08.19	334	6.7	8.8	39.6	65	430	50	15
Jordan Creek #1	2013.09.04	108	16.8	7.81	3.90	61	330	50	15
Jordan Creek #2	2013.09.04	108	16.8	7.81	3.90	61	330	50	15
ROGD	2013.09.06	100	16.9	7.66	7.26	225	160	50	15

Table 5: Number of fish caught at each site

Site	Date	RB	BT	CT	SB	SC	Total
Fitz Creek	2013.08.19	10	4	0	0	67	81
Jordan Creek #1	2013.09.04	4	0	0	10	3	17
Jordan Creek #2	2013.09.04	2	0	1	5	1	9
ROGD	2013.09.06	0	0	0	1	0	1

Table 6: Absolute abundance of fish captured

Site	*Area (m^2)*	Abundance (#fish/m^2)				
		RB	BT	CT	SB	SC
Fitz Creek	334	0.03	0.01	0	0	0.20
Jordan Creek #1	108	0.04	0	0	0.09	0.03
Jordan Creek #2	108	0.02	0	0.01	0.05	0.01
ROGD	100	0	0	0	0.01	0

Kokanee Spawning Surveys

Kokanee spawning surveys were conducted from August 25, through September 20, 2013 on Crabapple Creek, Jordan Creek, The River of Golden Dreams and Whistler Creek by a team of volunteers. There were no kokanee observed in Crabapple Creek or Jordan Creek despite daily observations. Cascade also observed kokanee in the River of Golden Dreams on September 4, 2013 (Map 9, Table 7, Photo 9).

Table 7: 2013 spawning kokanee observations

Site	Date	Time	KO
River of Golden Dreams	2013.09.04	15:00	35
River of Golden Dreams	2013.09.05	17:45	22
River of Golden Dreams	2013.09.09	17:30	26
River of Golden Dreams	2013.09.12	17:30	40+
River of Golden Dreams	2013.09.16	17:30	31
River of Golden Dreams	2013.09.17	17:30	21
River of Golden Dreams	2013.09.18	17:30	11
Whistler Creek	2013.08.25	12:00	6

3.2.5 Discussion and Recommendations

This report presents findings of the abundance of fish in the Whistler area creeks and the results of kokanee spawning in Whistler for the 2013 season.

Fitzsimmons Creek

Historical records from the FISS database show that sculpin, Dolly Varden, kokanee and rainbow trout have been observed in Fitzsimmons Creek. Given that bull trout and dolly varden are very similar morphologically and that the number of spawning kokanee was low this year, the electrofishing survey conducted on August 19, 2013 was representative of the fish species that occur in Fitzsimmons Creek. The abundance estimates however were very low. Fitzsimmons Creek is large and the area survey may not represent all the available habitats for fish in the creek. It is recommended that future studies include surveys in a variety of habitats within the fish bearing reaches of Fitzsimmons Creek.

Jordan Creek

Historical records from the FISS database show that mountain whitefish, rainbow trout, kokanee and stickleback have been observed in Jordan Creek. The electrofishing surveys conducted on September 4, 2013 suggest that the observation of sculpin and cutthroat trout are new or recent occurrences in Jordan Creek. The absence of kokanee in the creek may be a reflection of the low spawning numbers that were observed through the spawning visual surveys.

River of Golden Dreams

Sculpin, Dolly Varden, kokanee, rainbow trout and stickleback are known to occur in the River of Golden Dreams (FISS). One stickleback was captured during the electrofishing survey conducted on September 4, 2013. This creek is long and is fed by several other creeks including Crabapple Creek and 21 Mile Creek. Therefore it is recommended that future studies include surveys at different points of the creek to better determine the fish population of the creek.

Kokanee Spawning Surveys

The RMOW, Fish Stewardship Group has conducted kokanee spawning survey within Whistler since 2001. The data that has been gathered is a valuable historic record of the health and condition of the kokanee population in Whistler. During the 2013 spawning season over 186 individuals were observed on the River of Golden Dreams and six in Whistler Creek. Surveys are conducted by volunteers without scientific training. It is therefore recommended that volunteers undergo training in the foot survey method or shadow someone who is trained in this method so that the data collected can be used more effectively for population estimates as opposed to presence/absence indications.

3.3 Riparian Species Indicators

3.3.1 Coastal Tailed Frog

Amphibians have been widely recognized as useful indicator species of ecosystem health (Sheridan and Olson, 2003). They are considered to be sensitive to perturbations in both terrestrial and aquatic environments because of their dual life histories, highly specialized physiological adaptations, and specific microhabitat requirements (Welsh & Olliver, 1998). Tailed frogs (*Ascaphus truei*) are unique among anurans due to their habitat requirement. Tadpoles are present in streams characterized by fast current over coarse gravel, pebble, cobble or boulder substrates with a high water velocity and cold water temperatures (Welsh & Olliver, 1998).

The coastal tailed frog (*Ascaphus truei*) is provincially blue listed, and is regarded federally as a species of special concern (BC MOE, 2012; COSEWIC, 2011). This species is a known inhabitant of mountain streams in undisturbed forests and requires cold, clear, unsilted waters (Green & Campbell, 1992). The coastal tailed frog has a very unique life cycle as it remains a tadpole for up to four years prior to metamorphosis and takes up to 7 years to reach sexual maturity; with periods of highest activity from June to September (Dupuis & Steventon, 1999). The coastal tailed frog tadpole requires a continuous flow of clean, cold water throughout its lifecycle making this frog species vulnerable to habitat alteration and its degradation. The coastal tailed frog is sensitive to stream disturbance such as siltation and algal growth (Stevens, 1995). Coastal tailed frog tadpoles (in either stage 1 or 2 of their life cycle) were observed in Site 2 and 3 of Alpha Creek during an area-constrained search on August 30, 2013. (Cascade Environmental, 2013).

3.3.1.1 Indicator Stream Selection

Coastal tailed frogs are known to be generally ubiquitous across the landscape of mountain streams in Whistler. The Biodiversity Project has been actively inventorying streams in the Whistler area for occurrence of tailed frogs and Cascade has records of occurrences throughout the valley as well. However, in order to use coastal tailed frogs as an indicator of ecosystem health, trends in relative abundance should be monitored. The GIS was used to examine the geographic distribution of occurrence records from all available sources and from the streams known to contain tailed frogs, two were selected as representative of the range of tailed frog habitat (aquatic biophysical) conditions in Whistler; Scotia Creek and Alpha Creek (Map 10). These two creeks were intended as pilot sites to test the monitoring protocol with an aim of expanding to additional streams in subsequent years. To assist with future pre-screening for coastal tailed frog streams, a Habitat Capability Analysis model developed for the province by Friele and Dupuis, is presented in this report (2007).

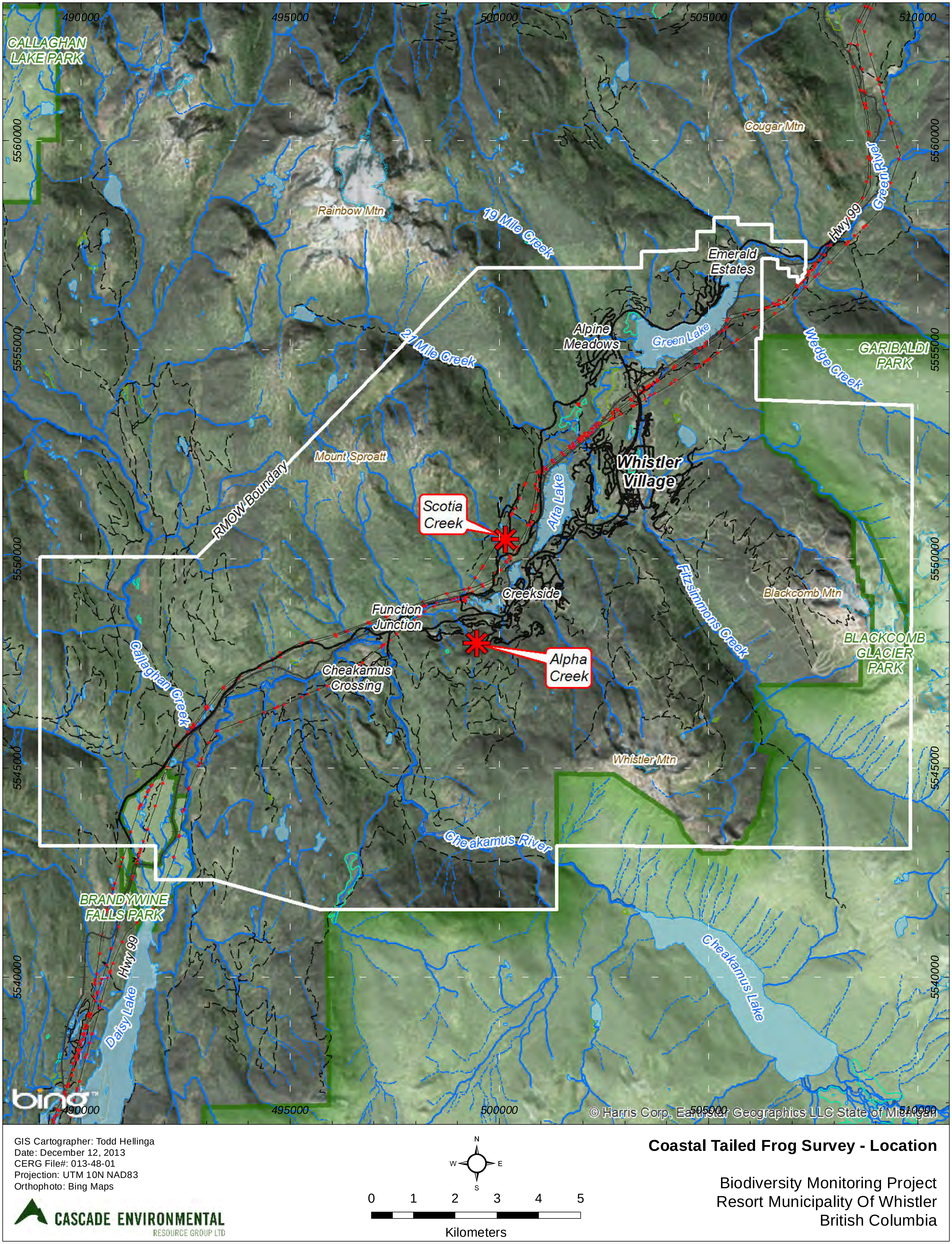
Coastal tailed frog surveys in Whistler were conducted by Cascade during the months of August 2013 and September 2013 in Scotia Creek and Alpha Creek (Map 11 and 12 respectively).

Hand and time constrained search methodology (MELP, 2000) was used for the coastal tailed frog survey. An area-constrained search (ACS) method was used for acquiring data on relative abundance (number of individuals/m^2) of tadpoles. Three 5 m sections per site were searched by hand for tadpoles. The stream survey was initiated downstream and carried out in one meter increments. The survey included an initial scan of the surface of the stream and the stream bank for active animals, followed by an in-depth search of the creek substrate. Unembedded cover objects such as rocks and coarse woody debris were overturned minimizing disturbance to the stream bank. Each object was carefully scanned for clinging tailed frog tadpoles before it was set back in its original position. Large anchored rocks and large woody debris were swept by hand. Dip nets were held immediately downstream of searchers to catch dislodged animals. The position (i.e. surface, under rock) and location information (depth and microhabitat) of each tadpole captured was recorded. In order to prevent recaptures, all captured individuals were placed in shaded buckets and released upon completion of the site survey (MELP, 2000).

Sampling was conducted during the dry summer months (June to September) when the chances of adult encounters are increased and when stream temperatures of 8^{o}C or higher are more tolerable for hand collection. Sampling was restricted to rainless periods since tadpoles tend to seek refuge during heavy rainfall periods (MFLNRO, 2000).

3.3.1.2 Sample Site Selection

Sampling was conducted at two locations in Scotia Creek and one location in Alpha Creek in Whistler (Map 10). At each location three sites were sampled. Sites were located in portions of the creek that were accessible by the surveyors and were characterized by a depth between 0.1 and 0.6 m, and a slow to moderate flow. Dominant substrate type consisted of small cobbles and large gravels as the sub-dominant substrate.

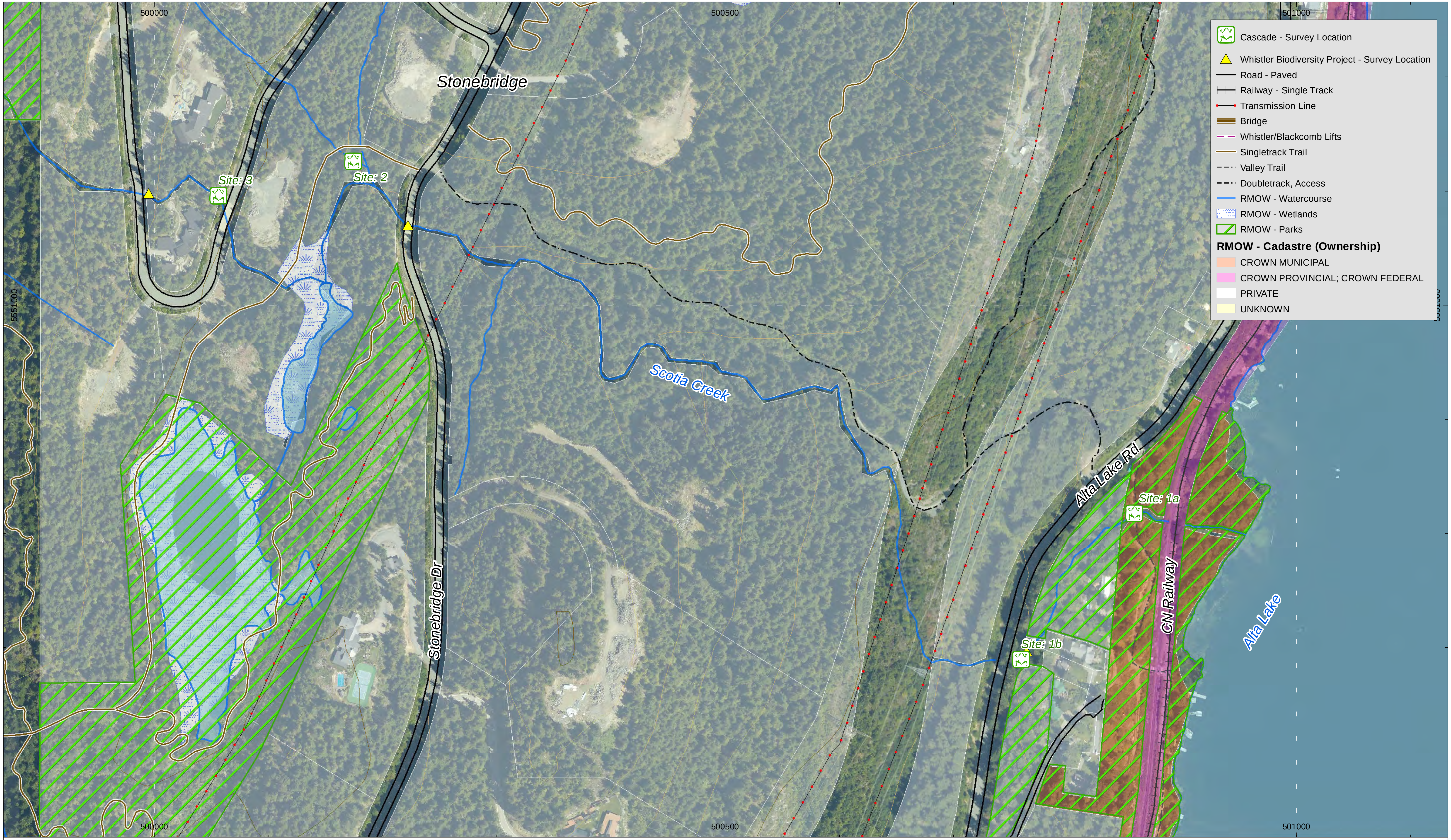


GIS Cartographer: Todd Hellinga
Date: December 12, 2013
CERG File#: 013-48-01
Projection: UTM 10N NAD83
Orthophoto: Bing Maps

CASCADE ENVIRONMENTAL RESOURCE GROUP LTD

Coastal Tailed Frog Survey - Location

Biodiversity Monitoring Project
Resort Municipality Of Whistler
British Columbia



GIS Cartographer: Todd Hellinga
Date: April 4, 2014
CERG File#: 013-48-01
Projection: UTM 10N NAD83
Orthophoto/Data: RMOW

CASCADE ENVIRONMENTAL RESOURCE GROUP LTD

0 100 200 300 400 500
Meters

Coastal Tailed Frog Survey Site - Scotia Creek

RMOW Biodiversity Monitoring Project
Whistler, British Columbia

GIS Cartographer: Todd Hellinga
Date: April 4, 2014
CERG File#: 013-48-01
Projection: UTM 10N NAD83
Orthophoto/Data: RMOW

CASCADE ENVIRONMENTAL
RESOURCE GROUP LTD

Coastal Tailed Frog Survey Site - Alpha Creek

RMOW Biodiversity Monitoring Project
Whistler, British Columbia

3.3.1.3 Tadpole Handling Procedure

In order to minimize stress and overheating, captured tadpoles were kept in a shaded bucket, immersed in the stream. All surveyors wore non-powdered vinyl gloves when handling amphibians and gloves were changed between animal captures. Captured individuals were placed in a Ziploc Bag during observation. Upon completion of the survey tadpoles were released at the upstream end of the altered reach so that they could drift to new desired locations. Tadpoles were measured, weighed and the developmental stage was identified.

3.3.1.4 Habitat Characterization

For each creek sampled; the water temperature, wetted width, bankful width, and substrate composition was measured and recorded.

3.3.1.5 Habitat Capability Analysis

To elucidate the distribution of coastal tailed frog, Friele and Dupuis (2007) have developed a “watershed level habitat model for British Columbia” seen in Table 8. The model is based on habitat requirements of coastal tailed frog in their lotic stage and includes the following parameters:

- Ecosection (from known range),
- Watershed Area (streams within area ,10 km^2 viewed “core”, basins with areas of 10-50 km^2 are considered potential occurrence but with low abundance, with larger streams considered important for dispersal but not breeding),
- Aspect of drainage (south facing aspects are ranked higher – more insulation, warmer water),
- Ratio of watershed’s relief above the treeline divided by the total watershed relief (Back-end rule), (tailed frogs are more common in streams near the front-end of a watershed, or in streams draining the faces between watersheds, and occurrence is often more spotty in the headwaters),
- Biogeoclimatic zone (reflection of mesoscale climate and a proxy of stream temperature)
- Presence of lakes (insolation may lead to warmer water temperatures, and may lead to higher abundance of tailed frog).

Table 8: Watershed level coastal tailed frog habitat capability model (adapted from Friele & Dupuis, 2007)

Variable	Variable State	Model Points	Subject Creek Variables	Subject Creek Points
Ecoregions	Eastern Pacific Ranges Ecosection	100	EPR	100
Basin Area	0-10 km2 10-50 km2 >50 km2	100 50 1	15.1 km^2	50
Aspect	13-225° 45-135°, 225-315° 315-360°, 1-45°3	4 3 2	295°	3

Variable	Variable State	Model Points	Subject Creek Variables	Subject Creek Points
Ratio of watershed's relief above the treeline	0-25% 25-50% 50-75% 75-100%	4 3 2 1	46%	3
Biogeoclimatic Zone	CWH MH AT	4 3 1	CWH*	4
Lake	Present Not present	10 0	Present	10
Ranking Total				170

*In lower reaches
Ranking Classification: <125 Out of Range; 150-175 Very Low; 200-206 Low; 207-210 Moderate; 211-225 High

Initial analysis focused on identifying sub-basins of < 10 km^2 and high capability ranking. Over time a more comprehensive occurrence inventory may be deemed appropriate by the RMOW. Once a candidate stream is identified as high capability, the RMOW and Biodiversity Project databases should be consulted for occurrences. In the absence of existing occurrence a survey is required to confirm presence.

3.3.1.6 Results

Three locations were sampled during the coastal tailed frog survey at Alpha Creek, lower Scotia Creek and upper Scotia Creek at Stonebridge (Table 9).

Table 9: Results of tailed frog tadpoles surveys in three creeks in Whistler, BC

Location	Upstream Reachbreak UTM	Length (m)	Gradient (%)	Average Wetted Width (m)	Stream Morphology	Dominant Substrate	Tailed tadpoles found
Alpha Creek	0499201 5548219	15.88	2	4.37	Riffle	LC	5
Scotia Creek	0500858 5550818	15.62	2	3.34	Riffle	SC	0
Stonebridge (Scotia Creek)	0500759 5550711	12.58	4	3.07	Riffle	SC	0

SC=small cobble
LC=large cobble

3.3.1.7 Relative Abundance Survey

Once an area was determined to contain tailed frogs a relative abundance survey was conducted (Table 10). This consists of intensely searching three 5 m sections of stream length for tailed frogs. Relative abundance of tailed frogs was calculated as the number of individuals encountered/area (wetted width x survey length).

Table 10: Relative Abundance Results

Location	Site #	Number of 5 m Stream Lengths Surveyed	Total Area Surveyed (m^2)	Total Number of Tadpoles Found	Length (mm)	Weight (g)	Life Stage	Average Abundance of Tadpoles (Tadpoles/m^2)
Alpha Creek	1	3	18.4	0	n/a	n/a	n/a	0
	2	3	15.4	2	25 35	<1 <1	1 2	0.13
	3	3	35.8	3	40 30 30	<1 <1 <1	2 1 1	0.08
Scotia Creek	1	3	21.5	0	n/a	n/a	n/a	0
	2	3	13.4	0	n/a	n/a	n/a	0
	3	3	17.5	0	n/a	n/a	n/a	0
Stonebridge (Scotia Creek)	1	3	9.10	0	n/a	n/a	n/a	0
	2	3	17.2	0	n/a	n/a	n/a	0
	3	3	7.20	0	n/a	n/a	n/a	0

Total area surveyed = (wetted width of sample area) x (total length of sample area)
Average abundance = Total number found / Total area surveyed

3.3.1.8 Discussion and Recommendations

The small number of tadpole observations to date would indicate a very low abundance of coastal tailed frogs in Alpha Creek. The absence of coastal tailed frogs captured in Scotia Creek is concerning since their presence was confirmed with 23 individuals captures over three sites (Biodiversity Project, 2006). There are two probable explanations for the null result. Firstly, the area constrained search methodology may need to be expanded to cover a wider area if the densities are too low for detection. Secondly, it is generally accepted that tailed frogs are sensitive to habitat destruction and degradation and that the population is decreasing. It is recommended that abundance of tailed frog tadpoles continues to be monitored in coming years to determine population trends and better identify hotspots where populations may be threatened.

3.3.2 Beaver

The North American Beaver (*Castor canadensis*) is considered a keystone species in North America and has an influential impact on the structure of an ecosystem. Beavers are archetypal ecosystem engineers in their construction of dams, lodges and wetland habitat that is capable of supporting herbaceous plant species not found elsewhere in the riparian zone (Wright *et al*., 2002). As such, the beaver can be used as a valuable indicator species of the health of an ecosystem since a variety of species rely on the habitat created by the beaver (Stevens *et al.*, 2007).

A beaver's lodge will provide the beaver with a stretch of calm water, where it can build its lodge. A typical lodge is built from felled trees, collected sticks, and mud. An indicator of an active lodge is the presence of fresh mud on the outside surface of the lodge and freshly cut/gnawed trees and branches (Baker & Hill, 2003). During the fall, northern beaver colonies will construct an underwater food cache of branches and logs close to the lodge to be consumed through the winter months. Locating an underwater food cache with fresh cuttings is also an indicator of active beaver presence (Jenkins & Busher, 1979).

3.3.2.1 Beaver Survey Methodology

Existing lodge inventories developed by the RMOW Fisheries Technicians were used to estimate the active beaver population in the Whistler area. Beaver lodges that were identified as *active* in previous surveys were revisited and new sites were established if they presented themselves (Tayless, 2010). The location of each lodge was determined by using a personal GPS unit (Garmin GPSmap 60C) which was downloaded into the GIS for distributional analysis. The status of each lodge was assessed; features including fresh mudding, addition of fresh trees, branches or shrubs and maintenance of entrances was used to determine the status of each lodge (Appendix B). Lodges were deemed *active* if signs of maintenance and construction were found—fresh mudding, addition of fresh trees, branches or shrubs, maintenance of entrances and the presence of an underwater food cache (Photo 10 to Photo 13). Lodges were deemed *inactive* if there were no signs of maintenance, continued construction or signs of activity surrounding the lodge (Tayless, 2010). Lodges were deemed *unknown* if there were signs of activity around the lodge (fresh cuttings) but the lodge itself showed no signs of maintenance or construction (fresh branches and mud).

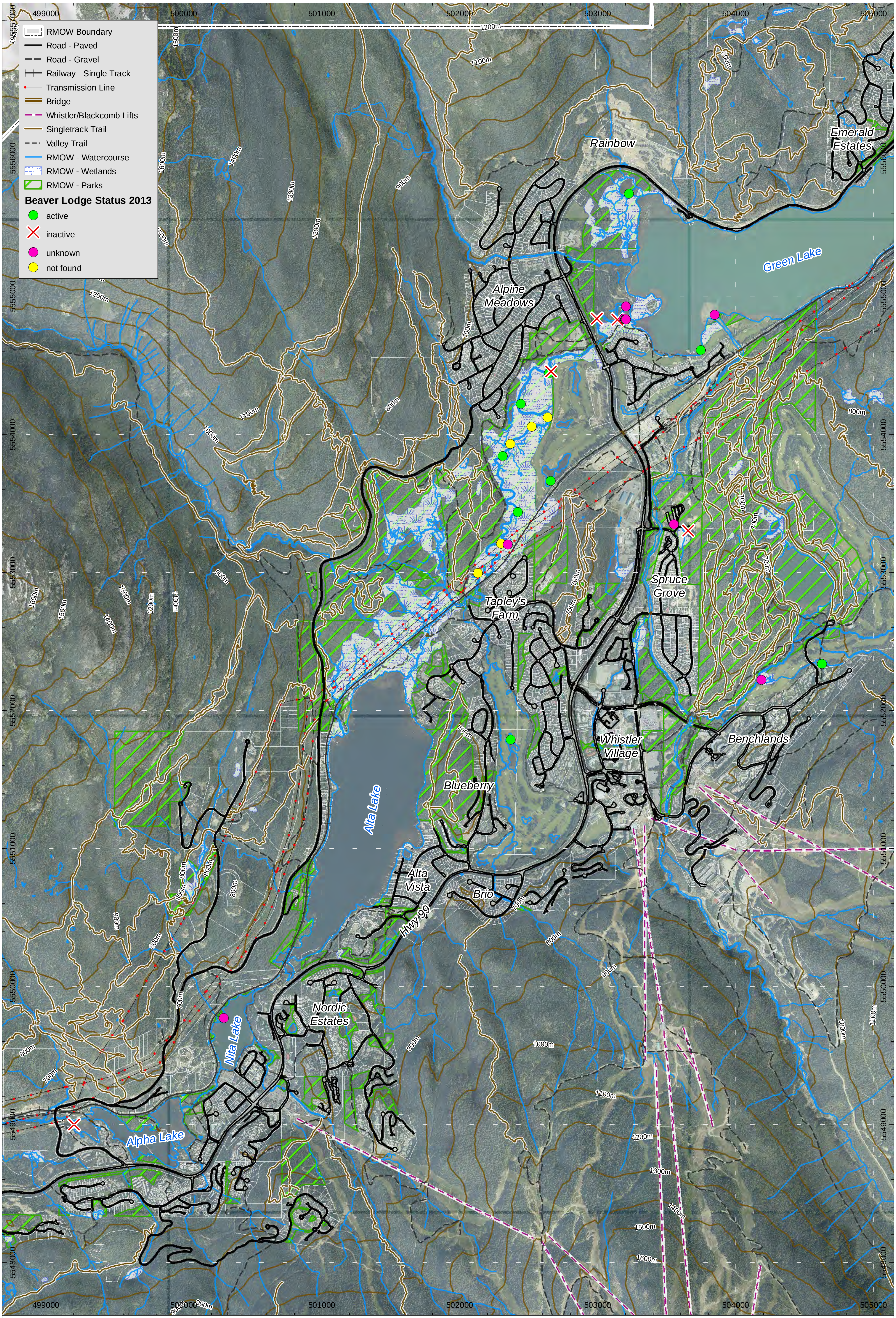
At each lodge, the waterway was classified as one of the following categories:

- Pond (<2m deep)
- Lake (>2m deep)
- Stream (<5m wide)
- River (>5m wide)

3.3.2.2 Site Selection

Previously identified lodges by Tayless (2010) were re-surveyed for signs of activity (Map 13). The survey sites will include the following:

- Alpha Lake
- Wedge Pond
- Green Lake
- Fitzsimmons Creek Fan
- Unnamed waterways (Nicklaus North Golf Course)
- Crystal Creek (Chateau Golf Course)
- Crabapple Creek (Whistler Golf Course)
- Nita Lake
- River of Golden Dreams



GIS Cartographer: Todd Hellinga
Date: April 4, 2014
CERG File#: 013-48-01
Projection: UTM 10N NAD83
Orthophoto/Data: Bing Maps, RMOW

CASCADE ENVIRONMENTAL RESOURCE GROUP LTD

0 200 400 600 800 1,000
Meters

Beaver Lodges - Location

RMOW Biodiversity Monitoring Project
Whistler, British Columbia

Photo 10. Active beaver lodge at Chateau Whistler Golf Course irrigation pond. Fresh mud present on lodge. October 15, 2013.

Photo 11. Fresh cut branches at Wedge Pond lodge indicate an active beaver lodge. October 15, 2013.

Photo 12. Tracks observed on muddy shore can be used as an indicator for the presence of beaver, Chateau irrigation pond lodge site. October 15, 2013.

Photo 13. Presence of underwater food cache indicates that ROGD Lodge #4 is active. October 16, 2013.

3.3.2.3 Beaver Population Abundance

The 2013 beaver population census surveyed 28 beaver lodges; 10 (36 %) of which were *active*, 5 (18 %) were *inactive*, 8 (29 %) were *unknown* and 5 (17 %) lodges from the previous survey year (2010) were not found.

The mean colony size of 5.8 individuals, which was established by Mullen (2008) was applied to the 10 known active lodges in the 2013 survey. Based on this extrapolation, an estimate of the beaver population in the Resort Municipality of Whistler is 58 beavers. The total population of beavers has decreased from the 2009 survey, and has significantly dropped from the 2008 total population result (Figure 1). However, the 2013 population represents an increase from the 2007 population estimate of

52. It should be stressed that lodges do not equate to colonies, and that the number of lodges is likely greater than the number of colonies due the potential for one colony to maintain up to three different lodges.

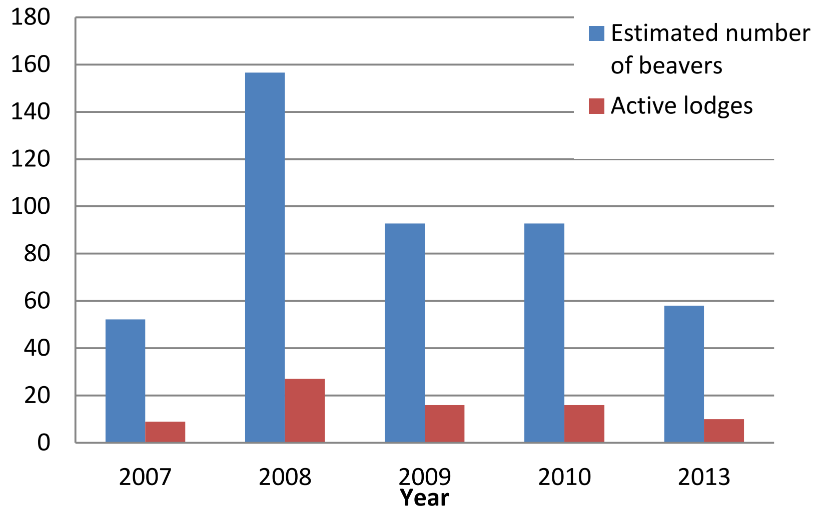


Figure 1. Total annual population of beavers over the five year study period and the corresponding active lodges.

Table 11 details the number of beaver lodges found in Whistler with their activity status over the past five years. There are 19 lodges that have been consistently monitored since the start of the beaver monitoring project in 2007. Four out of the nine *active* lodges have continued to remain active over five years. Five out of nine *inactive* lodges have remained inactive over five years and six lodges have changed from *active* to *unknown* due to minimal signs of activity (no fresh mud, no fresh cuttings, branches, etc.). Two previously *unknown* lodges have been deemed active this 2013 survey year, and two past *inactive* lodges were not found this year (dismantling or washout of the lodges are suspected).

Table 11. Summary of beaver lodge status in surveys from 2007-2013, Whistler, BC

	2007	2008	2009	2010	2013
Active	9	27	16	16	10
Inactive	9	12	13	17	5
Unknown	1	4	4	4	8
Not found	-	-	-	7	5
Not surveyed	-	-	10	1	-
TOTAL SITES	**19**	**43**	**33**	**46**	**28**

3.3.2.4 Population Distribution

The Whistler area provides ideal habitat for beaver populations. Beaver inhabit a variety of aquatic habitats in Whistler; including natural streams, rivers, ponds and lakes, as well as constructed ponds (golf course ponds for example) and drainage waterways.

On average, the number of beaver lodges observed over the five year period has grown. However, the 2013 survey saw an 18 percent drop in the number of beaver lodges observed from the earlier 2010 beaver lodge survey while still remaining higher than the 2007 survey.

Beaver lodge status as it relates to habitat type is summarized Table 12. In 2013, resident beaver lodges tended to be more active (fresh mudding was present, fresh twig and branch cuttings indicating an active beaver presence) when found on larger waterways (lakes and rivers) as opposed to smaller waterways (streams and ponds).

Table 12. Beaver lodge classification by habitat type, 2013 Whistler, BC Beaver Census

Habitat	Active	Inactive	Unknown
Pond <2m deep	4 (18%)	1 (5%)	2 (9%)
Lake >2m deep	1 (5%)	1 (5%)	1 (5%)
Stream <5m wide	0	0	0
River >5m wide	5 (23%)	3 (14%)	4 (18%)

Comparing 2013 survey data to 2010 survey data; there has been a 13 percent increase in the number of active lodges located in pond habitats, and a 3 percent increase in number of inactive lodges located in a river habitat. However, due to the 21 percent increase of unknown lodge status between 2010 and 2013 beaver population surveys, the confidence of the population estimated is reduced.

Identified Trends

Established trends over time are difficult to determine due to the limited amount of data collected thus far. Definite population patterns and statistics will be determined once the beaver population has been studied for an additional five years. However, the data collected thus far suggests the beaver population at a general scale is stable with 35 percent of the lodges found in years 2010 and 2013 classified as *active*. The return to a population level similar to 2007 may indicate a cyclic population curve, but it is not known if the 2007 represents the bottom of a 6 year cycle or simply a level of population recovery on a longer cycle.

3.3.2.5 Discussion and Recommendations

The Resort Municipality of Whistler constantly strives to find the balance between resort activities and attractions and protection of its natural resources; including its wildlife and habitat. Although the effects to beaver populations of these types of activities is not known, ongoing habitat alteration, development and increased tourism may affect habitat used by the beavers in Whistler and should be closely monitored.

In Algonquin Park, Ontario 30 beaver sites were continuously monitored over an 11 year period, and Fryxell (2001) determined that only 20 percent of known beaver sites were continuously occupied whereas 80 percent of sites were abandoned over the 11 year study period. Whistler beaver lodges appear to exhibit similar beaver behaviour in regards to continued habitation, abandonment and reuse (Fryxell, 2001).

As noted in the 2010 survey; the waterways chosen for the beaver survey were a very small percentage of the aquatic habitat in Whistler. Therefore, it is recommended that the study area is expanded in future surveys to identify new beaver lodges.

Future beaver population studies should be completed as late in the year as possible to avoid *unknown* lodge status due to poor indicator presentation. Surveying in the late fall (October/November) will allow field technicians to determine if a lodge is *active* or *inactive* more accurately. Fallen leaves can be used as an indicator of activity level—if fallen leaves are piled at the entrance of a lodge it would seem to indicate that the lodge is not used by an active beaver population.

Continued monitoring of beaver populations can be an indicator of land management decisions in Whistler, and population densities can be used as an indicator of ecosystem health.

3.4 Terrestrial Habitat Indicators

3.4.1 Terrestrial Ecosystem Units

One of the objectives of the Phase 2 study was identification of "hotspots" of biodiversity. Based on the evaluative criteria used to identify potential biodiversity hotspots and presented earlier in this report, Cascade reviewed the Wetland, Riparian and Other Sensitive Ecosystems identified in Schedules I, J, and K of the Official Community Plan (RMOW, 2013) to select trial plots. Mature/old forest hotspots were selected as the target ecosystem for establishing and testing a monitoring protocol on potential biodiversity hotspots. Additional hotspots may be added in subsequent years.

Using BEC and TEM inventory from the GIS, specific ecosystem units were identified and targeted for study. Terrestrial ecosystem plots were established to record ecosystem data associated with terrestrial wildlife surveys. Two plots were established at the locations of the red-backed vole and ground beetle survey sites.

3.4.2 Site Assessment

In order to select potential plot locations, GIS analysis focused on identification of candidate sites based on the following criteria:

1. Relatively undisturbed sites, either primordial forest or mature initial harvest forest;
2. Located on RMOW natural park land or Crown land with an unlikelihood of future development;
3. Zonal or representative of the general ecological condition of the area;
4. Little human contact (distance from roads and trails); and
5. Reasonably flat ground.

Based on these criteria two plots were selected; one on each side of the valley and close to the valley floor. Plot 1 is located on Blueberry Hill and Plot 2 is located in Rainbow Park, west of Alpha Lake Road (Map 14 and Map 15 and Map 16 respectively). Plot 1 is currently experiencing machine trail development by the RMOW in close proximity to the plot and therefore the risk factor is recreation use and potential invasive alien plants. Plot is embedded within the Westside trail network and is subject to similar risk although, the trails in this area are currently hand built. Terrestrial ecosystem plots consisted of 20 m by 20 m quadrats demarcated on the ground and a photo point.

Assessment of the terrestrial ecosystem plots consisted of filling out field forms developed by the BC Ministry of Forests and Range (MOFR) and the BC Ministry of Environment (MOE), including the Ecosystem Field Form, which describes the site, soil, vegetation and tree mensuration, as well as the Wildlife Habitat Assessment, Tree Attributes for Wildlife, and Coarse Woody Debris field forms. The forms were filled out in accordance with the *Field Manual for Describing Terrestrial Ecosystems 2nd Edition* (MOFR and MOE, 2010). These were filled out to the best of the ability of the surveyors given that there were time and budget constraints. A photo of each plot was also taken from a permanently established photo point.

3.4.3 Results

Collected data has been recorded using VENUS 5.1, a database made available by the BC Ministry of Forests and Range (MOFR) and the BC Ministry of Environment (MOE). The data will be delivered as Microsoft Excel spreadsheets, but are best viewed by importing into VENUS 5.1. No data analysis was conducted with the collected terrestrial ecosystems data in 2013. This data will be stored and remain available for between-year comparisons and future analysis in relation to terrestrial wildlife surveys.

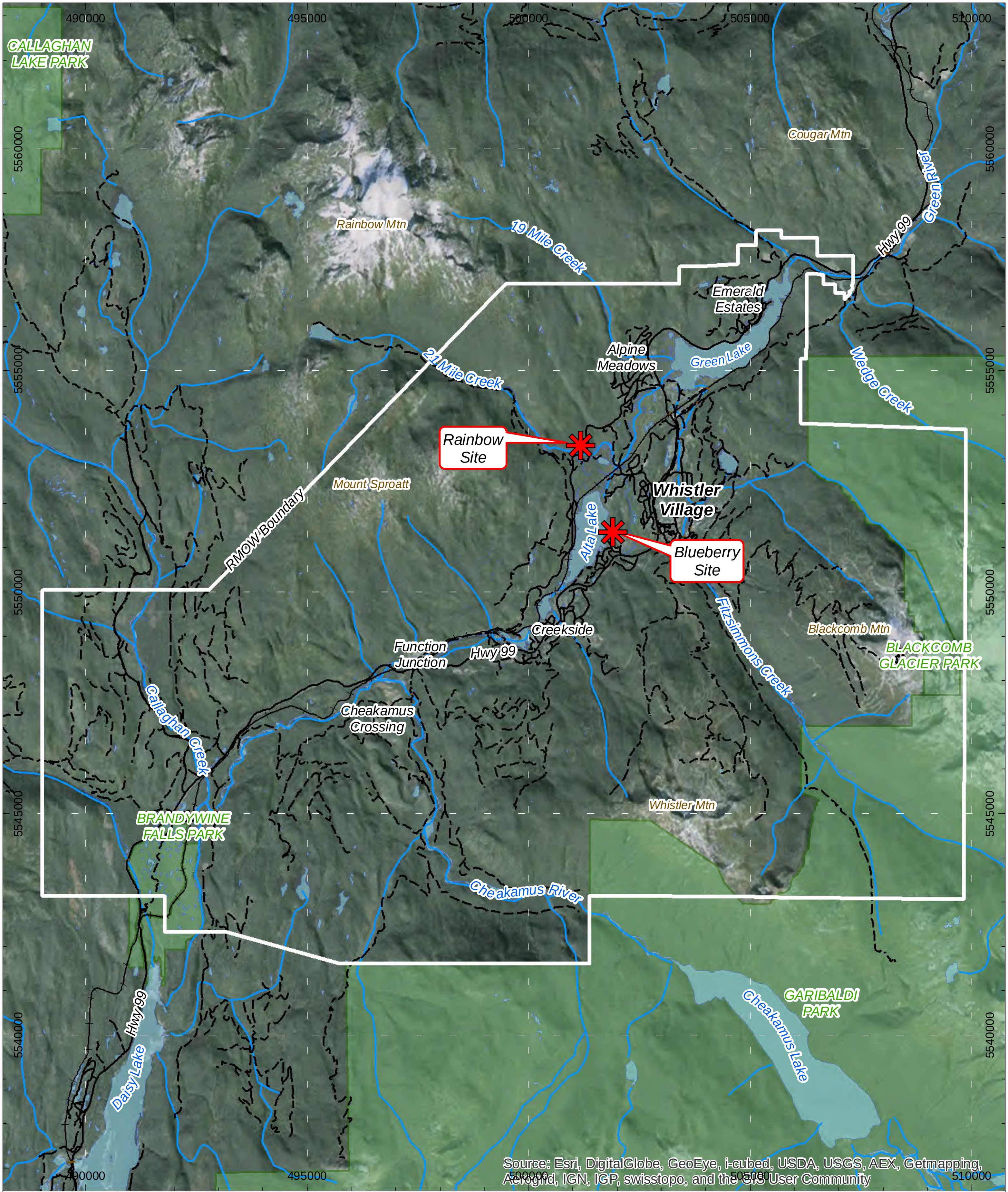
3.4.3.1 Site Classification

The valley bottom within the RMOW falls within Coastal Western Hemlock southern moist submaritime variant (CWHms1). The CWHms1 variant occurs at elevations of 650 to 1200 m and has a transitional climate between coastal and interior. The climate is typically cool year-round with moist winters including heavy snowfall and relatively dry summers (Green and Klinka, 1994).

Both plots represent zonal, or typical, conditions of the CWHms1 variant (Site Series 01 – western hemlock-Amabilis fir – Step moss). Zonal ecosystems typically have a canopy dominated by western hemlock (*Tsuga heterophylla*), Douglas-fir (*Pseudotsuga menziesii*), western redcedar (*Thuja plicata*) and Amabilis fir (*Abies amabilis*). Typical understory vegetation is dominated by Alaskan blueberry (*Vaccinium alaskense*) and mosses including step moss (*Hylocomium splendens)*, pipecleaner moss (*Rhyridopsis robusta)*, and red-stemmed feathermoss (*Pleurozium schreberi).* Occurring less commonly are black huckleberry (*Vaccinium membranaceum*), oval-leaved blueberry (*Vaccinium ovalifolium*), falsebox (*Paxistima myrsinites*), bunchberry (*Cornus canadensis*), queen's cup (*Clintonia uniflora*), five-leaved bramble (*Rubus pedatus*), and one-sided wintergreen (*Orthillia secunda*) (Green and Klinka, 1994).

3.4.3.2 Soils

Plot 1 is located on a terrace amidst a moderately steep slope (50 – 70%). The terrain texture consists of blocks and cobbles originating from colluvium and weathered bedrock. Plot 2 is undulating and is located on a gentle slope (5-20%). The terrain texture is finer, consisting of cobbles and sand, also originating from colluvium and weathered bedrock. The bedrock in the areas of the study plots consists of gneiss and the dominant soil type is Orthic Regosol. The soils are somewhat dry (i.e. submesic), well-drained and nutrient poor. The soil consists of clayey loam and the humus form is mor. Soil samples show that organic soil horizons are shallow at 8 cm for Plot 1 (Photo 14) and 3 cm for Plot 2 (Photo 15). The bedrock root restricting layer was assumed to be approximately 50 cm deep. The study plots are upland and there are no seepages at the plots; the water source is precipitation.



GIS Cartographer: Todd Hellinga
Date: April 4, 2014
CERG File#: 013-48-01
Projection: UTM 10N NAD83
Orthophoto: Bing Maps

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Terrestrial Ecosystem Plots - Location

Biodiversity Monitoring Project
Resort Municipality Of Whistler
British Columbia

GIS Cartographer: Todd Hellinga
Date: April 4, 2014
CERG File#: 013-48-01
Projection: UTM 10N NAD83
Orthophoto/Data: Bing Maps, RMOW

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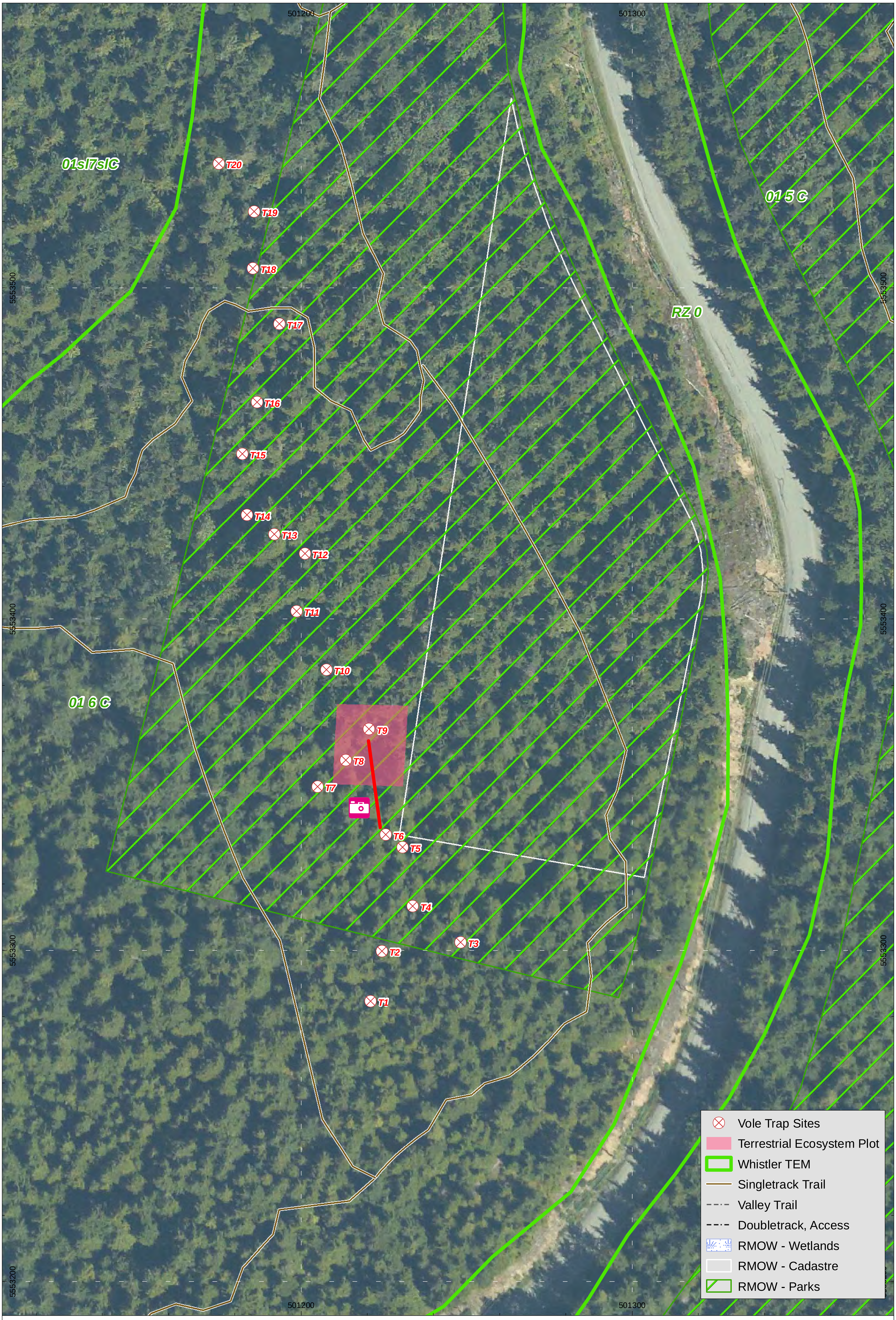
Terrestrial Ecosystems - Blueberry Site

RMOW Biodiversity Monitoring Project
Whistler, British Columbia



GIS Cartographer: Todd Hellinga
Date: April 4, 2014
CERG File#: 013-48-01
Projection: UTM 10N NAD83
Orthophoto/Data: RMOW

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Terrestrial Ecosystems - Blueberry Site

RMOW Biodiversity Monitoring Project
Whistler, British Columbia

Photo 14. Soil profile at Terrestrial Ecosystem Plot 1. October 16, 2013. Blueberry Hill

Photo 15. Soil profile at Terrestrial Ecosystem Plot 2. October 17, 2013. Rainbow Park

3.4.3.3 Vegetation

The successional stage of Plot 1 is mature single-storied coniferous forest (Photo 16). The dominant tree species is western hemlock with a small number of Douglas-fir. The largest trees in Plot 1 are Douglas-firs, the largest of which measures 67 cm in DBH (diameter at breast height) and is greater than 300 years of age. The largest hemlock on the site is 29.5 cm in DBH and 176 years of age. There are a total of 75 trees in Plot 1 having an average DBH of 20 cm.

The understorey is open and consists of young western hemlock, boxwood and evergreen huckleberry (*Vaccinium ovatum*). The only forb species identified in this plot is white-veined wintergreen (*Pyrola picta*). The abundant moss layer included several species and was dominated by pipecleaner moss, big red stem and golden short capsule moss (*Brachythecium frigidum*) with some step moss, broom moss (*Dicranum scoparium*) and cat-tail moss (*Isothecium myosuriodes*) present in smaller quantities Numerous mushroom species were observed but only admiral bolete (*Boletus mirabilis*) and pink-tipped coral (*Ramaria botrytis*) were identified and lichen species include witch's hair (*Alectoria sarmentosa*), *Cladonia* spp. and ragbag (*Platismatia glauca*).

Plot 2 has a successional stage of mature two-storied coniferous forest (Photo 17). Western hemlock is again the dominant tree species with one large Douglas-fir. The Douglas-fir has a DBH of 53 cm while the largest western hemlock has a DBH of 56 cm and an age of 200 + years. There are a total of 30 trees in this plot and an average DBH of 26 cm.

One western redcedar is present in the tall shrub layer, while cedar and Amabilis fir are both present in the low shrub layers. Additional low shrubs in the open understorey include black huckleberry, boxwood, red huckleberry (*Vaccinium parviflorum*), salal (*Gaultheria shallon*), false azalea (*Menziesia ferruginea*), twinflower (*Linnaea borealis*) and one-sided wintergreen. Herbs include rattlesnake plantain (*Goodyera oblongifolia*), prince's pine (*Chimaphila umbellata*) and bunchberry. The abundant moss layer was co-dominated by stepmoss, red-stemmed feathermoss and pipecleaner moss, with broom moss, cat-tail moss and another unidentified species of moss also present in small quantities. Lichens include witch's hair, blood-spattered beard (*Usnea wirthii)*, coastal reindeer (*Cladina potentosa)*, ragbag and dust lichens (*Lepraria* spp.). Unidentified mushrooms area again abundant.

Photo 16. Looking south at Terrestrial Ecosystem Plot 1 and the carabid beetle trap transect from the photo point. October 16, 2013.

Photo 17. Looking north at Terrestrial Ecosystem Plot 2 from the photo point. October 17, 2013.

3.4.3.4 Wildlife Habitat

Plot 1 provides valuable habitat for birds and small mammals. The large mature Douglas-firs provide feeding and perching habitat for birds, including woodpeckers. Insect holes are evident in some trees and woodpecker holes were observed in a tree located just outside of the plot (Photo 18). A number of snags having small DBHs were noted and a small amount of Coarse Woody Debris (CWD) is present, mostly in the later stages of decay and averaging 14 cm in DBH. Cavities formed under the CWD and rocks provide denning habitat for small mammals including voles.

Plot 2 also provides habitat for birds and small mammals. Bird species, including woodpeckers, may use larger trees at the site for perching and feeding. Plot 2 contains very little CWD, all of which is in the last stages of decay and has an average DBH of 17 cm. While there are no cavities under rocks and little CWD, there is some denning potential for small mammals between exposed tree roots. Small mammals may also use the site for other uses, such as feeding.

Photo 18: A western hemlock with woodpecker cavities in it, located just outside of Plot 1. October 17, 2013.

3.4.3.5 Discussion and Recommendations

Due to time and budget constraints, the terrestrial ecosystem plot assessments were not exhaustive and the field forms were not completed to the fullest extent possible. It is recommended that in future years, adequate time is allotted to the terrestrial ecosystem plot assessments so that all data can be recorded.

Portions of the terrestrial ecosystem plot assessments should be repeated in future monitoring years. This will allow for a between-year analysis of the data that may correlate to the results of terrestrial wildlife surveys. It is recommended that only data that is expected to change over time be re-assessed. This includes taking photos, updating the successional status and structural stage, and repeating vegetation, tree mensuration, tree attributes for wildlife, wildlife habitat assessment and coarse woody debris assessments. All other site information is not expected to change over the lifetime of this monitoring project. Additional plots in different ecosystems should be established in subsequent years.

3.4.4 Carabid Beetle

Carabid beetles are a good indicator of ecosystem health because they are sensitive to different environmental factors and have wide range of habitat requirements (Villa-Castillo and Wagner, 2002). Carabids appear to be useful model organisms and indicators because they are diverse, they are taxonomically and ecologically well-known, they efficiently reflect biotic and abiotic conditions, and they are relevant at multiple spatial scales (Koivula, 2011). Carabids are frequently used to indicate habitat alteration. They have been used in grasslands and boreal forests where species number and/or abundances have been noted to change along a habitat disturbance gradient (Rainio and Niemela, 2002). They are also a good species to monitor because data collection is simple and cost-effective.

3.4.4.1 Site Selection

Trapping was conducted in two sites. Sites were selected to be as similar as possible in order to use them as replicates in statistical analysis.

Site 1 is located on Blueberry hill, approximately 50m uphill from the trail. Site 2 is located west side of Alta Lake Road in Whistler, near the Rainbow Lake Trail parking lot (refer to Map 15 and Map 16). Both sites are characterized by a mature forest composed mainly of western hemlock (*Tsuga heterophylla*).

3.4.4.2 Insect Trapping

A pitfall trap method was used to study the carabid population. Each trap was made out of a plastic cup (10 cm diameter and 13 cm deep) installed flush with the ground (Photo 19). A cover was placed about 3 cm above the ground directly over the trap to protect it from the rain using a plastic plate and nails (Photo 19). Six traps were placed along a transect line with a minimum of five meters between them (Photo 20). Traps were filled with ethanol up to the ¾ mark. Sampling lasted for two weeks and traps were emptied weekly (

Table 13). Insects collected were stored in ethanol and identified to species level using Lindroth (1961). Abundance will be expressed as the number of individuals per pitfall trap per night (MELP, 1998).

Photo 19. View of a pitfall trap with its cover. September 16, 2013.

Photo 20. View of the transect line. September 16, 2013.

Table 13: Sampling dates for each site

Site	Date of the 1st sampling	Date of the 2nd sampling
#1 : Blueberry	16/09/13 to 24/09/13	24/09/13 to 01/10/13
#2 : Rainbow	17/09/13 to 24/09/13	24/09/13 to 01/10/13

3.4.4.3 Results

A total of 14 ground beetle specimens, representing 2 species were collected from the 16 days of trapping. The relative abundance ranges from 0.02 to 0.19 ground beetle per trap night. Site 1 had a relative abundance of 0.24 ground beetle per trap night, while Site 2 had a relative abundance of 0.07 ground beetle per trap night (Table 14). Relative abundance was lower during the second sampling period with 0.02 and 0 ground beetle per trap night at the Blueberry and Rainbow site respectively. *S. angusticollis* is the most abundant species and account for 79% of all the ground beetle collected. The *Pteristichus* sp. specimen collected had damaged legs which prevented further identification.

Table 14: Relative abundance (number of beetles per trap night) of carabid species collected from blueberry hill and rainbow between September 16, 2013 and October 01, 2013

Species	Site 1: Blueberry		Site 2: Rainbow	
	1st sampling	2nd sampling	1st sampling	2nd sampling
Pterostichus herculaneus	0.02	0.02	0	0
Pterostichus sp.	0	0	0.02	0
Scaphinotus angusticollis	0.19	0	0.05	0

3.4.4.4 Discussion and Recommendations

Species richness appears to be low—Latty *et al.* (2006) caught 39 carabid species in western Canada. The relative abundance is similar to the one found in Lavallee and Richardson (2010), where the relative abundance of *S. Angusticollis* ranges from 0 to 0.7 individual per trap night, although our results are on the lower end of the range observed in that study.

An important difference can be observed in the relative abundance between the two sampling periods at both sites where only one carabid was captured versus thirteen during the first sampling periods. This difference could be explained by the difference in temperature between the two sampling periods. Between September 16 and 24 the average temperature was 11.9°C while between September 24 and October 1 the average temperature was 7.1°C. This drop in temperature most likely reduced the activity of the carabid and therefore their trapability.

In order to maximize the chances of catching a larger number of species and a larger number of individuals; sampling should be conducted during the active growing season between May and September (MELP, 1998).

Carabids were more abundant at Site 1 (0.24 Carabid per trap night) than Site 2 (0.07 Carabid per trap night). This suggests a high variability in the population between the sample sites. The number of sample sites, or the number of trap line per site, should therefore be increased to account for this variability in subsequent study.

3.5 Terrestrial Species Indicators

3.5.1 Pileated Woodpecker

Woodpeckers (family *Picidae*) are considered good indicators of avian diversity in forests because their populations can be reliably monitored, and their foraging and nesting activities can positively influence the abundance and richness of other forest birds (Drever *et al.*, 2008). The pileated woodpecker (*Dryocopus pileatus*) is a keystone habitat modifier. It forages primarily by excavating and is the only species capable of creating large cavities in hard snags and decadent live trees. A wide array of species use old pileated nest and roost cavities. In addition, pileateds provide foraging opportunities for other species, accelerate decay processes and nutrient cycling, and mediate insect outbreaks. Because of the indicator and keystone role of pileated woodpeckers in forests, it is appropriate to give special attention to their habitat needs in forest management plans and monitoring activities (Aubry and Raley, 2002).

3.5.1.1 Site Selection

Using the information contained in the GIS geodatabase and focusing on the RMOW TEM information combined with 1:2000 scale base mapping (topography, hydrology, and urban features), the entire municipality was assessed to identify two linear transects of between 4 and 7 km in length that maximize suitable pileated woodpecker habitat below 1,200 m in elevation. Two transects were established in areas of potentially suitable pileated woodpecker habitat. Transect 1 is located along the Comfortably Numb trail and Transect 2 is located west of Alta Lake Road in the area of the Rainbow/Madely Trail. Each transect consists of 10-11 survey stations located 300 m apart. The transect locations were selected to be within mature to old forests in suitable site series of the CWHmm biogeoclimatic subzone, including Site Series 01 (TEM Code: AM - HwBa – Step moss), Site Series 04 (TEM Code: AO – BaCw – Oak fern), and Site Series 03 (TEM Code: DF – FdHw - Falsebox).

3.5.1.2 Survey Method

The call-playback survey method was used to determine the relative abundance of pileated woodpeckers. At each survey station, pileated woodpecker calls and drums were broadcasted using a megaphone. Surveys were conducted on September 11 and 12, 2013 during favourable weather conditions consisting of clear skies, warm temperatures and no wind to a light breeze. Upon arrival at each station, the surveyors listened for one minute for calling birds. If no birds were heard, three 20 s calls were broadcasted, each followed by 30 seconds of listening and watching. Each call was broadcasted at 120° directional rotation (360°) from the previous one. If there was no response to the calls, a drumming sequence was then broadcasted three times. Each drumming sequence was broadcast for 5 seconds followed by a 10 second listening period. In the event that a pileated woodpecker did respond, all broadcasts were stopped and the location of the woodpecker was recorded. Abundance will be reported in terms of number of woodpeckers detected per hectare, based on an acoustic range of 300 m from each survey station.

3.5.1.3 Habitat Data Collection

Habitat attributes were also collected including species composition, stand age (i.e. structural stage), stand density, and the number and quality of dead or dying trees. Where potential pileated woodpecker cavities were observed, associated data was recorded including the tree species, height and decay class and cavity height, size and shape. Evidence of recent use (i.e. presence of wood chips and fresh colour of wood) was also noted. Each cavity tree was recorded in the GPS and photo documented.

3.5.1.4 Results

One single pileated woodpecker was detected during the call-playback surveys. This was located along Transect 1 (Map 17). The relative abundance of pileated woodpeckers is therefore 0.007 pileated woodpeckers per hectare for both transects.

Further details regarding survey data collected at both transects is provided in Appendix C.

3.5.1.4.1 Transect 1

One pileated woodpecker was detected along this transect (Photo 23, Map 17). Relative abundance of pileated woodpeckers along this transect is therefore 0.013 per hectare for this transect. In addition to the pileated, red-breasted sapsuckers (*Sphyrapicus ruber*) and northern flickers (*Colaptes auratus*) were also observed. Additional incidental wildlife observations noted during the survey include red-breasted nuthatch (*Sitta canadensis*), Steller's jay (*Cyanocitta stelleri*), American robin (*Turdus migratorius*), chipmunks (*Tamias* family) and squirrels (*Sciuridae* family).

The forest along this transect consists of mature coniferous forest with an open understorey and an abundance of snags and fallen trees (Photo 21). The canopy cover is dominated by Douglas-fir

(*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), and western redcedar (*Thuja plicata*) with western white pine (*Pinus monticola*), amabilis fir (*Abies amabilis*) and yellow cedar (*Chamaecyparis nootkatensis*). A total of 17 cavity trees were identified, many potentially being the result of pileated woodpeckers (Photo 22).

3.5.1.4.2 Transect 2

No pileated woodpeckers were located during the survey of this transect, although a pair of northern flickers did respond to the call playback. Numerous other bird species were also observed incidentally including red-breasted nuthatch, spotted towhee (*Pipolo maculatus*), American robin, varied thrush (*Ixoreus naevius*) and Steller's jay. Squirrels and deer scat were also observed.

The forest along this transect was more varied with some open areas having very little understory and some denser areas having a well developed understorey layer, primarily in proximity to Mile 21 Creek (Photo 24). The canopy cover was dominated by Amabilis fir, western redcedar, western hemlock, Douglas-fir, yellow cedar, western white pine and red alder (*Alnus rubra*). The areas along the creek also had an understorey of false azalea (*Menziesia ferruginea*), vaccinium species and mosses. Few cavity trees (4) were identified along this transect, most of these appearing to be old and unused. The apparent lack of pileated woodpecker cavities indicates that the habitat along Transect 2 may not be suitable habitat.

3.5.1.5 Discussion and Recommendations

The detection of pileated woodpecker, which is rare to uncommon in southwestern BC, indicates that the site selection process accurately identified suitable habitat. As no woodpeckers were detected along Transect 2, however, the site selection process could be improved. It is also recommended that the survey area be expanded to include additional transects in future years.

Challenges arose during the site selection process due to the limited distribution of suitable habitat with the result that the two transects surveyed in 2013 were not of the same size (one having 11 stations and the other having 10). For this reason, relative abundance is provided as the number of woodpeckers detected per hectare, instead of per transect, as recommended in some methodologies (MELP, 1999)..

Based on the results of the 2013 survey, with one specimen encountered for 134 ha surveyed, the density is 0.007 per hectare. Therefore, the estimated population in Whistler can be derived in two ways.

The first estimate is based on an assumption of even distribution across all natural habitat types below 1200 m asl and would yield an estimated population of 105 pileated woodpeckers within the boundaries of the RMOW based on a land base of 14,987 ha. Based on general knowledge of pileated woodpecker populations, this estimate seems to be high. The second method involves using only suitable habitat below 1200 m asl. Suitable habitat was determined by identifying Vegetation Resource Inventory forest of age class 7, 8, and 9 using the GIS. This would yield an estimated population of 39 individuals based on a suitable habitat base of 5,509 ha. This number also feels high, but can be used as a starting point for monitoring change over time is provided for interest purposes only. Calculating population is further confounded by the fact that woodpeckers fly and do not respect arbitrary lines like municipal boundaries when establishing their home ranges. Regardless, for monitoring ecosystem health, the key value is the density.

Pileated woodpecker surveys are typically considered to be more effective during the breeding season of April to late July (MELP, 1999). Future monitoring efforts should therefore be conducted during this window.

Photo 21: Mature open forest typical of Transect 1. September 11, 2013.

Photo 22: Fresh cavity excavation along Transect 1. September 11, 2013.

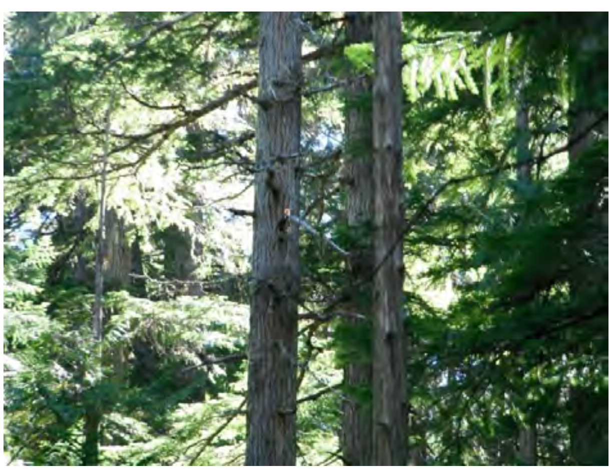
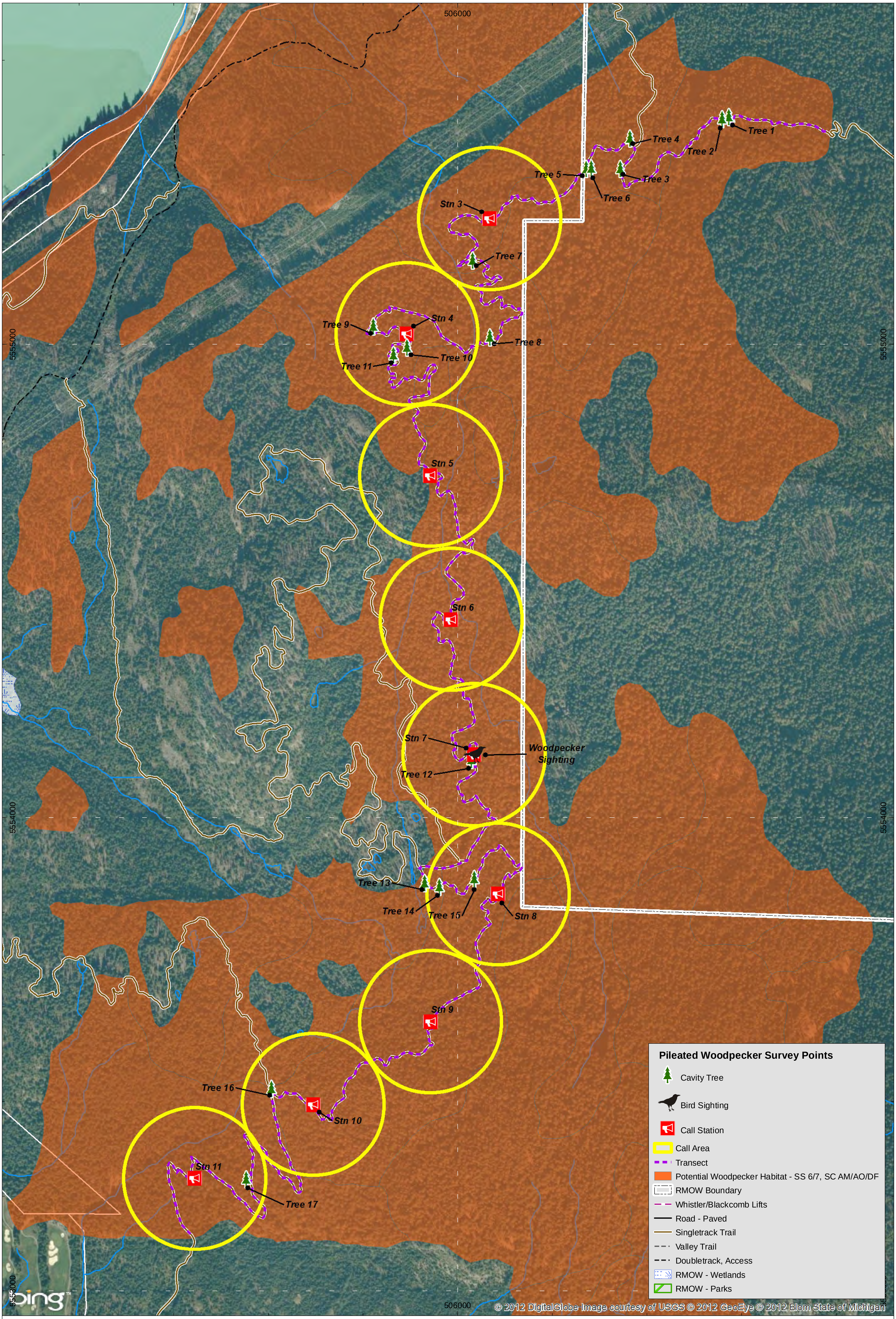


Photo 23: Pileated woodpecker identified along Transect 1. September 11, 2013.

Photo 24: Suitable pileated woodpecker habitat located along Transect 2. September 12, 2013.



GIS Cartographer: Todd Hellinga
Date: November 8, 2013
CERG File#: 013-48-01
Projection: UTM 10N NAD83
Orthophoto/Data: Bing Maps, RMOW

CASCADE ENVIRONMENTAL RESOURCE GROUP LTD

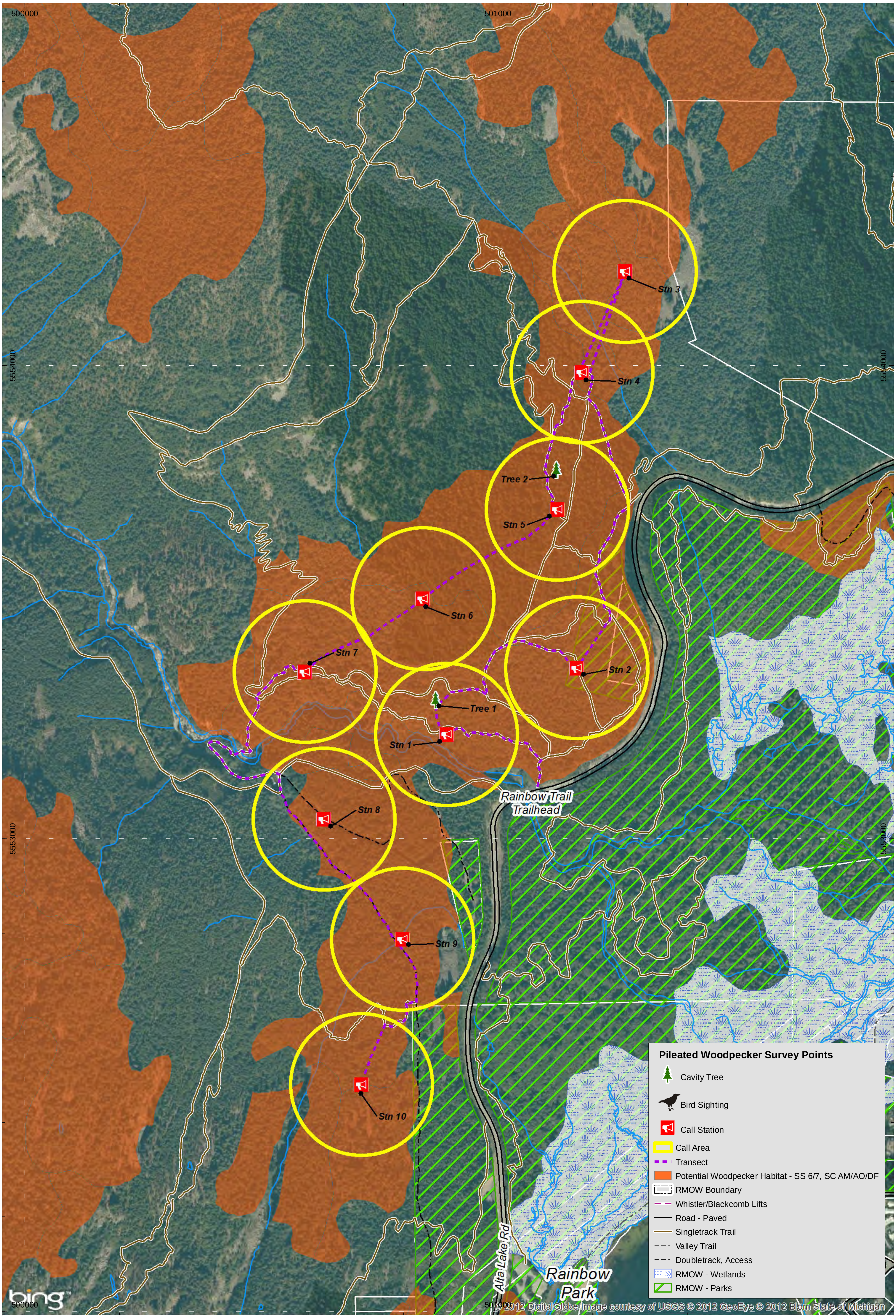
N W E S

0 100 200 300 400 500

Meters

Pileated Woodpecker Survey - Transect 1

RMOW Biodiversity Monitoring Project
Whistler, British Columbia



GIS Cartographer: Todd Hellinga
Date: November 8, 2013
CERG File#: 013-48-01
Projection: UTM 10N NAD83
Orthophoto/Data: Bing Maps, RMOW

CASCADE ENVIRONMENTAL
RESOURCE GROUP LTD

N W E S

0 100 200 300 400 500
Meters

Pileated Woodpecker Survey - Transect 2

RMOW Biodiversity Monitoring Project
Whistler, British Columbia

3.5.2 Red-backed Vole

Small mammals have been used as indicator species in numerous studies (Avenant and Cavallini, 2007; Orrock *et al.*, 2000 and Chase *et al.*, 2000). They play a key role in nutrient cycling, habitat modification, plant consumption, seed dispersal, but also constitute the primary link between primary producers and secondary consumers. These predator-prey relationships are widely recognized and researched. For example the boom and bust population relationship between the snowshoe hare (*Lepus americanus*) and Canadian lynx (*Lynx canadensis*) is well documented and correlated (Sheriff, et al, 2009). In general, changes in small mammal habitats are associated with changes in diversity and community structure, and ecological disturbance of these habitats is associated with the presence or absence of indicator species and decreases in small mammal species richness. As such, they have been identified as valuable indicators of habitat. In addition, small mammals are relatively easy to trap, handle and mark and it is simple to monitor their movements (Avenant and Cavallini, 2007).

3.5.2.1 Site Selection

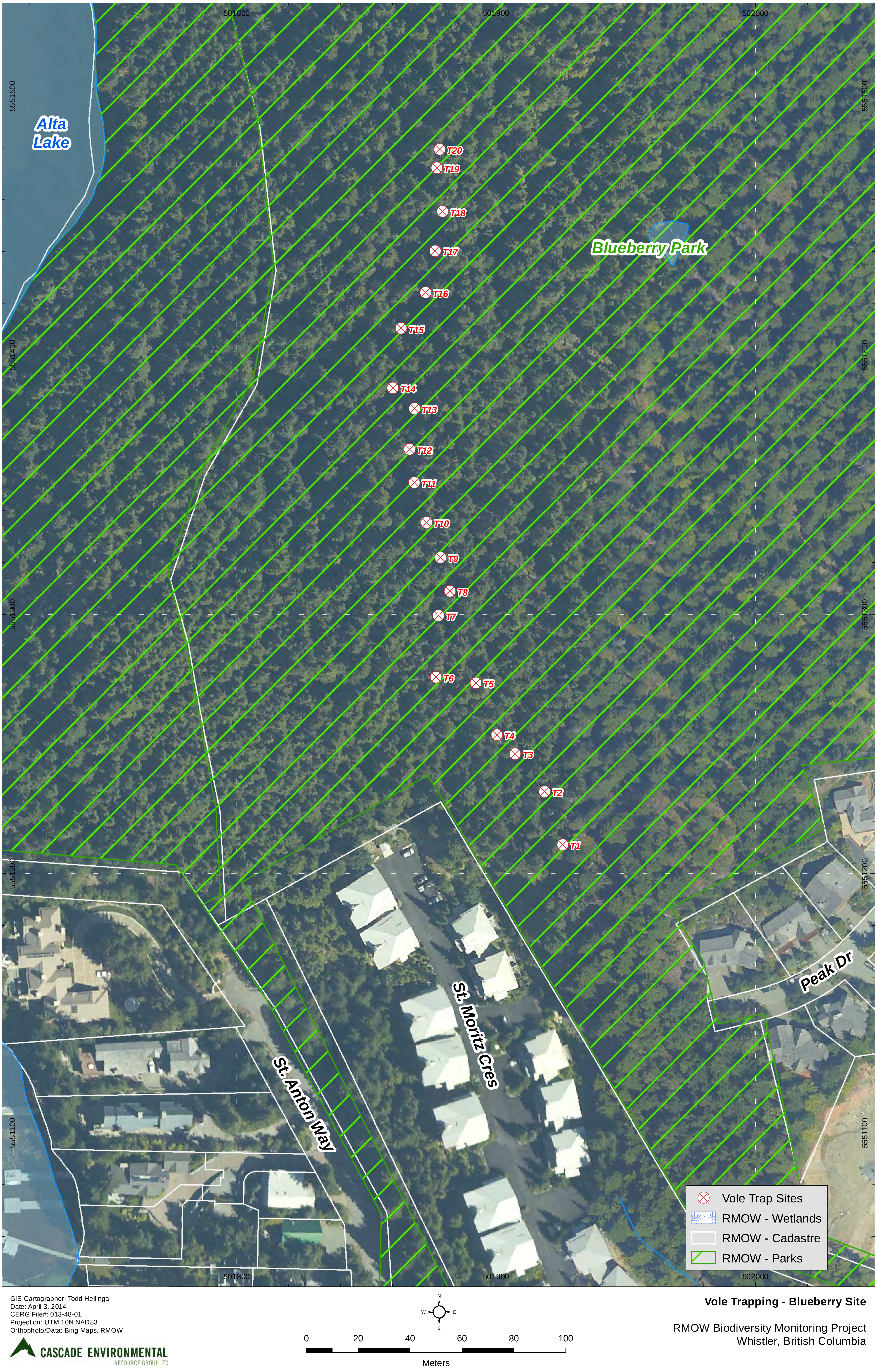
The vole sampling site was located on the terrestrial ecosystem sampling plots in an effort to build a more complete inventory of the ecological condition. As an indicator species, vole sampling was used to contribute to the faunal database generated for the plot. The analysis and site selection criteria for the terrestrial ecosystem plot sites is described more fully in that section of the report as part of the terrestrial habitat health monitoring program.

Two independent sites with similar characteristics were sampled. The first site (Blueberry site) is located near the Blueberry subdivision in Whistler, BC approximately 50 m off Blueberry Trail (Map 19). The second site (Rainbow site) is located on the west side of Alta Lake Road in Whistler, near the Rainbow Lake Trail parking lot (Map 20). Both sites were chosen to be within mature to old forests and as far from manmade trails as possible to minimize human disturbance and trap tampering.

3.5.2.2 Animal Trapping

Vole abundance was calculated using the live trap method. Sherman traps were placed following an index line. 20 capture stations followed the transect line with a minimum of 15 m between each capture station. One trap was placed at each station, with every fourth station having two traps, making a total of 25 traps at each of the two sites. Relative abundance was measured in terms of number of individuals captured per trap night. (MELP, 1998)

A pre-baiting period of 2 weeks preceded sampling. Each trap was baited with slices of carrots and whole oats and cotton bedding material was provided. The traps were covered with debris or vegetation for camouflage. Once the pre-baiting period was complete, the traps were set in the afternoon. The traps were checked the following morning as early as possible. Captured voles were carefully placed into a holding bucket while species, sex class, length and age class of individuals were determined (Photo 25). The animals were separated into juveniles (with remains of juvenile pelage and smaller size), subadults (adult fur and size but not reproductively active), adults (reproductively active). Each vole was marked with a black permanent marker in order to identify recapture (Photo 26). The index traplines remained active for 2 nights (Oct. 7 to Oct. 9, 2013) (MELP, 1998).

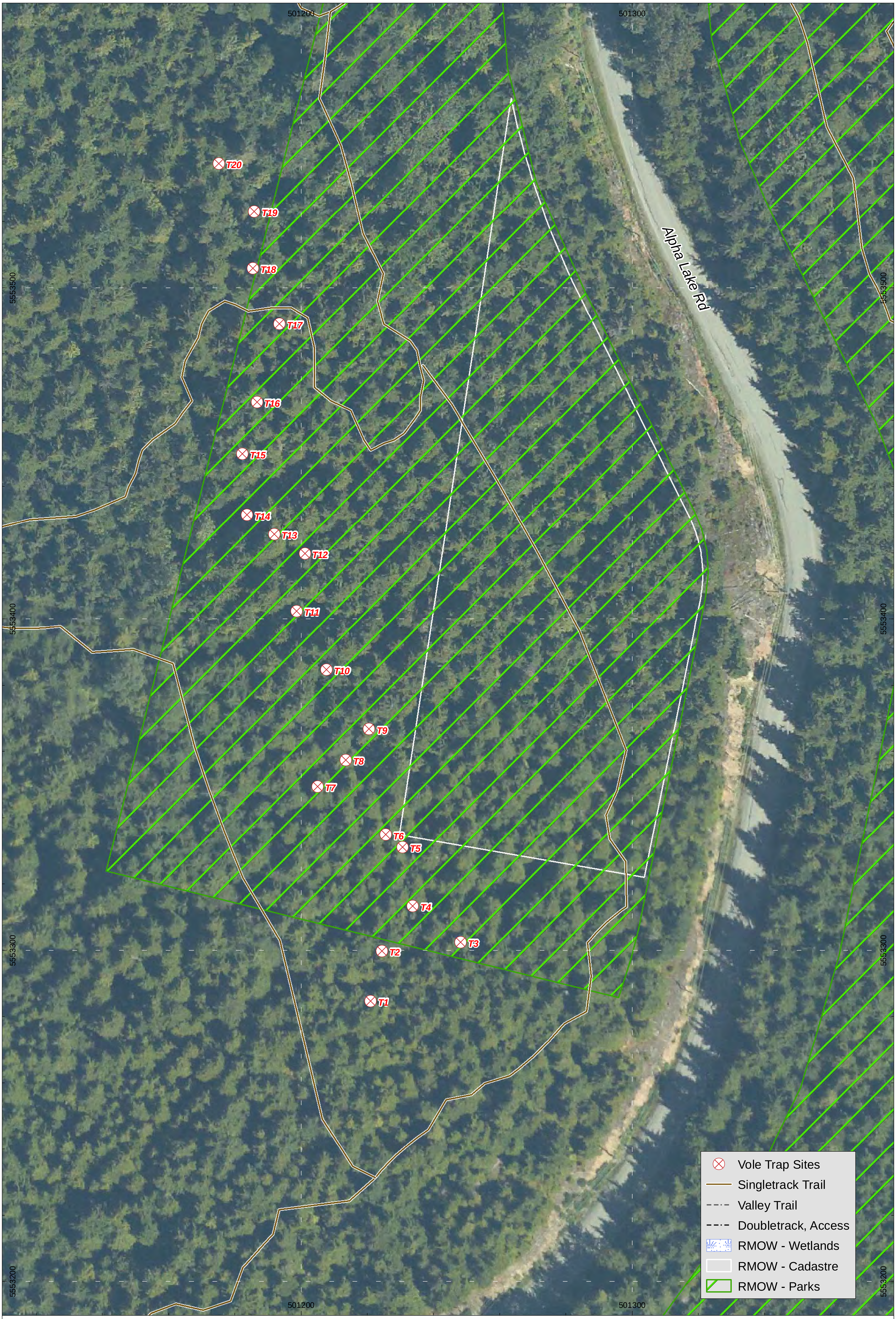


GIS Cartographer: Todd Hellinga
Date: April 3, 2014
CERG File#: 013-48-01
Projection: UTM 10N NAD83
Orthophoto/Data: Bing Maps, RMOW

CASCADE ENVIRONMENTAL RESOURCE GROUP LTD

Vole Trapping - Blueberry Site

RMOW Biodiversity Monitoring Project
Whistler, British Columbia



GIS Cartographer: Todd Hellinga
Date: April 3, 2014
CERG File#: 013-48-01
Projection: UTM 10N NAD83
Orthophoto/Data: Bing Maps, RMOW

CASCADE ENVIRONMENTAL RESOURCE GROUP LTD

Vole Trapping - Rainbow Site

RMOW Biodiversity Monitoring Project
Whistler, British Columbia

Photo 25. Southern red-backed vole in holding bucket. Oct. 8, 2013.

Photo 26. Marking of a captured southern red-backed vole with a tick on its snout. Oct. 8, 2013.

3.5.2.3 Results

A total of 29 small mammals were captured and released at the two sites over two nights including 25 southern red-backed voles (*Clethrionomys gapperi*), 3 montane shrews (*Sorex monticolus*) and 1 least weasel (*Mustela nivalis*). A summary of species abundance at each site is given in Table 15.

As shown in Figure 2, fewer voles were caught on Night 2 in comparison to Night 1 and fewer voles were caught at the Rainbow site than at the Blueberry site. The vole relative abundance measured in number of voles captured per trap night was 0.44 at the Blueberry survey site and 0.06 at the Rainbow site. Five of the 25 captured voles were deceased upon opening the trap, giving a vole mortality rate of 20%.Of the 25 voles captured, 52% were males and 48% were females and the average length is 7.3 cm.

Table 16 shows the number of voles in each age class per sex at both sites. At the Blueberry site, 50% (11 voles) were males and 50% (11) were females. Among the males no adults were caught, and the subadult class represented 64% (7) of the males captured while juveniles accounted for 36% (4). 9% (1) of females caught were adults, 64% (7) were subadults and 27% (3) were juveniles. At the rainbow site 67% (2) were males and 33% (1) were females. Half of the males were adults while the other half was subadults and the only female caught at this site was a subadult.

No voles were recaptured at either of the sites.

Regarding trap availability, at the Blueberry site, 32% of the traps remained empty on Night 1 (Oct. 7 to Oct. 8, 2013) and 76% were empty on Night 2 (Oct. 8. to Oct. 9, 2013). The Rainbow site had a higher proportion of empty traps with 80% of traps empty on Night 1 and 92% of traps empty on Night 2.

Details regarding individual trap data can be obtained in Appendix D.

Table 15: Relative abundance of small mammal species at Blueberry and Rainbow Sites expressed as the number of individual captured per trap night.

	Red-backed vole	Montane shrew	Least weasel
Blueberry site	0.44	0.02	0
Rainbow site	0.06	0.04	0.02

Table 16: Total number of red-backed vole caught at each site for each sex and age class

	Male			Female		
	Adult	**Subadult**	**Juvenile**	**Adult**	**Subadult**	**Juvenile**
Blueberry site	0	7	4	1	7	3
Rainbow site	1	1	0	0	1	0

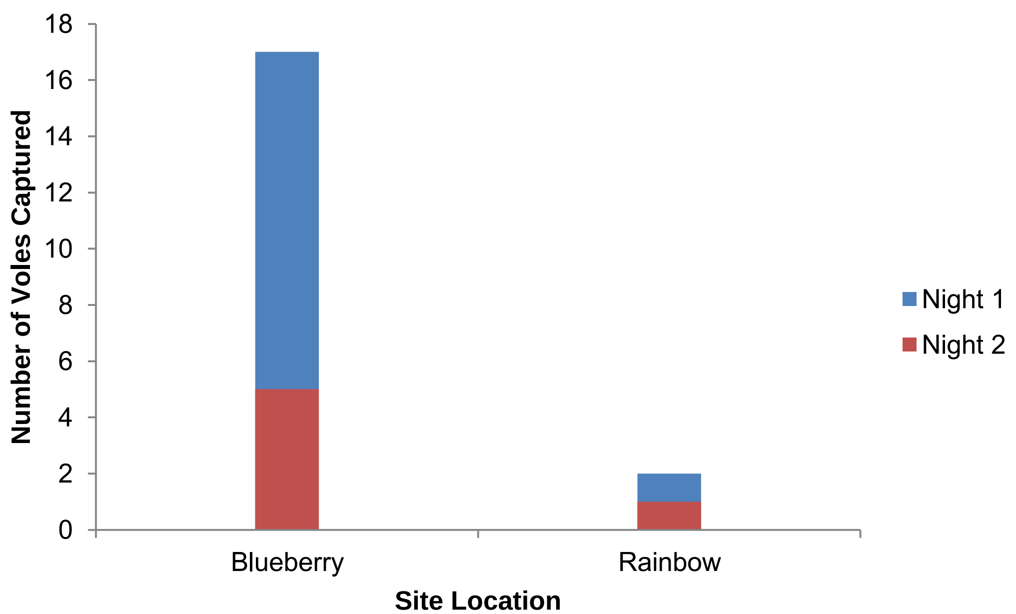


Figure 2. Total Voles Captured. Total number of southern red-backed voles (*Clethrionomys gapperi*) captured on each night in 25 traps at each of the two sites. The first active trapping period occurred from Oct. 7, 2013 to Oct. 8, 2013 (Night 1) and the second from Oct. 8, 2013 to Oct. 9, 2013 (Night 2).

3.5.2.4 Discussion and Recommendations

In order to accurately display the size of a vole population, greater than 20% of the traps must remain empty (MELP, 1998). This was accomplished at both the Rainbow and Blueberry sites, since greater than 5 of the 25 traps remained empty on both nights.

The sex class, length, and age class of all red-backed voles were determined, but sex class and reproductive status of the montane shrews could not be determined since the shrews could not be handled without harm. The size of the least weasel led surveyors to conclude that it would not be contained by the bucket. Therefore, the least weasel was released onto the ground and sex and reproductive status were not determined.

One possible explanation for the fewer number of voles caught on Night 2 in comparison to Night 1 could be the difference in temperature between the two nights. On Night 2 temperatures reached down to -0.6 °C, whereas on the first night the minimum temperature was 4.2 °C (Environment Canada, 2013). Temperatures below freezing on Night 2 may have caused decreased vole activity and resulted in fewer captures.

Although efforts were made to select survey sites that were as similar as possible, variation in the number of voles captured is observed between the Blueberry and Rainbow sites. This variation decreases the precision of the survey. Reasons for this variation could include a difference in habitat features between the sites such as availability of food and protection which could affect vole abundance in the area.

For future monitoring programs, capture sessions should occur at least twice during the active season (May to October) as recommended by MELP (1998). In this study, the recommended capture session during the fall, after breeding was completed, but the recommended capture session during the spring breeding period was not completed. Now that the sampling protocol is successfully field tested and standardized, sampling should be conducted at the same times each year (MELP, 1998).

For future vole abundance monitoring initiatives, precision could be improved by increasing the number of trapping sites in order to increase the number of replicates. As well, since none of the voles were recaptured from the first night, future vole monitoring efforts would likely benefit from increasing the number of nights the traps are set out for. In future years additional plots in different ecosystems should be established to provide additional data from more diverse sources. However, the availability of traps and the windows for sampling will need to be considered. The recommended sample windows for Blueberry and Rainbow plots are: the last two weeks of May for the spring trapping session and the two first week of October for the fall trapping session. Vole population fluctuates greatly, it is therefore important to conduct trapping session at the same time each year.

Continuation of vole abundance monitoring in future years would provide valuable information regarding biodiversity trends in Whistler. By tracking vole abundance it would be possible to indicate the effects of habitat loss or gain, changes in biodiversity and ecosystem structure.

3.6 Invasive Alien Plant Monitoring

3.6.1 Methodology

The spread of invasive alien plant and animal species is directly correlated to proximity to pathways (Hougan, et al., 2012). This fact is readily apparent by the occurrence records provided through the ISCBC (Map 21). Identification of invasive hotspots is based on the occurrence records and the pathway risk assessment. Land, water or its ecotones occurring near any of these identified risk factors were assessed by GIS analysis and identified for consideration as invasive hotspots, subject to field verification of condition and risk. Three key risk factors that are considered are:

a. Mobile equipment (automobiles) and heavy machinery (excavators) – transfer of plants and seeds between sites. Whistler has just recently come through a 25 year cycle of explosive growth and development involving a great deal of heavy machinery movement in and out of the valley.

b. Contaminated seed mixes – areas of past revegetation efforts. Large revegetation projects have been part of the Sea to Sky Highway, Operation Green Up on the local mountains, and widespread landscaping efforts thought the valley.
c. Infested soil – Soil transferred from one site to another, especially top soil and bio-soil. Due to its montane environment, Whistler has very little naturally occurring top soil. As a result top soil was traditionally imported into the valley from Pemberton, Squamish and the Lower Mainland. Bio-soil currently comes from the Lower Mainland as well as from the local source.

3.6.1.1 Occurrence

Previous works on biodiversity indicators and ecosystem health using invasive alien plants (IAPs) relied on the cumulative number of IAP species recorded in the RMOW over time. Historical occurrence records of IAPs within the RMOW were garnered from existing data sources such as the Invasive Alien Plant Program (IAPP) database. A list of the invasive species and the year that they were first recorded in the RMOW was produced. Using this list, a simple graph was prepared to illustrate the number of IAP occurrences recorded per year. The parameters for occurrence surveys are not known and do not appear to be applied to a consistent area or level of effort. In order to develop a more replicable and standardized approach to monitoring IAPs as an indicator of ecosystem health a new methodology was developed.

3.6.1.2 Relative Abundance

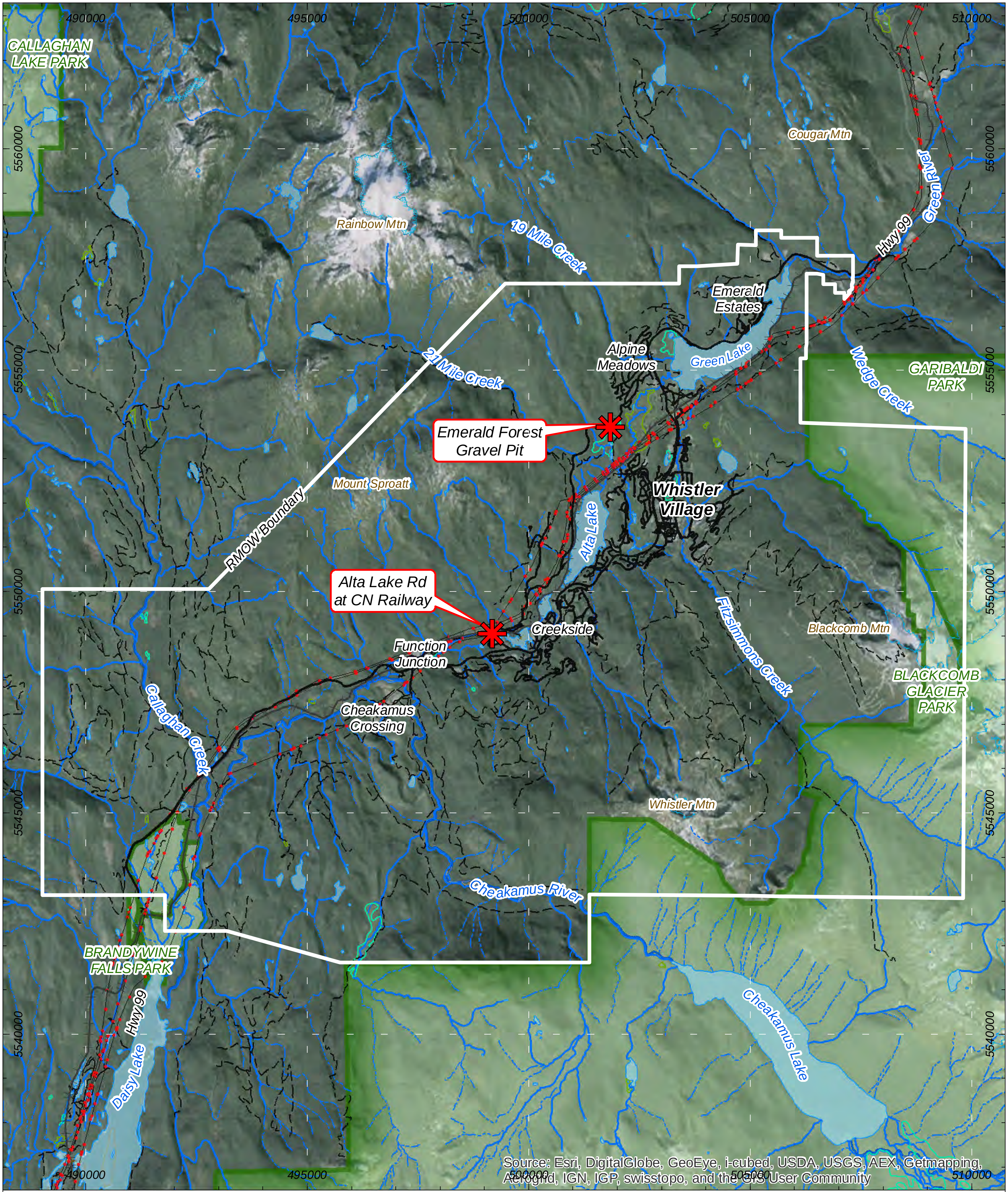
Relative abundance is suggested as a potential alternative for using IAPs as an indicator of ecosystem health. The relative abundance of native versus non-native plant species in established vegetation study plots can be monitored over time. Signs of wildlife use within and adjacent to the plot also provide an indicator of the quality of the habitat within the plot for wildlife species. Evidence of wildlife use may include scat, tracks, trampled vegetation, foraged vegetation and direct observation.

3.6.1.3 Site Selection

Two permanent study plots consisting of 20 m x 20 m quadrats (1/25 ha) were established. Study plot locations were selected in locations having high potential for IAP occurrences and low potential for future disturbance, such as public crown land and parks. Plot 1 is located at the crossing of the CN railroad and Alta Lake Road, near the southwest corner of Alpha Lake (Map 22). This plot is adjacent to potential IAP vectors including a road, railroad and power lines, and is also in proximity to a known occurrence record from the Invasive Alien Plant Program (IAPP). The IAPP record is from 2010 and includes burdock species (*Arctium* spp.), knapweed species (*Centaurea* spp.), Canada thistle (*Cirsium arvense*), orange hawkweed (*Hieracium aurantiacum*), St. John's wort (*Hypericum perforatum*), oxeye daisy (*Leucanthemum vulgare*), common tansy (*Tanacetum vulgare*), and western goat's-beard (*Tragopogon dubius*) (MFLNRO, 2013). Plot 2 is located in the previously disturbed site of the old gravel pit east of Alta Lake Road and adjacent to the bike trail named *A River Runs Through It* (Map 23).

3.6.1.4 Survey Method

At each study plot, the abundance of native versus alien plant species was assessed. This included the identification of each plant species occurring within the plot and noting whether it is native or alien, followed by a stem count for each species and an estimation of the area covered by that species and the percent cover. The developmental stage (i.e. leafing out, flowering, senescing) was also noted for each species. While assessing the study plots, assessors also noted signs of wildlife and wildlife use within or adjacent to the plots. A photo of each plot was also taken from a permanently established photo point.



GIS Cartographer: Todd Hellinga
Date: December 10, 2013
CERG File#: 013-48-01
Projection: UTM 10N NAD83
Orthophoto: Bing Maps

CASCADE ENVIRONMENTAL RESOURCE GROUP LTD

0 1 2 3 4 5
Kilometers

Invasive Alien Plant Plots - Location

Biodiversity Monitoring Project
Resort Municipality Of Whistler
British Columbia

3.6.2 Results

3.6.2.1 Occurrence

Invasive alien plant occurrence records were collected from the IAPP database (MFLNRO, 2013). A complete list of IAPs and the earliest year that they were recorded within the RMOW was prepared and can be found in Appendix E. In total 33 species have been reported with the IAPP database within the RMOW. Figure 3 below illustrates the number of IAPs recorded in each year.

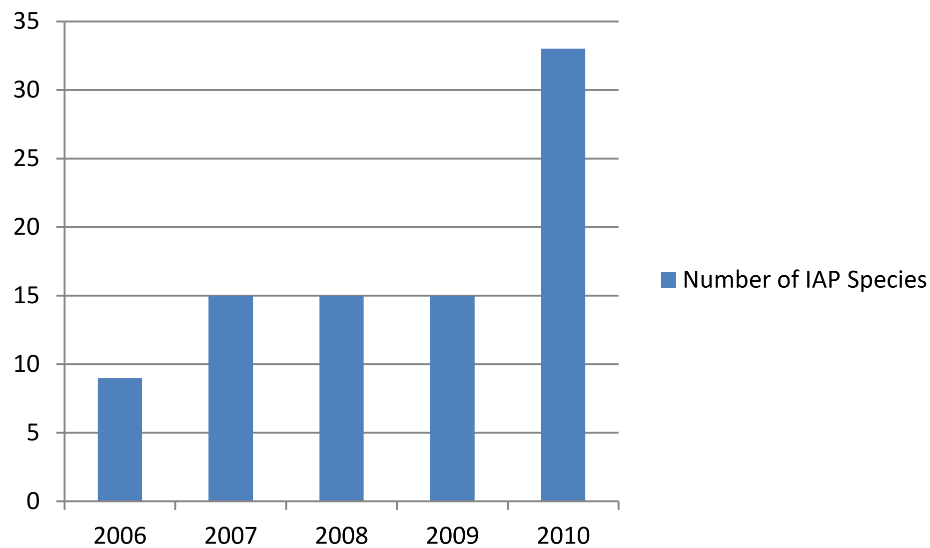
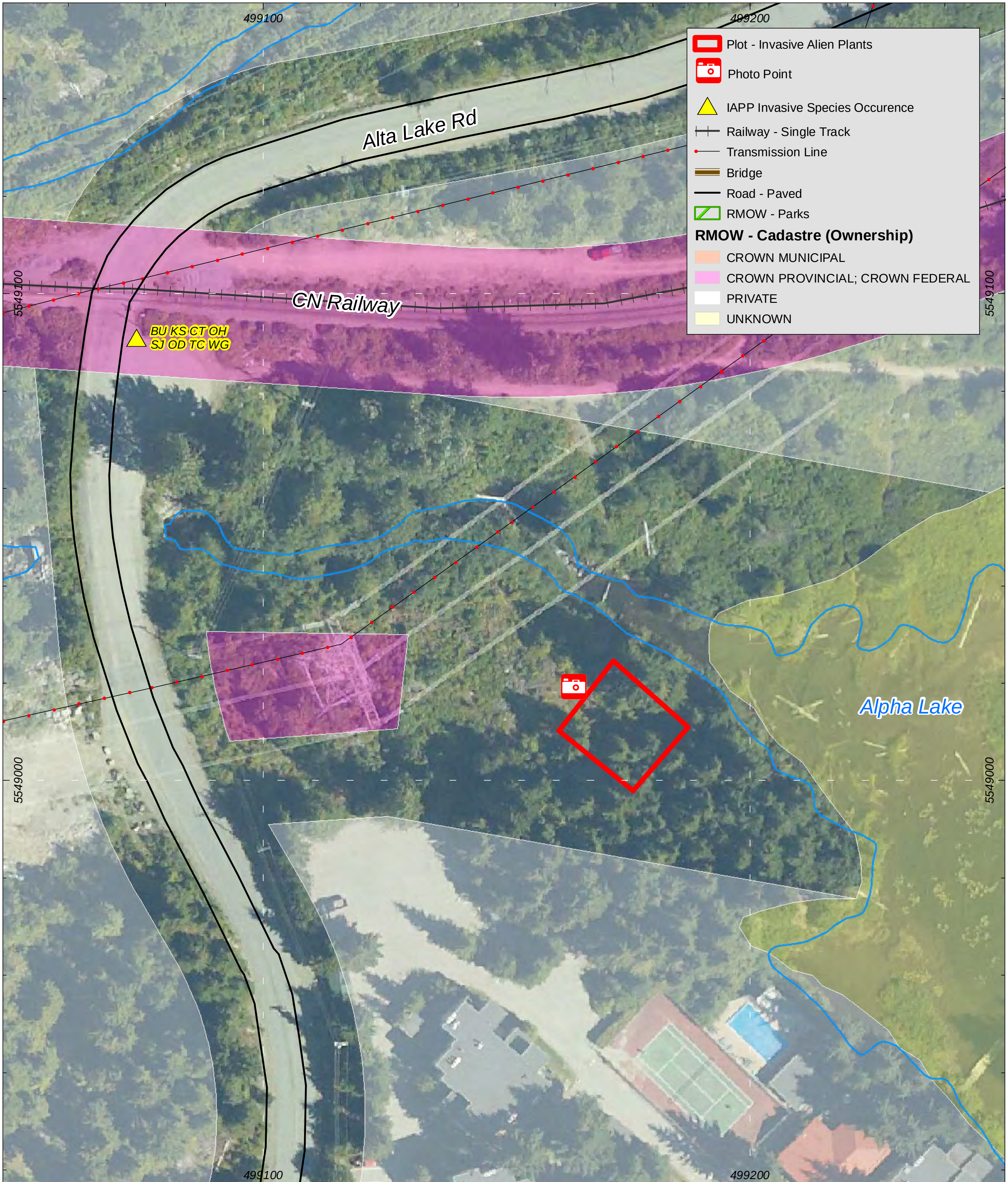


Figure 3. Number of Invasive Alien Plant species reported within the RMOW per year.

3.6.2.2 Relative Abundance

Plot 1 consists of open coniferous forest over bedrock (Photo 27). The dominant tree cover is young and mature western hemlock with some western redcedar and Douglas-fir. The understorey is dominated by oval-leaved or Alaskan blueberry (*Vaccinium ovalifolium or alaskense*) and low ground covers such as prince's pine (*Chimaphila umbellata*), bunchberry (*Cornus canadensis*), one-sided wintergreen (*Orthilia secunda*) and kinnikinnick (*Arctostaphylos uva-ursi*) and mosses.

Despite the high potential for IAPs to occur at this location, none were found within the plot. The number and abundance of native species identified within the plot is provided in Table 17, while the abundance by species is provided in Appendix E. Due to the late season timing of the survey and the fact that many plants were lacking leaves, it was difficult to identify some species (Photo 28).

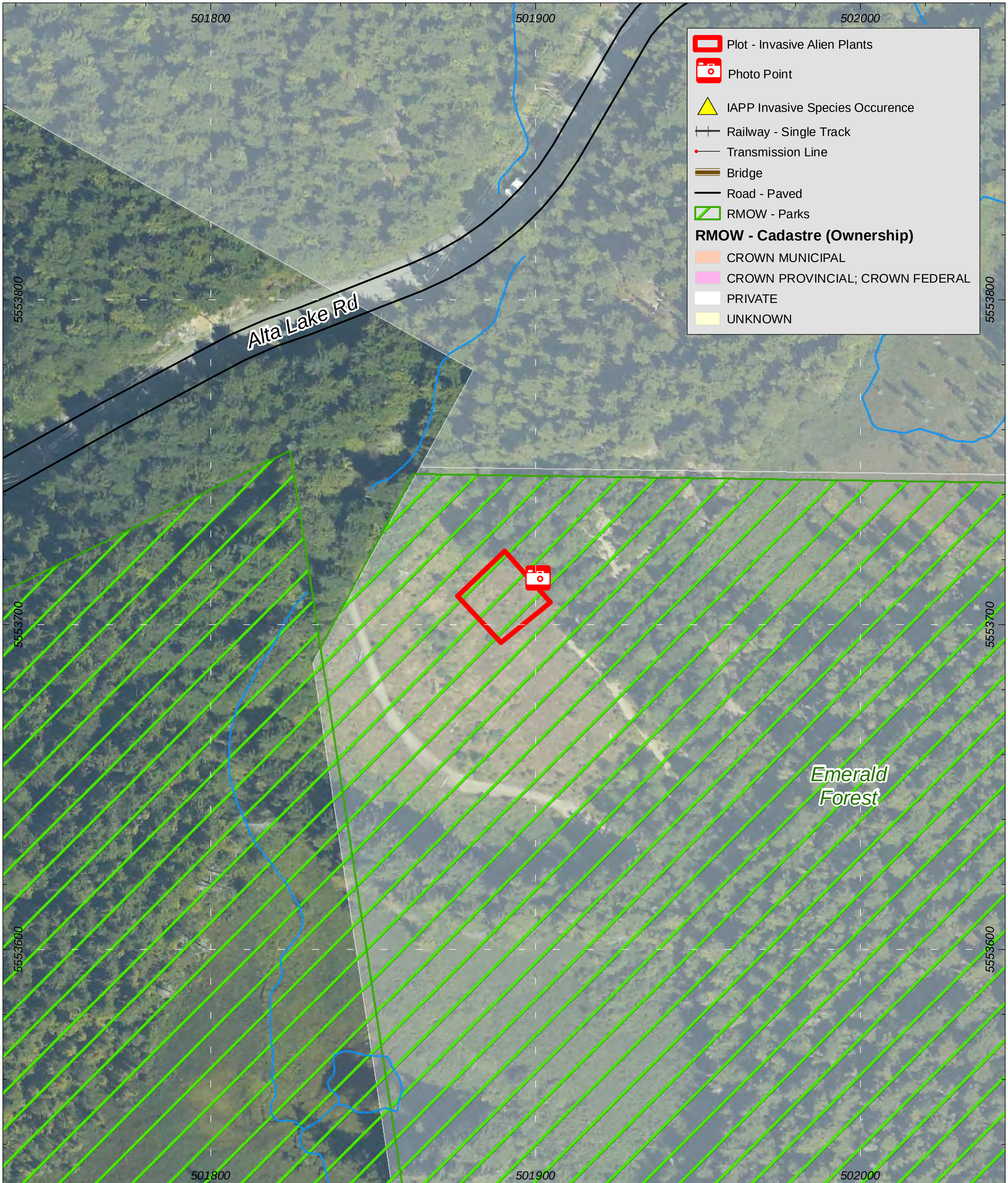


GIS Cartographer: Todd Hellinga
Date: December 10, 2013
CERG File#: 013-48-01
Projection: UTM 10N NAD83
Orthophoto/Data: Bing Maps, RMOW

CASCADE ENVIRONMENTAL RESOURCE GROUP LTD

Invasive Alien Plant Plot 1
Alta Lake Rd at CN Railway

RMOW Biodiversity Monitoring Project
Whistler, British Columbia



GIS Cartographer: Todd Hellinga
Date: December 10, 2013
CERG File#: 013-48-01
Projection: UTM 10N NAD83
Orthophoto/Data: Bing Maps, RMOW

CASCADE ENVIRONMENTAL RESOURCE GROUP LTD

0 10 20 30 40 50
Meters

Invasive Alien Plant Plot 2
Emerald Forest Gravel Pit

RMOW Biodiversity Monitoring Project
Whistler, British Columbia

Table 17: Number and abundance of native plant species in Plot 1

	Number of Species	Number of Individuals (i.e. Stems)	Area Covered (m^2)	% Cover
Native Species	23	5817	267.4	66.85

Incidental wildlife observations at the site include visual observations of a Swainson's thrush (*Catharus utulatus*), droppings that possibly originate from a domestic dog, and an old stump that had been chewed by a beaver. A small foot path surrounds the site.

Photo 27. Looking East at Plot 1 from the photo point. October 17, 2013.

Photo 28. Shrub species having already lost their leaves. October 17, 2013.

Plot 2 consists of open, grassy habitat adjacent to the forest edge (

Photo 29). The site is heavily dominated by grass species with a shrub layer dominated by black cottonwood (*Populus balsamifera*) and Douglas-fir (*Pseudotsuga menziesii*) saplings, hardhack (*Spiraea douglasii*), black twinberry (*Lonicera involucrate*), falsebox (*Paxistima myrsinites)*, oceanspray (*Holodiscus discolor*) and Saskatoon (*Amelanchier alnifolia*), and a forb ground cover layer dominated by coastal strawberry (*Fragaria chiloensis*), yarrow (*Achillea millefolium*), great mullein (*Verbascum thapsus*), sheep sorrel (*Rumex acetosella*) and oxeye daisy (*Leucanthemum vulgare*). Along the northern boundary of the site the shrub cover is very dense and there are several trees (cottonwood and lodgepole pine (*Pinus contorta*)). Due to their late developmental stage at the time of the survey, several grass species and one shrub could not be identified and could be either native or alien. Known alien invasive species occurring in this plot include great mullein, sheep sorrel, oxeye daisy as well as edible thistle (*Cirsium edule*), Himalayan blackberry (*Rubus armeniacus*), common tansy (*Tanacetum vulgare*), yellow salsify (*Tragopogon dubius*), quackgrass (*Elymus repens*) and orchard grass (*Dactylis glomerata*). A complete list of the species identified within Plot 2 and their abundances is found in Appendix E.

In total, 18 native and 9 alien species (Photo 30) were identified, while one shrub and 4 grasses could not be identified. Measures for abundance of these species are summarized in Table 18 below. The percent cover is 14.95 % (59.8 m^2)) for native species and 7.65 % (30.6 m^2) for invasive alien species. Note that 30.25 % cover (121 m^2) was attributed to the unidentified grass species. The ratio of known native species to alien invasive species is 2:1 based on the percent cover and the number of species.

Table 18: Number and abundance of native and alien plant species in Plot 2

	Number of Species	Number of Individuals (i.e. Stems)	Area Covered (m^2)	% Cover
Native Species	18	1664	59.8	14.95
Alien Species	9	1000	30.6	7.65
Unknown Species	5	80	121	30.25

Incidental wildlife observed at the plot includes visual observations of Steller's jays (*Cyanocitta stelleri*) and a small unidentified rodent and droppings. A tree frog (*Pseudacris regilla*), chipmunk (*Tamias* spp.) and common raven (*Corvus corax*) were also heard in proximity to the site. The bike trail *A River Runs Through It* comes to within 7 m of the northeast corner of the plot.

Photo 29. Looking South at Plot 2 from the photo point. October 18, 2013.

Photo 30. Invasive alien species found in Plot 2, including Himalayan blackberry and edible thistle. October 18, 2013.

3.6.3 Discussion and Recommendations

3.6.3.1 Occurrence

Due to time and budget constraints, historical data was only garnered from a single source, which was the readily accessible IAPP database. The Sea to Sky Invasive Species Council (SSISC) is collecting additional inventory of other species occurrences, not currently being collected by the IAPP database. However, it was not readily transferable into the geodatabase. It is recommended that the additional potential sources of IAP occurrence data be incorporated into the geodatabase for next year.

In addition, to ensure that the list is comprehensive, it is recommended that an inventory be conducted of current IAP occurrences within the RMOW. This would consist of a team of qualified biologists surveying transects in targeted areas such as transportation corridors and public green spaces, including lakeshores. The list would be updated and any species not on the list of historical occurrences will be given the current year as the year first recorded.

It should be noted that while the number of IAPs is expected to be cumulative over time, some species may be removed as a result of treatment. As a result, treatment records should also be tracked through the geodatabase in the GIS and submitted to the IAPP database.

3.6.3.2 Abundance

Site selection for the invasive species monitoring plots proved to be challenging. As most invasive alien plants occur in disturbed areas or along roadsides, it was difficult to identify sites that contained IAPs that would also not be disturbed in the future to allow for ongoing monitoring of the plots. Further, the georeferencing of occurrences in IAPP were generalized to the degree that the actual location of IAPs could not be determined. It is recommended that more effort be spent assessing potential plots that meet these criteria, which was limited in 2013 due to budget constraints. While Plot 1 did not contain any IAPs during the 2013 surveys, it may be worthwhile to continue monitoring this site over time due to its proximity to known IAP occurrences and vectors.

Within-year data analysis includes a comparison of the abundance of native versus alien species at each plot, while following multiple years of data collection; additional data analysis can include comparisons of the numbers and abundances over time. Changes in habitat use by wildlife may also be observed over several years. Since IAPs respond to opportunities provided by anthropogenic vectors, their distribution and abundance is often a direct response to those vectors. Identified monitoring plots that show an increase in relative abundance over time should be considered as biodiversity hotspots.

Ideally, repeat monitoring visits would occur at the same time of year to allow for a more direct comparison of between-year data as plants will be in the same developmental stages. Due to the very late developmental stage of the plants during the 2013 surveys, however, it is recommended that consecutive surveys be conducted earlier in the growing season.

Conducting surveys earlier in the growing season will also aide in the identification of the grasses and shrub that were not identified. This will affect the between-year comparisons as these species were excluded from the 2013 data analysis.

After discussion of the monitoring results from this initial year with RMOW staff and SSISC, there was concern about duplication of effort and parallel, overlapping studies. Therefore, it is recommended that the invasive species plot surveys be removed from the ecosystem monitoring program and that SSISC monitor and prepare an annual report on results.

3.7 Climate Indicators

Climate change is an over-arching, macro-scale modifier of ecosystems and ecosystem response to climate change can be mis-interpreted as being the response to meso or micro-scale effects. While the rate of change and natural periodicity of climate fluctuations is subject to debate, climate change is a generally accepted phenomenon. In consultation, with the RMOW use of Alta Lake freeze-up and thaw was selected as an indicator of climate change that is easily monitored with the potential to reveal emerging trends and cycles with the local climate. Historic records were gathered by the RMOW and combined with records provided by Stephen Vogler for the Spring Thaw Fundraiser (Figure 4 and Figure 5). The records are provided in Appendix F.

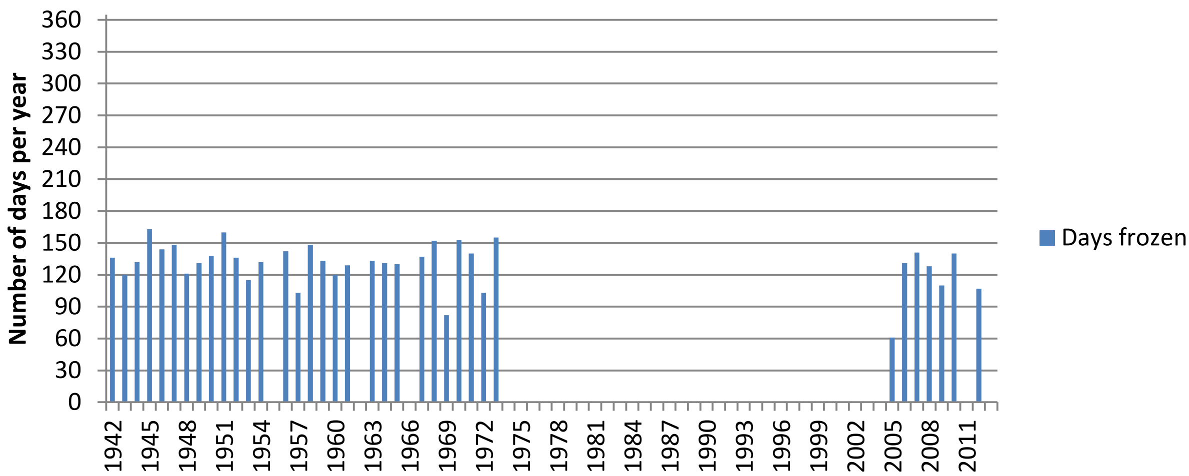


Figure 4: Number of ice days on Alta Lake – 1942 to 2012.

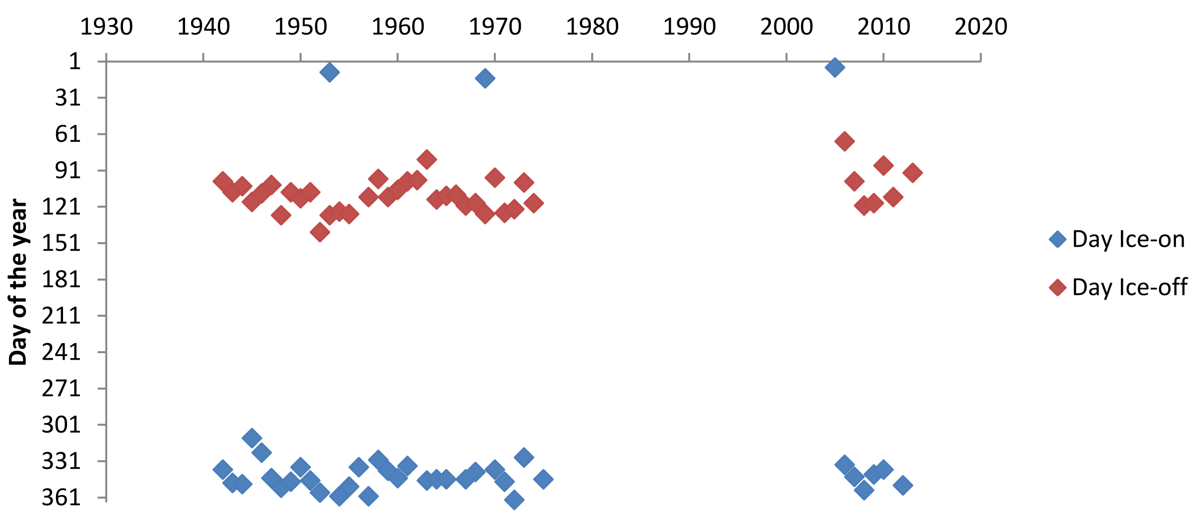


Figure 5: Dates of freeze up and thaw on Alta Lake – 1942 to 2012.

3.7.1 Discussion and Recommendations

With a discontinuous record extending back for over 70 years, the records indicate little change in the pattern or duration of freeze up for Alta Lake. These results may indicate a relatively consistent climatic pattern for the area and may appear to call into question any theories of rapid and observable climate change. However, two potentially significant factors may be influencing these results. At the meso-scale, Alta Lake is a relatively warm lake and coupled with the recent volcanism in the area, the effects of climate change may be buffered. Similarly at the macro-scale, the buffering effects from the proximity of the Pacific Ocean on coastal mountain climate are long understood (Wall and McBoyle, 1991).

While it is recommended that this indicator should continue to be monitored, other indicators should also be investigated next year. Whistler is fortunate to have a long established weather station and the data merits review with an aim to identifying other indicators such as temperature and precipitation.

4 Recommendations

4.1 General Recommendations

Ecosystem health monitoring and by association biodiversity monitoring within the RMOW aligns with the goals and objectives of the Natural Step, Whistler 2020 and the Natural Areas Strategy and the Official Community Plan 2013 (http://www.whistler2020.ca/strategy/natural_areas). However, moving from the macro-scale down to a set of relevant, measurable indicators of ecosystem health and developing a viable monitoring program is challenging. While every effort was made to keep the ecosystem monitoring program simple and cost effective, the draw of an expanded program was attractive. As with virtually all studies and development of programs, the researcher is often drawn into investigations outside the defined scope of the project. Likewise, some aspects of the program proved to be more difficult to achieve than initially anticipated at the scoping phase of the project. All of these challenges manifested themselves at some point over the course of the project. Nevertheless, as the second stage of the ecosystem monitoring program, this project should be considered another successful step on the road to the RMOW goal of moving toward sustainability. In order to prepare the way for the next phase of the ecosystem monitoring program, Cascade reached a number of conclusions based on outcomes of this phase and developed a set of recommendations that will support the program as it moves forward.

4.1.1 Standardization and the Geodatabase

By far the biggest challenge with this phase of the project was assembling the data from a wide range of source organizations and moving it into a common georeferrenced database so it could be subjected to analysis. Historically and continuing to present, there are few established data standards and as a result, groups and agencies gather and record data in a format that suits their specific needs. This issue is symptomatic at the local, regional, provincial and national levels and has no simple solution.

At the initial stages of this phase of the ecosystem monitoring project data sourcing work was completed, then the so called “low hanging fruit” was harvested and brought into the GIS. However, a considerable amount of the data was missing key attributes or was in a format that would require additional work to transform it into a common format and therefore could not be included in this phase.

4.1.1.1 Recommendations

1. As a coordinating agency, the RMOW is in a position to develop and impose (yet another) standard format for data recording by the organizations that it supports and that contribute to ecosystem monitoring and the Natural Areas Strategy. The RMOW should strike a task force, using provincial and local expertise to develop a standard database.

2. The RMOW should hire a student to work through the existing data to edit and migrate it into a format that can be used by the ecosystem monitoring program

4.1.2 Phase 3 Ecosystem Monitoring Program

The Golder study developed the rationale for ecosystem monitoring and provided initial scoping recommendations. Phase two refined the scope by selecting the indicators and developing protocols for monitoring. Should the RMOW deem that the project is worthy of carrying into the next phase, then Phase 3 should focus on the following objectives:

4.1.2.1 Recommendations

3. Execute the prescribed monitoring program for the tested indicator sites from Phase 2, complete the inventory as per the data cards and further refine the methodologies as needed.
4. Add 2 additional study plots representing the other identified sensitive terrestrial ecosystems of interest. Subject to confirmation by RMOW, the target ecosystem should be regenerating alluvial forest.
5. Investigate additional indicators for monitoring climate change in Whistler.
6. Expand participation under close supervision of QEP's, to stewardship groups and citizen scientists to increase local participation and awareness.

4.2 Survey Specific Recommendations

4.2.1 Fish Surveys

- Future studies should include surveys in a variety of habitats within the fish bearing reaches of Fitzsimmons Creek to achieve a more accurate representation of the available fish habitat.
- Futures studies should include surveys at different points throughout the length of The River of Golden Dreams to better determine fish population.
- Volunteers should undergo training in the foot survey method or shadow someone who is trained so that the data collected can be used more effectively for population estimates as opposed to presence/absence indications.

4.2.2 Water Quality Sampling

- Permanent monitoring sites and regular monitoring should be established on key Whistler creeks which will allow the RMOW to identify changes that could impact the health and productivity of aquatic and riparian flora and fauna within Whistler.

4.2.3 Wetlands Surveys

- Existing and known wetlands should be properly delineated and classified.
- Use DP process to identify and classify wetlands
- A field verification and survey should be developed based on the results of the GIS analysis.
- If higher resolution infrared imagery becomes available, the model of using infrared signals of known riparian vegetation to detect potential small and ephemeral wetlands should be fine tuned in order to more accurately predict the potential presence of new, unknown wetlands.

4.2.4 Coastal Tailed Frog Surveys

- The abundance of tailed frog tadpoles and adults should continue to be monitored in coming years to identify population trends and areas where populations may be threatened.
- If abundance surveys of Scotia Creek produce null results next year, the occurrence survey method should be used to confirm presence.

- The abundance surveys should be expanded to include additional streams with known occurrence.
- The occurrence surveys should continue to confirm presence in unsampled streams within the RMOW.

4.2.5 Beaver Surveys

- A larger area should be covered in future beaver surveys in order to identify new beaver lodges.
- Future beaver population studies should be completed as late in the year as possible to avoid *unknown* lodge status due to poor indicator levels.
- Monitoring of beaver populations should be continued in future years as an indicator of healthy ecosystems and of land management decisions in Whistler's urban environment.

4.2.6 Pileated Woodpecker Surveys

- The survey area should be expanded to include additional transects in future years.
- Future monitoring efforts should be conducted during the first week of July to capture pileated woodpecker breeding season from April to late July. This should increase survey effectiveness.

4.2.7 Red-backed Vole Surveys

- For future monitoring program, capture sessions should occur at least twice during the active season (May to October) and should be conducted at the same time each year (Last week of June and first week of October).
- The number of trapping sites should be increase in order to increase the precision of monitoring efforts.
- Traps should be set out for an increased number of nights in order to achieve a better recapture estimate.
- Vole abundance monitoring should be continued in future years to provide valuable information regarding biodiversity trends in Whistler.

4.2.8 Carabid Beetle Surveys

- Sampling should be conducted during active growing season (May to September) in order to maximize the number of species caught and the number of individuals caught. Surveys should be conducted at the same time each year (Mid July).
- The number of sample sites, or number of trap lines per site should be increased to account for the variability between sample sites in future studies.

4.2.9 Terrestrial Ecosystem Plots

- For future studies, more time should be allotted to the terrestrial ecosystem plot assessments in order to ensure that all data are properly collected.
- Portions of the terrestrial ecosystem plot assessments should be repeated in future years to allow for a between-year analysis of data that may correlate to the results of terrestrial wildlife surveys.
- Only data that is expected to change over time should be re-assessed which includes taking photos at photo points, updating successional status and structural stage, repeating vegetation, tree mensuration, tree attributes for wildlife, wildlife habitat assessment and coarse woody debris assessments.

4.2.10 Invasive Alien Plant Monitoring

- Monitoring of invasive species should be the responsibility of SSISC. The following recommendations are offered to SSISC and the RMOW based on experience monitoring this first season.
- Additional potential sources of IAP occurrence data should be collected and the existing list should be updated.
- An inventory should be conducted of current IAP occurrences within the RMOW which would consist of a team of biologists surveying transects in targeted areas such as transportation corridors and public green spaces, including lakeshores.
- More time should be spent assessing potential plots that are in disturbed areas or along roadsides, but that are not disturbed by public on a regular basis.
- Monitoring visits should occur at the same time of year (preferably earlier in growing season) to allow for a more direct comparison of between-year data as plants will be in the same developmental states.

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APPENDICES

APPENDIX A: INDIVIDUAL FISH DATA

Table 19: Fish captured during first pass at Bar 16 of Fitzsimmons Creek on August 8, 2013

<table>
<tr><th colspan="5">Daily Fish Log</th></tr>
<tr><td colspan="2">MOE licence number: SU13-86303</td><td colspan="3">DFO licence number: 13-HPAC-PA2-00396</td></tr>
<tr><td colspan="2">Project number: 013-09-07-02</td><td colspan="3">Site number (Reach): Bar 16 u/s of Spruce Grove Wooden Bridge</td></tr>
<tr><td colspan="2">Contractor: RMOW</td><td colspan="3">Field team: CRT, AB, DW, APD, RB</td></tr>
<tr><td colspan="2">Date: 2013/08/19</td><td colspan="3">Waterbody name: Fitzsimmons Creek</td></tr>
<tr><td colspan="2">Weather: Cloudy</td><td colspan="3">Waterbody location: Whistler</td></tr>
<tr><th colspan="5">Fish Collection Summary Information</th></tr>
<tr><td colspan="2">Turbidity/Visibility: _39.6____NTU
clear lightly turbid moderately turbid turbid</td><td colspan="3">GPS co-ordinates(D/S end- U/S end):
Accuracy:</td></tr>
<tr><td colspan="2">Water temperature (ºC): 6.7</td><td colspan="3">Conductivity (μS/cm): 65</td></tr>
<tr><td colspan="2">pH: 8.8</td><td colspan="3">D.O:</td></tr>
<tr><td colspan="2">Block nets: U/S D/S Partial None</td><td>Start time:</td><td colspan="2">End time:</td></tr>
<tr><td colspan="2">Electrofishing specifications</td><td colspan="3">Minnow trap specifications</td></tr>
<tr><td>Pass number: P1</td><td>Seconds: P1=2591,</td><td colspan="3">Trap number:</td></tr>
<tr><td>Voltage: 430</td><td>Frequency: 50</td><td colspan="3">Trap depth:</td></tr>
<tr><td>EF Length(m): 44</td><td>EF Width(m): 7.6</td><td colspan="3">Soak time (hrs):</td></tr>
<tr><th colspan="5">Individual Fish Data</th></tr>
<tr><th>Species</th><th>Length (mm)</th><th>Weight (gr)</th><th>Stage</th><th>Total caught</th></tr>
<tr><td>RB (P1)</td><td>30</td><td></td><td></td><td>7</td></tr>
<tr><td>RB (P1)</td><td>25</td><td></td><td></td><td>1</td></tr>
<tr><td>SC (P1)</td><td>75</td><td></td><td></td><td>8</td></tr>
<tr><td>SC (P1)</td><td>70</td><td></td><td></td><td>4</td></tr>
<tr><td>SC (P1)</td><td>65</td><td></td><td></td><td>11</td></tr>
<tr><td>SC (P1)</td><td>50</td><td></td><td></td><td>5</td></tr>
<tr><td>SC (P1)</td><td>45</td><td></td><td></td><td>9</td></tr>
<tr><td>SC (P1)</td><td>55</td><td></td><td></td><td>14</td></tr>
<tr><td>SC (P1)</td><td>60</td><td></td><td></td><td>8</td></tr>
<tr><td>BT (P1)</td><td>55</td><td></td><td></td><td>1</td></tr>
<tr><td>SC (P1)</td><td>85</td><td></td><td></td><td>2</td></tr>
<tr><td>SC (P1)</td><td>45</td><td></td><td></td><td>1 Mort.</td></tr>
<tr><td>RB (P1)</td><td>25</td><td></td><td></td><td>1</td></tr>
<tr><td colspan="5">Total number of fish collected: 71</td></tr>
<tr><td colspan="5">Comments (additional species caught): DC=15%</td></tr>
</table>

Table 20: Fish captured during second pass at Bar 16 of Fitzsimmons Creek on August 19, 2013

Daily Fish Log					
MOE licence number: SU13-86303			DFO licence number: 13-HPAC-PA2-00396		
Project number: 013-09-07-02			Site number (Reach): Bar 16 u/s of Spruce Grove Wooden Bridge		
Contractor: RMOW			Field team: CRT, AB, DW, APD, RB		
Date: 2013/08/19			Waterbody name: Fitzsimmons Creek		
Weather: Cloudy			Waterbody location: Whistler		
Fish Collection Summary Information					
Turbidity/Visibility: _39.6____NTU clear lightly turbid moderately turbid turbid			GPS co-ordinates(D/S end- U/S end): Accuracy:		
Water temperature (ºC): 6.7			Conductivity (µS/cm): 65		
pH: 8.8			D.O:		
Block nets: **U/S** **D/S** Partial None			Start time:	End time:	
Electrofishing specifications			**Minnow trap specifications**		
Pass number: P2	Seconds: P2=991,		Trap number:		
Voltage: 430	Frequency: 50		Trap depth:		
EF Length(m): 44	EF Width(m): 7.6		Soak time (hrs):		
Individual Fish Data					
Species	**Length (mm)**	**Weight (gr)**	**Stage**	**Total caught**	
SC (P2)	55			3	
RB (P2)	25			1	
SC (P2)	80			1	
SC (P2)	60			2	
BT (P2)	50			1 Mort.	
BT (P2)	65			1	
BT (P2)	55			1	
Total number of fish collected: 10					
Comments (additional species caught): DC=15%					

Table 21: Fish captured during third pass at Bar 16 of Fitzsimmons Creek on August 19, 2013

Daily Fish Log				
MOE licence number: SU13-86303		DFO licence number: 13-HPAC-PA2-00396		
Project number: 013-09-07-02		Site number (Reach): Bar 16 u/s of Spruce Grove Wooden Bridge		
Contractor: RMOW		Field team: CRT, AB, DW, APD, RB		
Date: 2013/08/19		Waterbody name: Fitzsimmons Creek		
Weather: Cloudy		Waterbody location: Whistler		
Fish Collection Summary Information				
Turbidity/Visibility: _39.6____NTU clear lightly turbid moderately turbid turbid		GPS co-ordinates(D/S end- U/S end): Accuracy:		
Water temperature (ºC): 6.7		Conductivity (µS/cm): 65		
pH: 8.8		D.O:		
Block nets: **U/S** **D/S** Partial None		Start time:	End time:	
Electrofishing specifications		**Minnow trap specifications**		
Pass number: P3	Seconds: P3=155	Trap number:		
Voltage: 430	Frequency: 50	Trap depth:		
EF Length(m): 44	EF Width(m): 7.6	Soak time (hrs):		
Individual Fish Data				
Species	**Length (mm)**	**Weight (gr)**	**Stage**	**Total caught**
Total number of fish collected: 0				
Comments (additional species caught): DC=15%				

APPENDIX B: BEAVER LODGE DATA

Table 22: Location and level of activity observed for each beaver lodge visited in Whistler, BC for 2010 and 2013. The status of each lodge was assessed; features including fresh mudding, addition of fresh trees, branches or shrubs were observed and used to make an activity level status for each lodge

Location	Easting	Northing	Year 2010	Year 2013	Observations
Wedge Pond Lodge	503224	5555745	active	active	Fresh cut twigs, muddy and worn path on lodge
Green Lake Lodge	503746	5554612	active	active	Fresh mud on path and on lodge
Fitz Fan Lodge	503847	5554866	active	*unknown*	Fresh cut twigs, worn grass path, tracks in mud
Nicklaus North Tee 12	502659	5553663	active	active	Worn path present, considerable fresh cut twigs present, freshly cut wood in lodge construction
Spruce grove #1	503653	5553302	**	inactive	No fresh cuts or fresh mudding on or near lodge
Spruce grove #2	503551	5553348	**	*unknown*	Fresh cut branches nearby
Chateau Irrigation Pond Lodge	504625	5552337	active	active	Fresh mud on dam, worn trail, fresh mud on lodge, fresh cut twigs in water
Chateau Golf Course	504184	5552221	active	*unknown*	2 lodges, prints in mud and fresh cuts around the lodges
Whistler Golf Course #2	502367	5551790	active	active	Fresh mud on lodge and prints in mud present
Nita Lake Lodge	500290	5549772	active	*unknown*	Fresh cut around lodge, no mud on lodge, no worn path to/from lodge
Alpha Lake Lodge	499203	5548997	active	inactive	Debarked branches, minimal fresh cuts
ROGD Lodge #1	502130	5552997	inactive	not found	
ROGD Lodge #2	502297	5553210	*unknown*	not found	
ROGD Lodge #3	502348	5553202	active	*unknown*	Fresh cut branches nearby
ROGD Lodge #4	502421	5553438	*unknown*	active	Fresh cut branches in lodge construction
ROGD Lodge #5	502309	5553844	active	active	Fresh cut branches in lodge construction
ROGD Lodge #6	502364	5553932	inactive	not found	No longer a lodge (destroyed)
ROGD Lodge #7	502521	5554056	inactive	not found	
ROGD Lodge #8	502635	5554124	*unknown*	not found	
ROGD Lodge #9	502440	5554221	active	active	Fresh mud and prints
ROGD Lodge #10	502645	5554445	active	active	Fresh mud and prints
ROGD Lodge #11	502660	5554457	inactive	inactive	
ROGD Lodge #12	502994	5554838	*unknown*	inactive	
ROGD Lodge #13	503142	5554830	inactive	inactive	
ROGD Lodge #14	503203	5554929	active	*unknown*	Prints in mud nearby
ROGD Lodge #15	503188	5554839	active	*unknown*	Prints in mud nearby
ROGD Lodge #16	503196	5554835	*unknown*	active	Fresh mud on lodge and fresh cuts
ROGD Lodge #17	503203	5554833	*unknown*	*unknown*	Prints in mud nearby

**These lodges were not present in the 2010 beaver survey—these lodges were added to the survey for the 2013 beaver survey.

APPENDIX C: PILEATED WOODPECKER SURVEY DATA

Table 23: Summary of cavity trees and attributes identified along Transects 1 and 2

Tree #	Tree Information				Cavity Information					
	Species	Height (m)	DBH (cm)	Decay Class*	Number of Cavities	Shape	Size (cm)	Height (m)	Signs of Recent Use	Result of Pileated Woodpecker?
Transect 1										
1	Douglas-fir	8	50	7	2	Oval	10	7-8	Appear old	Potential
2	Douglas-fir	5	50	8	1	Round	7	4	Appears old	No
3	Western hemlock	4	40	8	1	Round	6	3	Old and decayed	No
4	Western hemlock	10	45	7	Multiple	Oval	≤14	1-4	Wood chips on ground, appear fresh	Likely
5	Western hemlock	20	35-50	1	Multiple	Round to oval	1-2	All over	3 trees with sapsucker markings.	No
6	Western hemlock	8	40	8	Multiple	Round to oval	4-12	All over	Appear fresh	Potential
7	Douglas-fir	20	60	3	Multiple	Round	2-4	Near base	Some cavities appear fresh with sawdust at the base.	No
8	Western redcedar	20	65	3	Multiple	Oval	≤15	≤6	Overgrown with lichen and moss	Likely
9	Douglas-fir	3	45	8	5	Round	2-10	1	Old and quite decayed	No
10a & b	Western hemlock	3		8	6	Round	≤7	1 & 2	Appear old	No
11	Western hemlock	5	30	8	1	Round	4	1.5	Appears old	No
12	Western hemlock	8	50	8	1	Oval	Large	7	Difficult to see	Potential
13a	Western redcedar	10	25	5	2	Oval to rectangular	≤9	≤2	Appear old and overgrown	Potential
13b	Douglas-fir	15	50	4	Multiple	Oval to rectangular	≤15	All over	Some smaller holes qppear fresh with sawdust on ground	Likely
14	Western redcedar	20	50	5	3	Round to oval	4-15	≤4	Some appear fresh from colour of wood	Potential
15	Yellow cedar	18	50	2	3	Round	≤13	1.5 – 4	Old and overgrown with lichens	No
16	Yellow cedar	25	40	1	4	Oval to rectangular	≤15	2	Old and overgrown	Likely
17	Western redcedar	25	50	1	2	Oval	10-15	3	2 grown over cavities	Likely

Tree #	Tree Information				Cavity Information					
	Species	**Height (m)**	**DBH (cm)**	**Decay Class***	**Number of Cavities**	**Shape**	**Size (cm)**	**Height (m)**	**Signs of Recent Use**	**Result of Pileated Woodpecker?**
Transect 2										
1	Western redcedar	20	51	1	4	Oval to rectangular	≤10	≤2	Some with dust in bottom.	Likely
2	Western hemlock	15	45	6	Multiple	Oval	Large	All over	Old and decayed	Likely
3	Western hemlock	20	42	1	3	Oval to rectangular	≤10	≤3	Some with dust in bottom	Likely
4	Western hemlock	10	20	4	1	Round	8	4	Appears old	No

- Decay classes from MOFR and MOE, 2010.

Table 24: Survey effort at call playback stations along Transects 1 and 2

Station	Start Time	End Time	Species Detected	Comments
Transect 1				
1	0954	0959	-	
2	1036	1040	-	
3	1057	1101	-	
4	1139	1157	Red-breasted Sapsucker	Heard pecking before calls broadcasted
5	1234	1246	Red-breasted Sapsucker	Heard pecking, saw briefly
6	1255	1303	-	
7	1320	1336	Pileated Woodpecker	Flew in from NE after 2 calls
8	1414	1420	Pileated Woodpecker	Still heard Pileated Woodpecker calling from Station 7, did not play calls
9	1430	1439	-	
10	1447	1455	-	
11	1519	1530	Northern Flicker	Responded to broadcasted call
Transect 2				
1	0922	0932	-	
2	0951	1000	-	
3	1042	1052	Northern Flicker	Began chirping after first call
4	1107	1118	-	
5	1131	1145	Northern Flicker	Chirping when arrived, pair flew in
6	1201	1211	-	
7	1224	1232	-	
8	1311	1319	-	
9	1330	1339	-	
10	1359	1408	-	

APPENDIX D: SMALL MAMMAL TRAP DATA

Table 25: Small mammal trap counts on Night 1 at Site 1 near Blueberry subdivision in Whistler, BC. Traps were set in the morning on Oct. 7, 2013 and checked the morning of Oct. 8, 2013. RBV = Southern Red-backed Vole (Clethrionomys gapperi), MS = Montane Shrew (Sorex monticolus)

Trap Number	Species	Sex (M/F)	Reproductive status	Length (cm)	Notes
1	RBV	M	Subadult	7	-
2	RBV	M	Subadult	8	-
3	RBV	M	Subadult	8	-
4a	RBV	M	Juvenile	6.5	-
4b	RBV	F	Juvenile	6	Mortality
5	RBV	F	Subadult	7.5	-
6	RBV	M	Juvenile	7	-
7	Empty	-	-	-	-
8a	RBV	M	Juvenile	7	-
8b	RBV	F	Juvenile	6.5	Mortality
9	MS			4	-
10	RBV	M	Subadult	7.5	-
11	Empty	-	-	-	-
12a	Empty	-	-	-	-
12b	Empty	-	-	-	-
13	RBV	F	Subadult	8	-
14	RBV	F	Juvenile	6	-
15	RBV	M	Juvenile	7	-
16a	Empty	-	-	-	-
16b	Empty	-	-	-	-
17	Empty	-	-	-	-
18	Empty	-	-	-	-
19	RBV	F	Subadult	7.5	Mortality
20a	RBV	M	Subadult	7	-
	RBV	F	Subadult	7	-
20b	RBV	F	Subadult	7.5	-
Total Small Mammals		**18**			

Table 26: Small mammal trap counts on Night 2 at Site 1 near Blueberry subdivision in Whistler, BC. Traps were set in the morning on Oct. 8, 2013 and checked the morning of Oct. 9, 2013. RBV = Southern Red-backed Vole (Clethrionomys gapperi), MS = Montane Shrew (Sorex monticolus), LW = Least Weasel (Mustela nivalis)

Trap Number	Species	Sex (M/F)	Reproductive status	Length (cm)	Notes
1	RBV	F	Subadult	7	-
2	Empty	-	-	-	Trap triggered
3	RBV	M	Subadult	9.5	Mortality
4a	Empty	-	-	-	-
4b	Empty	-	-	-	-
5	Empty	-	-	-	-
6	RBV	F	Adult	7	-
7	Empty	-	-	-	-
8a	Empty	-	-	-	-
8b	Empty	-	-	-	-
9	Empty	-	-	-	-
10	RBV	M	Subadult	7	-
11	Empty	-	-	-	-
12a	Empty	-	-	-	-
12b	Empty	-	-	-	-
13	RBV	F	Subadult	7	-
14	Empty	-	-	-	-
15	Empty	-	-	-	-
16a	Empty	-	-	-	-
16b	Empty	-	-	-	-
17	Empty	-	-	-	-
18	Empty	-	-	-	Trap triggered
19	Empty	-	-	-	-
20a	LW	-	-	20	-
20b	Empty	-	-	-	-
Total Small Mammals		**6**			

Table 27: Small mammal trap counts on Night 1 at Site 2 near Rainbow Lake Trail parking lot in Whistler, BC. Traps were set in the afternoon on Oct. 7, 2013 and checked the afternoon of Oct. 8, 2013. RBV = Southern Red-backed Vole (Clethrionomys gapperi), MS = Montane Shrew (Sorex monticolus)

Trap Number	Species	Sex (M/F)	Reproductive status	Length (cm)	Notes
1	RBV	M	Adult	9	-
2	Empty	-	-	-	-
3	Empty	-	-	-	-
4a	Empty	-	-	-	-
4b	Empty	-	-	-	-
5	Empty	-	-	-	-
6	MS	-	-	4	Mortality
7	Empty	-	-	-	-
8a	Empty	-	-	-	-
8b	Empty	-	-	-	-
9	Empty	-	-	-	-
10	Empty	-	-	-	-
11	Empty	-	-	-	-
12a	Empty	-	-	-	-
12b	Empty	-	-	-	-
13	Empty	-	-	-	-
14	Empty	-	-	-	-
15	MS	-	-	4	-
16a	Empty	-	-	-	-
16b	Empty	-	-	-	-
17	RBV	M	Subadult	8	Tick on nose
18	Empty	-	-	-	-
19	Empty	-	-	-	-
20a	Empty	-	-	-	-
20b	Empty	-	-	-	-
Total Small Mammals		**4**			

Table 28: Small mammal trap counts on Night 2 at Site 2 near Rainbow Lake Trail parking lot in Whistler, BC. Traps were set in the afternoon on Oct. 8, 2013 and checked the morning of Oct. 9, 2013. RBV = Southern Red-backed Vole (Clethrionomys gapperi), MS = Montane Shrew (Sorex monticolus)

Trap Number	Species	Sex (M/F)	Reproductive status	Length (cm)	Notes
1	Empty	-	-	-	-
2	Empty	-	-	-	-
3	RBV	F	Subadult	7	Mortality
4a	Empty	-	-	-	-
4b	Empty	-	-	-	-
5	Empty	-	-	-	-
6	Empty	-	-	-	-
7	Empty	-	-	-	-
8a	Empty	-	-	-	-
8b	Empty	-	-	-	-
9	Empty	-	-	-	-
10	Empty	-	-	-	-
11	Empty	-	-	-	Trap triggered
12a	Empty	-	-	-	-
12b	Empty	-	-	-	-
13	Empty	-	-	-	-
14	Empty	-	-	-	-
15	Empty	-	-	-	Trap triggered
16a	Empty	-	-	-	-
16b	Empty	-	-	-	-
17	Empty	-	-	-	-
18	Empty	-	-	-	-
19	Empty	-	-	-	-
20a	Empty	-	-	-	-
20b	Empty	-	-	-	Trap triggered
Total Small Mammals		**1**			

APPENDIX E: INVASIVE PLANT SPECIES DATA

Table 29: Invasive Alien Plant Species in the RMOW and date of first observation

Species Name	Common Name	Year First Observed in RMOW	Source
Tanacetum vulgare	Common tansy	2006	IAPP database
Hypericum perforatum	St. John's wort/ Goatweed	2006	IAPP database
Arctium spp	Burdock species	2006	IAPP database
Cirsium arvense	Canada thistle	2006	IAPP database
Cirsium vulgare	Bull thistle	2006	IAPP database
Leucanthemum vulgare	Oxeye daisy	2006	IAPP database
Fallopia japonica	Japanese knotweed	2006	IAPP database
Hieracium aurantiacum	Orange hawkweed	2006	IAPP database
Cytisus scoparius	Scotch broom	2006	IAPP database
Verbascum thapsis	Mullein	2007	IAPP database
Centaurea biebersteinii	Spotted knapweed	2007	IAPP database
Potentilla recta	Sulphur cinquefoil	2007	IAPP database
Hieracium spp	Hawkweed species	2007	IAPP database
Sonchus species	Sowthistle species	2007	IAPP database
Hypochaeris radicata	Hairy cat's-ear	2007	IAPP database
Matricaria perforata	Scentless chamomile	2010	IAPP database
Rumex crispus	Curled dock	2010	IAPP database
Rumex acetosella	Sheep sorrel	2010	IAPP database
Tragopogon dubius	Western goat's-beard	2010	IAPP database
Iris pseudachoris	Yellow iris	2010	IAPP database
Centaurea spp.	Knapweed species	2010	IAPP database
Hieracium pratense	Yellow hawkweed	2010	IAPP database
Euphorbia cyparissias	Cypress spurge	2010	IAPP database
Sinapis arvensis	Wild mustard	2010	IAPP database
Impatiens glandulifera	Policeman's helmet/himalayan balsam	2010	IAPP database
Lamiastrum galeobdolon	Yellow archangel	2010	IAPP database
Vinca minor	Common periwinkle	2010	IAPP database
Sonchus oleraceus	Annual sow thistle	2010	IAPP database
Berteroa incana	Hoary alyssum	2010	IAPP database
Linaria vulgaris	Yellow/common toadflax	2010	IAPP database
Senecio vulgaris	Groundsel	2010	IAPP database
Senecio jacobaea	Tansy ragwort	2010	IAPP database
Centaurea diffusa	Diffuse knapweed	2010	IAPP database

Table 30: Plant abundance by species at Plot 1 of the terrestrial ecosystem plots

Common Name	Scientific Name	Native/Non-Native	Developmental Stage	Stem Count	Area Covered (m^2)	Percent Cover
Western hemlock	*Tsuga heterophylla*	Native	Tree	18	80	20
Western hemlock	*Tsuga heterophylla*	Native	Sapling	21	10	2.5
Western redcedar	*Thuja plicata*	Native	Tree	7	25	6.25
Western redcedar	*Thuja plicata*	Native	Sapling	30	20	5
Douglas-fir	*Pseudotsuga menziesii*	Native	Tree	2	6	1.5
Douglas-fir	*Pseudotsuga menziesii*	Native	Sapling	12	2	0.5
Western white pine	*Pinus monticola*	Native	Sapling	1	0.1	0.025
Sitka spruce	*Picea sitchensis*	Native	Sapling	2	0.5	0.125
Amabilis fir	*Abies amabilis*	Native	Tree (fallen)	1	2	0.5
Sitka Mountain-ash	*Sorbus sitchensis*	Native	Senescence	73	3	0.75
Red huckleberry	*Vaccinium parviflorum*	Native	Senescence	120	5	1.25
Oval-leaved/Alaska blueberry	*Vaccinium ovalifolium/alaskense*	Native	Senescence	2300	100	25
Black huckleberry	*Vaccinium membranaceum*	Native	Senescence	3	0.1	0.025
Salal	*Gaultheria shallon*	Native	Leaf	380	1	0.25
Prince's pine	*Chimaphila umbellata*	Native	Leaf	830	4	1
Bunchberry	*Cornus canadensis*	Native	Leaf	525	2	0.5
Kinnikinick	*Arctostaphylos uva-ursi*	Native	Berry	350	3	0.75
One-sided wintergreen	*Orthilia secunda*	Native	Leaf	265	1	0.25
Sitka burnet	*Sanguisorba canadensis*	Native	Senescence	34	0.5	0.125
Twinflower	*Linnea borealis*	Native	Leaf	700	0.5	0.125
Falsebox	*Paxistima myrsinites*	Native	Leaf	4	0.2	0.05
Rattlesnake-plantain	*Goodyera oblongifolia*	Native	Leaf	125	1	0.25
Sample C	Unknown	Unknown	Senescence	14	0.5	0.125
TOTAL				**5817**	**267.4**	**66.85**

Table 31: Plant abundance by species at Plot 2 of the terrestrial ecosystem plots

Common Name	Scientific Name	Native/Non-Native	Stem Count	Area Covered (m^2)	Percent Cover
Great mullein	*Verbascum thapsus*	Non-native	201	3	0.75
Coastal strawberry	*Fragaria chiloensis*	Native	320	3	0.75
Thimbleberry	*Rubus parviflorus*	Native	30	1	0.25
Himalayan blackberry	*Rubus armeniacus*	Non-native	10	0.5	0.125
Saskatoon	*Amelanchier alnifolia*	Native	55	2	0.5
Oceanspray	*Holodiscus discolor*	Native	45	2	0.5
Douglas-fir	*Pseudotsuga menziesii*	Native	8	3	0.75
Western dock	*Rumex aquaticus*	Native	4	0.1	0.025
Oxeye daisy	*Leucanthemum vulgare*	Non-native	465	2	0.5
Yarrow	*Achillea millefolium*	Native	540	5	1.25
Common tansy	*Tanacetum vulgare*	Non-native	130	1.5	0.375
Black cottonwood	*Populus trichocarpa*	Native	22	8	2
Black twinberry	*Lonicera involucrata*	Native	185	5	1.25
Sheep sorrel	*Rumex acetosella*	Non-native	185	2	0.5
Hardhack	*Spiraea douglasii*	Native	230	3	0.75
Lodgepole pine	*Pinus contorta*	Native	1	3	0.75
Unidentified shrub	Unknown	Unknown	80	1	0.25
Falsebox	*Pachistima myrsinites*	Native	155	3	0.75
Edible thistle	*Cirsium edule*	Non-native	5	0.5	0.125
Western hemlock	*Tsuga heterophylla*	Native	1	0.5	0.125
Pearly everlasting	*Anaphalis margaritacea*	Native	66	1	0.25
Vilous cinquefoil	*Potentilla villosa*	Native	1	0.1	0.025
Yellow salsify	*Tragopogon dubius*	Non-native	4	0.1	0.025
Lupine	*Lupinus*	Native	1	0.1	0.025
Tufted hairgrass	*Deschampsia cespitosa*	Native	Unknown	15	3.75
Quackgrass	*Elymus repens*	Non-native	Unknown	20	5
Western fescue	*Festuca occidentalis*	Native	Unknown	5	1.25
Orchard grass	*Dactylis*	Non-native	Unknown	1	0.25
Unidentified grasses	Unknown	Unknown	Unknown	120	30
TOTAL			**2744**	**59.8**	**30.6**

Appendix F: Climate Change Indicators

Table 32: Alta Lake Ice Records

Year	Ice-On	Ice-Off	Barrel	Day Ice-on	Day Ice-off	Year	Year	Days frozen
1942	04-Dec-42	10-Apr-42		338	100	1942	1942	136.00
1943	15-Dec-43	19-Apr-43		349	109	1943	1943	120.00
1944	15-Dec-44	13-Apr-44		350	104	1944	1944	132.00
1945	08-Nov-45	27-Apr-45		312	117	1945	1945	163.00
1946	20-Nov-46	20-Apr-46		324	110	1946	1946	144.00
1947	11-Dec-47	13-Apr-47		345	103	1947	1947	148.00
1948	18-Dec-48	07-May-48		353	128	1948	1948	121.00
1949	14-Dec-49	19-Apr-49		348	109	1949	1949	131.00
1950	02-Dec-50	24-Apr-50		336	114	1950	1950	138.00
1951	13-Dec-51	19-Apr-51		347	109	1951	1951	160.00
1952	22-Dec-52	21-May-52		357	142	1952	1952	136.00
1953	10-Jan-54	08-May-53		10	128	1953	1953	115.00
1954	26-Dec-54	05-May-54		360	125	1954	1954	132.00
1955	18-Dec-55	07-May-55		352	127	1955	1955	
1956	01-Dec-56			336		1956	1956	142.00
1957	26-Dec-57	23-Apr-57		360	113	1957	1957	103.00
1958	26-Nov-58	08-Apr-58		330	98	1958	1958	148.00
1959	05-Dec-59	23-Apr-59		339	113	1959	1959	133.00
1960	10-Dec-60	16-Apr-60		345	107	1960	1960	120.00
1961	01-Dec-61	10-Apr-61		335	100	1961	1961	129.00
1962		09-Apr-62	21-Apr-62		99	1962	1962	
1963	13-Dec-63	23-Mar-63		347	82	1963	1963	133.00
1964	11-Dec-64	24-Apr-64		346	115	1964	1964	131.00
1965	12-Dec-65	22-Apr-65		346	112	1965	1965	130.00
1966		21-Apr-66			111	1966	1966	
1967	12-Dec-67	30-Apr-67		346	120	1967	1967	137.00
1968	05-Dec-68	27-Apr-68		340	118	1968	1968	152.00
1969	15-Jan-70	07-May-69		15	127	1969	1969	82.00
1970	04-Dec-70	06-Apr-70		338	97	1970	1970	153.00
1971	14-Dec-71	06-May-71		348	126	1971	1971	140.00
1972	28-Dec-72	02-May-72		363	123	1972	1972	103.00
1973	24-Nov-73	11-Apr-73		328	101	1973	1973	155.00
1974		28-Apr-74			118	1974	1974	
1975	12-Dec-75			346		1975	1975	
1976						1976	1976	
1977						1977	1977	

Year	Ice-On	Ice-Off	Barrel	Day Ice-on	Day Ice-off	Year	Year	Days frozen
1978						1978	1978	
1979						1979	1979	
1980						1980	1980	
1981						1981	1981	
1982						1982	1982	
1983						1983	1983	
1984						1984	1984	
1985						1985	1985	
1986						1986	1986	
1987						1987	1987	
1988						1988	1988	
1989						1989	1989	
1990						1990	1990	
1991						1991	1991	
1992						1992	1992	
1993						1993	1993	
1994						1994	1994	
1995						1995	1995	
1996						1996	1996	
1997						1997	1997	
1998						1998	1998	
1999						1999	1999	
2000						2000	2000	
2001						2001	2001	
2002			14-Apr-02			2002	2002	
2003			17-Mar-03			2003	2003	
2004			25-Mar-04			2004	2004	
2005	6-Jan-06		Tropical Punch?	6		2005	2005	61.00
2006	30-Nov-06	8-Mar-06		334	67	2006	2006	131.00
2007	10-Dec-07	10-Apr-07	29-Apr-08	344	100	2007	2007	141.00
2008	20-Dec-08	29-Apr-08	29-Apr-09	355	120	2008	2008	128.00
2009	08-Dec-09	28-Apr-09	28-Mar-11	342	118	2009	2009	110.00
2010	04-Dec-10	28-Mar-10	23-Apr-11	338	87	2010	2010	140.00
2011		23-Apr-11	23-Apr-12		113	2011	2011	
2012	16-Dec-12		02-Apr-13	351		2012	2012	107.00
2013		03-Apr-13			93	2013	2013	