OYAMA AND VERNON CREEK SOURCE WATER ASSESSMENT

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EXECUTIVE SUMMARY

Ecoscape Environmental Consultants Ltd. (Ecoscape) has completed a Source Water Assessment of the Oyama and Vernon Creek watersheds for the District of Lake Country (DLC). This health risk assessment is required by the Interior Health Authority and it broadly follows Modules 1, 2, 7 and 8 of the draft Comprehensive Drinking Water Source to Tap Assessment Guidelines (MHS & MWLAP, 2005). The overall objectives of the assessment were to characterize and delineate the watershed area, identify current and/or future drinking water hazards and vulnerabilities, characterize the risk posed by each hazard and provide recommendations to reduce the overall impacts on source water.

The Oyama and Vernon Creek watersheds together encompass approximately 141.1 km^2. They are located east of the DLC and expand across four biogeoclimatic zones. Together, the two community watersheds supply the DLC with approximately 80% of their source water. Both watersheds are dependent on upland storage reservoirs that rely on snow pack for annual water regeneration and supply needs.

The assessment characterized all hazards (both intrinsic and anthropogenically influenced) that have the potential of effecting surface water quantity and quality. Hazards identified in the assessment were generally categorized into three different hazard types: biological, chemical or physical. The risk of most hazards is very much dependent on where a hazard occurs within the watershed. Therefore, the assessment area was divided into very high, high, moderate and low vulnerability zones and the risk of the hazards were evaluated individually for the different vulnerability zones (to simplify the analysis, very high and high were treated as one).

Watershed vulnerability was determined based on three broad measures including: distance to water, buffering capacity, and terrain features. Very high vulnerability zones include all locations below the high water level of watercourses in the residual areas (e.g. lower watershed), and high vulnerability zones include buffers surrounding watercourses in the lower watershed and below the high water level of watercourses in the upland basins.

Intrinsic hazards included the presence of birds and wildlife, raw water characteristics including high turbidity associated with spring freshet, the potential for slope failures/debris flows, wildfire, climate change, mountain pine beetle, and algal blooms. Anthropogenically influenced hazards included human access and recreation, land ownership (including private and Crown leased lots), forestry, roads and associated stream crossings, livestock, mining and wind generation.

Four of the identified hazards; characteristics of raw water, mountain pine beetle, climate change and affects of forestry on peak flows were evaluated for risk independently of vulnerability zones, while roads and associated stream crossings were evaluated using a more detailed, semi-quantitative analysis. The remaining ten hazards were given a risk rating (Likelihood x Consequence = Risk) based on the assumption that a contaminant generated by a specific hazard in each of the vulnerability zones would have to travel from the site of contamination to the intake, where it may have an effect on water quality and thus human health. In the very high and high

vulnerability zones, nine hazards were identified and eight of the nine have a high to very high risk level depending on the severity of the event. For comparison, the evaluation in the low vulnerability zone identified nine hazards, one of which had a high risk rating.

Site specific contaminants, including 27 and 28 in the Oyama and Vernon Creek watersheds respectively, were also identified and are summarized in contaminant summary tables. The risk of each contaminant is determined and specific risk management actions with suggested timelines are included.

Recommendations, or risk management actions were put forth to reduce the overall impact on source water. Examples of broad recommendations include: 1) Activities which generate drinking water hazards (both existing and proposed) should avoid very high and high vulnerability zones; 2) Ensure that governmental agencies have the resources available to provide adequate levels of compliance and enforcement; 3) Development of a single depository for watershed reports and associated GIS data to ensure proper storage, easy accessibility and to promote the use of existing data to appropriately evaluate future changes to the watersheds; 4) DLC should be given the opportunity to provide comment and to integrate source water protection concerns on all land use decisions (e.g. changes to existing zoning, proposed development) through a well established referral process; 5) A detailed access management plan which prioritizes areas for access (motorized and non-motorized) and identifies other areas that could be decommissioned should be carried out; 6) Water quality should be a priority for watershed users and stakeholders. A universal monitoring system and reporting procedure should be developed so that stakeholders can notify the appropriate personnel if concerns are identified; and 7) A mapping initiative (GPS inventory) of fences and cattle guards should be undertaken to assess the effectiveness of existing structures and to gain a broader understanding of how and where cattle are gaining access to source streams, diversions and reservoirs.

Given the diversity of drinking water hazards that currently exist in the Oyama and Vernon Creek watersheds, it is imperative that the various stakeholder groups come together to do their part to reduce the risks on source water. Several of the identified drinking water hazards are highly regulated (e.g. forestry), while others are not (various forms of recreation). Access is the underlying hazard which facilitates increased risk levels of other hazards, (e.g. recreation, livestock) and thus implementation of a comprehensive *Access Management Plan* should be a high priority.

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DISCLAIMER

The results contained in this report are based on data collected during surveys occurring over less than a one-year period. Biophysical systems respond differently both in space and time, resulting in variability in risks to water quality. For this reason, conservative assumptions have been used and these assumptions are based upon field results, previously published material and air photo interpretation. Due to the inherent problems of brief inventories (e.g., property access, GPS/GIS accuracies, air-photo interpretation concerns, etc.), professionals should complete their own detailed assessments of source water areas to understand, evaluate, classify, and reach their own conclusions. Data in this assessment was not analyzed statistically and no inferences about statistical significance should be made if the word significant is used. Use of or reliance upon conclusions made in this report is the responsibility of the party using the information. Neither, Ecoscape Environmental Consultants Ltd., District of Lake Country, nor the authors of this report are liable for accidental mistakes, omissions, or errors made in preparation of this report because best attempts were made to verify the accuracy and completeness of data collected and presented.

Source Water Protection is everyone's concern!

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1.0 BACKGROUND

Throughout the last several decades drinking water legislation and requirements in British Columbia have been continually updated to reflect the most recent theories on how to adequately protect drinking water. The importance of the mandate cannot be understated, as safe drinking water is a basic necessity for each and every one of us. British Columbia continues to make the availability of safe drinking water a vital public health priority (MHS & MWLAP, 2005). With the most recent updates, water suppliers are now regulated under the Drinking Water Protection Act (DWPA; enacted in May, 2003). A legal requirement of Section 8 of the DWPA is a drinking water source assessment, which generally occurs as a condition of the permit. The source to tap assessment is thought to provide a consistent approach for thoroughly evaluating risks to the drinking water supply (MHS & MWLAP, 2005).

The source to tap theory follows a multi-barrier approach to regulate drinking water by highlighting the importance of thoroughly understanding the drinking water supply from the source all the way to the consumer's tap. By carefully considering all aspects of each step from the source water to the tap, potential and known hazards can be identified, and barriers can be put in place to either eliminate or minimize the potential impacts to safe drinking water. This approach recognizes that while each individual barrier may not completely prevent contamination, together the multiple barriers provide a greater assurance that water is and will be safe to drink in the long term.

The Interior Health Authority has directed the District of Lake Country (DLC) to conduct a Source Water Assessment of the Oyama and Vernon Creek watersheds. Both the Oyama Creek and Vernon Creek watersheds have been integrated into one assessment for ease of use by the DLC. The following source assessment follows Modules 1, 2, 7 and 8 of the draft Comprehensive Drinking Water Source to Tap Assessment Guidelines (the Guideline) (MHS & MWLAP, 2005). They are further guided by review and comments from relevant watershed stakeholders. Only modules relevant to the water source are considered. The overall objectives of this source water assessment are to identify current and/or future drinking water health hazard(s) and vulnerabilities, characterize the risk posed by each identified hazard and provide recommendations to reduce the overall impacts on the drinking water source.

2.0 INTRODUCTION

The DLC supplies domestic and irrigation water for the communities of Oyama, Winfield, Okanagan Centre, and Carr's Landing. Eighty (80%) percent of the water delivered to the Lake County communities originates from the Oyama and Vernon Creek watersheds. Infrastructure within these watersheds was constructed approximately 100 years ago for irrigation, but in the 1970's the systems were updated, and evolved to become a major domestic water supply. As the service population continues to expand, there has been a significant increase on the demands of these watersheds.

Both the Oyama and Vernon Creek watersheds are multi-use and have numerous on-going activities (e.g. forestry, range, recreation, etc.). Under the BC Government's Action Plan for Safe Drinking Water, the primary responsibility for protecting drinking water from land-use activities lies with the agency responsible for approving those activities. This can create complex governance that makes addressing source water concerns a significant challenge.

Ecoscape Environmental Consultants Ltd. (Ecoscape) has been retained to assist the DLC in the implementation of source water assessments for both the Oyama and Vernon Creek watersheds. In doing so, Ecoscape evaluated components and factors contributing to the source water prior to it passing through the intake. Our assessment has gathered as much current information as possible, identifies existing and future drinking water hazards, and characterizes their associated risks.

3.0 MODULE 1

3.1 Objectives

The broad objective of Module 1 is to delineate and characterize the surface drinking water source(s). Because the drinking water sources (surface water only) include creeks and reservoirs, the assessment components are as follows:

1. Delineate the contributing watershed area;
2. Define the assessment area in which to conduct the source characterization and potential contaminant source inventory;
3. Characterize the watershed and water bodies; and
4. Evaluate the integrity and location of the intake.

Characterization of the drinking source water area involves the evaluation of source water characteristics, including surrounding lands to gain insights on the biogeophysical influences. The objective is not only to characterize the source area, but also to evaluate the biogeophysical features and their implications for water quality and quantity.

3.2 Methodology

To achieve the objectives described above, Ecoscape used a range of methodologies. Detailed mapping was completed using GIS and GPS technologies. Field personnel spent 10 days (2 person crew) ground truthing the watersheds to accurately characterize reservoirs, source streams, water diversions, infrastructure, and existing and potential water quality hazards.

In addition to field work, Ecoscape compiled existing data/information through communications with private and governmental agencies that have a working interest in the watersheds. A literature review using a number of sources was also utilized. The DLC was instrumental in providing relevant literature and reports, while additional studies were accessed through the Ecological Reports Catalogue (EcoCat). Spatial and statistical data was obtained from various governmental agencies including Environment Canada, the Ministry of Forests and Range, the Ministry of Environment, as well as from other watershed stakeholders such as forest licensees. A comprehensive listing of references is included in the Literature Cited section.

Ecoscape has relied upon information provided to us and has assumed the accuracy of this information. A tremendous amount of spatial GIS data has been collected and reviewed as part of this assessment and new spatial information has been created.

3.2.1 Hazard Definition and General Hazard Types

The Canadian Council of Ministers of the Environment (2004) provides the following definition for a hazard: “Hazard refers to a source of potential harm to the functioning of any aspect of the drinking water system or to human health”.

For the purposes of this assessment, potential hazards are separated into either: 1) natural biogeophysical; or 2) anthropogenically influenced. Module 1 details the natural biogeophysical features that occur within the assessment areas and identifies any features which may act as a hazard. A summary of these potential hazards appears in Table 1-12 in Section 3.9 of Module 1.

Module 2 identifies all anthropogenic activities that exist within the assessment area and provides a discussion of their potential to act as a hazard. Anthropogenic hazards are summarized in Table 2-9 in Section 4.5 of Module 2.

Potential hazards identified in this report can generally be categorized into three different hazard types: biological, chemical or physical. The following table lists specific contaminants associated with each of the three hazard types and their possible effects on water quality and ultimately human health. This classification system has been commonly used by others to categorize water contaminants or hazards (e.g., Dobson Engineering Ltd., 2007, Olson-Russello and Schleppe, 2009).

Table 1-1. Hazard Types and Possible Effects.

Hazard Type	Contaminant	Possible Effects
Biological	**Bacteria** – contamination can result from wildlife, human presence, domestic pets & cattle.	• Waterborne illnesses including *Salmonella, Camplyobacter, E. coli* • Risk to human health
	Protozoa – contamination can result from wildlife, human presence, domestic pets & cattle.	• Waterborne illnesses including *Giardia, Cryptosporidium, Toxoplasma* • Risk to human health
	Viruses - contamination can result from wildlife, human presence, domestic pets & cattle.	• Waterborne illnesses including viral gastroenteritis, hepatitis A, poliomyelitis • Risk to human health
Physical	**Sedimentation** - resulting from either natural or anthropogenic influences (e.g. landslide; road development)	• Alters turbidity, total suspended solids, total dissolved solids, specific conductivity and pH. • Can compromise disinfection process • Risk to human health
	Total Organic Carbon - resulting from water percolating through the upper soil layers releasing organic materials and thus carrying higher concentrations of organic carbon.	• Reaction of organics (total organic carbon) with water disinfection resulting in formation of trihalomethanes (THMs) in drinking water • Risk to human health
Chemical	**Hydrocarbons** – Petroleum contamination from industrial fuel spill or recreational vehicles.	• Contamination of drinking water • Risk to human health
	Pesticides/herbicides/fertilizers - From applications on private and crown lands	• Contamination of drinking water • Risk to human health

3.3 Licensed Stakeholders and Other Relevant Parties

A watershed stakeholder meeting was held on September 23, 2009 with the intension of briefing stakeholders on the work completed thus far and to gain input on any outstanding issues which remain in the watersheds. The stakeholder meeting facilitated discussions in four major areas including: forestry, recreation, private holdings/lease lots, and livestock. There was also an open comment session where stakeholders could bring up additional concerns and provide further information.

In addition to group discussion, stakeholders were asked to complete a questionnaire, as well as to pinpoint areas of concern on a poster map. The questionnaire, with stakeholder responses is included in Appendix A. In response to the question, “What do you see as the greatest threat to drinking water quality?” the most common answer was not a single hazard, but rather a combination of hazards resulting in cumulative impacts. Encouragingly, a collaborative approach to the resolution of issues was the most frequent response to the question, “What are the most important steps that should be undertaken to successfully protect source water?”

A second stakeholder meeting was held on January 27, 2010. At this meeting, stakeholders voiced concerns and comments pertaining to the initial draft report. Stakeholders also provided written comments that were incorporated into the final document.

The minutes from the September 23 and January 27 stakeholder meetings are included in Appendix B and a comprehensive list of stakeholders is provided in Table 1-2.

Table 1-2. Stakeholders and other relevant parties with interests in the Oyama and Vernon Creek watersheds.

Watershed	Stakeholder	Level of Interest
Both	District of Lake Country (DLC)	Water Licensee and Local Government
Both	Interior Health Authority (IHA)	Oversees Drinking Water Safety
Both	Regional District of Central Okanagan (RDCO)	Local Government
Oyama	North Okanagan Regional District (NORD)	Local Government
Both	Ministry of Forests and Range (MOFR)	Oversees Forestry and Range Resources
Both	Ministry of Environment (MOE)	Source Water Protection
Both	Ministry of Tourism, Culture and the Arts (MOTCA)	Oversees Recreational Activities
Vernon	Ministry of Transporation (MOT)	Oversees Provincial Roads
Both	Integrated Land Management Bureau (ILMB)	Oversee Land Resources
Oyama	BC Timber Sales	Forestry Licensee
Both	Tolko	Forestry Licensee
Both	Small Scale Salvage Program	Forestry Licensee
Both	Okanagan Indian Band	Aboriginal Interests
Both	First Nations Alliance	Aboriginal Interests
Vernon	Beaver Lake Resort	Resort Licensee
Vernon	Dee Lake Wilderness Resort	Resort Licensee
Oyama	Oyama Lake Fishing Lodge	Resort Licensee
Oyama	Cabin Owners (13)	Lease Lots
Vernon	Cabin Owners (42)	Lease Lots
Oyama	Dave Allingham	Grazing Licensee
Oyama	George Holt	Grazing Licensee
Vernon	Coldstream Ranch	Grazing Licensee
Vernon	Macintosh Properties	Private Land Owner
Vernon	Alto Utilities Ltd.	Private Land Owner
Oyama	Pier Mac	Private Land Owner
Oyama	Dave Young	Private Land Owner
Both	Kelowna Snowmobile Club	Recreational Interests
Both	Okanagan Trail Riders	Recreational Interests
Both	Oceola Fish and Game Club	Recreational and Environmental Protection Interests
Both	LC Environmental Society	Environmental Protection Interests

3.4 Watershed Boundary and Assessment Area Delineation

Ecoscape obtained the watershed boundary information (shapefiles) from Fergus Stewart of FPS Drafting & Geomatics Ltd. We understand that the boundaries were acquired from Tolko, and then compared with 1:20,000 provincial contour data to pinpoint any glaring errors. The boundaries were then modified as necessary to achieve sufficient accuracy. The watershed boundaries, as shown in Figure 1-1 depict the entire drainage area associated with each watershed. Due to their adjacency, both watersheds are displayed on a single figure.

Although Figure 1-1 illustrates the entire watershed boundary, it is important to understand that this assessment addresses a smaller subset of the area. Specifically, as recommended by the Guideline, the assessment area encompasses the entire watershed upstream of the intake and the 100 m radius surrounding the intake structure (see Figure 1-2). Therefore, the total assessment areas for the Oyama and Vernon Creek watersheds are 42.5 and 85.2 km^2, respectively (see Table 1-3). Of additional note, the Vernon assessment area does not include the Clark Creek sub-basin which enters Vernon Creek approximately 110 m below the DLC intake.

Table 1-3. Details Pertaining to Oyama and Vernon Creek Watersheds.

Watershed	Watershed Code	Watershed Area (km^2)	Assessment Area (km^2)	2007 BCGS orthophotos (1:20,000; 500 mm pixel)
Oyama Creek	310-939400-34700	43.5	42.5	82L.004, 82L.014, 82L.015
Vernon Creek	310-939400	97.6	85.2	82L.004, 82L.005, 82L.014, 82L.015

3.5 Characterization of Source Areas

The Oyama and Vernon Creek watersheds are located east of the DLC in the Southern Interior of British Columbia. Both watersheds are snow dominated hydrologic systems with peak flows occurring from mid-April through June. They are both used as a source of domestic and irrigation water supply.

3.5.1 Oyama Creek Watershed

Historic hydrometric records are available for Oyama Creek, as two hydrometric stations have been previously operated. Data was collected between 1920 and 1931 at the Oyama diversion during the summer months only (WSC Station #08NM028), and between 1921 and 1987 above the DLC intake (WSC Station #08NM048; 50º 6’ 57”, 119º 20’ 5” W) (Water Survey Canada, 2009). Figure 1-3 includes a subset of the flow data (1973-1986[1]; WSC Station #08NM048) and illustrates the mean monthly discharge of Oyama Creek. The hydrograph shows the snow dominated system with snowmelt driving peak flows. The graph also illustrates the variability of peak flows amongst years, which is largely dependent on the levels of snow pack and spilling time of reservoirs. Usage data by the DLC is also included to show the portion of the Oyama Creek flows utilized by the district. Water not brought in to the distribution system continues downstream as conservation and fish flows.

[1] Only the years with a complete dataset are included in the graph.

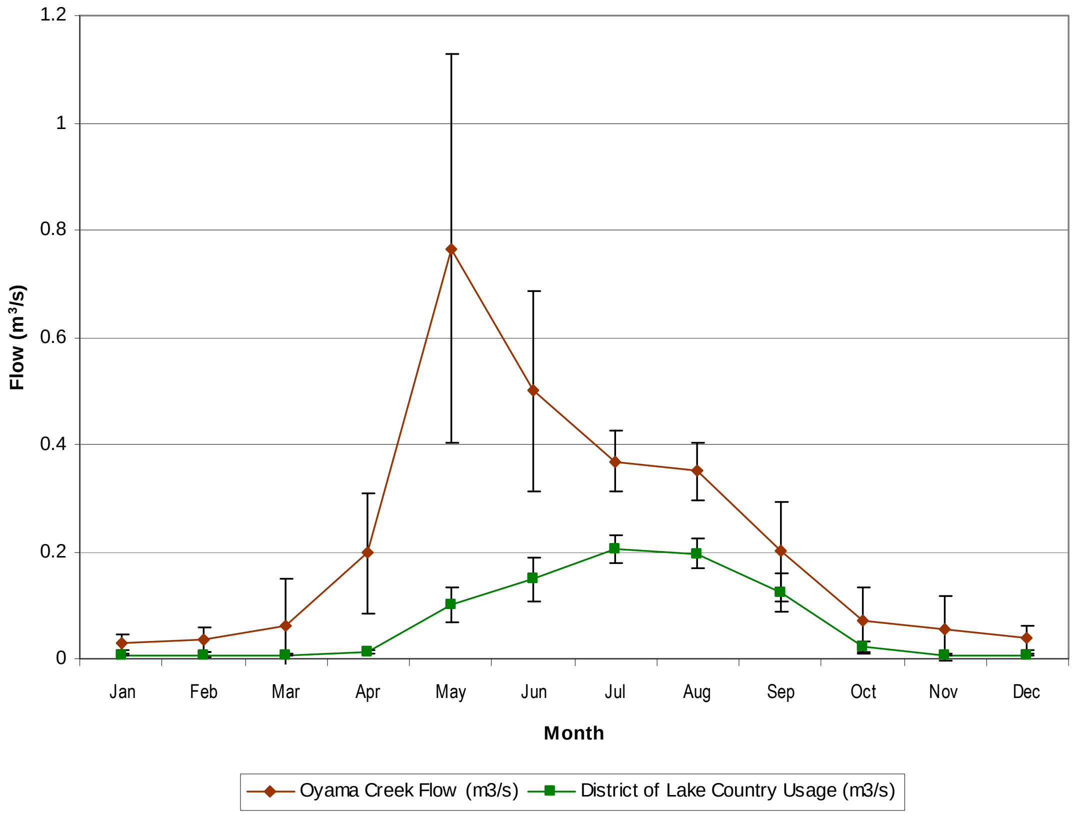


Figure 1-3. Mean monthly discharge data (±SD) for Oyama Creek above the DLC intake (WSC Station 08NM048, 1973-1986) compared with DLC usage from 2004-2008.

Upper Oyama Residual

There are two distinctive hydrometric basins (Oyama North Basin and Oyama Lake Basin) and one residual area within the assessment area of the Oyama Creek watershed (see Figure 1-4a). A lower Oyama residual also exists, but it is outside of the assessment area and therefore is not included in this discussion.

The upper Oyama residual includes all areas and portions of Oyama Creek below Oyama Lake and portions of Oyama Creek North below Chatterton Lake to the DLC intake. Oyama Creek is the main creek within the watershed. It is a third order stream that originates in the Oyama Lake Basin and flows for approximately 12.7 km prior to emptying into Kalamalka Lake. The creek consists of a mainstem and a north arm fork which originates in the Oyama North Basin and flows into the mainstem about halfway between Oyama Lake and Kalamalka Lake. Within the Upper Oyama Residual both stems of Oyama Creek outflow from the reservoir lakes and flow through a series of low lying swamps and wetland complexes, prior to joining together and dropping off the plateau into a well incised canyon with a narrow defined channel.

The north arm of Oyama Creek typically dries up in the late summer and the dry channel provides access for wildlife, cattle, recreation, etc. This poses a challenge for the DLC, as deposited contaminants are incorporated into source waters once flows resume. These contaminants are in addition to enhanced turbidity which results from the scouring of available source material as the channels fill during spring freshet. The enhanced turbidity and fecal coliform levels are typically of short duration with levels declining after the initial flush and once materials have been scoured from defined channels. Nevertheless, the last several years have been a bit of an anomaly with elevated coliforms extended throughout the summer months.

Oyama Lake Basin

The Oyama Lake basin consists of the entire drainage area for Oyama Lake. Oyama Lake is the largest of the lakes in the watershed and acts as the main storage reservoir. It has a volume of 5,800 acre-feet and supplies more than 97% of the potable water. The stored water is held by a concrete dam and an earth fill wing dam situated at the northwest side of the lake. The dam was constructed in the late 1960's and is now equipped with an automatic release gate that can be operated from the DLC. This system helps reduces operational time and enables better water conservation because managers can quickly change release rates from the reservoir (i.e., after periods of high demand, an operator does not need to drive to the reservoir to turn a valve reducing flow).

Typically, Oyama Lake is filled by either the last week of May or the first week of June. However, during the last decade Oyama Lake has failed to reach full pool four times. The normal operating procedure is to open the gate in the fall to release approximately 30 l/sec for the winter months. In mid April, the release rates from the reservoir are increased to reduce the effects of highly coloured water from freshet flows and releases from Damer Lake. This operational procedure is only done if the snowpack and storages are at or above normal. During this period of peak release, approximately 50 to 100 l/sec of higher quality storage water from Oyama Lake is released. During periods of increased demands, typically during spring, summer and fall, the releases from the automatic gate are set to supply approximately 105% of system demand. This allows 5% for daily variations in demand and leaves sufficient water for conservation/fish flows. Based on this operating procedure, the approximate residence time of Oyama Lake is 2.5 years.

Oyama North Basin

The Oyama North Basin includes the drainage area for Damer, Ince and Chatterton Lakes. Damer Lake is the water storage reservoir located on the North fork of Oyama Creek. The reservoir is located at approximately the 1300 m elevation at 50º 08'31" N and 119 º 16' 00" W. The water stored is held by an earth fill dam situated at the south end of the lake. The dam was constructed in the early 1970's and the lake has a capacity of 215 acre-feet.

Typically Damer Lake fills and begins to spill during the last three weeks of April. The storage reservoir has filled to full pool every year since the dam was constructed. The normal operating procedure is to open the gate to release approximately 50 l/sec in mid-April. If the snow pack is over 120% normal, then this release is increased. Operationally, the release is increased approximately 1% for every percent the snow pack is over 100%. This operational practice is continued until the reservoir has finished spilling (until approximately the first week of June) at which time the releases are adjusted to approximately 50% of the April releases. By August 1 the storage in the reservoir is typically around 10% of full pool. From August until the next freshet, two different release strategies have been utilized.

The first approach has been to slowly reduce flows from the reservoir to allow a limited amount of water to be released to maintain a base flow in North Oyama Creek throughout the remainder of the season. The second approach has been to leave the gate at its June setting and allow nature to regulate the flow into North Oyama Creek. The DLC has received varied input from different stakeholders, and thus a formal operating procedure has yet to be developed.

Once the water is released from Damer Lake it flows downstream to Ince Lake (volume approximately 5% of Damer) and then to Chatterton Lake (volume approximately 1% of Damer). From these lakes, Oyama Creek North flows to the confluence of Oyama Creek. Only about 3% of the water supply originates from the north arm of Oyama Creek and Damer Lake. The water quality from the north fork of Oyama Creek has high colour, however, for the most part this water has a limited effect on the overall quality at the intake because of the higher flows from Oyama Lake provide sufficient dilution. The dilution factor is approximately 10 to 1. This factor is reduced during spring freshet, and especially in drier years, as snowmelt occurs earlier in the Oyama North Basin.

Integrity and Vulnerability of the DLC Intake (Oyama Creek)

The DLC intake on Oyama Creek is located approximately 2.6 km upstream of the confluence with Kalamalka Lake at an elevation of 624 m above sea level (50º 07' 50" N and 119º 20' 22" W) (see Figure 1-2). The channel is well incised in this location; adjacent slopes are steep, coupled (i.e. connected to the channel and floodplain), and forested. The head pond, intake building, and access road are all built on a narrow floodplain area that occurs adjacent to the channel. This location has experienced previous debris floods, with past evidence visible on a fan immediately upstream of the head pond. Debris floods on the mainstem are most likely triggered by landslide impacts on the channel upstream of the intake and/or instream mobilization of steep floodplain materials (sediment and woody debris) during high flow events. Debris floods could be triggered by large landslide impacts on the channel that continue down the mainstem to the intake and beyond. Future debris flood or debris flow events on Oyama Creek are considered likely based on natural processes, evidence of past landslide activity on steep slopes upstream of the intake and the uncontrolled nature of drainage on old roads above the canyon in the uppper residual area. Debris flood or debris events, or materials associated with them that reach the DLC intake can be expected to damage or destroy infrastructure resulting in significant down time and loss of distribution capabilities.

Runoff from the entire upper residual flows into Oyama Creek and directly downstream to the intake. The estimated travel time for a contaminant to travel from either the Oyama or Damer Reservoir to the intake is approximately 5 – 6 hrs during normal flow periods (Patti Hansen, pers. com.). Thus, Oyama Creek where it flows through the upper residual area is highly vulnerable to contaminants which have the potential to affect water quality at the intake.

Runoff from the Oyama Lake and North Oyama Basins enters the reservoir lakes prior to flowing into Oyama Creek below the reservoirs. Residence times in the reservoirs vary depending on the reservoir, operating conditions, and the climatic conditions of any given year. In the event of a contamination event upstream of the reservoirs, controlled water release at the reservoirs allows a level of protection from contaminants at the intake. This protection is substantially reduced during spring freshet when reservoirs are spilling.

Flows from Oyama Creek enter the DLC intake pond (volume approximately 40,000 liters), and approximately 95% of that water is diverted into the screening building where it passes through mesh screens (40 squares per inch) and then directly into the distribution system. The water is disinfected by chlorine some 1600 m downstream, just before it reaches the first drinking water customers.

At the time of assessment, all indoor and outdoor facilities appeared tidy and well kept. Buildings were secured and locked with dead bolts. The DLC has agreements with two private property owners for a road easement across their properties to access the intake. These properties have locked gates and thus one must cross through several locked gates in order to get to the intake. The location of the intake, adjacent to private property, likely provides a reduction in access by the general public. Nevertheless, a non-status road along the north side of the canyon does facilitate all terrain vehicle access if one is determined, and the intake is certainly accessible by foot. Therefore, we must conclude that there is a very real possibility for public access and/or vandalism at the intake.

Vandalism can be a major burden on a water purveyor’s resources and budget (EPA, 2010). The investigation of a simple act of vandalism is not only time consuming, but also expensive. The investigative process may require comprehensive water quality sampling and a “do not drink” order until it can be determined if contamination has occurred. As a means to detect and prevent vandalism, some water purveyor’s are proactively investing in high tech security systems that will immediately notify authorities of any breaches (EPA, 2010).

3.5.2 Vernon Creek Watershed

The Water Survey of Canada has also previously maintained stream flow gauges in the Vernon Creek watershed. Many were operated seasonally as a means of managing the supply of water used for irrigation (Northwest Hydraulic Consultants, 2003). Although some gauges were active as recently as the 1990's, Ecoscape understands that there are no stream flow gauges currently being maintained above the DLC intake.

A hydrological station was operated at the outlet of Swalwell Reservoir (Station 08NM022) from 1921 through July of 1996 (Water Survey Canada, 2009). The hydrograph below illustrates the mean monthly discharge of Vernon Creek between the years of 1970 and 1995[2] (Figure 1-5). The Vernon Creek watershed exhibits a snow dominated hydrological regime with peak flows occurring from mid-April through June. Usage data by the DLC is also included to illustrate the portion of flows utilized by the district. Water not brought in to the distribution system continues downstream as conservation/fish flows.

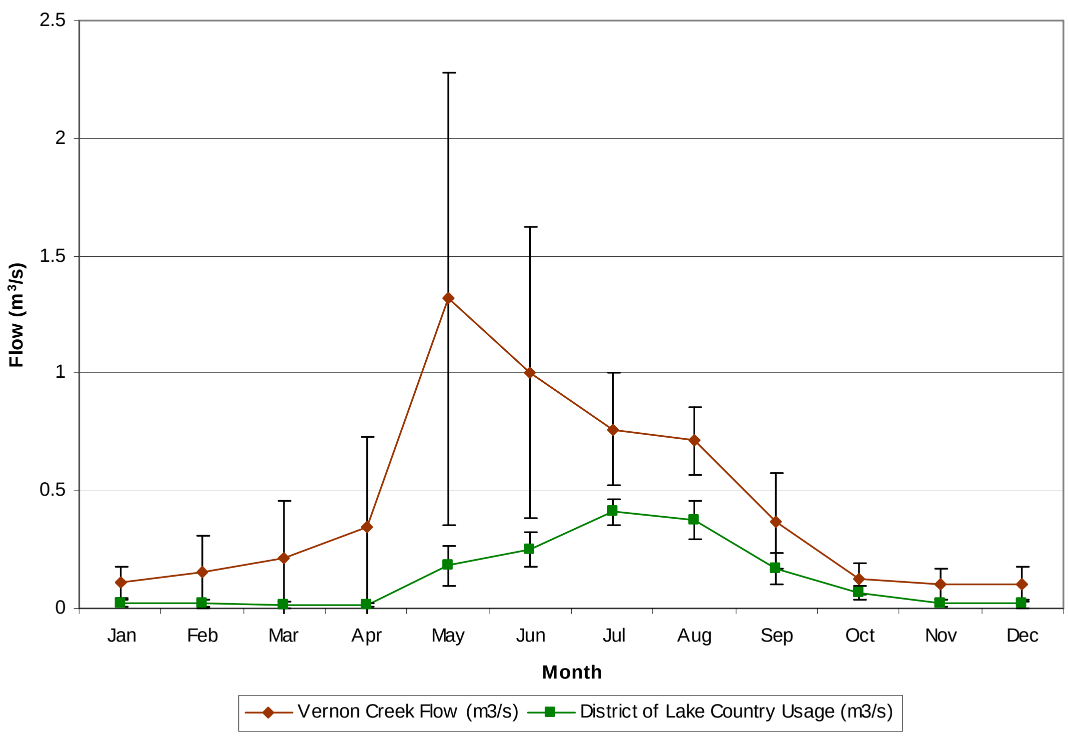


Figure 1-5. Mean monthly discharge data (±SD) for Vernon Creek downstream of Swalwell Reservoir (WSC Station 08NM022, 1970-1995) compared with DLC usage (2004-2008).

[2] Only the years with a complete dataset are included in the graph.

Upper Vernon Residual

There is a single hydrometric basin and one residual area within the assessment area of the Vernon Creek watershed (see Figure 1-4b). The Upper Vernon Residual extends from the DLC intake to the dam of Swalwell Reservoir. The Clark Creek tributary is just outside of the assessment area, as it flows into Vernon Creek approximately 110 m downstream of the DLC intake. Therefore, it was not assessed as apart of this study.

Within the Upper Vernon Residual, Vernon Creek drops off the upland plateau and flows into a steep canyon generally composed of soft alluvial soils. The stream has a highly dynamic channel, with significant evidence of previous stream avulsions and debris flows. In several locations, there are examples of historic movements of large volumes of materials along floodplain areas of the stream. These concerns are compounded by numerous instances of recent historic slope failures, which are evident on airphotos and discussed within several previously published reports. Historic movements of soils to Vernon Creek have resulted in interruptions to service in the past and thus the slope conditions above the intake are considered an important concern.

The Eldorado Reservoir was constructed in 2007, and is located approximately 2.8 km west of the intake. The reservoir's storage capacity will last for approximately 12 hours during peak demands and for about 10 days during minimal demands; making it possible to bypass the turbid waters of Vernon Creek (DLC, 2007; Jack Allingham, pers. com.). Given the sedimentation and landslide issues above the intake, the Eldorado Reservoir is a key component, albeit limited, in the mitigation of potential effects on water quality.

Vernon Creek Basin

The Vernon Creek Basin includes the entire upland catchment area. It encompasses Swalwell Reservoir and all drainage areas which contribute flows to this reservoir. Vernon Creek is a 5th order stream that originates in the Vernon Creek Basin. From the headwaters, Vernon Creek flows through Hidden, Min, Wilma, Dee, Island, Deer, Crooked and Swalwell lakes prior to dropping off the plateau. Below the intake, the creek continues west for approximately 10 km, prior to the confluence with Duck Lake.

Within the Vernon Creek Basin, the DLC maintains two licensed drinking water storage reservoirs, Crooked and Swalwell Lake. Crooked Lake reservoir is located just upstream of Swalwell Lake at an elevation of approximately 1350 m and at 50º 03' 47" N and 119 º 12' 26" W. The water stored is held by an earth fill dam situated at the south end of the lake. The residence time of Crooked/Dee Lake chain is approximately 2.5 years. The dam was constructed in stages from the 1930's to the 1970's and the reservoir has a volume of 2,383 acre-feet.

Typically Crooked Lake fills most years by mid to late May. The normal operating procedure is to open the gate in the fall to release approximately 40 l/sec during the winter months. These releases are typically held constant until the first week of May when the gate is opened further to release approximately 100 l/sec. As irrigation demand increases in the summer months and runoff from freshet declines, releases from Crooked Lake are altered to adequately supply Swalwell Lake and to match the drawdown of both lakes. Once the water is released from Crooked Lake, it flows through a short 100 m channel into Swalwell Lake.

The water of Swalwell Lake is held by an earth fill dam situated at the southeast end of the lake and it has an approximately 3 year residence time. The dam was also constructed in stages from the 1940's to the 1970's and the reservoir has a volume of 9,629 acre-feet. Typically Swalwell Lake fills most years by the last week of May or first week of June. The normal operating procedure is to open the gate in the fall to release approximately 100 to 150 l/sec over the winter. In past years these releases have been held constant until the first week of May unless ample water is available in storage. In high water years, water is released to reduce the impact of a high runoff in late May or early June. Recent court rulings have indicated that water purveyors need to adjust storage volume to help prevent flooding. As irrigation demand increases in the valley below and runoff from freshet decreases, releases from the gate at Swalwell Lake are balanced with the water system demands. An additional 30 to 200 l/sec of water is also released for conservation/fish flows. This operating procedure is followed until after the irrigation season, when the system is once again returned to the winter flow regime. In June 2009, the DLC commissioned a hydroelectric generating station on the Vernon Creek Supply distribution system. The efficient operation of the water system in conjunction with the new station will require some adjustments and may slightly alter the operating procedure described above.

Integrity and Vulnerability of the DLC Intake (Vernon Creek)

The DLC intake is located on Vernon Creek approximately 5.5 km upstream of the confluence with Duck Lake (see Figure 1-2). Once water is released from Swalwell Lake, it flows down Upper Vernon Creek to a 500 m^3 intake pond, which is located at an elevation of 819 m at 50º 01' 07" N and 119º 19' 08" W. From the intake pond 80 to 95% of the water is diverted into the screening building where it passes through mesh screens (20 squares per inch) then directly into the distribution system. The water is disinfected by chlorine downstream, just as it leaves the Eldorado Balancing Reservoir and before it reaches the first drinking water customer.

The estimated travel time for a contaminant to travel from the outflow of Swalwell Reservoir to the intake is approximately 5 – 6 hours during normal flow periods (Patti Hansen, pers. com). Thus, the Upper Vernon Residual is a highly vulnerable area which is susceptible to activities and contaminants that pose a risk to water quality.

The holding pond and intake building are located on the main channel of Vernon Creek within a steep, well-incised canyon with highly erodible soils. The canyon floor above the intake is relatively broad and forested. Previous landslide activities in combination with debris jams have resulted in a highly dynamic stream channel. Given that landslides have interrupted service in the past, it is really a matter of when, and not if water quality at the intake will be affected. The presence of numerous unstable, steep coupled slopes pose a significant risk, if not the primary risk to water quality and infrastructure at the intake. Depending on the location and size of a potential landslide and/or debris flow, the actual intake infrastructure could be at risk. If debris events reach the intake, the infrastructure could be damaged or destroyed and significant down time and loss of distribution capabilities would result. Ecoscape understands that water quality concerns mostly due to sedimentation, was one of the reasons for constructing the Eldorado Balancing Reservoir downstream of the intake. This reservoir provides a modest level of flexibility if service is interrupted at the intake.

In addition to the highly erodible soils upstream of the intake, there is a steep, coupled slope with soft material which over shadows the intake building and head pond. A narrow trail extends across this slope and provides access to the upper portions of the head pond. During the summer of 2009, works were undertaken to stabilize the trail with the use of a wooden walkway.

At the time of assessment all facilities were secured and well kept. The intake building was locked with a dead bolt. To access the DLC intake on Vernon Creek, one must exit off of Beaver Lake Main and travel through a locked gate. It is then a 10-15 minute drive across private land. At the entrance to the intake there is another gate which remains open so that if cattle traverse into the canyon they do not get caught in the immediate vicinity of the intake. From a trespass/vandalism perspective, the Vernon Creek intake is fairly isolated, however the intake can also be accessed on foot by descending into the canyon from the upper plateau. Therefore, the intake location is as such that the general public will not happen upon it, but if the intention is for trespass/vandalism, it is certainly possible.

3.6 Assessment Area Vulnerability

The effect of a hazard on water quality at the intake is dependent on where the hazard occurs within the watershed, and the severity of occurrence. To capture the spatial aspect, Ecoscape developed zones of vulnerability, with the assumption that if a hazard occurs within a particular zone, then the resultant risk is consistent within that zone. As an example, a deleterious substance spilled on a steep slope adjacent to a mainstem channel can be expected to have a higher probability of affecting water quality at the intake than the same substance spilled on gentle terrain in the upper watershed.

The criteria for determining vulnerability zones included broad measures such as distance to water, the buffering capacity of reservoirs, and terrain features (terrain stability and soil erosion potential). These criteria were identified because they could potentially influence the risk that a hazard may pose on water quality at the intake. Ecoscape has collected spatial data from many sources and has attempted to create zones as accurately as possible, given that the legitimacy of the resulting zones is very much dependent on the accuracy of the incorporated data. In some cases, data gathered was out of date and/or only partially accurate (e.g., data specific to watercourses is available through the Province but the accuracy is limited).

Therefore, prior to determining vulnerability zones, Ecoscape remapped the locations of all streams using a combination of airphoto interpretation and a digital elevation model which was derived from terrain resource inventory management (TRIM) data. In addition, the high water level of reservoir lakes was remapped using the same methods. We also pulled out additional aquatic features such as wetlands, swamps and seasonally inundated areas which are connected to source watercourses. The extent of these features were mapped using airphoto interpretation, vegetation resource inventory (VRI) data, field survey information and previously updated streams and lakes.

Ecoscape then used this more accurate hydrology data to determine the zones of vulnerability. Two terrain attributes, terrain stability class and soil erosion potential (Terrain Stability Mapping in British Columbia), were also incorporated into the vulnerability analysis. Presumably one could argue that this data also has shortcomings with regard to accuracy at relatively small scales, however, more detailed mapping of these features in a quick turn around time was deemed beyond our ability. Instead, Ecoscape assessed the output files and used professional judgment based on our experience in the watersheds to make minor adjustments. The sub-basin information, used to differentiate buffered and non-buffered source water, was provided by consulting hydrologists (M.J. Milne & Associates Ltd. and Dobson Engineering Ltd.).

The zones of vulnerability for each watershed were calculated using an index with the aforementioned data. An index is a numerical or categorical scale used to compare variables. For each of the classifications, scores were assigned as shown in Table 1-4. Higher scores indicate areas of higher vulnerability. ArcGIS 3D Analyst and Spatial Analyst were used to carry out the analysis and the resulting areas of vulnerability are shown in Figures 1-6a and b. Watershed vulnerability is classified using the following descriptive scores: very high, high, moderate, and low.

The vulnerability ratings are useful when evaluating activities which may have an impact on source water quality. Activities that occur within moderate and low vulnerability zones are less likely to affect source water quality at the intake than if the same activities were to occur in very high or high vulnerability zones. One exception which does not follow the vulnerability model is the loss of forest cover within the snow sensitive zone (SSZ) of the watersheds. The SSZ is the area that provides the greatest contributions to peak flows during spring freshet. Most of the SSZs have been classified as having low vulnerability, yet it is important to note that if there is a large scale loss of forest cover within these areas (due to clear cuts or mountain pine beetle), then there will be significant impacts to water quantities, and then potentially subsequent impacts to water quality at the intakes.

Although it is reasonable to assume that activities occurring on reservoir lakes closer to the outlet pose a higher risk than those further away, the vulnerability model is unable to account for this variation, and therefore all areas below the high water level (of reservoir lakes) have the same vulnerability rating.

Table 1-4. Determination of Assessment Area Vulnerability.

Rating Criteria	Index Scores	Classifications	Assumptions
Buffering Capacity	2	Residual Area	▪ The lower sub-basins have a greater sensitivity because flows originating in these basins are not buffered by reservoirs.
	1	Upper sub-basins	
Proximity to water	6	Extents of lakes, streams and aquatic features which function as source water for the DLC.	▪ *****Main creeks below the storage reservoirs were buffered by 3 m on each side in order to estimate the extent of the high water level. ▪ All other tributary creeks were buffered by 1 m on each side to estimate the extent of the high water level.
	5	Main creeks in the lower sub-basins plus 50 m on each side.	▪ Upland areas adjacent to main creeks maintain a higher sensitivity therefore the main creeks were buffered by 50 m.
	4	Tributary streams, aquatic features, and lakes in the lower watershed plus 30 m buffer on each side.	▪ Other connected watercourses in the lower basins contribute water directly to the intake. Therefore, the upland areas adjacent to these features were also buffered, but to a lesser degree (30 m).
	3	Main storage reservoirs plus 50 m buffers	▪ Upland areas adjacent to storage reservoirs maintain a higher sensitivity, and therefore the storage reservoirs were buffered by 50 m.
	2	All other contributing watercourses plus 30 m buffer	▪ The remaining connected watercourses and aquatic features contribute water to the reservoirs. They were buffered by 30 m to account for the sensitivity of the upland areas surrounding them.
	1	All other areas.	
Terrain Stability (slope and soil erosion potential) [¥]	2	Stability class IV, V and III where soil erosion potential is either high or very high and adjacent to source watercourses	▪ Upland areas adjacent to source watercourses which have significant slopes and surficial deposits are more vulnerable than other areas.
	1	All other areas	

*Creeks were buffered where the extent of the channels could not be determined from airphoto interpretation.
[¥]Rating definitions for terrain stability class and soil erosion potential are available at http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/TERRAIN/

3.7 Water Quality Characteristics and Assessment

Raw Water Quality Sampling

The DLC collects raw water samples at the intake in the Vernon and Oyama Creek watersheds on a weekly basis (4 samples per month). Weekly parameters include: total coliform, *E. coli*, true color, turbidity, temperature, pH, conductivity, apparent color and hardness. In the Vernon Creek watershed, raw water is also sampled at the site of treatment (Eldorado Reservoir) to verify on-line water quality equipment and to ensure there are no differences in water quality between there and the intake. More comprehensive nutrient testing is carried out twice annually at the outflow of major reservoir lakes and includes nutrient parameters, as well as total organic carbon, total dissolved solids and total suspended solids.

Water Quality Compared with Draft Provincial Objectives

There are specific provincial water quality objectives (in draft form) that pertain to raw water quality for both the Oyama and Vernon Creek watersheds. Ministry of

Environment commissioned independent studies to examine the existing water quality of both Oyama and Vernon Creeks. Water quality data was collected between 1997 and 2001 and subsequent recommendations for water quality objectives were made, based on the potential impacts and water quality parameters of concern (Phippen, 2008; Einarson, 2008). Tables 1-5 and 1-6 detail the water quality objectives outlined in these reports as well as provide a comparison of recent water quality data collected by the DLC in 2008 and 2009.

Table 1-5. Vernon Creek: Comparison of Provisional Water Quality Objectives with Water Quality Data Collected by the DLC in 2008 and 2009.

Variable	Objective Value* (at DLC intake)	DLC – Vernon Creek Intake 2008 Water Quality Results	DLC – Vernon Creek Intake 2009 Water Quality Results[§]
Temperature[¥]	≤19º (short-term) ≤15º (long-term)	Temperatures met the short-term provisional objectives, as the maximum temperature recorded was 18.2º	A single temperature reading exceeded the short term objective value (19.6 º on July 28th).
Turbidity**	≤1 NTU above background levels	The objective was met approximately 33% of the time.	The objective was met approximately 29% of the time.
True Color	≤40 TCU between July 1 and March 31st ≤50 TCU between April 1 and June 30th	The objectives were not met for May, June & July. The maximum value was 110 TCU in May. The annual average was 38 TCU.	The objectives were not met in May. The maximum value was 84 TCU in May. The annual average was 31 TCU.
Total Organic Carbon[£]	≤7.1 mg/l maximum (short-term) ≤4.0 mg/l maximum (long-term)	Swalwell Reservoir - June 11th, 2008 - 12.9 mg/l October 29th, 2008 - 14.1 mg/l	Swalwell Reservoir - June 18th, 2009 - 19.4 mg/l
Escherichia coli	≤10 CFU/100 ml (90th percentile based on a minimum of five weekly samples collected over a 30-day period)	Sampling frequency did not allow an evaluation of the 90th percentile based on a minimum of five weekly samples collected over a 30-day period. However, the *E. coli* objective of ≤10 CFU/100 ml was met in 73% of the samples in 2008. The maximum was 92 CFU per 100 ml.	Sampling frequency did not allow an evaluation of the 90th percentile based on a minimum of five weekly samples collected over a 30-day period. However, the *E. coli* objective of ≤10 CFU/100 ml was met in 87.5% of the samples, but the maximum was 190 per 100 ml.

*Objective Values are taken from: Einarson, E.D. 2008. Draft Water Quality Assessment and Objectives for Upper Vernon Creek Community Watershed. Technical report prepared for: Ministry of Environment.

[§] 2009 water quality data is inclusive through October 19th.

[¥]Short-term temperature objective refers to the mean weekly water temperature, while the long term objective is that maximum summer temperatures do not exceed 15 º C between June and September.

[£]Sampling for total organic carbon is only carried out twice annually. All collected samples were well above the provincial objective.

Fecal Coliform is not included above since the DLC samples total coliforms rather than fecal coliforms. Therefore, direct comparisons cannot be made.

Table 1-6. Oyama Creek: Comparison of Provisional Water Quality Objectives with Water Quality Data Collected by the DLC in 2008 and 2009.

Variable	Objective Value (at DLC intake)	DLC – Oyama Creek Intake 2008 Water Quality Results	DLC – Oyama Creek Intake 2009 Water Quality Results
Temperature	≤20º (short-term) ≤15º (long-term)	Temperatures generally met the short-term provisional objectives. A single temperature recording exceeded it (20.7 º on August 18th)	All temperatures recorded met the short-term provisional objective.
Turbidity	≤1 NTU above background levels	The objective was met approximately 26% of the time.	The objective was met approximately 26% of the time.
True Color	≤80 TCU	The objectives were not met for April, May and June. The maximum value was 140 TCU in May. The annual average was 49 TCU.	The objectives were not met for April and May. The maximum value was 95 TCU in May. The annual average was 43 TCU.
Total Organic Carbon[£]	≤4.0 mg/L maximum	Oyama Lake – June 11th – 14.5 mg/l October 29th – 14.4 mg/l Damer Lake – June 11th – 27.3 mg/l October 29th – 23.9 mg/l	Oyama Lake – June 16th – 19.3 mg/l Damer Lake – June 16th – 34.6 mg/l
Escherichia coli	≤10 CFU/100 ml (90th percentile based on a minimum of five weekly samples collected over a 30-day period)	Sampling frequency did not allow an evaluation of the 90th percentile based on a minimum of five weekly samples collected over a 30-day period. However, the *E. coli* objective of ≤10 CFU/100 ml was met in 62% of the samples. The maximum was 120 CFU per 100 ml.	Sampling frequency did not allow an evaluation of the 90th percentile based on a minimum of five weekly samples collected over a 30-day period. However, the *E. coli* objective of ≤10 CFU/100 ml was met in 59% of the samples. Two samples collected were over grown with *E. coli*.

*Objective Values are taken from: Phippen, B. 2008. Draft Water Quality Assessment and Objectives for Oyama Creek Community Watershed. Technical appendix prepared for: Ministry of Environment.

[§] 2009 water quality data is inclusive through October 27th.

[¥]Short-term temperature objective refers to the mean weekly water temperature, while the long term objective is that maximum summer temperatures do not exceed 15 º C between July and September.

[£]Sampling for total organic carbon is only carried out twice annually. All collected samples were well above the provincial objective.

Fecal Coliform is not included above since the DLC samples total coliforms rather than fecal coliforms. Therefore, direct comparisons cannot be made.

The raw water quality variables of greatest concern with regards to drinking water quality are turbidity, colour, organic carbon and pathogenic organisms. When comparing the results of water quality data in both Vernon and Oyama Creek from 2008 and 2009 with the provincial objectives, we see that turbidity, total organic carbon and *E. coli* are the parameters which least often meet the outlined objectives. Typically, these parameters may fall short during spring freshet, when flows are enhanced, and also during extreme weather events. A correlation analysis of compromised water quality and weather events was not undertaken, however in reviewing DLC's water quality data, a comments section does specify pertinent information (i.e. summer rainstorms) that in some cases may explain changes in water quality.

Microbial pathogens pose the most significant threat to drinking water as their effects can be acute. Typically the effect of pathogenic ingestion is an acute gastrointestinal illness which can occur in a matter of hours or days (CCME, 2004). The three primary sources of fecal coliforms and *E. Coli* are: 1) recreation, including domestic pets; 2) cattle and other domestic grazing animals; and 3) wildlife species, including birds and mammals (Phippen, 2008). Generally, all warm-blooded species are capable of carrying fecal coliforms and *E. coli*, while virtually every mammal can also carry Giardia and Cryptosporidium. Surface water contamination by wildlife is one of the primary reasons that all surface waters must be disinfected prior to consumption (Phippen, 2008).

Total coliforms, fecal coliforms, *E. coli*, and enterococci are bacterial indicators used in water quality and health assessments. The bacteriological indicators themselves (total coliforms, *E. coli*) are usually not pathogenic, however they are used because they are much easier and less costly to detect and analyze than the pathogens themselves (Meays et al., 2004). The presence of fecal coliforms suggests that enteric pathogenic microorganisms could also be present (Health Canada, 1998).

The water quality testing which was conducted in Vernon Creek to set provincial objectives revealed that fecal coliforms appeared in significant concentrations throughout the watershed, but that the residence time of reservoir lakes was such that the majority of coliforms entering the lakes were killed by sun exposure or precipitated out of the water column. This was evidenced by the fact that samples collected at the outflows had very low concentrations (Einarson, 2008).

This idea was further developed in the Oyama Creek watershed, where peak coliform values were considerably higher below Damer Lake along the north fork of Oyama Creek than compared to the mainstem of Oyama Creek downstream of Oyama Lake. The author speculated that a reduction in coliforms did not occur downstream of High, Damer, or Chatterton Lakes because the residence time of these lakes was either too short to affect coliform viability, or that there was a continual source of fecal matter in those areas (Phippen, 2008). Given that the Chatterton Lake area is low lying with a defined creek channel of continual flow and that the residence time of Damer Lake is estimated at less than 6 months, Ecoscape is of the opinion that the high coliform counts are likely due to the short residence time of these areas. This further emphasizes the importance of limiting sources of coliforms to Oyama Creek North, as additional inputs of coliforms below the lakes will have an additive affect with those already present at the outflows of High, Damer and Chatterton lakes.

Turbidity and colour are other drinking water quality parameters of concern. Turbidity is a measure of the relative clarity of water and is caused by suspended and colloidal matter, such as clay, silt, organic and inorganic matter, plankton and other microscopic organisms (Health Canada, 2003). Turbidity is a concern for health reasons because the particulate matter causing turbidity can contain toxins, harbour microorganisms and interfere with disinfection. Furthermore, organic matter in the water can also react with disinfectants such as chlorine to create disinfection by-products which may in turn cause adverse health effects (Health Canada, 2003).

Colour is often due to the presence of coloured dissolved organic matter in the water originating from soil and decaying vegetal matter and it is measured in platinum-cobalt units or TCU. Generally people can detect colour above 15 TCU and as a result, an aesthetic objective of 15 TCU has been established for colour in drinking water on the basis that higher levels may give rise to consumer complaints (Health Canada, 1979). Chlorination of coloured water can also produce disinfection by-products (e.g. trihalomethanes) and create difficulties in maintaining adequate levels of disinfection.

There is a direct correlation between water colour levels and total organic carbon concentrations. This is primarily due to enhanced water colour originating from decomposition of organic matter (Phippen, 2008). During spring runoff, water percolates through the upper soil layers releasing organic materials and carries higher concentrations of organic carbon. There is also concern that the decomposition of floating trees within the reservoirs directly enhance water colour through the release of tannins (pers com., Lloyd Manchester, OCOA). Phippen (2008) reported that TOC concentrations collected to set provincial objectives were consistently above the drinking water guideline. Therefore the recommended provincial objective is that maximum TOC values should not exceed 4.0 mg/L. Likewise, the DLC results from 2008 and 2009 show levels which are considerably higher than the set objective values. Currently, TOC levels are only measured twice yearly, and with such limited sampling, it is not possible to understand the natural variability and whether TOC is consistently a concern at the DLC intake.

High levels of total organic material will result in the formation of total trihalomethanes (TTHM) when water is chlorinated. The Guidelines for Canadian Drinking Water Quality have set the interim maximum acceptable concentration for TTHMs at 0.100 mg/l. TTHMs are measured twice annually within the distribution system and Figure 1-7 shows the annual mean levels of TTHMs for both Oyama and Vernon from 2004 through 2008. TTHMs are consistently over 0.100 mg/l and the graph suggests there is an increasing trend, especially in Vernon Creek. This trend has also been documented in other local watersheds, specifically Duteau Creek (Kerr Wood Leidal Associates Limited and Dobson Engineering Ltd., 2008). Ecoscape understands that there is a high level of organics and peat in the soils throughout the entire Aberdeen plateau, and thus TOC levels are likely affected in most, if not all of these watersheds.

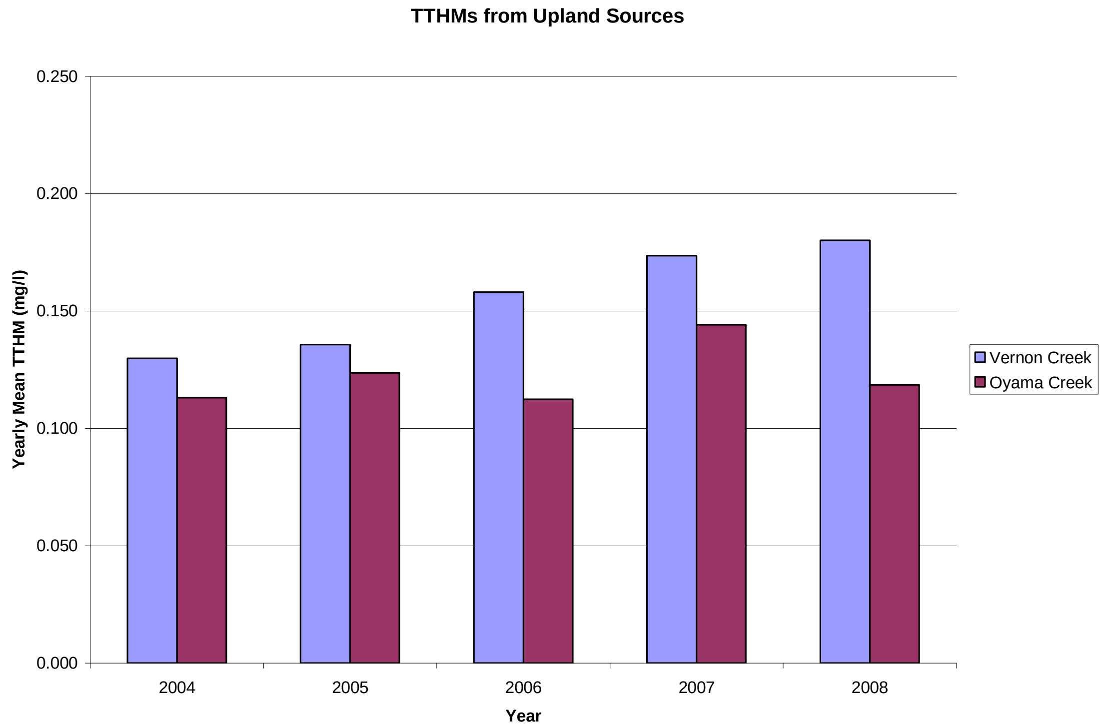


Figure 1-7. Annual mean of trihalomethane formation, 2004 – 2008.

Evaluation of Raw Water Sampling Program

The raw water quality sampling carried out by the DLC is intended to identify water quality concerns in order to facilitate safe drinking water to consumers. The District is not currently collecting water samples to manage or address changes in water quality resulting from land uses or activities within the watersheds.

The frequency of raw water sampling does not allow direct comparisons for all parameters with the draft provincial water quality objectives. The water quality objectives should be finalized for both watersheds, as they would provide a creek specific standard for comparing and trending water quality data over time.

The water quality sampling program undertaken by the DLC will help achieve the 43210 treatment objective. This treatment objective is intended to facilitate preparation of designs for a treatment system at some future point. An increase in sampling of total organic carbon (from biannually to at minimum quarterly, or preferably weekly) would provide further information that would be beneficial for the development of the 43210 treatment objective. With current sampling of twice yearly, it is not possible to understand the natural variability and whether total organic carbon is consistently a concern at the DLC intake.

3.8 Biogeophysical Features

3.8.1 Regional Climate

Climate generally determines the amount of water recharged via precipitation, lost due to evaporation and the timing of high and low flow periods. Climate affects all aspects of the watershed including factors such as spring temperatures and speed of snow melt. Climatic fluctuations can largely influence the quantity and quality of the drinking source water. Literature suggests that most North American waterborne illness originates from extreme weather events (Charron et al., 2004).

Climatic data (temperature and precipitation) is available from the nearest Environment Canada weather station at Winfield (Station #1128958) (Lat: 50° 2.400' N, Long: 119° 25.200' W, Elevation 502.9 m) (see Figure 1-8). This station is approximately 7 km west of the Vernon Creek intake. Temperatures at this station experience considerable annual fluctuations which range from -3.1ºC in January to 19.9ºC in July. Average total annual precipitation is 388.2 mm, with 103.5 mm falling as snow. Because this weather station is located at a relatively low elevation, the temperatures and precipitation are not reflective of what would be expected in the upper portions of the watersheds. Precipitation increases (and a larger portion of the precipitation occurs as snowfall) with increasing elevations.

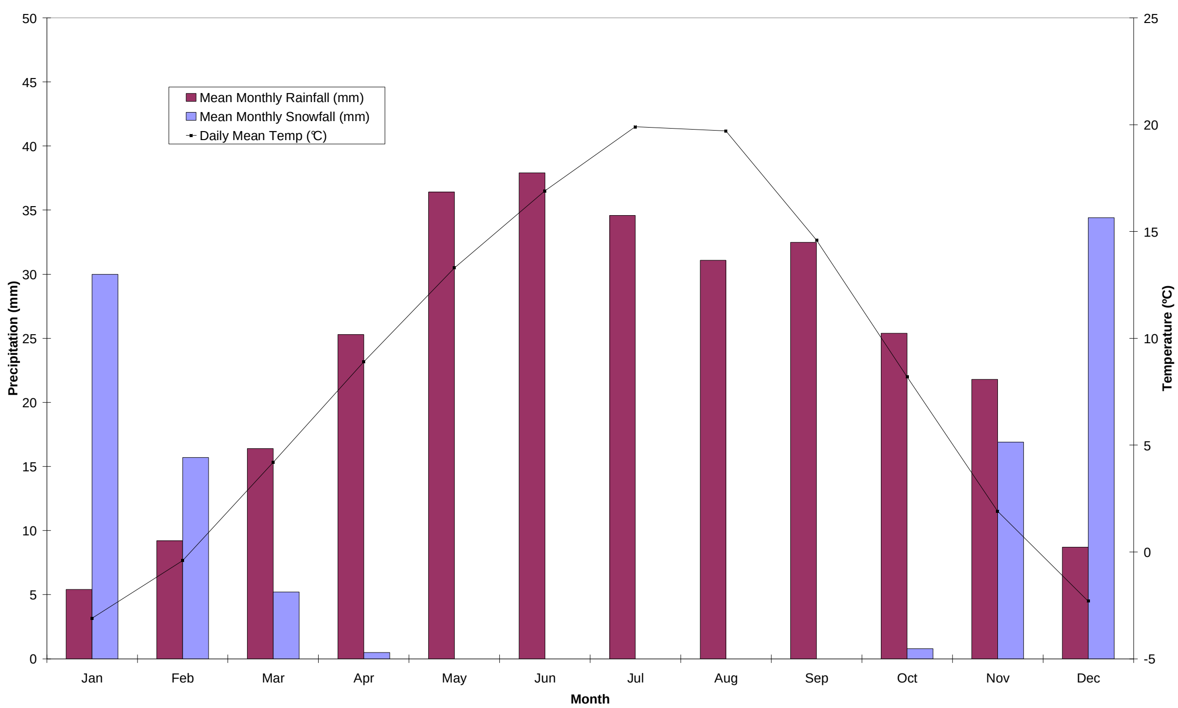


Figure 1-8. Mean monthly precipitation and temperature at Winfield (Environment Canada Station #1128958) from 1971 -2000.

3.8.2 Topography and Terrain Stability

Elevations within the two watersheds range from 1638 m at the highest point to 624 m at the lowest point (Oyama intake). The mean elevations for Oyama and Vernon are 1365 and 1398 m above sea level, respectively. Relative relief of the watersheds above the intakes was calculated by dividing the difference in elevation between the intake and the highest point of the assessment area by the square root of the assessment area, as recommended by the Guideline (see Table 1-7).

Table 1-7. Topographic Details for the Oyama and Vernon Assessment Areas.

Watershed	Highest Elevation	Elevation at the intake	Mean Elevation	Relative Relief
Oyama Creek	1638	624	1365	0.156
Vernon Creek	1638	819	1398	0.089

A slope analysis was conducted for each assessment area based on the specified slope intervals and rationale in Table 1-8. This analysis shows that on a whole, the Vernon Creek watershed has flatter terrain with the majority of slopes ranging between 0 to 10% (Figure 1-9b), while the majority of slopes within the Oyama Creek watershed are between 11 to 30% (Figure 1-9a). Both watersheds exhibit steep slopes (> 60%) upstream of the intakes.

Table 1-8. Slope Values within the Oyama and Vernon Watershed Assessment Areas.

		Oyama Creek		Vernon Creek	
Slope (%)	Rationale	Area (km^2)	Percent of Assessment Area	Area (km^2)	Percent of Assessment Area
0-10	Majority of flows infiltrate	15.07	36	44.32	52
11-30	Increased overland flows	21.15	50	35.60	42
31-60	Majority of overland flows	5.28	12	4.72	6
>60	Increased slope failure	1.02	2	0.64	<1

Terrain stability mapping is available for both watersheds (Reid, 1998), and Figures 1-9a and b provides an overlay of slope stability (class I-V) and soil erosion potential (VL – VH) across the residual areas. The terrain stability criterion for both classifications is provided in Tables 1-9 and 1-10 below (Reid, 1998). The slope stability class provides the relative potential for landslide occurrence, with higher numbers indicating an increased potential for landslides. The erosion potential summarizes the relative likelihood of the occurrence of erosion and ranges from very low to very high potential (Reid, 1998).

In general, the surficial material found within the assessment areas is largely a product of the Fraser ice sheet advance (19,000 BP) and retreat (10,500 BP) (Reid, 1998). Sediments and landforms, such as thicker accumulations of till, development of rill complexes and meltwater channels and eskers are related to the ablation of “dead ice”. Other glaciofluvial deposits (eskers and kames) occur where larger amounts of sediment accumulated in areas of stagnant ice (Reid, 1998).

In the Oyama Creek watershed, the canyon upstream of the intake has a slope stability class of IV and a soil erosion potential that ranges from high to very high. M.J. Milne &

Associates Ltd. documented three landslides upstream of the intake in the summer of 2009 (see Figure 1-10a for landslide locations). This work corroborates that from the 1998 Interior Watershed Assessment Procedure (IWAP) which identified two landslides in the lower reaches of Oyama Creek, neither of which was associated with forest development. This IWAP study rated the overall landslide hazard index for the Oyama Creek watershed as low (Dobson Engineering Ltd., 1998).

Table 1-9. Slope Stability Criteria (modified from Reid, 1998).

Stability Class	Slope Range (%)	Description
I	0-15	No problems with instability expected (generally based on slope, typically areas of no to low relief, wide range of materials).
II	6-27 28-49	No significant problems with instability expected (typically in a wide range of materials with low to moderate relief).
III	28-49 50-70	Minor instability may develop in some areas. Based on slope, material and drainage, in areas with greater than moderate relief.
IV	50-70 >70	Potentially unstable terrain, based on slope, material and drainage. Typically steep slopes.
V	Any	Any terrain (often with steep slope) where indicators of potential slope instability are present (active or inactive).

Other factors incorporated in the slope stability criteria include typical drainage, typical material and terrain types, and typical processes. See Reid (1998) for a comprehensive explanation of these factors.

Table 1-10. Erosion Potential Criteria (reproduced from Reid, 1998).

Class	Rating	Description
VL	Very Low Potential	No problems with erosion expected. Typically flat or gently sloping terrain (i.e. 0-15%), or steeper slopes in rock. Possible materials could include massive rock, organic deposits, or cemented sediment.
L	Low Potential	No significant problems with erosion expected. Typically gentle slopes, short slopes of moderate gradient, moderate slopes on rock. Can include many material types, especially rock, and highly cohesive, dense or very coarse-grained soils (i.e. <15% sand size and smaller clasts).
M	Moderate Potential	Areas where minor erosion may occur. Moderately steep short slopes and longer slopes of moderate gradient, particularly those with looser soil materials with a significant proportion of fines (i.e. > 40% sand size and smaller clasts).
H	High Potential	Areas where significant erosion could potentially occur. Typically steep slopes with almost any material, areas of gullying, moderately steep slopes with highly erodible soil materials (typically loose, non-cohesive soils) or with patchy or poorly established vegetation cover present.
VH	Very High Potential	Areas with active erosion (sediment sources). Typically areas where exposed mineral soil occurs without full vegetation cover present. Would include such areas as recent slides (initiation zones, runout tracks and debris deposits), Aeolian deposits, weathered bedrock, terrace scarps, gully sidewalls.

In the Vernon Creek watershed, the canyon upstream of the intake has a slope stability class of V and a soil erosion potential of very high. The soils in this portion of Vernon Creek developed on glaciofluvial and glaciolacustrine materials that are highly erodible. The down cutting of Vernon Creek through these soils has created over steepened slopes that are naturally prone to failure (Einarson, 2008). Ecoscape used a combination of field surveys, airphoto interpretation and previous reports to document landslide locations (see Figure 1-10b). All of the documented landslides (7 in total) are within 4 km of the DLC intake and a few of them are quite extensive. The two landslides which are closest to the DLC intake are within private property.

Previous studies have concluded that these landslides are the principal sediment sources within the Vernon Creek watershed (DEL, 2008; Summit, 1999; Summit, 1997b). The general instability of the area has been the focus of numerous assessments over the last 20 years. The level I - IWAP identified the high natural loading of fine sediments from landslides upstream of the DLC water intake as one of five issues (MOF, 1995). In subsequent studies, three high priority and nine moderate priority landslides were identified (Summit, 1997). These landslides were prioritized for remediation work and prescriptions were prepared for the higher priority sites (Summit, 1997b). Landslide rehabilitation was undertaken in 1997 and 1998, using biotechnical erosion control on three high risk sites along the lower reaches of Vernon Creek (Summit, 1999). Ecoscape visited one of these rehabilitated landslides during our field surveys, and we concluded that previous rehabilitation works had been compromised due to cattle traversing the landslide near the creeks edge. Sediment continues to be actively delivered to the creek at this location.

Terrain stability issues are very prevalent in the Vernon Creek canyon and will continue to be over the long term. Continued monitoring of Vernon Creek is considered critical, including detailed stream mapping (e.g., modified SHIM focusing on erosion sites, slope failures, and debris flow potential should be carried out by a registered professional).

3.8.3 Biogeoclimatic Zones and Vegetation

The Oyama and Vernon Creek watersheds transcend across four broadly defined biogeoclimatic zones that include the Englemen Spruce Subalpine Fir (ESSF), Montaine Spruce (MS), Interior Douglas fir (IDF) and Interior Cedar Hemlock (ICH). This intensely forested region varies in slope and aspect and harbors a diversity of flora. The forest canopy is composed primarily of lodgepole pine, but other species include fir (interior-Douglas fir, alpine fir and true fir), spruce (Engelmann spruce (*Picea engelmannii*) and white spruce (*Picea glauca*)), aspen and others. Common shrubs include Saskatoon, tall-Oregan grape, common snowberry and *Rosa* ssp. Persistent grasses are bluebunch wheatgrass (*Agropyron spicatum*), pine grass (*Calamagrostis rubescens*) and the rough and Idaho fescues (*Festuca campestris F. scabrella* var. *major* and *Festuca idahoensis*, respectively). For a complete listing of flora within the four biogeoclimatic zones, refer to the BC Species and Ecosystem Explorer of the BC Conservation Data Centre: http://a100.gov.bc.ca/pub/eswp/.

Because these watersheds maintain extensive stands of lodgepole pine, they are highly susceptible to mountain pine beetle infestation, which has the potential to dramatically influence both water quantity and quality.

3.8.4 Fish, Wildlife and Birds

The presence of wildlife within the watersheds is significant from a water quality point of view for two reasons. First, the presence of these resources has resulted in commercial resorts, hiking trails, and excellent sport fishing and hunting opportunities which attract a broad range of recreational user groups. These user groups increase the recreational pressures on the watersheds, which can then impact water quality. Second, all warm-blooded wildlife species (including birds and mammals) are capable of carrying and disseminating fecal coliforms and *E. coli* and their presence in the watershed results in a basal level of risk.

Mammalian and avian species that support hunting activities within the Oyama and Vernon Creek watersheds include mule deer, whitetail deer, moose, black bear, coyote, lynx, bobcat, cougar, blue and ruffed grouse, turkey and various species of water foul (MOE, 2009). The forested communities within the watersheds provide habitat for a variety of migrating passerine birds and the many reservoirs and creeks support water foul including the common loon, and several species of grebes and ducks.

Rainbow trout (*Onchorhynchus mykiss*) support a substantial angler effort in both the Oyama and Vernon Creek watersheds. Many of the streams in the watersheds are fish bearing and maintain spawning populations of rainbow trout. Further, stream flows in these creeks are critical to kokanee populations in lower areas below the water intakes. With increasing water demands, there will continue to be management concerns associated with providing sufficient fish flows while still maintaining and providing a safe drinking water source.

3.8.5 Wildfire

Fire potential is influenced by environmental factors including biomass fuels, weather, topography and sources of ignition. Correlated with climate change, recent studies suggest that there will be a redistribution of global fire activity and that Canada will likely see significant increases in fire weather severity and fire activity, although regional variation will occur (Taylor et al., 2009). Currently in BC, there are approximately 2,000 fires every year that burn about 80,000 hectares (Taylor et al., 2009). British Columbia in particular is predicted to have an increase in seasonal fire severity and an increase in fire season length of 1-2 weeks by the year 2045 and 2-3 weeks by the year 2085 (Flannigan et al., 2002). Earlier snowmelt and green up of understorey in combination with readily available biomass (resulting from fire suppression and MPB) may very well lead to more intense fires coupled with longer fire seasons.

Depending on the severity and location of fire, the potential impact and cost to water treatment could be immense. Several studies have shown that severe wildfire alone and in combination with salvage logging increases the likelihood of debris flows, changes in channel morphology and flood (Covert et al., 2009; Eaton et al., 2009; Jordan et al., 2009). These wildfire related changes can then have direct implications on water quality treatment including chemical coagulant demand, sludge production and oxidant demand for disinfection against waterborne pathogens (Emelko et al., 2009; Emelko et al., *In Review*). They may also present public health protection challenges including increases in microcystins (cyanobacteria), increases in the formation of potentially carcinogenic disinfection by-products such as trihalomethanes, and increases in aqueous toxic heavy metal concentrations (Emelko et al., 2009; Emelko et al., *In Review*).

During 2009, there was one fire in the Oyama Creek watershed. On June 11th, an approximately 2 km wildfire occurred within 50 m of the Oyama Lake in the immediate proximity of the lease lots. Figure 1-11 depicts the location and approximate extent of the fire. Ecoscape understands that a fuel management treatment (i.e. reduction in canopy closure and ground fuel) was undertaken in the fall of 2008, and it likely assisted in limiting the spread of the fire and facilitating access for fire fighters. The fire was successfully extinguished prior to the loss of any structures or affects to the water delivery infrastructure. However, more than 2 months after the fire, it was noted that fire retardant remained at the site covering the remaining standing trees, downed vegetation and soils. It was also noted that there was an ephemeral drainage which flowed from the burned area into the Oyama Reservoir (i.e., a non classified drainage). This direct drainage connection, lead to concerns that the fire retardant may act as a source of contamination to the drinking water supply.

Ecoscape contacted the manufacturer of PHOS-CHeK® fire retardants and learned that the retardant was primarily composed of a blend of ammonium phosphate and/or sulfate (a type of fertilizer) and thus it is expected that there could have been increased nutrient levels in Oyama Lake immediately following the fire and possibly slightly elevated levels since. The most likely result of enhanced nutrients is the increased potential for algal blooms, which can have implications for public health.

The above example highlights how even small fires have the potential to impact source waters. It also highlights the extreme costs that can result if significant fires do occur, as there is increased potential for treatment requirements in heavily burned areas.

3.8.6 Algal Blooms

Algal blooms are most likely to occur during summer months when water temperatures are warmer and water volumes are low due to high peak demands. The availability of nutrients and lake limnology is also a key concern when considering algal blooms. Nutrients can occur naturally but can also be significantly altered by anthropogenic influences such as faulty septic systems, livestock, fire retardants, agricultural runoff, and landslide events resulting from poor storm runoff or road construction on both sanctioned and non sanctioned roads. Treatment of drinking water contaminated with blue-green algae can be effective when the cyanobacteria are removed through specialized filtration systems. However, standard disinfection techniques (e.g. chlorine) are ineffective as the treatment may chemically corrode the cell wall and release more toxins into the water (MOE, 2005). The effect of algal blooms on human health can be quite severe depending on the type of algae and if contaminated water is consumed. Symptoms can include headaches, fever, diarrhea, abdominal pain, nausea and vomiting (MOE, 2005).

Monitoring and detection of cyanobacterial toxins can be difficult, as quick and inexpensive tests have poor detection limits or are qualitative (presence/absence) only. Also, due to the toxicity of cyanobacteria, the best available detection limits are often very close to the WHO guidelines (i.e. detectable levels as low as 0.1 to 0.5 ug/L, while WHO guideline is 1 ug/L). Furthermore, because cyanobacteria do not make significant quantities of cyanotoxins at all times, and microscopic identification cannot be used to determine toxicity (Larratt Aquatic Consulting, 2009b).

During the field assessments, Ecoscape noted algae near the outflow of Damer Lake, however the species of algae was not assessed. It is thought that the benthic topography, in combination with low lake levels and nutrient loading from fecal and recreational inputs, are all likely contributors to the algae observed.

Ecoscape understands that algal blooms have been periodically documented in other locations in the Oyama and Vernon Creek watersheds. For example, in the fall of 2006, there was an algal bloom on Oyama Lake which was believed to be cyanobacteria, but it dissipated prior to verification. Although algal blooms to date have not created a substantial problem for the water purveyor, this may not be the case in the future as climate change, MPB and wildfires will likely contribute to increased nutrient inputs to the reservoirs. Coupled with these increases in nutrients, it is also likely that climate change could result in slightly warmer water temperatures, further increasing the potential for algal blooms.

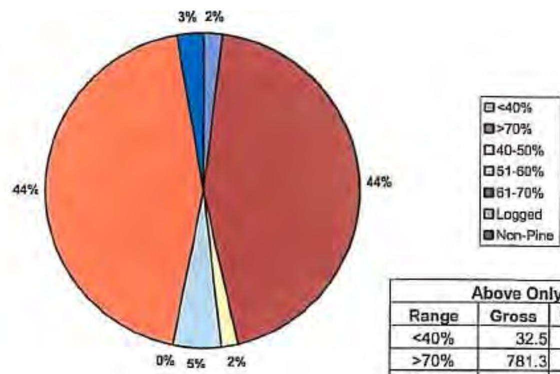
At this time, DLC does not have treatment available to effectively eliminate the toxins (microcystins) generated by blue-green algae.

3.8.7 Mountain Pine Beetle

The current mountain pine beetle (MPB) outbreak in BC has been facilitated by several factors including landscape, host condition and abundance, climate, fire and insect population dynamics. The outbreak is so extensive that only the depletion of the host will cause a collapse in the MPB population and that collapse is currently being witnessed (Maclauchlan, 2009). With the extensive loss of forest cover, hydrological changes are expected. Severity will depend on weather, watershed and forest characteristics, extents of attack and salvage harvest. But in general, one can expect that more water will be delivered to the soil surface, more quickly and more often (Winkler and Redding, 2009). One way to evaluate how quickly water is delivered to the soil surface is to determine the peak flow hazard. Peak flows are largely dependent on the snow accumulation and snow melt above the snowline (also referred to as the snow sensitive zone). Significant peak flow increases can lead to increased channel instability, bed load transport and diminished water quality (DEL, 2008b). Canopy loss above the snowline is thought to have the greatest impact on peak flows.

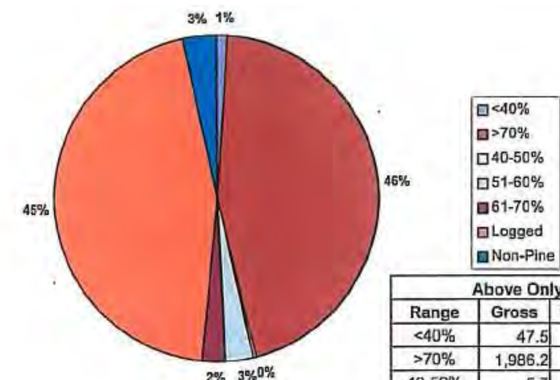
The potential of MPB infestation in the Oyama and Vernon Creek watersheds was estimated based on the availability of mature lodgepole pine (as per Vegetation Resource Data). Dobson Engineering Ltd. (2008) completed hydrologic impact assessments of the MPB infestation based on the availability of lodgepole pine within the watersheds and the proposed retention plans by the forestry tenures. Figure 1-12 is taken from Dobson's reports and illustrates the condition as of 2006 above the snowline elevation (% harvested, % non-pine, and various densities of lodgepole pine stands) within each watershed (refer to Dobson, 2008a & b for details on snowline determination). The two watersheds are very similar with approximately 45% of the area above the snowline already logged and about 45% of the remaining area composed of more than 70% lodgepole pine. Based on the forest composition, it was speculated that the MPB infestation would be severe and will likely have a significant impact on peak flows and the water quality at the intake (DEL, 2008a & b).

Oyama Creek Watershed



Above Only		
Range	Gross	%of Total
<40%	32.5	1.9%
>70%	781.3	44.7%
40-50%	28.1	1.6%
51-60%	84.4	4.8%
61-70%	0.0	0.0%
Logged	774.6	44.3%
Non-Pine	48.6	2.8%
	1,749.4	100.0

Vernon Creek Watershed



Above Only		
Range	Gross	%of Total
<40%	47.5	1.1
>70%	1,986.2	45.1
40-50%	5.7	0.1
51-60%	124.7	2.
61-70%	105.9	2.4
Logged	1,984.8	45.0
Non-Pine	151.4	3.4
	4,406.2	100.0

Figure 1-12. Distribution of Mature Pine above the Snowline for Oyama and Vernon Creek Watersheds (taken from DEL, 2008a and b).

Table 1-11 is also taken from Dobson's reports; it details the ECAs above the snowline for 2006 conditions with no MPB, with losses of all mature pine, and after the proposed retention plan by the forestry tenures. These numbers illustrate that the peak flow hazard would change from low (based on 2006 conditions) to high if all mature lodgepole pine die. The peak flow would be further elevated with the salvage harvesting of dead trees. Based on these numbers and the limited understanding of the effects of salvage harvesting as opposed to no harvest (e.g. assumption that grey stands would have a similar hydrologic effect as clearcuts), DEL (2008a & b) concluded that the proposed salvage harvest and plant scenario, although considerable in the short term, would have a significant benefit to the long-term hydrology since the recovery would be greater and would occur more quickly (as a result of silviculture).

Table 1-11. Equivalent clearcut area at December 31, 2006 for no MPB, loss of all mature pine, and proposed retention plans for areas above the snowline (DEL., 2008a & b).

1 Basin	*2 Area Above Snowline (ha)*	*3 ECA assuming no beetle (ha/%)*	*4 ECA Assuming all Mature Pl Dies*	*5 ECA For Proposed Harvesting (ha/ %)*	*6 ECA For Retention Plan (ha/ %)*
Oyama Creek above Intake	1,749.4	476.1/27.2	1,196.9/68.4	1179.9/67.4	1327.4/75.9
Oyama Creek above Oyama Reservoir Outlet	1,500.0	367.3/24.5	1,046.5/69.8	974.7/65.0	1112.9/74.2

1 Basin	*2 Area Above Snowline (ha)*	*3 ECA assuming no beetle (ha/%)*	*4 ECA Assuming all Mature Pl Dies*	*5 ECA For Proposed Harvesting (ha/ %)*	*6 ECA For Retention Plan (ha/ %)*
Vernon Creek above Lake Country Intake	4,406.2	951.8/ 21.6	2,897.4/ 65.8	2350.8 53.4	3046.5 69.1
Vernon Creek above Swalwell Reservoir Outlet	3,984.0	751.5/ 18.9	2,624.4/ 65.9	2120.9 53.2	2773.0 69.6
Clarke Creek	1,106.0	510.7/ 46.2	700.7/ 63.4	670.5 60.6	6776.0 70.2

More recent MPB infestation data is available via aerial flyovers conducted by the Ministry of Forests. Figure 1-13a and b show the severity of the MPB infestation as of 2008 in both the Oyama and Vernon Creek watersheds. The beetle attack severity ranges from trace to moderate, indicating that the MPB infestation may not be as dire as originally anticipated. The pattern of MPB is usually green attack through red attack to dead standing in two to five years. The deadfall occurs after 15 -25 years depending on size, site, pre-attack health, age, etc. The effect of MPB on ECA further depends on the stand characteristics, in particular the presence of non-pine species in the overstory and all the species in the understory.

More recent studies have indicated that peak flow change is more sensitive to salvage harvesting than to beetle-kill alone and that generally peak flow change is relatively insensitive to beetle kill (Schnorbus et al., 2009). Others have suggested that salvage logging should be planned to minimize clearcuts in areas which contribute to peak flows

(Teti, 2009). Work has also been recently completed by the Ministry of Environment to more comprehensively determine the stand structure for MPB-ECA modeling, with particular focus on understory diversity (Huggard, 2009). A more detailed understanding of species composition will allow for accurate projections with regard to the extent of MPB infestations and more accurate peak flow estimates.

Forest clearing as a result of the MPB infestation has the potential to create both short and long term effects. For example, the Hydraulic Creek watershed which supplies water to southeast Kelowna, underwent a severe pine beetle infestation during the 1980s. The dead pine and intensive logging which ensued resulted in immediate water quality impacts, but over the long term, the affects of the infestation are still felt in the watershed in the form of severe recreational access to reservoirs and creeks from historic road development.

3.8.8 Drought Management and Climate Change

Climate change has the potential of having a significant impact on the Vernon and Oyama Creek watersheds. It is thought that over the next century BC will experience an increase in mean annual temperature (~2-4 ºC) and a modest increase in total annual precipitation, with the bulk of additional precipitation occurring in winter (Tyedmers and Ward, 2001). Specific impacts of climate change in the Okanagan include: less precipitation as snow, earlier snow melt, an increase in evapotranspiration, and longer growing seasons with increased agricultural demand (Cohen & Kulkarni, 2001). Earlier snow melt peaks will lead to increased flow during winter and spring months and less available water during the summer months when irrigation demand is greatest (Cohen & Kulkarni, 2001). These potential changes are of particular concern, as approximately 80% of the water supplies in the Vernon and Oyama Creek watersheds are used for irrigation of farmland (Jack Allingham, pers. com.). Although most of the concerns surrounding the impacts of climate change on drinking water management are water quantity related, water quality may also be impacted, as reservoirs have shorter residence times and as water temperatures increase.

Between 2002 and 2004, the DLC experienced a water supply shortage as a result of a drought which was in the order of a one in one hundred year event (Mould Engineering, 2005). The reservoirs within the Oyama and Vernon Creek watersheds experienced record low levels and severe water restrictions were implemented. Since then, drought management and supply augmentation options have been widely assessed (Mould Engineering, 2005). In 2007, the DLC submitted an application with Front Counter BC to raise the upland reservoir lake levels of Oyama, Swalwell and Crooked lakes in order to accommodate more storage. Ecoscape understands that there is limited information concerning the hydrology and inundation effects of each of the reservoirs and surrounding lakeshore areas, and thus the Ministry of Environment is requiring an additional study to investigate these issues prior to approval (to be completed in 2010, pending funding approval).

Ecoscape carried out a modeling exercise to estimate the inundation zone on Swalwell, Crooked and Oyama reservoirs. A digital elevation model was generated based on elevations derived from TRIM data. To complete this task, we determined the high water level of lakes by digitizing them from the airphoto. The digitized high water level of the lake was added to the digital elevation model. Finally, the anticipated elevations of the reservoirs were mapped according to the proposed raises to give us a more accurate extent of the lake.

This analysis provides a general understanding of areas that may become inundated if the reservoirs are raised. However, the elevation models are only as accurate as the data that was used to generate them. Although we have increased the accuracy of these models by digitizing the shorelines of the lakes, better surveys of the reservoirs are required to accurately determine the extent of inundation. Ultimately, the accuracy is limited because the TRIM data has a scale of 1:20,000 and TRIM data was the primary source of elevations used in the model.

The analysis of the proposed inundation zones is an overview and should only be used as such. The data generated will help the DLC determine approximate water volumes that may be gained through raising the reservoirs and help provide background information for more detailed assessment. Prior to approval, a detailed environmental impact assessment will be required. This assessment should address fisheries, wildlife, hydrological, and feasibility concerns (e.g., species loss, (Lloyd Manchester, pers.com.)), and outline mitigative measures to reduce the impact of raising the dams.

Figures 1-14a-c depicts the approximate inundation zones. Existing infrastructure that is anticipated to be affected by these activities include the following: Forest Service Recreation sites; lease lots; and resorts.

Ecoscape understands that the Okanagan Cabins Owners Association (OCOA) completed a similar mapping exercise to determine the extent of flooding in relation to the existing cabins. Their mapping illustrated that only two cabins would be directly affected by the increased water levels. Ecoscape did not evaluate the affect on actual structures, but based on our model, 17 lease lots (including all 3 resorts) would experience encroachment within the lot boundaries. Although in most cases the cabins will not be directly affected, there would be a reduction in the distance between the high water level of the reservoirs and cabin infrastructure such as septic systems and pit toilets. Finally, there is variability between the outputs of the two mapping exercises, which further emphasizes the need for a detailed survey in order to determine the actual extent of inundation.

3.9 Intrinsic Hazard Identification Table

All biogeophysical hazards encountered during the watershed characterization step are summarized in Table 1-12.

Table 1-12. Intrinsic Hazard Identification Table

Hazard #	Drinking water hazard	Possible effects	Source level existing preventative measures	Associated barrier(s)	Comments	Report Section #
1-1	Characteristics of raw water including high turbidity associated with spring freshet	• Naturally high levels of turbidity and colour due to organic and sediment runoff. • Unless filtered, particulate matter can reduce the effectiveness of disinfection, potentially causing illness if pathogens are present. • Disinfection bi-products	• Coarse and fine screens at the Oyama and Vernon Creek intakes reduce the amount of large particles and debris which enter the distribution system. • Routine inspection and maintenance of upland reservoirs and infrastructure.	• Intake management in the form of settling ponds and intake screens	• Water quality sampling/monitoring (including for turbidity) occurs regularly at the intakes and can indicate problems in the watersheds. • Sources are variable and natural characteristics of the watershed are a significant contributor to raw water characteristics.	3.7
1-2	Slope failure/debris flows within the assessment areas	• Sediment and nutrient influx into source watercourses • Increased turbidity and colour parameters	• Routine inspection and maintenance of upland reservoirs and infrastructure	• Reservoirs buffer events in upper watershed • Pre-settlement basins bear intakes provide some protection, but mostly for small events	• Landslides in the Vernon Creek watershed are a significant concern.	3.8.2
1-3	Presence of birds and wildlife	• Pathogenic bacteria (*Escherichia coli*) and protozoa (*Giardia lamblia* and *Cryptosporidium parbum*)	• None identified	• None identified	• Barriers exist at the treatment level	3.8.4
1-4	Wildfire Potential	• Destabilization of soils leading to erosion • Ash can lead to increased nutrient loading in streams and lakes • Fire retardant is 90% fertilizer and thus may influence algal blooms • Changes in vegetation species composition	• Fuel management treatments have been undertaken (i.e. reductions in canopy closure and ground fuels) to reduce the intensity of fires and to increase access for fire fighters	• None identified	• The province issues bands on camp fires when fire potential is greatest.	3.8.5
1-5	Algal blooms	• Potential toxins (microcystins) which may be harmful to human health • Symptoms could include headaches, fever, diarrhea abdominal pain, nausea and vomiting	• Nutrient sources are limited and monitored	• None identified	• Algal blooms have yet to create significant concerns in the Oyama and Vernon Creek watersheds, however, future blooms may coincide with climate change, wildfire and anthropogenic impacts.	3.8.6
1-6	• Mountain pine beetle	• Increased water reaching soil surface and flowing from hill slopes • Increased spring and total annual stream flow volumes • Earlier onset of snowmelt • Potential conversion of subsurface to surface water along roads • More rapid stream flow response to storms	• Selective harvesting of infested stands • Rapid reforestation	• MOE has undertaken a study to more accurately identify stand structure for ECA modeling (Huggard, 2009). • Associated harvesting also influences peak flow hazards and the extent of impact.	• Water quality sampling/monitoring (including for turbidity) occurs regularly at the intakes and can indicate problems in the watersheds.	3.8.7
1-7	• Drought management and climate change	• Increase in annual temperature • Increase in precipitation, but less as snow • Longer growing seasons • Increase in agricultural demand • Increase in evapotranspiration • Enhanced flows during winter and spring months and less available water during summer months	• None identified	• The DLC has submitted an application to raise the elevations of three reservoir lakes	• Impacts due to climate change are difficult to predict and manage.	3.8.8

4.0 MODULE 2

4.1 Objectives

The objective of Module 2 is to inventory land uses and activities within the assessment area and identify potential sources of contamination associated with these activities that could affect drinking water quality. This information, together with the watershed characterization undertaken as part of Module 1, will then be used as a basis for evaluating risks associated with the source area to the drinking water supply as required in Module 7.

4.2 Methodology

The contaminant source inventory was completed through a series of different activities which include: 1) on site visual inspection of land use activities and potential contaminant locations within the assessment areas. Although Ecoscape does not claim to have covered the entire assessment area, we did document potential contaminants across its majority with particular attention paid to source water creeks, lakes and reservoirs. Potential contaminants, land uses and activities were marked using a spatially accurate Trimble GPS and included incidences of human recreation (e.g. camping sites, outhouses, off road activities), cattle presence, erosion, etc. 2) A review of relevant maps, reports, scientific literature, and provincial, federal, and local government data sources; and 3) Additional information was obtained through interviews and communications with the following sources:

- Jack Allingham, District of Lake Country
- Patti Hansen, District of Lake Country
- Fergus Stewart, FPS Drafting & Geomatics Ltd.
- Don Dobson, Dobson Engineering Ltd.
- Brian Gaucher, GauTech Technical Consulting Services
- Michael Milne, M.J. Milne & Associates
- Sharon Mandrusiak, Ministry of Tourism, Culture and the Arts
- Jeff Jacobi, Ministry of Tourism, Culture and the Arts
- John Glaspie, Ministry of Tourism, Culture and the Arts
- Bryn Lord, Interior Health
- Wolfgang Beck, Okanagan Shuswap Forest District
- Rob Dinwoodie, Okanagan Shuswap Forest District
- Duncan Watson, Okanagan Shuswap Forest District
- Ray Crampton, Okanagan Shuswap Forest District
- Kimm Magill-Hofmann, Okanagan Shuswap Forest District
- Matthew Simons, Integrated Land Management Bureau
- Harold Waters, Tolko Industries Ltd.
- Dave Gill, BC Timber Sales
- Brian Bedard, BC Timber Sales
- Katherine Ladyman, Okanagan Shuswap Forest District

- Solvej Patschke, Ministry of Environment
- Steve Milne, Cabin Forestry Services Ltd.
- Rick Simpson, Oceola Fish and Game Club
- Heather Larratt, Larratt Aquatic Consulting
- Colin Cameron, ICL Performance Products Canada Ltd
- Donna McGeachie, BC Transmission Corporation
- Lloyd Manchester, Okanagan Cottage Owners Association
- Bruce Williams, Dee Lake Wilderness Resort
- Margaret Bakelaar, Regional District of Central Okanagan

4.3 Contaminant Inventory

During the field surveys, 79 watershed assessment points were collected which incorporated site specific information, with a particular focus on cattle, sanctioned recreation, unsanctioned recreation, motorized vehicle use and non-motorized use. Figure 2-1 illustrates the location of each watershed assessment point, and generally provides the reader with an idea of the areas covered. For reference, the complete database of watershed assessment points is included in Appendix C, and 38 field photos of interest with specific descriptions, are included in Appendix D.

The following sections detail anthropogenically influenced source contaminants.

4.3.1 Land Ownership

As with other hazards, land occupation has an inherent level of risk that cannot be entirely eliminated. The risk level is reduced or heightened, depending on the due diligence or poor judgment of the occupant. Despite the inherent risk, land occupation can, and often times is beneficial, as occupants act as the eyes and ears of the watershed.

Potential Impacts on Water Quality

The actual impacts of private land and Crown lease lots on source water quality are highly variable, and largely dependent on the activities that occur within individual properties. Likely effects of land occupation within the watersheds have been previously identified by others (Olson & Schleppe, 2009; Summit, 2007) and may include:

- Improper management of biological waste and effluents (e.g. outhouses, septic or sewage);
- Enhanced sediment runoff due to land clearing, poor landscaping practices, construction of boat launches, etc.;
- Trace chemical release. The most notable are hydrocarbons, but other potential chemicals may include fertilizers, stains, paints, wood treatment products and pesticides;

- Lakebed or foreshore substrate modifications that results in the subsequent release of sediments and/or organic matter; and
- Livestock and domestic animal presence resulting in potential biological contaminants entering source waters;
- Runoff from impervious and disturbed surfaces; and
- Accidental contamination and erosion.

Often times, land owners are unaware that actions which are undertaken may have serious and significant impacts to water quality. Further, there is often a perception that individual action's are of little consequence. Regardless, individual actions can and do have potential impacts on water quality and overtime they become measurable. Nevertheless, the potential impacts outlined above can be mitigated through the implementation of best management practices and governmental regulations.

Wilderness resorts on reservoir lakes have an increased potential to affect water quality as compared with individual lots, simply because of their enhanced size and greater number of users. For example, high density usage results in substantial volumes of sewage effluent that must be appropriately treated. Coupled with high density usage at these facilities, are existing zoning policies that in some cases facilitate activities which may impact water quality (e.g. marinas, petting zoos).

Relevant Legislation

Currently, the most applicable legislation to private and lease lands is the Riparian Areas Regulation (RAR) and the Zoning and Official Community Plan Bylaws of the Regional District of Central Okanagan (RDCO) and DLC. The RAR is a methodology that is utilized to determine appropriate building setbacks from a watercourse. The purpose of RAR is to protect fish and their habitats, which are sensitive to changes in water quality. The RAR is applicable to any residential, commercial, or industrial type of development structure, landscaping activity, soil disruption, or construction within 30 m of the high water mark of a watercourse. The province has also indicated that on gauged lakes (i.e., those with dams) that a static elevation should be used for determination of setbacks.

At this time, the RDCO has drafted and approved amendments to the zoning bylaw no. 871-178, that includes the addition of CL8 Conservation Lands and RU7 Cottage Lot. The cottage bylaw (Zone RU7) has been developed specifically for upland reservoir areas and includes requirements for minimum parcel size, dwelling size (maximum of 150 m^2) and parcel coverage. The bylaw also includes incorporation of a minimum 30 m setback from a watercourse. However, the bylaw does not address how or where the setbacks are measured from (i.e., present natural boundary versus top of spill way elevation for a gauged lake). Further, this bylaw does not specifically address strategies to mitigate impacts of land development on water quality.

The purpose of the Conservation Lands zone (CL8) is to manage lands and watercourses where protection and conservation of the natural environment is the principle objective and to permit passive recreational uses where appropriate. It also specifies a 30 m setback from watercourses and permits uses such as interpretive centers and forest and wilderness oriented recreation.

The Wilderness Resort Commercial Zone (C8) is the other applicable zoning that pertains to resorts on reservoir lakes. This zone does not specify minimum setback requirements from a watercourse, and thus it is presumed that the RAR is the next most applicable legislation to guide foreshore development. The C8 zoning does allow numerous activities including marinas, riding stables, restaurants and mini golf. It also allows a maximum of 25 wilderness accommodation units per hectare and a maximum of 50 wilderness accommodation units per parcel. Again, the zoning bylaw does not contain specific strategies to mitigate potential impacts of wilderness resorts on water quality. A perfect example of this is the allowable use of marina facilities, which typically have boat launches (which we have documented introduce sediments and act as a conduit of other trace and biological contaminants) and moorage facilities for numerous watercraft (e.g., hull leachates, release of hydrocarbons during over water fueling, etc.).

Other complications with crown lease lots revolve around the multiple jurisdictions which have governance over land development. For example, RDCO recently issued by-laws pertaining to lease lots (discussed above) and these bylaws contained few specific strategies to protect source waters. The RDCO is also responsible for issuing building permits for erection of structures and is therefore the agency most suited to provide specific measures to protect source waters through development of appropriate bylaws. Although the DLC is part of the referral process for development applications, they can only provide comment and do not have authority to authorize development or building permit applications. Further, the DLC also has little control over crown lands, licensees (e.g., forests or range license holders), or water act applications (i.e., docks, water licenses, etc). This greatly reduces the ability of DLC to protect source drinking waters.

Summary of Land Ownership

Table 2-1 and Figures 2-2a and b summarize current land ownership within the Oyama and Vernon Creek watersheds. A discussion regarding land ownership within each is found below.

Table 2-1. Crown Lease Lots and Private Lands within the Oyama and Vernon Creek Watersheds.

Watershed	Crown Lease Lots within RDCO jurisdiction (km^2)	Private Lands with DLC jurisdiction (km^2)	Remaining Crown Land	Total (km^2)
Oyama Creek	0.046	0.316	42.15	42.512
Vernon Creek	0.325	0.768	84.193	85.286

Oyama Creek Watershed

Within the Oyama Creek watershed there are both private holdings and crown lease lots. Private holdings in Oyama include several parcels that extend into the lower portions of the assessment area (see Figure 2-2a). The water intake and associated infrastructure occurs on two privately held parcels of land owned by the DLC and access to the intake requires the use of various easement roads across private lands. There is also a land parcel (31.3 ha) that occurs on the south side of Oyama Creek within the DLC just above the intake. This private parcel is zoned RLP which is a zoning designation for Rural Large Parcel. Under this zoning, this parcel cannot be further subdivided unless an alteration to the existing land zoning is obtained from the DLC Council. Due to the adjacency of these parcels to the intake, future changes in land use and/or zoning must be carefully considered and must incorporate appropriate protection measures to ensure the integrity of the intake and source waters. As previously discussed in Section 3.5.1, private land in this location is somewhat beneficial as it largely prevents public access to the intake. Further, it is even more beneficial that the DLC has control over any changes in land use within these parcels through a re-zoning process that requires council approval.

Around Oyama Lake there are a total of 13 crown lease lots. These lots are currently zoned RU7 as previously discussed. The lots are only accessible by foot and/or boat; no vehicular access was identified during field surveys. The Oyama Lake Wilderness Fishing Resort also occurs on Oyama Lake and is zoned C8 by the RDCO. The resort is serviced with power, and water is obtained from a well. The facility currently has a total of thirteen cabins, a main lodge and small store, a workshop/sawmill, and a number of camp sites.

Sewage disposal for the different lease lots was not assessed as a part of this study. However, efforts were made to review documents which detail existing sewage disposal methods and the lots capabilities of facilitating septic systems. Documents reviewed include Lakeshore Environmental (2003), Oland Engineering Ltd (2007), and Water Supply Association of BC (2003). Oland Engineering Ltd. (2007) reports that most of the lease lots on Oyama Lake have pit outhouses, with the exception of the Oyama Lake Wilderness Fishing Resort which is serviced by a possible non conforming septic system. Lakeshore Environmental Ltd. (2003) also reported several un-permitted septic systems servicing the resort (residence, cabins and shower house) as per a personal communication with the resort owner. Ecoscape has contacted the resort owner and understands that the septic system has been updated within the last several years. Of the remaining lots which are serviced by pit toilets, only one lot has the potential for onsite sewerage following standard subdivision guidelines, while the remaining lots require either a detailed site investigation to find a solution or a community sewerage system (Oland Engineering Ltd, 2007)[3].

Vernon Creek Watershed

Within the Vernon Creek watershed, both private and crown lease lots also exist. Privately held parcels are also located directly above the water intake structure and these parcels are zoned Agricultural (A1) within the DLC (See Figure 2-2b). Allowable land uses of the A1 zoning designation include agriculture, range uses, etc. With this particular zoning

[3] Ecoscape understands that if and when lease lot resorts and cabins are transferred to freehold, they will not have to conform to the subdivision guideline as discussed in Oland Engineering Ltd. (2007). We further understand that this issue was debated during the three year consultation process initiated by ILMB, and has since been clarified.

designation, the minimum parcel size is 3.8 ha and therefore further subdivision of the parcel into smaller pieces may be possible. At this time, the DLC has a policy within the Lake Country Community Agriculture Plan (2008) as follows:

> *It is recommended the AAC and Council discourage any further subdivision of any land parcels in the ALR.*

In addition, there are 42 residential and 2 commercial lease lots within the Vernon Creek watershed. There is 27 and 15 residential lease lots on Swalwell and Crooked Reservoirs, respectively. There are also two commercial lodges within the watershed, with one on Swalwell Reservoir (Beaver Lake Mountain Resort) and one on Dee Lake (Dee Lake Wilderness Resort). The resort on Swalwell Reservoir currently contains a total of 22 cabins, with some of the cabins on septic and some with outhouses. The lodge on Swalwell also has a petting zoo, with numerous types of domestic animals that patrons can view. Finally, the facility also has various camp sites that are leased on a daily, weekly, and yearly basis. On Dee Lake, the resort has full service cottages, log cabins, camping and RV facilities, lodge units and a store and office. Some of the facilities are on septic, while others utilize outhouses.

Sewerage disposal in the Vernon Creek watershed was also assessed by Oland Engineering (2007). The commercial resorts on Dee and Swalwell Lakes are both serviced by sewerage systems and have room for expansion (Oland Engineering Ltd., 2007). The sewerage system that is currently constructed on the Dee Lake resort does not conform to current subdivision servicing requirements and a larger area would need to be proven to meet current regulatory requirements (Oland Engineering Ltd., 2007). The Beaver Lake resort`s sewerage disposal system has been constructed under permit from IHA and has room for expansion (Oland Engineering Ltd., 2007). Most of the residential lease lots on Swalwell and Crooked reservoirs are currently serviced by pit toilets. These lots are typically small (i.e., 900 m^2) and do not have sufficient room for individual sewerage systems (Oland Engineering Ltd., 2007). However, it may be possible to construct a sewerage system with lot expansion or installation of a community system (Oland Engineering Ltd., 2007).

Lakeshore Environmental Ltd. (2003) assessed all of the lease lots within both watersheds and generally reported that there were minimal impacts to water quality. However, the report also highlighted the potential for siltation from frontage areas and Ecoscape corroborated these findings.

Identified Source Water Concerns Originating from Private / Crown Lease Lots

Ecoscape did not complete a detailed assessment of privately held parcels. Land access was only granted to observe facilities at the wilderness resorts. Thus, our assessment included an inventory of identified features from the foreshore of the reservoirs and a brief tour of the wilderness resort facilities.

All three of the resort facilities were generally clean and well kept. There were some instances of sediment point sources originating from access roads, boat launches, paths, etc.

These observations were generally similar to that observed around the forest recreation sites, or other sanctioned and unsanctioned recreational areas. The primary concern with the wilderness resorts is the usage intensity that occurs at these facilities on a year round basis, which increases the potential for water quality contaminants to enter the reservoirs.

Numerous issues were observed on the different residential lease lots. They are similar to issues identified in other watersheds and largely stem from manipulation of land to suit the desire of the lease holder. Documented issues observed in the Vernon and Oyama Creek watersheds included the following:

- Clearing of lakeside vegetation within riparian management zones. In some cases, clearing of vegetation was so extensive that nearly the entire foreshore area was cleared and soils were completely denuded of vegetation. In this same case, all of the vegetation that had been recently cleared was burned in two different locations below the high water level of the reservoir. This action resulted in further loss of foreshore aquatic vegetation due to the high temperatures. All of these impacts result in the release of potential contaminants and hinder the buffering capacity of the system.

- Sewerage, grey, and black water disposal has not been assessed in detail. However, it is presumed that all lease lots are equipped with at minimum an outhouse facility (although this has not been confirmed). Further, the wilderness resorts maintain year round activities with increased sewerage disposal requirements and some of these systems do not meet current requirements increasing risks. Finally, sewerage disposal systems that are used with highly variable peaks (i.e., extensive summer use, moderate fall use, and minimal winter usage) are more prone to failure because sewerage disposal systems provide the greatest water treatment under continuous flows. This occurs because these systems rely mostly upon biological treatment to remove contaminants and they require periods of startup and stabilization to reach optimal treatment. Given the lack of sewerage, it is possible that shallow pit toilets, dish washing, bathing, and other activities result in the release of contaminants to the reservoir. Further, it is possible that the sewerage disposal systems that do exist (mostly at the resorts) may not be operating at peak performance, as required to protect water quality.

- Numerous different point sources of sedimentation from cabins paths and access roads to the reservoirs were observed. These sources of sediment were not much different from sources of sediment observed on Forest Recreation Sites or on the wilderness resorts.

- There were several examples of construction of vehicle access roads (e.g. make shift boat launch) to the reservoirs which have resulted in clearing of vegetation and sediment sources.

- There were numerous examples of moorage construction. In many cases, moorages were over the 24 m^2 size limit and it is highly probable that appropriate permits were not obtained for these structures because they were not erected following standard best management practices (i.e., a Section 9 notification and appropriate lease for the moorage)[4]. It was also observed that some of the docks had been constructed using treated wood piles, had been recently painted or stained, and concrete was used as anchors below the high water level of the reservoir. Almost all of these construction practices do not conform to standard best practices for dock construction and it is probable that trace chemicals have leached or were directly released into the reservoirs.

- There were some examples of substrate modification observed along the foreshore areas of the reservoir. The most notable instance was the importation of sand along a gravel / cobble shoreline. This substrate was placed directly below the high water level of the reservoir and was migrating due to wave action along the shoreline. These practices are also not in compliance with best management practices and appropriate permits were not likely obtained to complete the works (i.e., a Section 9 notification of approval was not applied for).

- Evidence of ATV use below the high water level by lease lot owners was observed once within the Vernon Creek watershed. It appeared that an ATV may have been employed to transport a boat to the waters edge.

- Several examples of retaining wall construction were also documented. Similar to above, many of these walls were not constructed following standard best management practices (i.e., they were not bioengineered) and it is highly probable that appropriate permits were not obtained for the works.

Impacts to water quality due to residential lease lots appeared to be significantly greater in the Vernon Creek watershed than the Oyama Creek watershed. The differences were stark, with little to no foreshore modifications within the Oyama lease lots. We suspect that these lease lots remain in a more natural state due to their limited access. As previously mentioned, there is no vehicular access to the lease lots on Oyama Lake. Therefore, supplies must be transported in by foot or boat. This limited access makes lease lot modifications substantially more difficult and likely helps to limit some of the non-desirable activities described above.

[4] Ecoscape did not make a formal request to assess whether appropriate permits were obtained. Many of the structures were quite old. A formal survey of overwater structures should be completed to assess whether appropriate permits have been obtained.

Controversy of Lease Lot Sales

Crown lease lots are a complicated topic and have been a part of numerous politically charged discussions at many levels of government over the past several years. The sale of lease lots was initiated in the early 2000's by Land & Water BC, a corporation associated with the Ministry of Sustainable Resource Management, and 141 lease lots were initially listed to be sold. The project was deferred in 2003 when a restructuring of the government resulted in a lack of capacity to resource a further environmental review of the proposal. The Integrated Land Management Bureau (ILMB) re-established the sales project in 2006, and has worked with an Advisory Committee comprised of representatives from the water purveyors, local government, IHA and recreational leases to address potential water quality impacts.

The cabin owners (lessees) list the following as key benefits in transitioning the lease lots to freehold (pers com., Bruce Williams of Dee Lake Wilderness Resort and Lloyd Manchester, OCOA).

- Freehold would allow for financing to enable long term improvements to infrastructure (i.e. building improvements, establishment of powerlines and alternative heating to wood burning appliances);
- Eliminate escalating taxes and lease fees;
- Simplify relations with government; and
- Create profit from timber harvesting to be used for replanting and restoration.

The following are some drawbacks to the sale of lease lots which have been outlined in a previous assessment (Summit, 2007).

- Leases provide opportunities for landowners to protect water quality. While some lessees' and landowners may act responsibly, there is a risk of entrusting water quality protection to different landowners;
- Original private landowners may act responsibly, however if ownership is transferred, there is no guarantee that appropriate attitudes and practices will be transferred with the property; and
- There may be unforeseen impacts as a result of transferring to freehold.

Local water purveyors are generally opposed to the sale of lease lots on reservoir lakes and promptly issued a position statement and a critical review of a supportive assessment report by Lakeshore Environmental Ltd. (2003) (Water Supply Association of BC, 2002, 2003). Subsequent to these reviews, a more detailed investigation of the sewerage treatment options was completed (Oland Engineering Limited, 2007). The report on sewerage only focused on the feasibility of sewerage of lakeshore lease lots and simply contained a brief review of systems currently installed. Further, this review did not investigate the performance of existing systems and whether they are functioning at acceptable levels to protect source waters.

In 2007, Summit Environmental Consultants Ltd. also issued a report for ILMB which outlined a 3-step approach for protecting Okanagan upland lakes from land ownership related issues. This approach included: 1) determining the sensitivity of the lake; 2) performing a risk assessment considering lake sensitivity; and 3) identifying the most appropriate suite of practical and regulatory mechanisms to apply to lots.

The potential sale of lease lots within the Oyama and Vernon Creek watersheds does pose concerns. With the biggest concern relating to the water quantity limitations and the future water demands of the District. At this time, the DLC has submitted an application to increase the capacity of reservoirs to meet future water demands. However, if the sale of Crown lease lots occurs, the task of raising the reservoirs becomes ever more complicated and expensive.

Despite the outlined issues, there appears to be a general sentiment by some cabin owners to work together to improve water quality. In response to: “In your role as a watershed stakeholder, how can you best assist in source water protection?” A lease lot owner responded that “they would like guidance as to how to further protect the watershed”. The response continued with a suggestion that individual site visits of lease lots by an environmental professional would be beneficial to highlight areas of concern and potential courses of action to reduce their impact. This response suggests that cabin owners may not be entirely aware of how activities such as burning below the high water level of a reservoir, or how the clearing of land can affect source water quality.

4.3.2 Wind Generation

The following information was obtained through a referral request from FrontCounter BC and via communications with Matthew Simons of ILMB.

A license application has been approved on Crown land for the construction of meteorological towers for the purposes of wind monitoring and data collection to determine the characteristics of the wind energy resource. The investigative permit area (approximately 4,589 ha) and individual tower locations are shown on Figures 2-2a and b. The permit area overlaps both the Oyama and Vernon watersheds and the initial term of the investigative permit is 10 yrs. Ecoscape understands that meteorological towers are typically placed in previously disturbed locations (e.g. forestry landings) which have existing access roads. In the event that tree removal is required, then site specific information is submitted for approval.

Meteorological tower development will have little impact on source water quality if constructed at the locations indicated in Figures 2-2a and b. Depending on the need for tree removal, there could be some sedimentation issues and there may also be the potential for chemical contaminants originating from motorized equipment used to construct the towers. Nevertheless, if these contaminants do occur, there is a substantial distance from the tower locations to source watercourses. All currently defined tower locations occur in low vulnerability areas, however the investigative permit area does intersect higher vulnerability locations.

4.3.3 Human Access and Recreation

Potential Impacts on Water Quality

Human access within community watersheds can result in contaminants entering source water and may lead to a deterioration of water quality at the intake. It is presumed that as access increases, the potential for adverse contaminants also increases. In most cases, access is facilitated by pre-existing road networks that were originally intended for commercial purposes (i.e. forestry). Although many of these roads have been deactivated, they remain traversable by ATVs and 4x4 vehicles. Generally, the majority of activities that occur within community watersheds are legal and sanctioned (i.e. hunting, angling, hiking, etc.), however, some activities are unsanctioned and legal (i.e. camping outside of designated areas), while others are considered activities of crime (i.e. abandoned vehicles, intentional dumping, etc.).

The effect of these varied activities is highly dependent on the activity type and where it occurs within the watershed. We suspect that the most frequently occurring contaminant resulting from access and recreation is likely sediment and organic loads originating from roads and trails. Other contaminants include trace chemicals which are typically released during the operation of motorized equipment (e.g. hydrocarbons from boats, snowmobiles, all terrain vehicles, etc.) and pathogens which originate from humans and domestic pets. A potentially significant source of pathogens originates from septic contamination as a result of illegal dumping of storage tank waters from recreational vehicles.

The impact of access and recreation is also largely dependent on the due diligence of individual users. When carried out responsibly, activities such as motorized recreation can have relatively little effect on water quality. Intentional, illegal activities within the watersheds can be far more detrimental and difficult to control. In regards to watershed protection, the behavior of a few can certainly impact the many, especially when inappropriate activities take place on source water creeks and reservoirs.

Finally, consideration must be given to the additive effect of various activities. For example, motorized recreation can serve as a secondary transfer mechanism for sediment and feces (i.e. cattle) to source water courses via vehicle or ATV tires. The combination of recreation and range use can exacerbate biological contamination, as microbes originating from large scats can remain viable for long periods of time. Furthermore, it has been documented in other watersheds that sediment disturbance in creeks, as a result of motorized vehicles or dirt bikes can cause a spike in bacteria through suspension of previously dormant specimens (Larratt Aquatic Consulting, 2009).

General Findings

Ecoscape, as well as others, have documented recreational activities within the assessment area of both watersheds. During the summer, activities consist of fishing, camping, hiking, boating, horseback riding, mountain biking and various motorized activities (including ATV's, motorcycles and quads). While in the winter, popular activities include snowmobiling, cross country skiing and snowshoeing.

Mapping of recreational hot spots was carried out using GPS site surveys, air photo interpretation and spatial data obtained from various sources. Figures 2-3a and b shows recreational use within the watersheds with specific documentation of established hiking trails, forest recreation sites, motorized recreation, unsanctioned camping and commercial resort locations. This mapping is intended to inform the reader of the high intensity recreational areas, but it is not necessarily comprehensive or inclusive.

Table 2-2 details the locations of MOTCA regulated recreation camp sites. All sites, except High Lake, are maintained, however none of them are sizable enough to support a camp host. Ecoscape understands that there is a shortage of regulated campsites within these watersheds and in order to accommodate user demand, MOTCA is currently looking at expanding the number of vehicle units at both the Island and Swalwell Lake recreation sites (pers. com., John Glaspie). During site surveys, it was noted that all regulated sites were relatively clean and well maintained. Although garbage was noted, in no cases was it excessive. Erosion originating from access roads, camp site clearings and boat ramps was documented at most of the recreation sites listed in Table 2-2. The erosion severity ranged from negligible to moderate, where sediment was delivered directly to adjacent lakes. At the majority of sites, sedimentation can be controlled with the use of standard erosion control techniques such as water bars, sumps, ditch/swale, etc.

Table 2-2. Summary of MOTCA Regulated Recreation Sites within the Vernon and Oyama Creek Watersheds.

	# of Vehicle Units	Outhouses	Activities
Oyama Watershed			
Oyama Lake	4	1	Boat launch, Picnic table
Streak Lake	5	1	Picnic table
High Lake	1	0	Picnic table
Damer Lake	2	1	Picnic table
Vernon Watershed			Picnic table
Swalwell Lake	10	2	Boat launch, Picnic table
Island Lake	7	2	Boat launch, Picnic table
Lost Lake	0	1	Picnic table

*Information was provided by the Ministry of Tourism, Culture & the Arts (MOTCA).

In addition to regulated camping, we also documented unsanctioned campsites, which were evident by remnant fire pits. Unsanctioned campsites were most commonly encountered adjacent to roads, creeks and lakes. The site of greatest concern was within the Vernon Creek watershed and is located at the Crooked Lake dam. The following is a brief description of the site:

- At the time of the site visit a small fire was burning within a fire pit and no users were present. Ecoscape extinguished the fire. Extensive garbage and evidence of intentional dumping was observed across the site, include garbage located directly in the over flow spillway between Crooked and Swalwell Reservoirs. Two shallow outhouse pit toilets had been erected at the site and there was extensive evidence of

ATV activities, including recent trail clearing to Swalwell Reservoir that was also being utilized by cattle to access shoreline.

The site at Crooked Lake dam was by far the worst example of unsanctioned camping documented by Ecoscape. After discussions with Jeff Jacobi (MOTCA), Ecocape understands that this site was once a managed recreation site, but was decommissioned at the request of the water purveyor. The present condition of this site highlights the challenges and difficulties of decommissioning sanctioned campsites. The removal of infrastructure and management at Crooked Lake dam has not prevented its continual use, and without regular maintenance, the conditions of the site have become seriously compromised.

Motorized recreation (4x4/ATV/motorbikes) below the high water level of important streams and/or reservoirs is another documented activity of concern. Mud bogging was noted in both the shallow areas of reservoirs and in intensively used areas adjacent to source streams. The intensity of motorized activities below the high water level was substantially less than in other watersheds we have assessed. We attribute this to the sizable forest buffers that occur around Swalwell, Crooked, and Oyama Reservoirs. In general, access to these reservoirs is limited to a few access points. Large woody debris is very apparent along many of the shoreline areas and also assists in limiting motorized and cattle access at low water. Although it appears that mudbogging activities are occurring at low to moderate levels, Ecoscape is concerned that salvage harvesting within Lakeshore Management Zones may facilitate additional access and an increase in the intensity of motorized recreation below the high water level of reservoirs.

Fortunately, in November MOTCA announced new off-road vehicle regulations that will require a one time registration and vehicle license plates for use on Crown land. License plates on off-road vehicles will facilitate the identification of individuals who are damaging sensitive habitats and will hopefully limit activities below the high water level of source watercourses. It will also allow members of the public to assist by calling the RAPP line 1-877-952-7277 to report irresponsible operators.

In addition to the recreational activities described above, we also noted numerous incidents of criminal activities. These included dumping of garbage and hazardous materials, clearing of vegetation for vehicle access, illegal drug cultivation, and abandoned vehicle dumping. Criminal activities appeared to more prevalent in the Vernon Creek watershed, but were also documented in the Oyama Creek watershed.

The following are specific problem areas, pertaining to access and recreation in both the Vernon and Oyama Creek watersheds.

Vernon Creek Watershed

- The non-status road on the plateau above the Vernon Creek canyon is an example of an existing non-status road that has significant potential to impact water quality. The road occurs directly adjacent to historic landslides on steep, coupled slopes. The field survey indicated public access has resulted in activities such as abandoned vehicle dumping, access to creek for what is believed to be illegal drug cultivation activities, unsanctioned camping; and intentional dumping of garbage and animal carcasses. Attempts have been made by the DLC to block this road (i.e., a ditch was dug), but within weeks access was reestablished (i.e., the ditch was filled in).

- At the entrance to the High Rim Trail, excessive garbage has been dumped at the trail head along the main forest service road.

- See example above for unsanctioned camping at the Crooked Lake Dam site.

Oyama Creek Watershed

- On the main Oyama FSR, there is an area commonly referred to as “the lookout”. Access to this site appears to have been blocked in at least two locations, but ATV access around roadblocks is still possible, albeit slightly hampered. The biggest concern observed in this location was a substantial number of shotgun shells (i.e., in excess of 100); shots appear to have been fired out over the Oyama Creek canyon in the approximate vicinity of the intake.

- A non-status road above the water intake remains and has been kept open in order to drive cattle up into the watershed. Ecoscape understands that DLC currently maintains water bars along this road. Recreation use of this road is low. However, this site has been identified as one of concern by M.J. Milne & Associates, who assessed the road as very high risk. Mr. Milne indicated that the water bars are not sufficient to protect source waters because there is still potential for overland flows from the road resulting in mass wasting events (i.e., slumps or land slide) directly above the intake.

- The forestry access road to the recreational site on Damer Lake is contributing a substantial volume of sediment directly to the reservoir. Runoff waters from the main road flow for nearly 100 m before discharging to the reservoir. The erosion on the road is moderate, and flows appear to be capable of depositing sands and gravels directly to the reservoir. It is presumed that any other contaminants that are present on the road are also carried to the reservoir (e.g., fecal matter from cattle).

Managed Recreation

When stakeholders were asked, “What is the greatest threat to drinking water?” one resort owner responded “the lack of management with respect to the use of this resource as a recreation area.”

Managed recreation, in the form of Partnership Agreements is one avenue that MOTCA uses to help manage recreation on Crown land. Partnership Agreements are undertaken with specific user groups (i.e. Nordic Cross Country Ski Club, Okanagan Trail Riders Association) and specify term dates and operational expectations, such as water quality mitigation requirements. There are currently no Partnership Agreements within the Vernon or Oyama Creek watersheds however there are agreements in place in other local watersheds (i.e. Hydraulic Creek, Bear Creek).

Partnership Agreements have worked and are working to adequately protect the land and water resource, however there is currently one Partnership Agreement that has considerable debate on the ability to protect the land and water resource. On one hand, having Partnership Agreements allows MOTCA to exert control over the agreement holder to ensure that environmental resources are maintained. This may allow for the incorporation of specific strategies to mitigate potential impacts, such as erosion and sediment control. On the other hand, in order to ensure that an agreement is successful in protecting the land and water resource, key elements must be incorporated. These elements include, but are not limited to, a comprehensive planning process that directs activities away from key resources (i.e. no trail development across source watercourses), regular monitoring of activities and adequate levels of enforcement.

Another issue which should be considered is if sufficient resources and/or expertise are available to effectively carry out and meet the terms of the agreement. For instance, sufficient resources must be available to successfully incorporate mitigation strategies which may be required to reduce recreational impacts. Ecoscape understands that MOTCA may provide financial and other types of support, and that they must grant authorization to the agreement holder prior to the commencement of works. The cost of implementing mitigation efforts to control activities that can affect water quality is often times significant (e.g. substantial expenditure for construction of a bridge over a source stream, including design, engineering, construction, permitting, and maintenance). Therefore, it is our opinion that financial resources must be in place to ensure that there is an adequate level of planning and implementation. Without it, managed recreation may still have the potential for adverse effects on the land and water resource.

Access and Recreational Use Summary

The Okanagan Shuswap Land and Resource Management Plan (LRMP) identifies Okanagan watersheds as “Intensive Recreation – Shared Use – All Season”. The purpose of this designation is to “acknowledge and manage areas with significant four-season recreation attributes for all forms of recreation in a shared use environment created by a spirit of cooperation.” Despite this designation, the Okanagan Shuswap LRMP also identifies the watersheds as Community Watersheds and provides specific recommendations for development of access within them.

Detailed access management planning with on the ground implementation has yet to be undertaken in either watershed. From our cursory overview, human access and recreation is occurring throughout and the activities are diverse and numerous. We have attempted to comment on those which may have significant effects on water quality. However, we acknowledge that there are other recreational activities that have not been specifically addressed. Nevertheless, both watersheds are widely utilized. In our opinion, questionable human behavior and irresponsible use acts as the greatest risk to water quality. Thus, the importance of education and subsequent enforcement cannot be overstated.

4.3.4 Stream Crossings and Roads

IWAP Note

The interior watershed assessment procedure (IWAP) was previously conducted for the Vernon Creek watershed in 1995 and 1999 and for the Oyama Creek watershed in 1998 (MOF, 1995; Summit, 1999, Dobson Engineering Ltd., 1998). The 1995 assessment was carried out before the Forest Practices Code guidebook was published, and thus some of the values in the 1995 report were calculated using different methodologies. These assessments were directed at forest development impacts and did not necessarily reflect all the hazards that are of concern for the protection of drinking water.

Therefore in this assessment, some of the concept methodologies employed in previous IWAPs have been utilized, but we have also incorporated inspections and assessments of other hazards which have the potential to affect source water quality. The results of this assessment are not necessarily comparable to the 1999 IWAP assessment, just as the 1995 and 1999 assessments are not directly comparable due to differences in methodology (Summit, 1999). The biggest discrepancy between these works and the previous IWAPs is the size of the assessment area. Our focus is on areas above the DLC intakes, while previous IWAPs incorporated information from the watershed's entirety.

Potential Effects of Roads and Stream Crossings on Water Quality

The main effect of roads on source water quality is the potential re-routing of surface flows via ditch lines which can result in direct release of sediment and other contaminants to source watercourses. Directing storm flows to a creek can result in increased peak flows and adversely affect water quality parameters such as turbidity. Slope failures as a result of roads can also pose a significant risk to water quality. Increased road density generally tends to result in more stream crossings and the potential for enhanced sediment and organic transport to streams and/or storage reservoirs. Coupled with road density, is road positioning within the watershed. Finally, roads augment accessibility for people and livestock, and as a result there is an increase in the likelihood that chemical, biological and physical contaminants will originate from more locations within the assessment area.

Analysis Clarification

In order to achieve a varied perspective, two different hydrology-based consultants were asked to collect and provide data pertaining to road/stream crossings and forestry. For this section, M.J. Milne & Associates Ltd. provided road risk data and analysis for the Oyama Creek watershed and Dobson Engineering Ltd. provided stream crossing data for the Vernon Creek watershed. Evaluation methods obviously differ and thus the results are not directly comparable. However, despite the differences in their focus and methodologies (i.e. M.J. Milne & Associates Ltd. assessed roads and Dobson Engineering Ltd. assessed stream crossings), Ecoscape understands that the data collected was similar for both assessments. For example, Dobson Engineering Ltd. collected data pertaining to roads and associated ditches and incorporated this information into the stream crossing assessment.

In addition to the data provided by sub-consultants, Ecsocape also evaluated all drainage culverts along Beaver Lake Main between the second cattle guard and Beaver Lake Mountain Resort in the Vernon Creek watershed. Ecoscape followed the same methodology used by Dobson Engineering Ltd. to assess stream crossings, but applied it to the drainage culverts. The drainage culvert assessment was thought to be important, given that Vernon Creek parallels this road and that storm water is diverted beneath the road towards Vernon Creek.

Oyama Creek Watershed

Ecoscape made the following observations pertaining to roads and stream crossings in the Oyama Creek watershed:

- Some road networks have erosion associated with them, however, most of these roads were non-status roads occurring in the lower watershed. Erosion at these locations could result in contaminant transport, and may lead to an increased potential for large scale events (i.e. landslides).

- Primary forest service roads and stream crossings were generally in good order throughout most of the watershed. Several sediment traps consisting of a modified cattle guard that collected sediment and directed it to well vegetated areas were documented above stream crossings on primary forest service roads. It appeared that these structures are fundamental in the prevention of sedimentation from roads entering source water creeks. These structures were not identified within the Vernon Creek Watershed.

M.J. Milne & Associates Ltd. provides the following information pertaining to the road risk analysis in the Oyama Creek watershed:

Partial risk analysis methods have been used for the road risk rating evaluation[5] in the Oyama Creek watershed. Risk ratings are the product of the likelihood of hazard occurrence and the expected effect on the resource(s) at stake, or consequence. Water quality and water quantity are key resources at stake in this regard.

Hazards are a source of potential harm, or a situation with a potential for causing harm. Hazards in this evaluation include landslides, uncontrolled drainage, road erosion, and stream sedimentation. Access provided by roads for recreational and/or range management is not considered a hazard in this process, but rather an unintended use of the road. Issues involving recreation and range management activities are addressed in Sections 4.3.3 and 4.3.6, respectively.

Likelihood of hazard occurrence is determined through review and consideration of current and expected road condition, road location, proximity to water, date and method of construction, contribution of runoff from upslope areas, location with regard to unstable or potentially unstable terrain, level of expected maintenance and use, and past restoration priorities or risk ratings where available.

Resources at stake or consequences are those resources that can be affected by the hazard in question, as described above. Expected effect on resources at stake is the degree to which the resource will be negatively affected by the hazard in question. Magnitude of occurrence, slope coupling or connection to the resource at stake, and the presence of lakes and wetlands between a problem site and the DLC intake are important considerations in this regard.

Vernon Creek Watershed

In the Vernon Creek watershed, the Stream Crossing Quality Index (SCQI) was used to qualitatively assess the affect of stream crossings on water quality. Information was collected via the SCQI on all stream crossings within the assessment area, and for drainage culverts on Beaver Lake Road from the second cattle guard to approximately the Beaver Lake Lodge turn off. The index incorporates a variety of erosion indicators primarily focused on road surface and ditchline delivery of sediment to streams. P. Beaudry and Associates Ltd. (2006) provide a background summary and detailed methodology of the index.

Prior to initiating field surveys, predicted stream crossings were reviewed using GIS to identify the intersection of roads and TRIM streamlines. There were 21 predicted stream crossings in the Vernon Creek watershed and 27 stream crossings were field assessed. Additional stream crossings were encountered, as there were several ephemeral streams which were not included within the TRIM data. Generally, the majority of stream

[5] Partial risk analysis methods are described in Land Management Handbook 56, Landslide Risk Case Studies in Forest Development Planning and Operations, BC Ministry of Forests, 2001.

crossings were in fair to good condition. Documented problems included cattle intrusions at most sites, partially blocked culverts, damaged culverts, and overall maintenance issues.

Based on the SCQI ratings, sediment delivery scores ranged from 0 to 0.88. A score of zero indicates no problems with sediment delivery to streams, while 0.8 indicates moderate to high problems. Only a single stream crossing (#1) received a moderate to high rating, while the majority of crossings ranged from having slight problems to low to moderate problems with sediment delivery to streams. A detailed assessment table is provided in Appendix E and Figure 2-4 shows the locations of stream crossings and assessed drainage culverts.

Seventeen (17) drainage culverts were assessed along Beaver Lake Road. The drainage culverts are intended to capture surface flows originating from the active mainline road and transport flows beneath Beaver Lake Road and into the adjacent forested areas down slope. Vernon Creek also occurs down slope of Beaver Lake Road (less than 80 m in some locations), and thus there was some concern that the discharged runoff could be transported all the way to Vernon Creek. Therefore, each culvert was assessed for road surface and ditchline delivery to the culvert. In addition, evidence of drainage (i.e. channels and scour) was followed into the treed area to determine if surface flows were reaching Vernon Creek. The review of these culverts is critical because of their proximity to potentially unstable terrain.

One result of the drainage culvert assessment was the determination that three of the believed to be drainage culverts were actually facilitating flows of ephemeral creeks. These ephemeral creeks have defined channels and evidence of flow all the way to Vernon Creek, and yet they are not identified in the TRIM stream dataset. The ephemeral streams were added to the stream crossing assessment (#s 3, 5 & 11) database and are shown on Figure 7-2. This finding underscores the importance of having stream locations (ephemeral or not) accurately mapped and uploaded with the province. Because the forest licensee use trim data when carrying out forest planning, it is critical that all streams are identified.

In addition to the identified streams, several other drainage culverts had evidence of drainage significant distance (e.g. 100 m) from Beaver Lake Road. Drainage culvert information, including sediment delivery score, risk and recommendations, is available in Appendix E.

Beaver Lake Road is of particular concern given its size and frequency of use. Dust control measures used on this road may have the potential to effect water quality at the intake. It was determined that Argo Road Maintenance services Beaver Lake Main for the Ministry of Transportation, and that they use calcium chloride for dust control. Calcium chloride is a basic chemical that retains moisture for prolonged periods. It has many commercial applications including dust control, de-icing and road-base stabilization. Calcium chloride is classified as non-hazardous and safe for the environment when used as directed. Significant information on potential impacts of calcium chloride to source or drinking water quality was limited.

4.3.5 Forestry

Forest harvesting within the Oyama and Vernon Creek watersheds began in the early to mid 1900's, when fir and cedar were harvested at low to mid-elevations. Many of the non-status roads in the lower watersheds were likely constructed during this early harvesting period. By the 1960s, major licensees were harvesting in the watersheds based on volume based tenures. More recent harvest efforts (post 1980) have utilized conventional harvesting methods using roads, ground-based harvesting and clear-cutting.

Potential Impacts to Water Quality and Quantity

Forestry practices have the potential to affect both the water quality and quantity of a watershed. The historic harvesting, as described above, was focused in the residual areas that are now the most vulnerable from a water quality perspective. Many of the skid trails and roads from these early harvest periods remain, and although they typically have a low impact, some continue to affect the natural drainage patterns and down slope stability in both watersheds. Erosion from roads and ditchlines introduces sediment into watercourses and drainage onto unconditioned slopes can result in slumps and/or slides, which may also impact streams.

More recent forestry operations have moved higher in the watersheds, and road networks have expanded, increasing the risk of erosion affecting streams. Forest practices improved with the introduction of the Forest Practices Code (FPC) in 1994 and the Forest and Range Practices Act (FRPA) in 2003, but sediment delivery to streams remains an issue at some stream crossings.

Forest development activities can impact channel stability and riparian function through the removal of vegetation which plays a role in stream bank and channel stability. Since the introduction of the FPC which specifies riparian protection, disturbance in riparian areas along streams has been largely eliminated. However, some MPB salvage logging authorized through the Small Scale Salvage Program (SSSP) is occurring within Lakeshore Management Zones (LMZs) of reservoir lakes, and has the potential to affect riparian function if harvesting is not carried out with care. Furthermore, protection of riparian function is only as good as the streamline mapping. During this assessment we used provincial stream data and discovered numerous inaccuracies, as well as encountered several ephemeral streams that are not included in the provincial database. Ecoscape understands that when cut blocks and roads are designed, water features are mapped via GPS and are therefore included in the forestry site plans; however mapping does not typically extend beyond the cut block.

Currently, much if not all of the proposed forest development within the Oyama and Vernon Creek watersheds is focused on MPB infested stands. The temporary loss of forest cover from the current infestation, in combination with accelerated salvage harvesting will reduce the overall forest cover in the watersheds. Where forest cover is lost, either to harvesting or from the death of the stand, water yields will increase in the short-term, resulting in the potential for more runoff, higher soil moisture levels and increased stream flows. Eventually, as the early seral stage dominates in the mid to upper watershed, there may be a risk of less available water, as a result of the demands by these stands. This in turn will result in reduced stream flows and available water for use by the DLC. If harvesting can be scheduled to maintain an ECA in the moderate range (i.e. less than ~35 – 40%), it is likely that stream flows can be maintained within the natural range. Ecoscape understands that Tolko's retention plan has been designed to try to maintain the natural hydrologic regime while addressing the current MPB infestation.

The loss of forest cover in the upper elevations of a watershed (i.e. the area above the snowline), can be expected to increase winter snow accumulation and also advance the freshet peak by as much as two weeks, as well as increasing runoff and peak flows. These effects can be partially offset by wetlands, lakes and reservoirs, depending on their size and location. Excessive increases in peak flow can result in channel destabilization, increased sediment production from in-stream sources, increased sediment and debris transport, and decreased water quality at the intake.

Roads required for forest development will increase the number of stream crossings and the potential sediment delivery to streams. Specific water quality parameters that may be affected by forest development include turbidity, suspended particulate matter, colour, specific conductivity, pH, and nutrients. There is also the potential that the increased solar radiation that may reach streams as forest cover is lost, can affect water temperature and biological productivity.

As access increases in the watersheds, water quality can be impacted by augmented cattle and wildlife presence, and from unmanaged use by off road vehicles in and about streams. Although forest licensees do deactivate much of the secondary roads after salvage harvesting is completed, the deactivation works do not always eliminate use by cattle, wildlife and off road vehicles. Like many other watershed issues, the effect of increased access depends on its location in the watershed. Increased access to watercourses in high vulnerability zones, or across natural barriers intended to control cattle movement, can be detrimental.

Relevant Legislation and Self Regulation

FRPA, along with its regulations and standards, provides resource protection objectives for forest development activities, including logging, road building and reforestation on Crown land. Forest development within community watersheds must meet the objectives defined in the Forest Planning and Practices Regulation for water. Specifically, primary forestry activities should not negatively affect the quantity or timing of flow, or have a measurable impact on water quality that cannot be addressed by water treatment processes. The industry is regulated by multiple parties and addresses these objectives via individual Forest Stewardship Plans (FSP). These plans devote a section to community watersheds and results and strategies are designed to prevent cumulative hydrological effects of primary forest activities. For example, road development within community watersheds is deemed a higher risk, so road development must limit the delivery of sediment to streams, lakes and wetlands. To achieve this requirement, forest licensees will apply a higher level of road/stream crossing construction standards, a higher priority for road maintenance and an increased road inspection frequency.

Forest Licensees

Figure 2-5 shows the tenure boundaries of the forest licensees currently operating within the Oyama and Vernon Creek watersheds. Tolko Industries Ltd. is the main forest licensee and has an operating area which includes the entire Vernon Creek watershed and the south eastern half of the Oyama Creek watershed. BC Timber Sales (BCTS) operates in the remaining portions of the Oyama Creek watershed. The Tolko and BCTS operating areas are 10,756 and 1,999 ha, respectively. Tolko is currently active in both watersheds, while BCTS has no proposed development at this time.

In addition to the major forest licensees, minor tenure holders with forestry licenses to cut, issued by the MoFR SSSP, also operate in both watersheds, but do not have defined operating areas. The objective of the SSSP is to harvest small patches or scattered dead timber ($\leq$ 2000 m^3) not normally addressed through large or medium scale operations. Applicants are responsible for finding a harvest location and having an application prepared by a professional forester. Ecoscape understands that contractors that take part in the SSSP are typically small independent operators that have access to the necessary equipment needed for harvesting. Salvaged wood is usually sold to major licensees or used for commercial firewood (Katherine Ladyman, pers. com.). The program relies on existing roads to provide access for harvesting, as road construction is not permitted. Unless otherwise agreed-upon through a Road Maintenance Agreement with the road permit holder, SSSP licensees are responsible for maintaining the roads they use, as well as returning them to the condition they were in pre-harvest. However, they do not generally perform any upgrades on non-status roads.

Harvest Activities

The following sections summarize previous and proposed harvest activities, as well as provide a summary of the equivalent clear-cut area (ECA) for each watershed. The Oyama Creek watershed data has been provided by M.J. Milne & Associates Ltd., and Dobson Engineering Ltd. supplied the data for the Vernon Creek watershed.

Oyama Creek Watershed

Figure 2-6a illustrates the locations of previously harvested blocks within the Oyama Creek watershed. Approximately 50% of the watershed has been harvested to date. The percent of harvested area ranges from 44.2% in the Oyama Lake Basin to more than 69% in the Oyama North Basin. Salvage of pine using mostly selective harvesting (within the Oyama North Basin), is largely complete, as the BCTS operating area occurs at lower elevations and has a higher component of fir and larch. On the other hand, the Tolko tenure area is heavier in pine and mixed with spruce and balsam stands and occurs at mid to upper elevations. Most of this salvage has yet to be undertaken and occurs within the Oyama Lake Basin.

Locations of proposed Tolko and SSSP blocks that will likely be harvested within the next five years are shown in Figure 2-6b. The majority of the proposed blocks which total more than 547 ha occur above the H45 snowline. Currently, 55.8% of the area above the H45 snowline has been harvested and an additional 22% is proposed for harvest (see Table 2-3).

Hydrologic recovery (from a snow accumulation and melt perspective) is expected with regeneration in logged areas. As previously discussed in Section 3.8.7, the ECA concept is used to estimate the effective or actual clear-cut area in a watershed or basin based on recovery factors as determined by regeneration height and density. The portion of the watershed that falls above the snowline (the H_{45} in this case) is the most sensitive to the loss of forest cover as it provides the greatest contributions to peak flows. The snowline is estimated based on forest cover, topography, and aspect, and in the Oyama Creek watershed it occurs at approximately a 1387 m elevation.

The equivalent clear-cut area (ECA) projections for the Oyama Creek watershed were made following the methods of Huggard, with modifications specific for the Oyama Creek watershed (Huggard, 2008). In addition to the ECAs determined for the current condition within the watershed, four future harvest scenarios were evaluated to understand how the salvage of MPB killed stands might affect peak flows. Currently, the Oyama Creek watershed is experiencing moderate stages of MPB attack and we have yet to know the extent of mortality. Therefore, both moderate and full attack levels were utilized in this analysis, so that the worst case scenario could be considered. The moderate attack level assumes that stands ≥ 50 years old with ≥ 40% overstory pine are potentially susceptible to MPB, but only 50% of such stands in ESSF are killed. In other BEC zones, 65% of stands < 100 years old and 80% of stands ≥ 100 years old are killed. The full attack level assumes that all stands ≥ 50 years old with ≥ 40% overstory pine are attacked by MPB and all pines are killed. The four harvest scenarios which are included in this analysis are as follows: 1) Unsalvaged (the do nothing approach); 2) WTP 80% + Pl (targets stands with greater than 80% pine and retains 10% wildlife-tree patches); 3) Proposed only (Tolko's retention plan); and 4) Proposed + CC salvage (Tolko's proposed clearcuts and all of the remaining susceptible pine over a short time frame).

The areas of harvest within each basin and the associated ECAs are summarized in Table 2-3. This table provides the current condition of the watershed (previously harvested) and the projected ECAs based on the proposed harvest (Tolko's retention plan and SSSP planned blocks). Due to the uncertainty of the extent of MPB attack, both moderate and full attack levels are shown.

Table 2-3. Oyama Creek Watershed Equivalent Clear-Cut Area (ECA) Summary

Basin	Area (ha)	Area Above Snowline (ha)	Area Previously Harvested (ha) %	Area Harvested Above Snowline (ha) %	ECA Above Snowline (%)	Area Proposed for Harvest (ha) %	Area Proposed for Harvest Above Snowline (ha) %	Proposed ECA Above Snowline (%)	
								Moderate	Full
Oyama Lake Basin	2401.9	1651.7	1062.1 44.2	873.3 52.9	36.1	519.2 21.6	407.3 24.7	51.8	54.5
Oyama North Basin	836.7	193.6	579.1 69.2	144.2 74.5	38.1	27.3 3.3	19.8 10.2	38.0	39.8
Upper Oyama Residual*	1012.6	102.6	509.33 50.3	68.6 66.9	-	1.4 0.14	1.4 1.4	-	-
Total Area	4251.2	1947.9	2150.51 50.6	1086.1 55.8	36.2	547.9 12.9	428.5 22.0	49.2	51.7

*ECAs are not reported for residual areas.
**Data was obtained from M.J. Milne & Associates Ltd.

Currently, the Oyama Creek watershed above the snowline has an ECA of 36.2%. This percentage indicates a moderate peak flow hazard, where there may be an increase in peak flow on the mainstem channel, which could result in higher sediment generation from instream sources (see Table 2-4). With the additional proposed harvest, the ECAs are projected to increase to 49.2 and 51.7%, for moderate and full attack levels, respectively. These projections suggest that the peak flow hazard will increase from the middle of the moderate range to the cusp of the high range for the watershed as a whole (Table 2-4). In the Oyama Lake Basin, where the majority of the harvesting is planned, the projected ECAs for both the moderate and full attack levels are within the high peak flow hazard range.

Table 2-4. Equivalent Clearcut Area and Peak Flow Hazard Classifications.

% ECA	Peak Flow Hazard	Interpretation
<25%	Low	May still have an increase in peak flow
25 – 50%	Moderate	A possible measurable increase in peak flow and a shift in the flood frequency curve (flows which erode banks and mobilize sediment will be occurring more often)
>50 %	High	A likely increase in peak flows which will generally cause problems.

*The ECA and peak flow hazard classifications were provided by M.J. Milne & Associates Ltd.

To further understand how the proposed harvest activities compare with other possible forms of management, the ECA results of the four different harvest scenarios are depicted in Figures 2-7a-c.

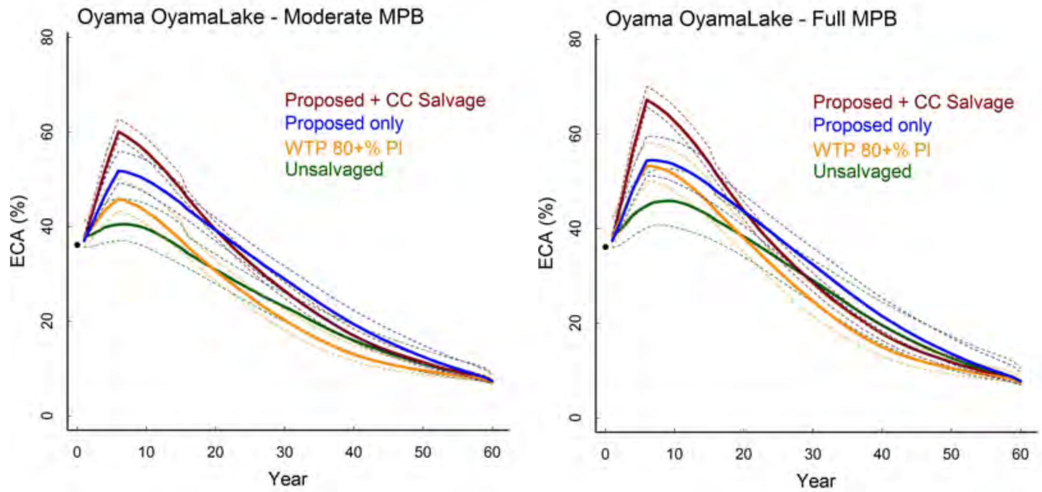


Figure 2-7a. Oyama Lake Basin – The equivalent clearcut area (ECA) projections for the four scenarios at both moderate and full mountain pine beetle attack levels.

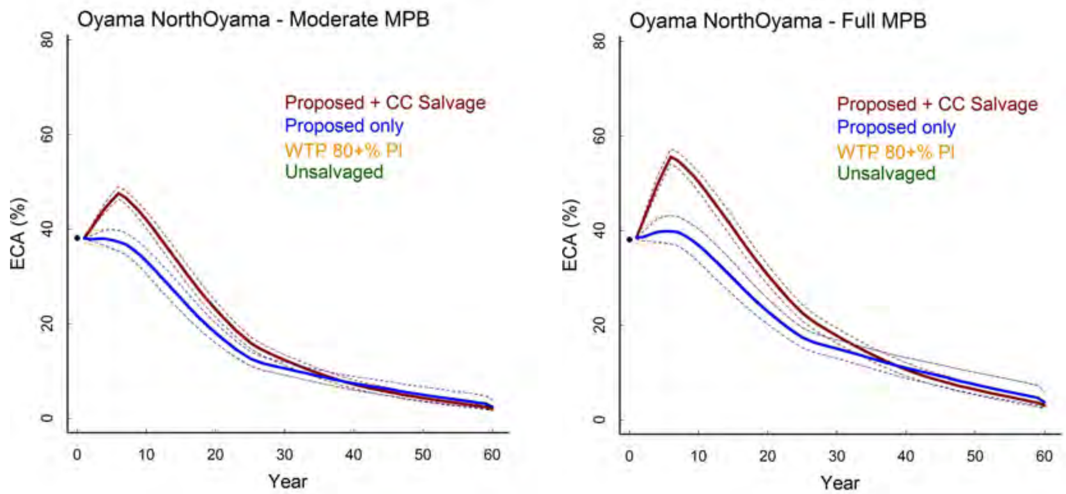


Figure 2-7b. North Oyama Basin – The equivalent clearcut area (ECA) projections for the four scenarios at both moderate and full mountain pine beetle attack levels.

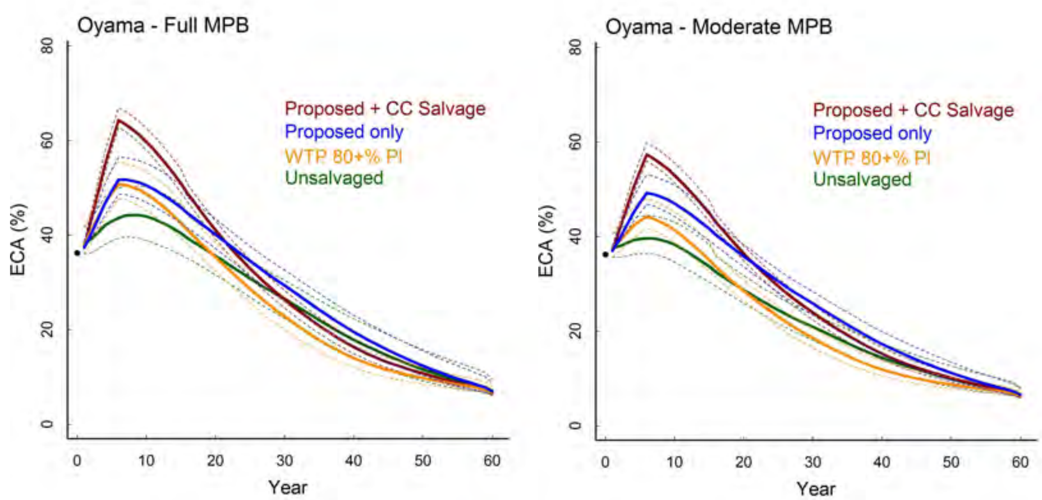


Figure 2-7c. Oyama Creek Watershed – The equivalent clearcut area (ECA) projections for the four scenarios at both moderate and full mountain pine beetle attack levels.

The watershed (Figure 2-7c) and the Oyama Lake Basin (Figure 2-7a) results are similar because as previously discussed, most of the proposed salvage and mature pine occur within the Oyama Lake Basin. The North Oyama Basin figure only shows two lines because the proposed line is plotted on top of the unsalvaged scenario. Further, the proposed + CC salvage line assumes that what little pine is there is salvaged.

Ecoscape provides the following as the key points of these figures. Additional analysis and interpretations will be available in an upcoming report for the Ministry of Environment (M.J. Milne & Associates Ltd., in prep).

- The proposed scenario has slightly higher ECAs than the WTP 80% + Pl, which targets greater than 80% pine and retains 10% wildlife-tree patches, suggesting that there may be opportunities for additional retention of stands that are less than 80% pine.

- The unsalvaged scenario has lower ECAs in the short term, but the ECAs are still within the moderate peak flow hazard level.

- Recovery rates are similar for the four different scenarios, with a slight advantage given to the Proposed + CC salvage scenario, however this scenario also carries the highest short term ECA response.

- The ECAs which result from any of the four scenarios typically return to pre-harvest levels in approximately 20 years and will completely recover within 60 years.

In conclusion, the data presented here suggests that the MPB salvage harvesting could result in a measurable increase to peak flows. However, Ecoscape understands that Oyama Lake will be instrumental in the mitigation of these possible peak flows. Because the majority of the proposed activities associated with salvage will occur within the Oyama Lake Basin, Oyama Lake will act as a partial buffer for the lower mainstem against increases in runoff and peak flows. The degree to which Oyama Lake will offset increases is hard to predict, but the effect on the mainstem will be arguably less than if there were no sizable lakes.

Vernon Creek Watershed

Similar to the presentation for the Oyama Creek watershed, Figures 2-8a and b indicate the locations of previously harvested blocks (the current condition) and the proposed harvest blocks, respectively. Currently, 43% of the Vernon Creek watershed has been harvested. The percent of harvested area ranges from 41% in the Upper Vernon Residual to 44% in the Vernon Creek Basin. The proposed harvest blocks account for another 11%, and thus within the next five years, approximately 54% of the assessment area will have been harvested.

The ECA of the Vernon Creek watershed has increased from 18% in 1999 when 35% of the watershed had been harvested (Summit, 1999), to 19% in 2009 when 43% of the watershed has been harvested. This very slight increase is likely due to multiple factors including hydrologic recovery of harvested blocks, differences in the size of the assessment area, and differences in the ECA calculation methodologies. The peak flow hazard remains at a low level for the watershed as a whole, but in looking at the area above the snowline (H_{40} = 1,400 m elevation), the ECA is 27% and is thought to have a moderate peak flow hazard (Table 2-5).

Table 2-5. Equivalent Clear-Cut (ECA) for the Vernon Creek Watershed for All Harvest Activities Through 2009.

Basin	Gross Area (ha)	Total Harvest Area (ha) %	ECA (ha) %	ECA Below Snowline (ha) %	Area Above Snowline (ha)	ECA Above Snowline (ha) %
Upper Vernon Residual*	1,898	775 41	-	163 11	422	-
Vernon Creek Basins	6,629	2,927 44	1,316 20	277 10	3,984	1,039 26
Total Assessment Area	8,527	3,702 43	1,654 19	441 11	4,406	1,214 27

*Although ECAs are not reported for the Upper Vernon Residual, they are included in the ECA calculations for the Total Assessment Area.

Table 2-6 shows the ECA numbers for both the previously harvested and the proposed blocks that are currently in the planning stage. It is important to note that since this analysis was conducted, Tolko has made changes to its retention plan which results in 225 ha less proposed harvest. Therefore, the numbers presented below are slightly elevated. With the incorporation of proposed harvest blocks, the ECA for the entire assessment area increases from 19% to 30%. The ECA for areas above the snowline also increases from 27% to 45%. With the inclusion of the proposed blocks, there continues to be a moderate peak flow hazard, although it is approaching a high flow hazard.

Table 2-6. Equivalent Clear-Cut (ECA) for the Vernon Creek Watershed, Including All Previously Harvested and Proposed Harvest Through 2013.

Basin	Gross Area ha	Total Harvest Area ha %	ECA ha %	ECA Below Snowline ha %	Area Above Snowline ha	ECA Above Snowline ha %
Upper Vernon Residual	1,898	853 45	416 22	219 15	422	197 47
Vernon Creek Basins	6,629	3,784 57	2,173 33	398 15	3,984	1,775 45
Total Assessment Area	8,527	4,637 54	2,590 30	617 15	4,406	1,972 45

**Since this analysis has been completed, Tolko has made changes to their Retention Plan which results in 225 ha less proposed harvest.

Unfortunately, the model that tries to account for the role of dead standing pine and non-pine overstory and understory on ECA over time was not conducted for the Vernon Creek watershed. Therefore, it is not possible to compare the proposed salvage with other management scenarios. Nevertheless, Tolko has the majority of planned blocks in both watersheds so it is likely that the planned activities are based on a similar rationale.

Potential Implications of Proposed Harvest

Major Licensees

The majority of the Tolko proposed harvest activities in both the Oyama and the Vernon Creek watersheds occur above the snowline elevation, and thus the greatest effect will likely be changes to peak flow. Tolko's retention plan attempts to stagger harvest blocks in order to reduce the effects at any one time and to exclude planned harvest from high vulnerability areas.

Over the long term, additional harvest activities will further expose the watersheds for subsequent access by cattle, wildlife and recreational users. After the proposed harvest has been implemented, more than 54 and 63 % of the Vernon and Oyama Creek watersheds, respectively, will be accessible by road. Although many of the roads will have undergone deactivation or rehabilitation, access is not always entirely prevented.

Minor Licensees

The proposed harvest locations by the minor licensees through the SSSP are especially noteworthy, with regards to harvesting within sensitive Lakeshore Management Zones (LMZs). Forestry development within LMZs of drinking water reservoirs is controversial given the possible effects on water quality and the potential to expose reservoirs to recreation and cattle. These factors must be balanced with the potential for increased wildfire, risk to public safety and the potential spread of forest health factors such as MPB, if harvesting is to be eliminated entirely. Ecoscape understands that harvest by SSSP licensees is only occurring within LMZs where it is consistent with district policy, the Okanagan-Shuswap Land and Resource Management Plan (LRMP), and the best management practices found in the Lakeshore Management Zone Guidebook. Prior to the issuance of a license under the SSSP, a professional forester must prepare a site plan for the proposed works that considers the impacts of the proposed harvesting on other resource values. Information for this plan is collected by on-site assessments and referrals to potentially impacted stakeholders (e.g. DLC and range tenure holders).

Based on the information that we have reviewed, we suspect that current and proposed harvesting within LMZs may result in increased access for cattle and motorized vehicles that could result in water quality impacts to the reservoirs. For example, a SSS tenure holder is currently working on a proposal for harvesting within the LMZ on the southeastern side of Oyama Lake. In addition to any windthrow issues, this proposal could increase recreational and cattle access to the lakeshore. Ecoscape understands that a proposal of this nature must outline mitigative measures to minimize the impact of access, and would also be referred to relevant stakeholders. Nevertheless, the importance of mitigative measures that are **successful** in preventing subsequent access cannot be overstated.

The long-term effect of increased access has been observed in other local watersheds, including Hydraulic Creek and Duteau Creek. Salvage harvesting during the 1980s increased the access to watercourses in these watersheds and today recreational activities below the high water level of reservoir lakes is on-going and a major concern. Once access has been established and used by recreational users, it is very difficult and expensive to successfully eliminate the use. Attempts to prevent access on non-status roads in both the Vernon and Oyama Creek watersheds have been largely unsuccessful since deactivation works are often by-passed or removed by those wanting access. **Therefore, it is our opinion that the prevention of access initially is the best form of management. At this point in time, both the Oyama and Vernon Creek watersheds are not experiencing extensive recreational use below the high water level of source watercourses, and access to these vulnerable areas is largely a preventable hazard.**

4.3.6 Range Tenures

Potential Impacts to Water Quality

Similar to other wildlife, cattle exhibit a strong preference for riparian areas. Attributes which attract cattle include the availability of water, shade and the quality and variety of forage (Kauffman and Krueger, 1984). The utilization of riparian areas by cattle appears to vary depending on the biogeoclimatic zone, wetter zones have less riparian disturbance while drier zones such as PP, IDF and MS exhibit more (Forest Practices Board, 2002). The impact of cattle on riparian zones has been a hot topic issue, with recent studies addressing the impacts of grazing cattle on stream ecology, water quality, channel stabilization, fish habitat, terrestrial riparian wildlife populations and riparian vegetation.

The topic of concern for this assessment is water quality, however it is important to recognize that the list of potential impacts from grazing cattle are interrelated and a deterioration of any one of them may ultimately result in reduced water quality. For instance, cattle grazing streamside have the potential to cause bank instability through trampling, which can result in sediment and fecal inputs to streams, thereby reducing water quality and affecting fisheries resources.

With regards to drinking water, biological contamination (pathogens originating from feces) is the greatest concern because of its potential to cause severe illness and even death. Mammals (including cattle) are potential sources of enteric pathogens including *Cryptosporidium* sp., *E. coli*, *Giardia* sp., *Leptospira* sp., noroviruses and others. Pathogens from feces enter a watercourse either by direct deposit, overland transport or through subsurface flows (Meays et al., 2006). Typically, cattle defecate about 12 times per day with an average defecation of 2-3 kg (Larsen et al., 1994). Hence when unmanaged, cattle have the potential to be a significant source of biological contamination. To further complicate matters, it has been shown that bovine *E. coli* can survive for long durations (e.g. over the winter), and are positively influenced by shade (Meays et al., 2006; Meays et al., 2005) (i.e., longevity is greater in shady conditions). The long term survival of *E. coli*, which is typically used as an indicator of pathogens, can confuse the interpretation of monitoring data since the time of deposit is unknown (Meays et al., 2006) (i.e., spikes in *E.coli* could be revealed, but the contamination may have originated from months prior).

In addition to biological contamination, the physical movements of cattle in riparian areas can affect stream channel morphology, vegetation, and channel shape; all of which contribute to sedimentation and organic loading (Agouridis *et al*., 2005; Kauffman and Krueger, 1984). Furthermore, sediment disturbance can also cause a spike in the bacteria which previously lay dormant in benthic substrates (Larratt Aquatic Consulting, 2009), thereby generating a combination of physical and biological contamination. Compounding the physical aspects of cattle is the potential of sediment interference with standard chlorination treatment. Significant sediment inputs allow bacteria places to “hide”, and increase the possibility of ineffective water treatment using primary disinfection (chorination). This phenomenon thereby increases potential risks of sedimentation and fecal deposition in an additive effect due to the potential for reduced effectiveness in typical treatment.

Summary of Range Tenures

Range tenures on Crown land are regulated by the BC Ministry of Forests and Range. Each permit issued has an associated Range Use Plan (RUP) which ideally incorporates watershed-specific strategies and objectives for minimizing cattle impacts on water quality. Table 2-7 provides details of the four range tenures which intersect the Oyama and Vernon Creek watersheds and Figure 2-9a depicts the boundaries of the individual tenures.

Table 2-7. Range Tenures Summary.

Range Tenure Specifications	Oyama Creek Watershed	Vernon Creek Watershed
Number of Range Tenures	3	2
Tenure Holders	George Holt, Dave Allingham and Coldstream Ranch (2002) Ltd.	Eldorado Ranch Ltd. and Coldstream Ranch (2002) Ltd.
Tenure Size (Percent of Assessment Area)*	39.38 km^2 (92.6 %)	79.17 km^2 (92.9 %)
Number of Cattle**	150 cow/calf pairs	800 cow/calf pairs 35 bulls
Cattle Usage Timeline***	May 1st – October 31st License expires December 31, 2009	June 1st – October 30th License expires December 31, 2011
Current Actions Outlined in Range Use Plans to Minimize Impacts on Water Quality	▪ Place salt blocks 100 m away from riparian areas; ▪ Cattle will not degrade more than 50 m of any stream bank; ▪ Constant contact with water purveyor; ▪ Maintain existing fences; and ▪ Monitor main source streams.	▪ Salt blocks will be placed 400 m from riparian areas and where no seepage occurs; ▪ Cattle will be removed from riparian areas when the average stubble height reaches 15 cm; ▪ Continued use of off stream watering and appropriate fencing to limit cattle access to Vernon Creek; and ▪ Weekly checks of cattle movement will be undertaken.

*With the exception of lakes and a small parcel of private land in each watershed, range tenures encompass the remaining areas. The private land immediately north of the Vernon Creek intake is also utilized by Eldorado Ranch Ltd. for cattle grazing.
*Because such a small portion of Coldstream Ranch Ltd. extends into the assessment area, the number of cattle associated with this range tenure is not included above.
**Although the range tenure licenses will soon expire, Ecoscape understands that unless there are extenuating circumstances, licenses are typically renewed for an additional 10 year term.

Even though there are defined tenure boundaries (see Figure 2-9a) and specific pastures which are intended for use at different times during the grazing season, it is extremely difficult, if not impossible for the rancher to know the whereabouts of all individuals at any one time. Ecoscape understands that it is not unusual for cattle to be outside a designated grazing pasture or outside of a tenure boundary (e.g. In 2009 Coldstream Ranch cattle were documented at Oyama Creek).

To assess the impacts of cattle on source water, Ecoscape collected field data that included fecal density, whether cattle activity was above or below the high water level, evidence of vegetation disturbance, sedimentation, aggregations, and the overall severity of cattle presence. Generally, the findings were similar across both watersheds. Cattle were documented throughout the watershed and utilize riparian areas wherever access was possible. In fact, in some cases, even when access was difficult (i.e., steep, well vegetated forests), cattle were still present at low densities along source streams.

Figures 2-9b and 2-9c illustrate documented instances of cattle within the most vulnerable portions of the Vernon and Oyama Creek watersheds, respectively (along riparian areas between the reservoirs and intakes). Cattle severity was rated as either: high, moderate or low. Intensive cattle use areas are intended to identify locations of concern. The degree of disturbance and severity within these sites is variable however they were pinpointed as areas of concern either because of the severity of the site or because of the sites adjacency to the intake. For example, in the Oyama watershed, intensive cattle use areas were more severe with extensive disturbance and numerous cattle below the high water level of watercourses, while in Vernon Creek generally the severity was less, but cattle did have access right down to the intake. Finally, the points depicted on Figures 2-9b & c are only reflective of areas that were field verified and since not all locations along source water courses could be documented, these points are not necessarily comprehensive.

Summary of Findings in the Vernon Creek Watershed

Cattle were documented throughout the entirety of the Vernon Creek watershed. There was generally a high correlation between cattle presence and linear corridors, whether it be roads, trails, or creeks. This correlation likely represents the ease at which animals could move (i.e., it is easier to walk along a road or trail than through the forest) and highlights the general interaction between other activities within the watershed (i.e., construction of forestry roadways can result in increased access for cattle). Cattle density around many of the lakes and reservoirs was generally limited to areas with a linear corridor. This observation differs from other watersheds we have observed and we attribute this to the large expanses of relatively non-accessible areas due to downed trees and extensive vegetative cover. The large woody debris clusters around the shoreline of the reservoirs make access for cattle (and people) difficult, and reduce the presence/density of animals significantly.

Although Ecoscape collected site specific data for cattle usage and severity across the watershed, the areas of greatest concern are those which have been designated as having very high and high vulnerability. The following are cattle instances in the Vernon Creek watershed that occur in highly vulnerable areas (between Swalwell Reservoir and the intake) and are thought to be high risk due to the severity of impact and/or the sites adjacency to the intake (see Figure 2-9b).

- Ecoscape visited the intake on Vernon Creek on two different occasions. During the first visit in June, four cows were documented along the creeks edge using a trail that immediately parallels the creek. During the second visit, no cattle were observed, but relatively fresh feces were noted below the high water level of the holding pond and sporadically along the creeks edge. Given that there is virtually no residence time prior to contaminants moving into the intake, there is a need to entirely eliminate cattle from this area.

- A non-status (secondary) road extends from Beaver Lake Main just after the second cattle guard. This road extends along the plateau near the edge of the Vernon Creek canyon. Cattle are using this road as a movement corridor and then dropping down the steep canyon to access the creek. Ecoscape documented several movement corridors (cattle trails) from the non-status road down to the creek. Ecoscape encountered one high use trail that is of particular concern. In addition to cattle, Ecoscape believes this trail was historically used as an access route for landslide rehabilitation and is currently being used for what appears to be illegal drug activity. The trail is well defined with steep grades, especially as it approaches the creek. Certain portions of this trail have extensive erosion concerns (the worst documented in the watershed) and it also provides cattle with direct access to a rehabilitated landslide at the creek edge (approximately 1.1 km from the intake). Cattle movement across the landslide is compromising rehabilitation efforts and resulting in direct sediment and fecal input to Vernon Creek.

- Cattle are accessing Vernon Creek from Beaver Lake Main via ephemeral creeks and drainage channels. Drainage is diverted under Beaver Lake Main via culverts and in some cases there is a defined channel from the roadway directly to Vernon Creek. Where defined channels exist, cattle (albeit, in relatively few numbers) use them as wallowing areas and movement corridors to access the main stem of Vernon Creek. These defined channels provide a direct route for sediment and fecal matter, resulting in pathogen inputs. Although no water quality samples were collected, it is possible that pathogen inputs to Vernon Creek are greater at the intersection of ephemeral tributaries with Beaver Lake Main than they are from cattle accessing the mainstem of Vernon Creek at these locations. This phenomenon occurs because cattle intensively use Beaver Lake Main as a movement corridor. They then congregate in the moist pockets adjacent to the road where water is diverted via culvert. In the crossings where there is a defined channel, fecal matter and sediment resulting from the congregating cattle is then transported to Vernon Creek during large storm events and during spring freshet. The extent of pathogen input is unknown, however it presents a potential risk along Beaver Lake Main, which is well away from the mainstem of Vernon Creek.

- High cattle densities were observed below the Swalwell Reservoir in the low lying treed area adjacent to a large floodplain. Cattle are likely attracted to this area for its cooler temperatures and shade. There was significant substrate disturbance from cattle and a high density of fecal matter. The low lying, “swampy” area has a direct transport mechanism for pathogens into Vernon Creek, especially during high flow periods. Finally, this high intensity area is of further concern because of the dense forest canopy. With little light exposure, it is more likely that pathogens will survive for longer durations (Meays et al., 2005) resulting in enhanced inputs during larger flow periods which have a greater capacity to carry both recent and older fecal deposits.

Summary of Findings in the Oyama Creek Watershed

Cattle, as managed in the 2009 grazing season, have proven to be one of, if not the greatest risk to source water in the Oyama watershed. Field investigations by DLC, MoFR, M.J. Milne and Associates, Ecoscape and even by the ranchers have revealed extreme cattle concerns in riparian areas on the main stem of Oyama Creek and the north fork of Oyama Creek. A combination of hot, dry weather, a small watershed with relatively little upland area, and fences which are either in need of repair, or are not designed to protect source water, make the management of cattle a very difficult task.

The cattle concerns documented in the Oyama watershed were very similar in nature to those in the Vernon watershed, but the extent of disturbance was greater. The following is a summary list of cattle related issues noted in the summer/fall of 2009.

- Cattle were observed in numerous riparian areas and consumption of grasses/sedges adjacent to creeks resulted in removal of most vegetative cover (i.e., vegetation was eaten almost to the ground);
- Evidence of extensive wallowing (e.g. feces, substrate disturbance) below high water levels of both the main stem of Oyama Creek and the north fork of Oyama Creek. Wallowing areas were most commonly observed in shaded locations. It should be noted that the longevity of *E. Coli* is greatest in these areas, which results in enhanced risk because water quality contamination may occur months after cattle were present;
- Areas of extensive streamside bank trampling and resultant sediment input were observed. This was also documented by M.J. Milne & Associates, who indicated that the "channels have been trampled beyond recognition" (Michael Milne, pers. com.) Ecoscape observed at least two instances where cattle had degraded streambanks greater than 50 m in length, which is in contradiction to the RUP.
- Existing fencing and cattle guards were in various states of repair and function. Some of the fencing was not working as intended and was not acting as a barrier to cattle access. In recent months, the MoFR has completed a more comprehensive investigation of the state of repair of fencing and has found similar results.

Although Ecoscape collected site specific data for cattle usage and severity across the watershed, the areas of greatest concern are those which have been designated as having very high and high vulnerability. The following are cattle instances in the Oyama Creek watershed that occur in highly vulnerable areas (between Oyama/Towgood/Damer Reservoirs and the intake) and are thought to be high risk due to the severity of impact and/or the sites adjacency to the intake (see Figure 2-9c).

- Two locations of high cattle density and source contaminants were observed on the main channel of Oyama Creek. The first location is about 1.5 km downstream of the Oyama Reservoir. It is a low lying area that may have had historical cattle issues, as a fence extends across the creek at this location. It appeared that cattle were using areas on both sides of the fence. At the time of assessment, creek flows were low, and thus cattle appeared to be moving back and forth across the channel. Generally, there was significant stream channel bank trampling and fecal deposition below the high water level.

- The second location of concern occurs approximately 3 km downstream from the Oyama Reservoir. In this site, cattle were accessing the creek from an old pathway or logging access road, which allowed direct cattle access to the stream channel. Similar observations were also made in this location, with cattle trampling stream banks and direct evidence of fecal contamination below the high water level.

- Additional areas of concern were noted on the north fork of Oyama Creek, around Chatterton Lake and directly below Damer Reservoir. Again, similar observations were made in each of these sites. The north end of Chatterton Lake was heavily utilized, as cattle appeared to be congregating amongst the willows. There was extensive substrate disturbance in this location.

- Below Damer Lake, an off channel watering tank has been placed along a non-status road just above Oyama Creek North. It has been strategically placed at the start of an old road which crosses the creek. Despite off channel watering, cattle still use the old road. Ecoscape understands that the road is not usable on the other side of the creek, but acts more as a cattle path (Patti Hansen, per. com.). Cattle use in this area is of particular concern because the north fork of Oyama Creek typically dries up in late August and then the cattle use the creek bed as a movement corridor. Given the sensitivity of this site, Ecoscape recommends that additional measures are undertaken to block the old road. A network of downed trees may be sufficient to prevent cattle from moving into this area.

- Ecoscape understands that approximately four years ago a fence was constructed about 300 m above the intake to prevent cattle access at the intake. There were no cattle documented in the immediate vicinity of the intake, but the cattle are congregating in a moist pocket with ground water seepage along the fence (approximately 5 m from the creek). Along some areas the fence is located immediately adjacent to the creek. It is possible that feces from this moist pocket would be transported to the creek, especially during spring freshet. Cattle fences should be set back from the creeks at least 20 to 50 m depending on the slopes and characteristics of the particular sites. At this particular site, it would be beneficial if the fence could be moved away from the creek to the top of ridge. Moving the fence back would substantially reduce fecal inputs and will likely require less maintenance as blow down would be reduced near the top of the ridge.

The extent of the cattle intrusion to source water streams became apparent in late July 2009, when water quality samples collected at the intake consistently revealed high counts of total coliforms and *E. coli*. Total coliform counts in August were without fail above 550 CFU/100 ml, with several counts greater than 800 CFU/100 ml. The August *E. coli* counts typically fell between 13 and 25 CFU/100 ml. These levels are higher than the provincial guideline for a system using only disinfection to treat drinking water. The guideline states that 90% of samples should have less than 10 *E.coli* per 100 ml (MOE, 2006).

The contamination levels exceeded the capability of the disinfection (gas chlorination) system, which is inadequate to deal with the high bacteriological counts. Interior Health was notified and together DLC and IH issued a boil water notice (BWN) on August 14, 2009. The BWN remains in place indefinitely, as DLC can not be certain that additional cattle feces will not make their way into watercourses, especially during the raining season (Patti Hansen, pers. com.).

As a result of the BWN, IH issued a written request for MoFR to implement a formal plan prior to the 2010 grazing season, which mitigates risks to drinking water from range cattle accessing source waters in both the Vernon and Oyama watersheds (Lord, 2009). Ecoscape understands that MoFR is currently preparing this document and that it will not be available for review until after this source water assessment is complete. Ecoscape has had the opportunity to review components of their proposed works, including their plans for infrastructure improvement and basic ideas for monitoring and implementation. Below is a summary of our understanding of what is proposed, followed by a discussion of the issues of existing management of cattle in riparian areas.

Summary of Proposed Works by MoFR

Ecoscape understands that the plan currently in preparation by MoFR to mitigate risks to drinking water in Oyama and Vernon Creek watersheds consists of a 2-tiered approach. First, existing infrastructure will be repaired and/or moved and additional infrastructure will be constructed with the goal of providing critical exclusion from high risk riparian areas. Some of this work has already been completed. Ecoscape understands that there are three sources of funding for infrastructure including the Crown range infrastructure replacement and protection program (CRIRPP), the Remedial Program which is used to pay for materials, and the Job Opportunity Program (JOP) which provides jobs for out of work forestry workers. Despite these programs, funding is limited and thus improvements must be prioritized. Figure 2-9d depicts the MoFR proposed infrastructure enhancement in the Oyama Creek watershed. Ecoscape understands that the proposed fencing is generally designed to exclude highly vulnerable riparian areas, but it is reliant on appropriate cattle guard placement and natural barriers such as steep coupled slopes or dense forest. With the new infrastructure, strategic placement of off channel watering will also be critical for success. The second component of the plan is to develop more comprehensive RUP which detail grazing schedules, target species and specific monitoring requirements with follow-up actions.

A meeting was held with the MoFR, cattle ranchers, Interior Health, Ecoscape and the DLC to discuss some of the proposed mitigation activities outlined above. At the end of the meeting, it was acknowledged by all parties that this was a “first step” to help mitigate immediate risks to source water quality. It was also acknowledged that an adaptive management approach would be required to attain a long term solution. Specifically, it was noted that some of the mitigation measures may not function as intended, and there must be flexibility to address these concerns if they arise. Given that the above is a “first step”, we provide the following discussion to point out some of the issues with the existing management of cattle; recommendations for improvement are detailed in Module 8.

Issues with Existing Range Practices

It appears that the aforementioned issues pertaining to range management are not isolated occurrences, as similar findings have been documented across British Columbia. In 2002, the Forest Practices Board issued a results-based assessment of range practices under the

Forest Practices Code. The assessment addressed the health of riparian areas subject to cattle grazing on Crown land, and it pinpointed several issues with the Range Practices Regulation, which oversees range tenures.

Specifically, Section 7(3) of the Range Practices Regulation prohibits certain impacts in riparian areas. It states:

> "A holder of an agreement under the Range Act must not allow livestock use in a riparian area of a community watershed if the use would result in fecal deposits, tramping of vegetation, deposit of sediments or exposure of mineral soil to an extent that the district manager determines to be detrimental."

The problem with this regulation is that there is no measurable standard for fecal deposits and/or soil exposure, and its enforcement is difficult and highly subjective. Further, it is not appropriate to leave the criteria for these impacts to the discretion of district managers (Forest Practices Board, 2002).

In another example, the Operational Planning Regulation states that the RUP must specify strategies and measures to achieve or maintain proper functioning condition in riparian areas. The Operational Planning Regulation defines "proper functioning condition" to mean the ability of a stream, river, wetland or lake, and its riparian area, to

- Withstand normal peak flood events without experiencing accelerated soil loss, channel movement or bank movement;
- Filter runoff; and
- Store and safely release water.

This definition is open to interpretation, as there is no specific criterion for assessment (Forest Practices Board, 2002). The second issue is that the rancher is responsible for outlining actions to maintain proper functioning conditions in the RUP, yet the Forest Practices Board (2002) found that many ranchers did not have a strong understanding of what "proper functioning condition" and "desired riparian plant community" mean.

The monitoring of riparian areas for disturbance is also commonly referenced in RUPs. Yet, there is not sufficient detail to do so. For example, there are no maps showing the location of riparian areas, their relative sensitivities and there is no classification of riparian features (Forest Practices Board, 2002). Finally, RUPs specify a grazing schedule for each pasture. They typically include details such as dates, the number of cattle, and animal-unit months for each grazing period. However, the limitation of using the grazing schedule as a riparian management tool is that grazing schedule is not specified for dry weather conditions. In a dry year the forage production of upland areas may be low, and thus riparian vegetation may be impacted to a greater degree (Forest Practices Board, 2002).

An assessment was just recently issued on December 3, 2009, with the primary objective of examining the contents of RUPs and identifying key issues or constraints in achieving effective range planning (Forest Practices Board, 2009). The Boards investigation found numerous shortcomings in RUPs and collectively concluded that the range planning process is not effective or efficient and may not lead to achievement of government's objectives for the range tenure (Forest Practices Board, 2009).

The above discussion highlights some fundamental issues surrounding the management of range activities. At the time of this printing, the RUP is the main mechanism used to regulate range impacts on riparian features and therefore it is critical that the document provide sufficient detail to clearly outline objectives, actions and consequences. Nevertheless, the RUP may be short lived, as government is currently working on revising range planning requirements, and the Forest Practices Board believes that the government should investigate the potential for a new framework for range planning (Forest Practices Board, 2009).

4.3.7 Mining and Quarries

There are three mineral and placer claims staked at the northern edge of the Vernon Creek watershed, while none were identified within the Oyama Creek watershed (see Figure 2-10) (Land and Resources Data Warehouse, 2005). Although these claims exist, field surveys revealed no apparent activities and to the best of our knowledge the claims are not currently active. The DLC should review these claims to confirm if there are potential affects on source watercourses.

4.4 Contaminant Source Inventory Summary

The following tables provide a summary of the specific source contaminants identified in each watershed. Table 2-8a summarizes 27 contaminants in the Oyama Creek watershed, and Table 2-8b summarizes 28 contaminants in the Vernon Creek watershed.

Table 2-8a. Contaminant Source Inventory Table for the Oyama Creek Watershed.

Contaminant #	Contaminant Source Type (Hazard) & Description	Owner/Jurisdiction	Location	Approximate distance/direction to the Intake	Possible Contaminants of Concern	Contaminant Transport Mechanism	Comments
1	Natural characteristics of raw water - north arm of Oyama creek dries up annually, providing access for wildlife, cattle and recreation.	Crown - Oyama Creek Watershed	Between Damer Lake and the confluence with Oyama Creek	Between 1.5 and 5.5 km upstream of the intake	Biological (fecal coliforms & *E. coli* from manure), Physical (sediment)	deposited contaminants incorporated into source waters once flows resume	Ecsocape understands that even if this were a natural system, it is likely that the north arm of Oyama Creek would have intermittent flows.
2	Natural characteristics of raw water - enhanced turbidity which results from the scouring of available source material as the channels fill during spring freshet	Crown - Oyama Creek Watershed	Creek channels through out the watershed	More than 10 km of creek upstream of the intake	Physical (sediment)	deposited contaminants incorporated into source waters during higher flows	The level of snow pack influences spring freshet. Enhanced flows typically between April and mid-June.
3	Natural characteristics of raw water - north fork of Oyama Creek has high colour	Crown - Oyama Creek Watershed	North fork of Oyama Creek	Upstream of the confluence with Oyama Creek; between 1.5 and 9 km upstream of intake	Physical (dissolved organic matter)	deposited contaminants incorporated into source waters	Colour originates from dissolved organic matter in the water originating from soil and decaying vegetal matter. Chlorination of coloured water can produce disinfection by-products (e.g. trihalomethanes) and create difficulties in maintaining adequate levels of disinfection. Flows from the north arm of Oyama Creek are diluted with flows from Oyama Creek to reduce the levels of colour.
4	Natural characteristics of raw water - peak coliform values were considerably higher along the north fork of Oyama Creek (below the lakes) than compared to the mainstem of Oyama Creek downstream of Oyama Lake (Phippen, 2008)	Crown - Oyama Creek Watershed	North fork of Oyama Creek immediately downstream of Damer Reservoir	6 km upstream of intake	Biological (fecal coliforms, *E.coli* from manure),	contaminants present due to short residence time of Damer Reservoir and additional inputs to the creek from wildlife and cattle	A reduction in coliforms did not occur downstream of High, Damer, or Chatterton Lake because the residence time of these lakes was either too short to affect coliform viability, or that there was a continual source of fecal matter in those areas (Phippen, 2008). This further emphasizes the importance of limiting sources of coliforms to Oyama Creek North, as additional inputs of coliforms below the lakes will have an additive affect with those already present at the outflows of High, Damer and Chatterton lakes.
5	Slope failure/debris flows - location, integrity and vulnerability of Oyama Creek Intake	Private Land - District of Lake Country	Intake located approximately 2.6 km upstream of the confluence with Kalamalka Lake at an elevation of 624 m (50º 07’ 50” N and 119 deg 20’ 22” W)	-	Physical (sediment from debris floods, landslides)	deposited contaminants incorporated into source waters immediately above the intake	The head pond, intake building, and access road are all built on a narrow floodplain area that occurs adjacent to the main channel. This location has experienced previous debris floods, with past evidence visible on a fan immediately upstream of the head pond. Debris flood or debris events, or materials associated with them that reach the Oyama Creek intake can be expected to damage or destroy infrastructure resulting in significant down time and loss of distribution capabilities.
6	Human Access - integrity and vulnerability of Oyama Creek Intake	Private Land - District of Lake Country	Intake located approximately 2.6 km upstream of the confluence with Kalamalka Lake at an elevation of 624 m (50º 07’ 50” N and 119 deg 20’ 22” W)	-	Biological and Chemical (intentionally introduced materials)	Vandalism, intentional disruption of service	The location of the intake, adjacent to private property, likely provides a reduction in access by the general public. Nevertheless, a non-status road along the north side of the canyon does facilitate all terrain vehicle access if one is determined, and the intake is certainly accessible by foot. Therefore, public access and/or vandalism at the intake is a very real possibility.
7	Slope failure/debris flows - Evidence of three previous landslides upstream of intake	Crown - Oyama Creek Watershed	Along the North fork of Oyama Creek	Between 2.6 and 3 km upstream of intake	Physical (sediment from landslides)	Overland flows	The canyon upstream of the intake has a slope stability class of IV and a soil erosion potential that ranges from high to very high. The cause of the documented landslides is not known for certain, and given their size, they do not continue to pose a threat. Overall landslide hazard index for the Oyama Creek watershed is ranked as low (Dobson Engineering Ltd., 1998).

Table 2-8a. Contaminant Source Inventory Table for the Oyama Creek Watershed.

Contaminant #	Contaminant Source Type (Hazard) & Description	Owner/Jurisdiction	Location	Approximate distance/direction to the Intake	Possible Contaminants of Concern	Contaminant Transport Mechanism	Comments
8	Natural characteristics of raw water -wildlife (including birds and mammals) are capable of carrying and disseminating fecal coliforms and *E. coli*	Crown - Oyama Creek Watershed	Watercourses throughout the watershed	All watercourses upstream of intake	Biological (fecal coliforms & *E.coli* from manure)	Directly deposited in water and overland flows	All warm-blooded wildlife species (including birds and mammals) are capable of carrying and disseminating fecal coliforms and *E. coli* and their presence in the watershed results in a basal level of risk.
9	Access and Recreation - the presence of wildlife (including birds, mammals and fish) has resulted in excellent sport fishing and hunting opportunities	Crown - Oyama Creek Watershed	The entire watershed	The whole assessment area upstream of intake	Physical (sediment), Biological (fecal coliforms & *E. coli*), Chemical (gasoline, oils, etc.)	Directly deposited in water and overland flows	Hunting and fishing activities can result in all three contaminant types originating from roads (sedimenation), human and pet waste and trace chemical releases from motorized vehicles.
10	Wildfire Potential - 2 km wildfire occurred within 50 m of the Oyama Reservoir (June 11th, 2009)	Crown - Oyama Creek Watershed	North side of Oyama Reservoir	Approximately 5 km upstream of Oyama Creek intake	Physical (dissolved organic matter)	Overland flows	More than 2 months after the fire, it was noted that fire retardant remained at the site covering the remaining standing trees, downed vegetation and soils. An ephemeral drainage also flowed from the burned area into the Oyama Reservoir. The most likely result of enhanced nutrients is the increased potential for algal blooms.
11	Algae - Documented algae near the outflow of Damer Lake	Crown - Oyama Creek Watershed	South end of Damer Lake	Approximately 6 km upstream of Oyama Creek intake	Biological (cyanobacteria, cyanotoxins, or precursor conditions)	Availability of nutrients leads to algal blooms	Algal blooms are most likely to occur during summer months when water temperatures are warmer and water volumes are low due to high peak demands. Nutrients can occur naturally but can also be significantly altered by anthropogenic influences such as faulty septic systems, livestock, fire retardants, agricultural runoff, and landslide events resulting from poor storm runoff or road construction on both sanctioned and non sanctioned roads.
12	Moutain Pine Beetle - Oyama Creek watershed has extensive stands of lodgepole pine, which are highly susceptible to MPB	Crown - Oyama Creek Watershed	The entire watershed	The whole assessment area upstream of intake	Physical (dissolved organic matter, sediment)	Overland flows	The potential of MPB infestation in the Oyama Creek watershed can be estimated based on the availability of mature lodgepole pine. In 2006, approximately 45% of the area above the snowline was previously logged and about 45% of the remaining area was composed of more than 70% lodgepole pine . It was speculated that the MPB infestation would be severe and will likely have a significant impact on peak flows and the water quality at the intake (Dobson Engineering Ltd., 2008).
13	Land Ownership - commerical lease lot (Oyama Lake Wilderness Fishing Resort)	Crown - Oyama Creek Watershed	Northeast side of Oyama Reservoir	Approximately 4.5 km upstream of Oyama Creek intake	Physical (sediment), Biological (fecal coliforms & *E. coli* from domestic pets, septic & pit toilets), Chemical (gasoline, oil, fertilizers, etc.)	Overland flows, direct deposit, sub-surface flows	The facility currently has a total of 13 cabins, a main lodge and small store, a workshop/sawmill, and a number of camp sites. The septic system has been updated within the last several years. A minor sediment point source was documented from the boat launch and access road. There is a small marina and additional floating structures. The resort has increased risk due to intensity of use.
14	Land Ownership - 13 residential lease lots on Oyama Reservoir	Crown - Oyama Creek Watershed	The majority are on the northeast side of Oyama Reservoir	Approximately 4.5 km upstream of Oyama Creek intake	Physical (sediment), Biological (fecal coliforms & E. coli from domestic pets, septic & pit toilets), Chemical (gasoline, oil, fertilizers, etc.)	Overland flows, direct deposit, sub-surface flows	The lots are only accessible by foot and/or boat. Most, if not all are equipped with pit outhouses. Very little foreshore disturbance was documented and the majority of existing moorages are small (<24 m^2). There is concern that a road built to fight the Oyama fire could be used for future access to lease lots.

Table 2-8a. Contaminant Source Inventory Table for the Oyama Creek Watershed.

Contaminant #	Contaminant Source Type (Hazard) & Description	Owner/Jurisdiction	Location	Approximate distance/direction to the Intake	Possible Contaminants of Concern	Contaminant Transport Mechanism	Comments
15	Land Ownership - Three privately held parcels near the Oyama Creek intake	Private Land - Dave Young, Pier Mac, DLC	The 3 private parcels surround the intake	Intake is surrounded by parcels	Physical (sediment), Biological (fecal coliforms & E. coli from domestic pets, septic & pit toilets), Chemical (gasoline, oil, fertilizers, etc.)	Overland flows, direct deposit, sub-surface flows	The water intake and associated infrastructure occurs on two privately held parcels of land owned by the DLC and access to the intake requires the use of various easement roads across private lands. Due to the adjacency of these parcels to the intake, future changes in land use and/or zoning must be carefully considered.
16	Wind Generation - Four Investigative towers within the Oyama Creek watershed	Crown - Oyama Creek Watershed	Upper watershed, alway from source water	Towers range from 6-8 km away from the Oyama Creek intake	Physical (sediment from land clearing), Chemical (i.e. gasoline and oil from construction activities)	Overland flows	Meteorological towers have little impact on source water quality. Depending on the need for tree removal, there could be some sedimentation issues and there may also be the potential for chemical contaminants originating from motorized equipment used to construct the towers.
17	Access and Recreation - MOTCA regulated recreation camp sites (at Oyama, Streak, High and Damer Lakes),	Crown - Oyama Creek Watershed	Adjacent to lakes and reservoirs	Campsites range from 4-8 km away from the Oyama Creek intake	Physical (sediment from roads/land clearing), Biological (fecal coliforms & *E. coli* from domestic pets & pit toilets), Chemical (gasoline/oil from motorized vehicles)	Overland flows, direct deposit, sub-surface flows	During site surveys, it was noted that all regulated sites were relatively clean and well maintained. Although garbage was noted, in no cases was it excessive. Erosion originating from access roads, camp site clearings and boat ramps was documented at most of the recreation sites. The erosion severity ranged from negligible to moderate, where sediment was delivered directly to adjacent lakes. At the majority of sites, sedimentation can be controlled with the use of standard erosion control techniques such as water bars, sumps, ditch/swale, etc.
18	Access and Recreation - Motorized recreation (4x4/ATV/motorbikes) below the high water level of important creeks and/or reservoirs	Crown - Oyama Creek Watershed	Watercourses throughout the watershed	All watercourses upstream of intake	Physical (sediment from substrate disturbance), Chemical (gasoline/oil from motorized vehicles)	Direct deposit	Mud bogging was noted in both the shallow areas of reservoirs and in intensively used areas adjacent to source streams. However, the intensity of motorized activities below the high water level was relatively low. No sites were pinpointed as having intense activity.
19	Access and Recreation - "The lookout"	Crown - Oyama Creek Watershed	Adjacent to main road and on the edge of Oyama Creek canyon	Approximately 1.4 km upstream of Oyama Creek intake	Physical (sediment from roads/land clearing), Biological (fecal coliforms & *E. coli* from people & domestic pets), Chemical (gasoline/oil from motorized vehicles)	Overland flows	Access to this site appears to have been blocked in at least two locations, but ATV access around roadblocks is still possible. The biggest concern observed in this location was a substantial number of shotgun shells (i.e., in excess of 100). Shots appear to have been fired out over the Oyama Creek canyon in the approximate vicinity of the intake. Unsanctioned camping is also occurring at this location.
20	Access and Recreation - Activities of crime	Crown - Oyama Creek Watershed	Typically in close proximity to roads	The whole assessment area upstream of intake	Physical (sediment from land clearing), Biological and Chemical (intentionally introduced materials)	Overland flows, direct deposit	Activities of crime included dumping of garbage and hazardous materials, clearing of vegetation for vehicle access, illegal drug cultivation, and abandoned vehicle dumping. Criminal activities were less than what was observed in the Vernon Creek watershed, but were still documented.
21	Stream Crossings and Roads - Very High and High Risk roads	Crown and Private land- Oyama Creek Watershed	Within the residual area	High risk roads occur within <100 m of the Oyama Creek intake	Physical (sediment)	Overland flows	Very high and high risk ratings were applied to several non-status and Forest Service Roads in the residual area. Issues include failing deactivation infrastructure, uncontrolled drainage above steep coupled slopes, past landslides on steep terrain below roads, and running surface and ditch scour related erosion with direct input of sediment to Oyama Creek or major tributaries downstream of the lakes.

Table 2-8a. Contaminant Source Inventory Table for the Oyama Creek Watershed.

Contaminant #	Contaminant Source Type (Hazard) & Description	Owner/Jurisdiction	Location	Approximate distance/direction to the Intake	Possible Contaminants of Concern	Contaminant Transport Mechanism	Comments
22	Stream Crossings and Roads - Moderate and low risk roads	Crown and Private land- Oyama Creek Watershed	The entire watershed	Moderate and low risk roads occur within close proximity to the Oyama Creek intake	Physical (sediment)	Overland flows	Moderate risk roads occur in all parts of the Oyama Creek watershed and are mainly the result of insufficient water management, running surface erosion, ditch scour, and ultimately sediment input to source watercourses or fish bearing waters. Low risk roads are not an issue.
23	Forestry - Proposed harvest	Crown - Oyama Creek Watershed	The majority of proposed blocks occur in the Oyama Lake Basin	The closest block occurs within 4.5 km of the intake	Physical (sediment from land clearing)	Overland flows	With the additional proposed harvest, the ECAs are projected to increase to 49.2 and 51.7%, for moderate and full attack levels, respectively. These projections suggest that the peak flow hazard will increase from the middle of the moderate range to the cusp of the high range for the watershed as a whole. In the Oyama Lake Basin, where the majority of the harvesting is planned, the projected ECAs for both the moderate and full attack levels are within the high peak flow hazard range.
24	Forestry -Harvesting within sensitive Lakeshore Management Zones (LMZs)	Crown - Oyama Creek Watershed	The majority of these proposed blocks are adjacent to Oyama Streak, and Damer Lakes	The closest block occurs within 4.5 km of the intake	Physical (sediment from land clearing), Biological (fecal coliforms & *E. coli* from cattle)	Overland flows	Ecoscape is concerned that current and proposed harvesting within LMZs may result in increased access for cattle and motorized vehicles that could result in water quality impacts to the reservoirs. If increased access is realized then biological contaminants are also of concern.
25	Range Tenures - High cattle density and source contaminants observed in two locations on the main channel of Oyama Creek	Crown - Oyama Creek Watershed	Main channel of Oyama Creek below Oyama Lake	The high density areas occur 2.8 and 4.3 km upstream of the intake	Physical (sediment), Biological (fecal coliforms, *E.coli* from manure)	Overland flows, direct deposit	The first location is a low lying area and has a fence that extends across the creek. It appeared that cattle were using areas on both sides of the fence. At the second location cattle were accessing the creek from an old pathway or logging access road. At both sites there was significant stream channel bank trampling and fecal deposition below the high water level.
26	Range Tenures - High cattle densities on the north fork of Oyama Creek, around Chatterton Lake and directly below Damer Reservoir	Crown - Oyama Creek Watershed	North fork of Oyama Creek below Damer Lake	The closest high density area occurs 4.5 km upstream of the intake	Physical (sediment), Biological (fecal coliforms, *E.coli* from manure)	Overland flows, direct deposit	The north end of Chatterton Lake was heavily utilized, as cattle appeared to be congregating amongst the willows. There was extensive substrate disturbance in this location. Below Damer Lake cattle are accessing a non-status road just above Oyama Creek North. Cattle use in this area is of particular concern because the north fork of Oyama Creek typically dries up in late August and then the cattle use the creek bed as a movement corridor.
27	Range Tenures - Cattle congregating in a moist pocket with ground water seepage along a fence that is approximately 5 m from the Oyama Creek	Crown - Oyama Creek Watershed	Main channel of Oyama Creek	This moist pocket occurs approximately 300 m upstream of the intake	Physical (sediment), Biological (fecal coliforms, *E.coli* from manure)	Overland flows	It is possible that feces from this moist pocket would be transported to the creek, especially during spring freshet. Cattle fences should be set back from the creeks at least 20 to 50 m depending on the slopes and characteristics of the particular sites.

4.5 Hazard Summary for both the Oyama and Vernon Creek Watersheds

Table 2-9. Hazard Summary Table

Hazard #	Drinking water hazard	Potential Contaminants	Possible effects	Source level existing preventative measures	Associated barrier(s)	Contaminant Transport Mechanism	Comments	Report section #
2-1	Land ownership (private and Crown leased lots)	• Sedimentation • Bacteria, protozoa, viruses, algae • Hydrocarbons, pesticides, fertilizers and misc. chemicals	• Microbial pathogens due to domestic pets, livestock and humans • Increased runoff/sediment loads due to land clearing • Accidental chemical spills (e.g. hydrocarbons) • Increased nutrient loads and pesticides as a result of landscaping	• Zoning limits the types of activities on privately held land • Current moratorium on sale of leased lots	• Limited private and crown leased lots •• Private parcel zoning	• Overland flows • Subsurface sewage discharge	• Most, if not all private/lease lots are immediately adjacent to source water courses	4.3.1
2-2	Wind Generation	• Sedimentation • Hydrocarbons	• Increased runoff/sediment loads due to tree removal and possibly land clearing • Accidental chemical spills from motorized equipment (e.g. hydrocarbons)	• Ministry of Environment and Integrated Land Management Bureau permits and polices	• Ministry of Environment and Integrated Land Management Bureau permits and polices	• Overland flows	• The meteorological tower locations are **not** in close proximity to source watercourses, however the investigative use permit boundary does intersect higher vulnerability zones.	4.3.2
2-3	Human Access and Recreation	• Bacteria, protozoa, viruses • Sedimentation • Hydrocarbons and misc. chemicals	• Accidental and/or intentional chemical spills (e.g. hydrocarbons) • Sediment loading and re-suspension from motorized activities below high water level • Persistent trace chemical release (e.g. hydrocarbons, oil, metals, etc) • Sewage / fecal matter	• Locked gates to prevent vehicle access to intakes • Educational signage throughout the assessment area • Signage throughout watershed suggesting appropriate activities • Periodic presence of Conservation Officer	• Settling pond and screens at the intakes	• Overland flows • Contaminants deposited directly into source watercourses	• Recreational usage of the assessment area is moderate. Activities include fishing, hunting, camping, cross country skiing, snowmobiling and use of all terrain vehicles. • A high density of roads allows access to the many areas of the watershed	4.3.3
2-4	Roads and associated stream crossings	• Sedimentation • Hydrocarbon • Bacteria, protozoa, viruses, algae	• Increased sediment influx to adjacent watercourses • Increased accessibility for humans and cattle • Microbial pathogens due to domestic pets, livestock and humans	• Forestry and Range Practices Act places constraints on road development (e.g. road building must prevent entry of sediment into streams, lakes or wetlands). • Deactivation of new roads where appropriate. • Deactivation of non-status roads when funds are available.	• Settling pond and screens at the intake • Sediment collection and setline barriers around stream crossings	• Overland flows	• Some sediment barriers are working effectively, particularly in the Oyama watershed.	4.3.4
2-5	Forestry	• Sedimentation • Total organic carbon • Hydrocarbons	• Unstable terrain contributing to sediment sources • Changes to hydrology; increased runoff • Increased turbidity, organic carbon, colour • Indirect increase in pathogens • Accidental chemical spills (e.g. hydrocarbons)	• Forest and Range Practices Act governs all forestry activities • Limited logging of streamside management areas • Hydrological studies carried out prior to harvest • Forest and Range Evaluation program evaluates results of forestry practices	• Detailed harvest and retention plans • Excellent communication between forest licensees and DLC	• Overland flows	• Forestry activities are currently updating harvest and retention plans	4.3.5
2-6	Range Tenures / Livestock	• Bacteria, protozoa, viruses, algae • Sedimentation	• Release pathogens • Persistent sediment release due to de-vegetation and bank de-stabilization • Sedimentation can lead to increases turbidity and pathogens indirectly	• Range use plan details measures to protect source water • Cattle guards and exclusions fencing	• Cattle guards and exclusions fencing	• Contaminants deposited directly into source water courses • Overland flows	• Livestock may very well be a significant source of microbial pathogens, as they tend to congregate below the high water level	4.3.6
2-7	Mining	• Sedimentation • Hydrocarbons	• Extraction, processing and runoff from pits can cause increased turbidity and pathogens indirectly • Accidental spills of hydrocarbons	• Best Management Practices	• Settling pond and screens at the intake	• Overland flows • Subsurface soil transport	• Current mining activities are negligible	4.3.7

Table 2-8b. Contaminant Source Inventory Table for the Vernon Creek Watershed.

Contaminant #	Contaminant Source Type (Hazard) & Description	Owner/Jurisdiction	Location	Approximate distance/direction to the Intake	Possible Contaminants of Concern	Contaminant Transport Mechanism	Comments
1	Natural characteristics of raw water - enhanced turbidity which results from the scouring of available source material as the channels fill during spring freshet	Crown - Vernon Creek Watershed	Creek channels throughout the watershed	More than 15 km of creek upstream of the Vernon Creek intake	Physical (sediment)	deposited contaminants incorporated into source waters during higher flows	The level of snow pack influences spring freshet. Enhanced flows typically between April and mid-June.
2	Slope failure/debris flows - location, integrity and vulnerability of Vernon Creek Intake	Private Land - District of Lake Country	The intake is approximately 5.5 km upstream of the confluence with Duck Lake	-	Physical (sediment)	deposited contaminants incorporated into main creek channel upstream of intake	The holding pond and intake building are located on the main channel of Vernon Creek within a steep, well-incised canyon with highly erodible soils. Given that landslides have interrupted service in the past, it is really a matter of when, and not if water quality at the intake will be affected. The presence of numerous unstable, steep coupled slopes pose a significant risk, if not the primary risk to water quality and infrastructure at the intake.
3	Slope failure/debris flows -a steep, coupled slope with soft material immediately adjacent to the intake building and head pond	Private Land - District of Lake Country	The intake is approximately 5.5 km upstream of the confluence with Duck Lake	-	Physical (sediment)	Potential for deposited contaminants into holding pond from adjacent slope	The steep, coupled slope is located on the northwest corner of the holding pond. A narrow trail extends across this slope and provides access to the upper portions of the pond. During the summer of 2009, works were undertaken to stabilize the trail with the use of a wooden walkway.
4	Human Access - integrity and vulnerability of Vernon Creek Intake	Private Land - District of Lake Country	The intake is approximately 5.5 km upstream of the confluence with Duck Lake	-	Biological and Chemical (intentionally introduced materials)	Vandalism, intentional disruption of service	From a trespass/vandalism perspective, the Vernon Creek intake is fairly isolated, however the intake can also be accessed on foot by descending into the canyon from the upper plateau. Therefore, the intake location is as such that the general public will not happen upon it, but if the intention is for trespass/vandalism, it is very possible.
5	Slope failure/debris flows - Evidence of seven landslides upstream of the Vernon Creek intake	2 landslides within Private Land (Macintosh Properties Kelowna), 5 landslides on Crown Land	Adjacent to Vernon Creek channel	Between 1 and 4.5 km upstream of intake	Physical (sediment)	deposited contaminants incorporated into source waters	The canyon upstream of the intake has a slope stability class of V and a soil erosion potential of very high. The soils in this portion of Vernon Creek developed on glaciofluvial and glaciolacustrine materials that are highly erodible. Previous studies have concluded that these landslides are the principal sediment sources within the Vernon Creek watershed.
6	Natural characteristics of raw water -wildlife (including birds and mammals) are capable of carrying and disseminating fecal coliforms and *E. coli*	Crown - Vernon Creek Watershed	Watercourses throughout the watershed	All watercourses upstream of intake	Biological (fecal coliforms, *E.coli*, pathogens)	Directly deposited in water and overland flows	All warm-blooded wildlife species (including birds and mammals) are capable of carrying and disseminating fecal coliforms and *E. coli* and their presence in the watershed results in a basal level of risk.
7	Access and Recreation - the presence of wildlife (including birds, mammals and fish) has resulted in excellent sport fishing and hunting opportunities	Crown - Vernon Creek Watershed	The entire watershed	The whole assessment area upstream of intake	Physical (sediment), Biological (fecal coliforms & E. coli), Chemical (gasoline, oils, etc.)	Directly deposited in water and overland flows	Hunting and fishing activities can result in all three contaminant types originating from roads (sedimenation), human and pet waste and trace chemical releases from motorized vehicles.
8	Moutain Pine Beetle - Vernon Creek watershed has extensive stands of lodgepole pine, which are highly susceptible to MPB	Crown - Vernon Creek Watershed	The entire watershed	The whole assessment area upstream of intake	Physical (dissolved organic matter, sediment)	Overland flows	The potential of MPB infestation in the Vernon Creek watershed can estimated based on the availability of mature lodgepole pine. In 2006, approximately 45% of the area above the snowline was previously logged and about 45% of the remaining area was composed of more than 70% lodgepole pine . It was speculated that the MPB infestation would be severe and will likely have a significant impact on peak flows and the water quality at the intake (Dobson Engineering Ltd., 2008).

Table 2-8b. Contaminant Source Inventory Table for the Vernon Creek Watershed.

Contaminant #	Contaminant Source Type (Hazard) & Description	Owner/Jurisdiction	Location	Approximate distance/direction to the Intake	Possible Contaminants of Concern	Contaminant Transport Mechanism	Comments
9	Land Ownership - commerical lease lot (Beaver Lake Mountain Resort)	Crown - Vernon Creek Watershed	Southwest end of Swalwell Reservoir	Approximately 5 km upstream of Vernon Creek intake	Physical (sediment), Biological (fecal coliforms & E. coli from domestic pets, septic & pit toilets), Chemical (gasoline, oil, fertilizers, etc.)	Overland flows, direct deposit, sub-surface flows	The facility has a total of 22 cabins, some on septic and others are equipped with outhouses. There is a petting zoo, a general store, numerous camp sites, and a marina. In addition, many of the cabins have their own moorages. The boat launch has a moderate level of sedimentation flowing directly to Swalwell Reservoir.
10	Land Ownership - commerical lease lot (Dee Lake Wilderness Resort)	Crown - Vernon Creek Watershed	West side of Dee Lake	Approximately 14 km upstream of Vernon Creek intake	Physical (sediment), Biological (fecal coliforms & E. coli from domestic pets, septic & pit toilets), Chemical (gasoline, oil, fertilizers, etc.)	Overland flows, direct deposit, sub-surface flows	The resort has full service cottages, log cabins, camping and RV facilities, lodge units and a store and office. Some of the facilities are on septic, while others utilize outhouses. There is a boat launch and individual moorages.
11	Land Ownership - 15 residential lease lots (Crooked Lake)	Crown - Vernon Creek Watershed	West side of Crooked Lake	Approximately 10 km upstream of Vernon Creek intake	Physical (sediment), Biological (fecal coliforms & E. coli from domestic pets, septic & pit toilets), Chemical (gasoline, oil, fertilizers, etc.)	Overland flows, direct deposit, sub-surface flows	Documented concerns at residential lease lots include vegetation clearing, retaining walls, groynes, substrate importation, burning below the HWL, moorages > 24 m^2, and sediment point sources.
12	Land Ownership - 27 residential lease lots (Swalwell Reservoir)	Crown - Vernon Creek Watershed	Southwest and north side of Swalwell Reservoir	Approximately 5 km upstream of Vernon Creek intake	Physical (sediment), Biological (fecal coliforms & E. coli from domestic pets, septic & pit toilets), Chemical (gasoline, oil, fertilizers, etc.)	Overland flows, direct deposit, sub-surface flows	Documented concerns at residential lease lots include vegetation clearing, retaining walls, groynes, substrate importation, burning below the HWL, moorages > 24 m^2, and sediment point sources.
13	Land Ownership - privately held parcels near the Vernon Creek intake	Private Land - Macintosh Properties Kelowna	The 3 private parcels surround the intake	Intake is surrounded by parcels	Physical (sediment), Biological (fecal coliforms & E. coli from domestic pets, septic & pit toilets), Chemical (gasoline, oil, fertilizers, etc.)	Overland flows, direct deposit, sub-surface flows	Privately held parcels surround the water intake structure and these parcels are zoned Agricultural (A1) within the DLC. Allowable land uses of the A1 zoning designation include agriculture, range uses, etc. The parcels are currently leased for cattle grazing.
14	Wind Generation - One Investigative tower within the Vernon Creek watershed	Crown - Vernon Creek Watershed	Upper watershed, alway from source water	Approximately 14 km upstream of Vernon Creek intake	Physical (sediment from land clearing), Chemical (i.e. gasoline and oil from construction activities)	Overland flows	Meteorological towers have little impact on source water quality. Depending on the need for tree removal, there could be some sedimentation issues and there may also be the potential for chemical contaminants originating from motorized equipment used to construct the towers.

Table 2-8b. Contaminant Source Inventory Table for the Vernon Creek Watershed.

Contaminant #	Contaminant Source Type (Hazard) & Description	Owner/Jurisdiction	Location	Approximate distance/direction to the Intake	Possible Contaminants of Concern	Contaminant Transport Mechanism	Comments
15	Access and Recreation - MOTCA regulated recreation camp sites (at Swalwell, Island & Lost Lakes)	Crown - Vernon Creek Watershed	Adjacent to lakes and reservoirs	Campsites range from 6-14 km away from the Vernon Creek intake	Physical (sediment from roads/land clearing), Biological (fecal coliforms & E. coli from domestic pets & pit toilets), Chemical (gasoline/oil from motorized vehicles)	Overland flows, direct deposit, sub-surface flows	During site surveys, it was noted that all regulated sites were relatively clean and well maintained. Although garbage was noted, in no cases was it excessive. Erosion originating from access roads, camp site clearings and boat ramps was documented at most of the recreation sites. The erosion severity ranged from negligible to moderate, where sediment was delivered directly to adjacent lakes. At the majority of sites, sedimentation can be controlled with the use of standard erosion control techniques such as water bars, sumps, ditch/swale, etc.
16	Access and Recreation - Unsanctioned campsite at Crooked Lake Dam	Crown - Vernon Creek Watershed	Crooked Lake dam	Site is 9.3 km away from the Vernon Creek intake	Physical (sediment from roads/land clearing), Biological (fecal coliforms & E. coli from domestic pets & pit toilets), Chemical (gasoline/oil from motorized vehicles)	Overland flows, direct deposit, sub-surface flows	At the time of the site visit a small fire was burning within a fire pit and no users were present. Extensive garbage and evidence of intentional dumping was observed across the site, include garbage located directly in the over flow spillway between Crooked and Swalwell Reservoirs. Two shallow outhouse pit toilets had been erected at the site and there was extensive evidence of ATV activities, including recent trail clearing to Swalwell Reservoir that was also being utilized by cattle to access shoreline.
17	Access and Recreation - Motorized recreation (4x4/ATV/motorbikes) below the high water level of important creeks and/or reservoirs	Crown - Vernon Creek Watershed	Watercourses throughout the watershed	All watercourses upstream of intake	Physical (sediment from substrate disturbance), Chemical (gasoline/oil from motorized vehicles)	Direct deposit	Mud bogging was noted in both the shallow areas of reservoirs and in intensively used areas adjacent to source streams. However, the intensity of motorized activities below the high water level was relatively low. Other than at the Crooked Lake dam, no other sites were pinpointed as having intense activity.
18	Access and Recreation - Activities of crime	Crown - Vernon Creek Watershed	Typically in close proximity to roads	The whole assessment area upstream of intake	Physical (sediment from land clearing), Biological and Chemical (intentionally introduced materials)	Overland flows, direct deposit	Activities of crime included dumping of garbage and hazardous materials, clearing of vegetation for vehicle access, illegal drug cultivation, and abandoned vehicle dumping. Criminal activities appeared to be relatively prevalent in the Vernon Creek watershed.
19	Access and Recreation - Abandoned vehicle and hazardous material dumping at extensive landslide on Vernon Creek canyon	Crown - Vernon Creek Watershed	Extensive landslide in Vernon Creek canyon that is adjacent to non-status road	Approximately 2 km upstream of Vernon Creek intake	Physical (sediment from land clearing), Biological and Chemical (intentionally introduced materials)	Overland flows	Materials, including vehicles and animal parts have been intentially dumped at this site. The steep, coupled slope is already sensitive from a sedimenation perpective and the addition of dumpings is exacerbating the issue. The site is also risky from a public safety standpoint, and the slope is steep.
20	Stream Crossings and Roads - High risk roads	Crown and Private land- Vernon Creek Watershed	Generally between Swalwell Reservoir and the intake	The closest high risk road is within 600 m of the intake	Physical (sediment)	Overland flows	Road risk in the Vernon Creek watershed was determined based on stream crossing and culvert density, plus the vulnerability zones. Beaver Lake Road is of particular concern given its size, frequency of use and adjacency to steep, coupled slopes and Vernon Creek.
21	Stream Crossings and Roads - Moderate and low risk roads	Crown and Private land- Vernon Creek Watershed	The entire watershed	Moderate and low risk roads occur within close proximity to the Oyama Creek intake	Physical (sediment)	Overland flows	Moderate and low risk roads occur in all parts of the Vernon Creek watershed and are not of immediate concern.

Table 2-8b. Contaminant Source Inventory Table for the Vernon Creek Watershed.

Contaminant #	Contaminant Source Type (Hazard) & Description	Owner/Jurisdiction	Location	Approximate distance/direction to the Intake	Possible Contaminants of Concern	Contaminant Transport Mechanism	Comments
22	Forestry - Proposed harvest	Crown - Vernon Creek Watershed	The majority of proposed blocks occur in the Vernon Creek Basin	The closest block occurs within 2.3 km of the intake	Physical (sediment)	Overland flows	With the incorporation of proposed harvest blocks, the ECA for the entire assessment area increases from 19% to 30%. The ECA for areas above the snowline also increases from 27% to 45%. With the inclusion of the proposed blocks, there continues to be a moderate peak flow hazard, although it is approaching a high flow hazard.
23	Forestry -Harvesting within sensitive Lakeshore Management Zones (LMZs)	Crown - Vernon Creek Watershed	The only proposed block is adjacent to Dee Lake	The closest block occurs within 14 km of the intake	Physical (sediment from land clearing), Biological (fecal coliforms & E. coli from cattle)	Overland flows	Ecoscape is concerned that current and proposed harvesting within LMZs may result in increased access for cattle and motorized vehicles that could result in water quality impacts to the reservoirs. If increased access is realized then biological contaminants are also of concern.
24	Range Tenures - Cattle presence at the Vernon Creek intake	Private Land - Macintosh Properties Kelowna	Vernon Creek Intake	–	Physical (sediment), Biological (fecal coliforms, E.coli from manure)	Overland flows, direct deposit	Ecoscape visited the intake on Vernon Creek on two different occasions. During the first visit in June, four cows were documented along the creeks edge using a trail that immediately parallels the creek. During the second visit, no cattle were observed, but relatively fresh feces were noted below the high water level of the holding pond and sporadically along the creeks edge. Given that there is virtually no residence time prior to contaminants moving into the intake, there is a need to entirely eliminate cattle from this area.
25	Range Tenures - Cattle utilizing non-status road and trails to access Vernon Creek	Crown - Vernon Creek Watershed	The road xtends along the plataeu adjacent to Vernon Creek Canyon	The non-status road is 1.4 km upstream of the intake	Physical (sediment), Biological (fecal coliforms, E.coli from manure)	Overland flows, direct deposit	Cattle are using a non-status road as a movement corridor and then dropping down the steep canyon via trails to access Vernon Creek approximately 1.4 km upstream of the intake. One trail is of particular concern, as it is well defined with steep grades, especially as it approaches the creek. Certain portions of this trail have extensive erosion concerns (the worst documented in the watershed) and it also provides cattle with direct access to a rehabilitated landslide at the creek edge (approximately 1.1 km from the intake). Cattle movement across the landslide is compromising rehabilitation efforts and resulting in direct sediment and fecal input to Vernon Creek.
26	Range Tenures - Cattle accessing Vernon Creek from Beaver Lake Main via four ephemeral creeks and drainage channels	Crown - Vernon Creek Watershed	Ephemeral creeks flow perpendicular to Beaver Lake Main	The closest ephemeral creek is 2.4 km from the intake	Physical (sediment), Biological (fecal coliforms, E.coli from manure)	Overland flows, direct deposit	Drainage is diverted under Beaver Lake Main via culverts and in some cases there is a defined channel from the roadway directly to Vernon Creek. Where defined channels exist, cattle (albeit, in relatively few numbers) use them as wallowing areas and movement corridors to access the main stem of Vernon Creek. These defined channels provide a direct route for sediment and fecal matter, resulting in pathogen inputs.
27	Range Tenures - High cattle densities were observed below the Swalwell Reservoir in the low lying treed area adjacent to a large floodplain.	Crown - Vernon Creek Watershed	Outflow of Swalwell Reservoir	This low lying area is approximately 5.5 km from the intake	Physical (sediment), Biological (fecal coliforms, E.coli from manure)	Overland flows, direct deposit	Cattle are likely attracted to this area for its cooler temperatures and shade. There was significant substrate disturbance from cattle and a high density of fecal matter. The low lying, “swampy” area has a direct transport mechanism for pathogens into Vernon Creek, especially during high flow periods.
28	Mining and Quarries - Three mineral and placer claims	Crown - Vernon Creek Watershed	Northern edge of Vernon Creek watershed	The closest claim is 17 km from the intake	Physical (sediment), Chemical (gasoline, oil from motorized equipment)	Overland flows	Although these claims exist, field surveys revealed no apparent activities and to the best of our knowledge the claims are not currently active.

5.0 MODULE 7

5.1 Objectives

This module brings together information on vulnerabilities and hazards within the assessment areas in order to assess their potential effects on water quality and/or quantity. This module also evaluates the effectiveness of source protection barriers.

5.2 Determination of Barrier Effectiveness

The source level protection barrier is one of a multi-barrier approach that serves to protect drinking water. Appendix 7C of the Guideline suggests a series of questions to evaluate the source level protection barrier, and results specific to Oyama and Vernon watershed are shown in Table 7-1. Six of the nine questions asked resulted in “No” answers. Three of the questions pertain to the potential hazards/contaminants within the watershed and the inability of the DLC to control them, while the other “No” answers pertain to water quality and the location of the intake. Therefore, the effectiveness of the source protection barrier has been ranked as **low**. The guideline states that, “Sound management, effective governance and affordability are the supporting mechanisms that make a robust multiple barrier system possible”. Ecoscape argues that it DLC’s lack of authority to control activities within the watersheds that prevents an effective protection barrier at the source. This assessment has been prepared with the aim of engaging and informing regulatory agencies to strengthen the source protection barrier, and it will enable evidence based planning/development for use by the appropriate bodies.

Table 7-1. Source Protection Barrier Effectiveness

Source Protection Factors	Yes/No	Comments
Does the water supplier control the source area?	No	• DLC does not own the land associated with the watershed, nor do they have a formal management role.
Is there a source water protection and management plan in place?	In Progress	• It is currently being developed.
Are watershed uses limited and designated?	No	• The majority of the watersheds are managed as operable Crown land (multi-use) and have numerous stakeholders (e.g. logging, range tenures, recreational users). • However, it should be noted that although the watersheds are multi-use, activities are regulated via documents such as range use and harvest plans.
Are contaminant sources either low risk or absent from the catchment areas?	No	• High risk contaminants originate from wildlife, anthropogenic activities and livestock.
Does the integrity and location of the intakes ensure that the best quality source water is captured?	No	• The intakes both occur on the main channel of creeks and thus there is high velocity and little opportunity for settling. The location of the intakes is deemed best available, but is not ideal.
Is the source water quality consistently good with seasonal fluctuations that do not disrupt treatment systems?	No	• Source water quality is typically treatable with the exception of seasonal fluctuations in colour and turbidity. • However, DLC has had to issue boil water notices in both watersheds. In 2009, the Oyama Creek watershed was on a boil water notice for several consecutive months.
Can the total water source capacity supply current and projected water demand (accounting for climate change and drought)?	No	• Currently, water supply capacity is minimal. DLC has submitted an application to raise the levels of Oyama, Swalwell and Crooked lakes in order to address long term demand.
Is there a back-up or secondary source?	Yes	• In the Vernon Creek watershed, the Eldorado Reservoir acts as a backup storage supply. However, its storage capacity is limited and the water still originates from Vernon Creek. • Okanagan Lake also acts as a supplementary supply and backup, however supply is limited given the capacity of the distribution system to boost to higher elevations.
Are the community/water users aware of the impact of human activity on source water quality and quantity?	Yes	• Community watershed signage occurs throughout the watersheds

5.3 Qualitative Risk Assessment

5.3.1 Overview

In Modules 1 and 2 fourteen different hazards were identified. The different sources of potential contaminants originate from both anthropogenic activities and intrinsic features. Those identified are very similar to other source water protection plans in British Columbia (e.g., Triton Environmental Consultants Ltd., 2006; Dobson Engineering Ltd., 2007). The Guideline outlines an approach for determining the risk of each hazard based on its associated likelihood and consequence. This approach is useful, but does not provide water managers with sufficient information to evaluate the variable risks of hazards at different locations within the assessment area. To address this concern, Ecoscape used a GIS analysis to identify four different vulnerability zones within the assessment area (see Module 1 – Section 3.6), and then followed the Guidelines approach for determining risk of hazards within each zone. Four of the identified hazards (raw water characteristics, MPB, forestry (as it pertains to water quantity), and climate change) exist independent of vulnerability zones and thus were evaluated as such.

Qualitative risk was assessed at the DLC intake prior to treatment for the majority of hazards, while semi-quantitative risk was assessed for hazards (roads and stream crossings) that had more information available to determine site specific risk. The qualitative assessment assumes that a contaminant generated by a specific hazard in each of the vulnerability zones must travel from the site of contamination to the intake, where it may act as a risk to human health. As defined by the Guideline,

$$\boxed{\text{Risk} = \text{Likelihood X Consequence}}$$

where likelihood is a time-bound estimate of the probably that a harmful event, condition, action or inaction would occur and that negative impacts would result. Likelihood was generally evaluated over a 10 year time frame as suggested by the Guideline (except where otherwise noted, specifically for MPB and climate change). Table 7.2 shows the five qualitative measures of likelihood with example descriptions and percentage probabilities.

Table 7-2. Qualitative Measures of Likelihood (Reproduced from the Guideline, MHS & MWLAP, 2005)**.**

Level of Likelihood	Descriptor	Description	Probability of Occurrence in Next 10 Years
A	Almost Certain	Is expected to occur in most circumstances	>90%
B	Likely	Will probably occur in most circumstances	71-90%
C	Possible	Will probably occur at some time	31-70%
D	Unlikely	Could occur at some time	10-30%
E	Rare	May only occur in exceptional circumstances	< 10%

Consequence is defined as the nature and degree of impact if a hazard does occur. This measure helps one to understand the predicted nature, severity, duration and extent of impact from the unabated hazard. In Module 1 - Section 3.2.1, potential hazards were generally categorized into three different hazard types: biological, chemical or physical. Each of the likely contaminants and possible effects were then outlined in Table 1-1. These criteria act as the basis for determining consequence. In the case where an identified hazard (e.g. livestock) can act as two different hazard types (e.g. biological and physical), the hazard type is referred to as a combination. This approach allowed a better assessment of hazards and potential additive effects (e.g., release of sediment and fecal matter associated with cattle trampling could impair standard treatment). Descriptive measures of consequence which were used to assign scores are shown in Table 7-3.

Table 7-3. Qualitative Measures of Consequence (MHS & MWLAP, 2005).

Level	Descriptor	Description
1	Insignificant	Insignificant impact, no illness, little disruption to normal operation, little to no increase in normal operating costs.
2	Minor	Minor impact for small population, mild illness moderately likely, some manageable operation disruption, small increase in operating costs.
3	Moderate	Minor impact for large population, mild to moderate illness probable, significant modification to normal operation but manageable, operating costs increase, increased monitoring.
4	Major	Major impact for small population, severe illness probable, system significantly compromised and abnormal operation if at all, high level monitoring required.
5	Catastrophic	Major impact for large population, severe illness probable, complete failure of systems.

Once likelihood and consequence scores were determined for each hazard within each vulnerability zone, a risk matrix was used to assign risk by finding the cell in the matrix corresponding to the likelihood and consequence scores (see Table 7.4).

Table 7-4. Qualitative Risk Analysis Matrix (MHS & MWLAP, 2005)

Likelihood	***Consequence***				
	1 Insignificant	**2 Minor**	**3 Moderate**	**4 Major**	**5 Catastrophic**
A almost certain	Moderate	High	Very High	Very High	Very High
B likely	Moderate	High	High	Very High	Very High
C possible	Low	Moderate	High	Very High	Very High
D unlikely	Low	Low	Moderate	High	Very High
E rare	Low	Low	Moderate	High	High

5.3.2 Assumptions

The qualitative analysis makes the assumption that the three different hazard types result in different levels of risk. For example, hazards which lead to pathogenic contamination generally create a greater risk to public health than those leading to chemical or physical contamination. This is true, unless there is a catastrophic event which results in complete disruption of the distribution or treatment systems (e.g. rupture of chlorine tanks, significant landslide, etc.). Table 7-5 outlines the risk of individual hazard types, and a combination of hazard types (e.g. physical and biological) in each of the vulnerability zones. This risk table acts as the basis for determining the risk of identified hazards (e.g. livestock, forestry, etc) within each watershed.

Table 7-5. The risk of hazard types within different vulnerability zones.

	Hazard Type			
Vulnerability Zone	**Biological**	**Physical**	**Chemical**	**Any Combination**
Very High/High	Very High	High	High	Very High
Moderate	Moderate	Low	Low	Moderate
Low	Low	Low	Low	Low

The risk levels outlined above assume common, every day occurrences. These levels may increase with the severity of an event. For example, a trace chemical release in the creek above the intake carries a high risk (as shown in Table 7-5), however, if a 50-gallon drum of pesticide was spilled in the creek, then the risk would be very high. For the characterization of risk of the various hazards, Ecoscape assumed a reasonable worst case scenario (see Table 7-6a-d).

Other assumptions that were made in the determination of risk include:

- Industry (e.g. forestry, mining, cattle) is governed by legislation, best management practices and environmental management procedures. For this assessment, risk was determined based on reasonable worst case scenarios, where mitigative practices are not necessarily employed. As alluded to above, worst case scenarios can be numerous and can have varying levels of severity. Therefore the calculated risk is dependent on the severity of the hazard event.

- This assessment has determined risk based on worse case scenarios, it has not evaluated the probability of whether a worse case scenario will occur. However, it is likely that the probability of worse case scenarios will vary depending on the hazard.

- Risk is determined for each vulnerability zone. Therefore, it is assumed that the vulnerability zones are accurate. The vulnerability zones were developed based on the locations of water bodies. Ecoscape found numerous errors in the TRIM data and thus mapped the locations and extents of water features using air photo interpretation. Although this revised dataset is more accurate, it still has limitations. For example, in areas where the stream width could not be determined by air photo interpretation, the width was estimated using defined buffers, and may not reflect the actual stream width in some instances.

5.3.3 Risk Characterization Tables

In addition to the risk characterization for the broad drinking water hazards (see Tables 7-6a-d), likelihood, consequence and risk was also determined for site specific contaminants identified in Modules 1 and 2 (see Tables 7-7a and b for the Oyama and Vernon Creek watersheds, respectively). In the Oyama Creek watershed, three site specific contaminants were identified as having very high risk and 12 contaminants were classified as high risk. The very high risk contaminants included two instances of high densities of cattle below the high water level of creeks and harvesting within the Lakeshore Management Zones of drinking water reservoirs. High risk site specific contaminants ranged from documented algae in Damer reservoir to the enhanced turbidity levels experienced annually due to spring freshet (see Table 7-7a).

In the Vernon Creek watershed, six site specific contaminants were classified as having very high risk. These included specific instances of slope failures, cattle below the high water level and harvesting within Lakeshore Management Zones. Nine site specific contaminants were classified as high risk (see Table 7-7b).

Table 7-6a. RISK characterization table for hazards in the *very high and high vulnerability zones*.

	Hazard No.	General Drinking Water Hazard	Hazard Type	Likelihood	Consequence	Risk Level	Assumptions/Comments
Very High & High Vulnerability Zones	1-2	Slope failure/debris flows	Physical	Unlikely	Catastrophic	Very High	Although the Vernon Creek watershed has slope stability concerns, it is still unlikely that a major event will occur within the 10 year time frame. The consequence and risk of a slope failure and/or debris flow is very much dependent on the severity and location of the event.
	1-3	Presence of birds and wildlife	Biological	Almost Certain	Insignificant	Moderate	Natural densities of wildlife are typically low and thus the risk is moderate. Nevertheless, the presence of wildlife provides a background level of contamination which requires treatment.
	1-4	Wildfire	Combination	Possible	Catastrophic	Very High	The level of risk will depend on the fire severity and location.
	1-5	Algal Blooms	Biological	Possible	Major	High	The type (e.g. cyanobacteria), location and magnitude of bloom will affect the consequence and resultant risk.
	2-1	Land ownership	Combination	Possible	Moderate	High	The risk depends on the location and landuse of the property.
	2-3	Human access and recreation	Combination	Almost Certain	Minor	High	The risk depends on the severity. For example, a hydrocarbon release from a boat motor has a much smaller risk than a person intentionally dumping a 50 gal. drum of pesticide in a creek above the intake. Risk was determined based on a reasonable worst case scenario.
	2-5	Forestry (as it pertains to impacts on water quality)	Combination	Likely	Moderate	High	The forestry risk identified in this table (and in Tables 7-6b & c) only pertains to water quality impacts. The risk of forestry on water quantity is evaluated in Table 7-6d. The combination hazard types for forestry are physical and chemical. Risk depends on factors such as the size of the block, location, terrain stability, etc...
	2-6	Livestock in the form of cattle grazing on Crown land	Combination	Almost Certain	Moderate	Very High	The risk is very much dependent on the density of cattle and the duration of time spent below the high water level.
	2-7	Mining	Combination	Possible	Moderate	High	The risk depends on the type of mining, its location and its severity.

*The risk of roads, characteristics of raw water, climate change, forestry (as it pertains to impacts on water quantity) and MPB are evaluated elsewhere.
**Risk determination is based on a reasonable worst case scenario.

Table 7-6b. RISK characterization table for hazards in the *moderate vulnerability zones*.

	Hazard No.	General Drinking Water Hazard	Hazard Type	Likelihood	Consequence	Risk Level	Assumptions/Comments
Moderate Vulnerability Zones	1-2	Slope failure/debris flows	Physical	Unlikely	Minor	Low	A slope failure in a moderate vulnerability zone is unlikely, and if it did occur then it would affect smaller tributaries in the upper basins. The reservoirs would act as filters, allowing sediments to settle out.
	1-3	Presence of birds / wildlife	Biological	Unlikely	Insignificant	Low	Wildlire in moderate vulnerability zones are not a significant risk to water quality at the intake.
	1-4	Wildfire	Combination	Unlikely	Major	High	The level of risk will depend on the fire severity and location.
	2-1	Land ownership	Combination	Unlikely	Moderate	Moderate	Activities associated with land ownership (e.g. forest clearing and septic leakage) in the moderate vulnerability zone are less likely to result in contamination that would reach the intake.
	2-3	Human access and recreation	Combination	Possible	Minor	Moderate	Risk depends on severity and location.
	2-5	Forestry (as it pertains to impacts on water quality)	Combination	Possible	Moderate	High	The forestry risk identified in this table only pertains to water quality impacts. The combination hazard types for forestry are physical and chemical. Risk depends on factors such as the size of the block, location, terrain stability, etc...
	2-6	Livestock in the form of cattle grazing on Crown land	Combination	Possible	Moderate	High	Cattle in moderate vulnerability zones may still pose a risk due to overland transport of fecal material. However, the risk would depend on adjacency to water.
	2-7	Mining	Combination	Possible	Moderate	High	The risk depends on the type of mining, its location and its severity.

*The risk of roads, characteristics of raw water, climate change, forestry (as it pertains to impacts on water quantity) and MPB are evaluated elsewhere.
**Risk determination is based on a reasonable worst case scenario.

Table 7-6c. RISK characterization table for hazards in the *low vulnerability zones*.

	Hazard No.	General Drinking Water Hazard	Hazard Type	Likelihood	Consequence	Risk Level	Assumptions/Comments
Low Vulnerability Zones	1-2	Slope failure/debris flows	Physical	Rare	Minor	Low	Debris flows/slope failures in the low vulnerability zone would be uncommon and less likely to impact water quality at the intake.
	1-3	Presence of birds / wildlife	Biological	Rare	Insignificant	Low	The risk is substantially reduced when wildlife activity occurs away from source watercourses.
	1-4	Wildfire	Combination	Rare	Moderate	Moderate	The risk level from wildfire will vary depending on the location and severity of the fire.
	2-1	Land ownership most commonly results in land clearing and thus sedimentation	Combination	Rare	Insignificant	Low	Land ownership in low vulnerability zones is unlikely to affect water quality at the intake.
	2-2	Wind Generation	Combination	Rare	Insignificant	Low	Only the locations of met towers were assessed (see Figure 2-1).
	2-3	Human access and recreation	Combination	Rare	Insignificant	Low	Increased risk could result from unlikely scenarios, such as dumping of a significant quantity of a highly toxic substance.
	2-5	Forestry (as it pertains to impacts on water quality)	Combination	Possible	Minor	Moderate	The forestry risk identified in this table only pertains to water quality impacts. The combination hazard types for forestry are physical and chemical. Risk depends on factors such as the size of the block, location, terrain stability, etc...
	2-6	Livestock in the form of cattle grazing on Crown land	Combination	Unlikely	Minor	Low	Livestock that occurs in low vulnerability zones are not likely to impact water quality at the intake.
	2-7	Mining	Combination	Rare	Minor	Low	The moderate risk level assumes that any sedimentation generated by mining in the low vulnerability zone would have little chance of entering source water, and if it did, then it would likely settle due to the buffering capacity of reservoirs.

*The risk of roads, characteristics of raw water, climate change, forestry (as it pertains to impacts on water quantity) and MPB are evaluated elsewhere.
**Risk determination is based on a reasonable worst case scenario.

Table 7-6d. RISK characterization table for hazards which are independent of vulnerability zones.

	Hazard No.	General Drinking Water Hazard	Hazard Type	Likelihood	Consequence Level	Risk Level	Assumptions/Comments
Independent of Vulnerability Zones	1-1	Characteristics of raw water including high turbidity associated with spring freshet	N/A	Almost Certain	Minor	High	Because surface water is exposed to the elements, it carries a high level of risk and has to be treated.
	1-6	Mountain pine beetle (as it pertains to impacts on water quantity)	Physical	Almost Certain	Insignificant	Moderate	The risk of MPB on water quantity is determined independent of harvest activities, and is assessed over a longer time period (50 – 100 years). The ECA modeling that has been completed suggests that the loss of forest cover due to MPB will result in increased peak flows of moderate levels.
	1-7	Climate change	N/A	Almost Certain	Moderate	Very High	The risk assumes significant operational costs associated with drought and water shortages. Climate change is assessed over a longer time period (50 – 100 years).
	2-5	Forestry (as it pertains to impacts on water quantity)	Physical	Almost Certain	Minor	High	The risk of forestry on water quantity is determined based on the ECAs for each watershed and the potential for changes to peak flows.

N/A – not applicable

Table 7-7a. Site Specific Contaminant Risk Characterization Table for the Oyama Creek Watershed.

Contaminant #	Contaminant Source Type (Hazard) & Description	Comments	Likelihood Level	Consequence Level	Risk Level	Assumptions
1	Natural characteristics of raw water - north arm of Oyama creek dries up annually, providing access for wildlife, cattle and recreation	Ecsocape understands that even if this were a natural system, it is likely that the north arm of Oyama Creek would have intermittent flows.	Almost Certain	Minor	High	Low flows within the channel invite higher risk activities (cattle, recreation) - all with the potential to contaminate source water.
2	Natural characteristics of raw water - enhanced turbidity which results from the scouring of available source material as the channels fill during spring freshet	The level of snow pack influences spring freshet. Enhanced flows typically between April and mid-June.	Almost Certain	Minor	High	Water quality is substantially diminished during spring freshet.
3	Natural characteristics of raw water - north fork of Oyama Creek has high colour	Colour originates from dissolved organic matter in the water originating from soil and decaying vegetal matter. Chlorination of coloured water can produce disinfection by-products (e.g. trihalomethanes) and create difficulties in maintaining adequate levels of disinfection. Flows from the north arm of Oyama Creek are diluted with flows from Oyama Creek to reduce the levels of colour.	Almost Certain	Minor	High	The disinfection by-products generated from the treatment of coloured water is a significant long term concern.
4	Natural characteristics of raw water - peak coliform values were considerably higher along the north fork of Oyama Creek (below the lakes) than compared to the mainstem of Oyama Creek downstream of Oyama Lake (Phippen, 2008).	A reduction in coliforms did not occur downstream of High, Damer, or Chatterton Lake because the residence time of these lakes was either too short to affect coliform viability, or that there was a continual source of fecal matter in those areas (Phippen, 2008). This further emphasizes the importance of limiting sources of coliforms to Oyama Creek North, as additional inputs of coliforms below the lakes will have an additive affect with those already present at the outflows of High, Damer and Chatterton lakes.	Almost Certain	Minor	High	The natural characteristics of the raw water requires additional treatment which may have long term impacts.
5	Slope failure/debris flows - location, integrity and vulnerability of Oyama Creek Intake	The head pond, intake building, and access road are all built on a narrow floodplain area that occurs adjacent to the main channel. This location has experienced previous debris floods, with past evidence visible on a fan immediately upstream of the head pond. Debris flood or debris events, or materials associated with them that reach the Oyama Creek intake can be expected to damage or destroy infrastructure resulting in significant down time and loss of distribution capabilities.	Rare	Catastrophic	High	The risk determination takes into account past evidence of debris floods.
6	Human Access - integrity and vulnerability of Oyama Creek Intake	The location of the intake, adjacent to private property, likely provides a reduction in access by the general public. Nevertheless, a non-status road along the north side of the canyon does facilitate all terrain vehicle access if one is determined, and the intake is certainly accessible by foot. Therefore, public access and/or vandalism at the intake is a very real possibility.	Almost Certain	Minor	High	The risk assumes that even small cases of vandalism can be costly, in order to ensure that water quality has not been impacted.
7	Slope failure/debris flows - Evidence of three previous landslides upstream of intake	The canyon upstream of the intake has a slope stability class of IV and a soil erosion potential that ranges from high to very high. The cause of the documented landslides is not known for certain, and given their size, they do not continue to pose a threat. Overall landslide hazard index for the Oyama Creek watershed is ranked as low (Dobson Engineering Ltd., 1998).	Rare	Moderate	Moderate	The risk assumes that these landslides no longer pose a significant threat.
8	Natural characteristics of raw water -wildlife (including birds and mammals) are capable of carrying and disseminating fecal coliforms and *E. coli*	All warm-blooded wildlife species (including birds and mammals) are capable of carrying and disseminating fecal coliforms and *E. coli* and their presence in the watershed results in a basal level of risk.	Almost Certain	Insignificant	Moderate	
9	Access and Recreation - the presence of wildlife (including birds, mammals and fish) has resulted in excellent sport fishing and hunting opportunities	Hunting and fishing activities can result in all three contaminant types originating from roads (sediment), human and pet waste and trace chemical releases from motorized vehicles.	Almost Certain	Minor	High	

Table 7-7a. Site Specific Contaminant Risk Characterization Table for the Oyama Creek Watershed.

Contaminant #	Contaminant Source Type (Hazard) & Description	Comments	Likelihood Level	Consequence Level	Risk Level	Assumptions
10	Wildfire Potential - 2 km wildfire occurred within 50 m of the Oyama Reservoir (June 11th, 2009)	More than 2 months after the fire, it was noted that fire retardant remained at the site covering the remaining standing trees, downed vegetation and soils. An ephemeral drainage also flowed from the burned area into the Oyama Reservoir. The most likely result of enhanced nutrients is the increased potential for algal blooms.	Rare	Insignificant	Low	This risk rating assumes that the fire from June 2009 will create water quality concerns at the intake in the future.
11	Algae - Documented algae near the outflow of Damer Lake	Algal blooms are most likely to occur during summer months when water temperatures are warmer and water volumes are low due to high peak demands. Nutrients can occur naturally but can also be significantly altered by anthropogenic influences such as faulty septic systems, livestock, fire retardants, agricultural runoff, and landslide events resulting from poor storm runoff or road construction on both sanctioned and non sanctioned roads.	Possible	Moderate	High	The risk is very much dependent on the type of algal bloom. This risk determination assumes the possibility of cyanobacteria.
12	Moutain Pine Beetle - Oyama Creek watershed has extensive stands of lodgepole pine, which are highly susceptible to MPB	The potential of MPB infestation in the Oyama Creek watershed can be estimated based on the availability of mature lodgepole pine. In 2006, approximately 45% of the area above the snowline was previously logged and about 45% of the remaining area was composed of more than 70% lodgepole pine . It was speculated that the MPB infestation would be severe and will likely have a significant impact on peak flows and the water quality at the intake (Dobson Engineering Ltd., 2008).	Almost Certain	Insignificant	Moderate	This risk is calculated independent of harvest activities.
13	Land Ownership - commerical lease lot (Oyama Lake Wilderness Fishing Resort)	The facility currently has a total of 13 cabins, a main lodge and small store, a workshop/sawmill, and a number of camp sites. The septic system has been updated within the last several years. A minor sediment point source was documented from the boat launch and access road. There is a small marina and additional floating structures. The resort has increased risk due to intensity of use.	Possible	Minor	Moderate	The risk takes into account the current levels of activity.
14	Land Ownership - 13 residential lease lots on Oyama Reservoir	The lots are only accessible by foot and/or boat. Most, if not all are equipped with pit outhouses. Very little foreshore disturbance was documented and the majority of existing moorages are small (<24 m^2). There is concern that a road built to fight the Oyama fire could be used for future access to lease lots.	Possible	Minor	Moderate	The risk takes into account the current levels of activity.
15	Land Ownership - Three privately held parcels near the Oyama Creek intake	The water intake and associated infrastructure occurs on two privately held parcels of land owned by the DLC and access to the intake requires the use of various easement roads across private lands. Due to the adjacency of these parcels to the intake, future changes in land use and/or zoning must be carefully considered.	Unlikely	Insignificant	Low	The risk assumes activities that are currently on-going within private lands will affect water quality at the intake.
16	Wind Generation - Four Investigative towers within the Oyama Creek watershed	Meteorological towers have little impact on source water quality. Depending on the need for tree removal, there could be some sedimentation issues and there may also be the potential for chemical contaminants originating from motorized equipment used to construct the towers.	Rare	Insignificant	Low	The risk assumes current activities associated with the investigative towers, however risk could increase with additional infrastructure.
17	Access and Recreation - MOTCA regulated recreation camp sites (at Oyama, Streak, High and Damer Lakes),	During site surveys, it was noted that all regulated sites were relatively clean and well maintained. Although garbage was noted, in no cases was it excessive. Erosion originating from access roads, camp site clearings and boat ramps was documented at most of the recreation sites. The erosion severity ranged from negligible to moderate, where sediment was delivered directly to adjacent lakes. At the majority of sites, sedimentation can be controlled with the use of standard erosion control techniques such as water bars, sumps, ditch/swale, etc.	Almost Certain	Insignificant	Moderate	The risk takes into account the documented conditions of the recreation camp sites.

Table 7-7a. Site Specific Contaminant Risk Characterization Table for the Oyama Creek Watershed.

Contaminant #	Contaminant Source Type (Hazard) & Description	Comments	Likelihood Level	Consequence Level	Risk Level	Assumptions
18	Access and Recreation - Motorized recreation (4x4/ATV/motorbikes) below the high water level of important creeks and/or reservoirs	Mud bogging was noted in both the shallow areas of reservoirs and in intensively used areas adjacent to source streams. However, the intensity of motorized activities below the high water level was relatively low. No sites were pinpointed as having intense activity.	Likely	Insignificant	Moderate	The risk takes into account the current levels of activity.
19	Access and Recreation - "The lookout"	Access to this site appears to have been blocked in at least two locations, but ATV access around roadblocks is still possible. The biggest concern observed in this location was a substantial number of shotgun shells (i.e., in excess of 100). Shots appear to have been fired out over the Oyama Creek canyon in the approximate vicinity of the intake. Unsanctioned camping is also occurring at this location.	Possible	Insignificant	Low	The risk takes into account the considerable distance of "the lookout" from source watercourses.
20	Access and Recreation - Activities of crime	Activities of crime included dumping of garbage and hazardous materials, clearing of vegetation for vehicle access, illegal drug cultivation, and abandoned vehicle dumping. Criminal activities were less than what was observed in the Vernon Creek watershed, but were still documented.	Almost Certain	Minor	High	
21	Stream Crossings and Roads - Very High and High Risk roads	Very high and high risk ratings were applied to several non-status and Forest Service Roads in the residual area. Issues include failing deactivation infrastructure, uncontrolled drainage above steep coupled slopes, past landslides on steep terrain below roads, and running surface and ditch scour related erosion with direct input of sediment to Oyama Creek or major tributaries downstream of the lakes.	Likely	Minor	High	The calculated risk assumes that very high and high risk roads could result in additional issues such as substantial slope failures, erosion, etc.
22	Stream Crossings and Roads - Moderate and low risk roads	Moderate risk roads occur in all parts of the Oyama Creek watershed and are mainly the result of insufficient water management, running surface erosion, ditch scour, and ultimately sediment input to source watercourses or fish bearing waters. Low risk roads are not an issue.	Unlikely	Minor	Low	
23	Forestry - Proposed harvest	With the additional proposed harvest, the ECAs are projected to increase to 49.2 and 51.7%, for moderate and full attack levels, respectively. These projections suggest that the peak flow hazard will increase from the middle of the moderate range to the cusp of the high range for the watershed as a whole. In the Oyama Lake Basin, where the majority of the harvesting is planned, the projected ECAs for both the moderate and full attack levels are within the high peak flow hazard range.	Almost Certain	Minor	High	The risk pertains to increases in the peak flow hazard (i.e. water quantity), rather than impacts to water quality at the intake.
24	Forestry -Harvesting within sensitive Lakeshore Management Zones (LMZs)	Ecoscape is concerned that current and proposed harvesting within LMZs may result in increased access for cattle and motorized vehicles that could result in water quality impacts to the reservoirs. If increased access is realized then biological contaminants are also of concern.	Almost Certain	Moderate	Very High	The calculated risk assumes access for cattle and motorized recreation.
25	Range Tenures - High cattle density and source contaminants observed in two locations on the main channel of Oyama Creek	The first location is a low lying area and has a fence that extends across the creek. It appeared that cattle were using areas on both sides of the fence. At the second location cattle were accessing the creek from an old pathway or logging access road. At both sites there was significant stream channel bank trampling and fecal deposition below the high water level.	Almost Certain	Moderate	Very High	The calculated risk assumes livestock activity below the high water level.
26	Range Tenures - High cattle densities on the north fork of Oyama Creek, around Chatterton Lake and directly below Damer Reservoir	The north end of Chatterton Lake was heavily utilized, as cattle appeared to be congregating amongst the willows. There was extensive substrate disturbance in this location. Below Damer Lake cattle are accessing a non-status road just above Oyama Creek North. Cattle use in this area is of particular concern because the north fork of Oyama Creek typically dries up in late August and then the cattle use the creek bed as a movement corridor.	Almost Certain	Moderate	Very High	The calculated risk assumes livestock activity below the high water level.
27	Range Tenures - Cattle congregating in a moist pocket with ground water seepage along a fence that is approximately 5 m from the Oyama Creek	It is possible that feces from this moist pocket would be transported to the creek, especially during spring freshet. Cattle fences should be set back from the creeks at least 20 to 50 m depending on the slopes and characteristics of the particular sites.	Possible	Moderate	High	The risk at this location is reduced because the fence prevents direct fecal deposit to Oyama Creek.

Table 7-7b. Site Specific Contaminant Risk Characterization Table for the Vernon Creek Watershed.

Contaminant #	Contaminant Source Type (Hazard) & Description	Comments	Likelihood Level	Consequence Level	Risk Level	Assumptions
1	Natural characteristics of raw water - enhanced turbidity which results from the scouring of available source material as the channels fill during spring freshet	The level of snow pack influences spring freshet. Enhanced flows typically between April and mid-June.	Almost Certain	Minor	High	
2	Slope failure/debris flows - location, integrity and vulnerability of Vernon Creek Intake	The holding pond and intake building are located on the main channel of Vernon Creek within a steep, well-incised canyon with highly erodible soils. Given that landslides have interrupted service in the past, it is really a matter of when, and not if water quality at the intake will be affected. The presence of numerous unstable, steep coupled slopes pose a significant risk, if not the primary risk to water quality and infrastructure at the intake.	Possible	Catastrophic	Very High	The likelihood of a substantial landslide occurring is determined over a 10 year time frame. So although there is significant potential from a landslide perspective, the likelihood is much less than with other contaminants.
3	Slope failure/debris flows -a steep, coupled slope with soft material immediately adjacent to the intake building and head pond	The steep, coupled slope is located on the northwest corner of the holding pond. A narrow trail extends across this slope and provides access to the upper portions of the pond. During the summer of 2009, works were undertaken to stabilize the trail with the use of a wooden walkway. Nevertheless, sedimentation is probable at this site.	Likely	Insignificant	Moderate	
4	Human Access - integrity and vulnerability of Vernon Creek Intake	From a trespass/vandalism perspective, the Vernon Creek intake is fairly isolated, however the intake can also be accessed on foot by descending into the canyon from the upper plateau. Therefore, the intake location is as such that the general public will not happen upon it, but if the intention is for trespass/vandalism, it is very possible.	Almost Certain	Minor	High	The risk assumes that even small cases of vandalism can be costly, in order to ensure that water quality has not been impacted.
5	Slope failure/debris flows - Evidence of 7 landslides upstream of the Vernon Creek intake	The canyon upstream of the intake has a slope stability class of V and a soil erosion potential of very high. The soils in this portion of Vernon Creek developed on glaciofluvial and glaciolacustrine materials that are highly erodible. Previous studies have concluded that these landslides are the principal sediment sources within the Vernon Creek watershed.	Almost Certain	Catastrophic	Very High	The calculated risk takes into account that these landslides continue to be a significant sediment source.
6	Natural characteristics of raw water -wildlife (including birds and mammals) are capable of carrying and disseminating fecal coliforms and *E. coli*	All warm-blooded wildlife species (including birds and mammals) are capable of carrying and disseminating fecal coliforms and *E. coli* and their presence in the watershed results in a basal level of risk.	Almost Certain	Insignificant	Moderate	
7	Access and Recreation - the presence of wildlife (including birds, mammals and fish) has resulted in excellent sport fishing and hunting opportunities	Hunting and fishing activities can result in all three contaminant types originating from roads (sedimenation), human and pet waste and trace chemical releases from motorized vehicles.	Almost Certain	Minor	High	
8	Moutain Pine Beetle - Vernon Creek watershed has extensive stands of lodgepole pine, which are highly susceptible to MPB	The potential of MPB infestation in the Vernon Creek watershed can estimated based on the availability of mature lodgepole pine. In 2006, approximately 45% of the area above the snowline was previously logged and about 45% of the remaining area was composed of more than 70% lodgepole pine . It was speculated that the MPB infestation would be severe and will likely have a significant impact on peak flows and the water quality at the intake (Dobson Engineering Ltd., 2008).	Almost Certain	Insignificant	Moderate	This risk is calculated independent of harvest activities.
9	Land Ownership - commerical lease lot (Beaver Lake Mountain Resort)	The facility has a total of 22 cabins, some on septic and others are equipped with outhouses. There is a petting zoo, a general store, numerous camp sites, and a marina. In addition, many of the cabins have their own moorages. The boat launch has a moderate level of sedimentation flowing directly to Swalwell Reservoir.	Possible	Minor	Moderate	The calculated risk takes into account the current activites within the property.
10	Land Ownership - commerical lease lot (Dee Lake Wilderness Resort)	The resort has full service cottages, log cabins, camping and RV facilities, lodge units and a store and office. Some of the facilities are on septic, while others utilize outhouses. There is a boat launch and individual moorages.	Possible	Minor	Moderate	The risk takes into account the current levels of activity.
11	Land Ownership - 15 residential lease lots (Crooked Lake)	Documented concerns at residential lease lots include vegetation clearing, retaining walls, groynes, substrate importation, burning below the HWL, moorages > 24 m^2, and sediment point sources.	Possible	Minor	Moderate	The risk takes into account the current levels of activity.
12	Land Ownership - 27 residential lease lots (Swalwell Reservoir)	Documented concerns at residential lease lots include vegetation clearing, retaining walls, groynes, substrate importation, burning below the HWL, moorages > 24 m2, and sediment point sources.	Possible	Minor	Moderate	The risk takes into account the current levels of activity.

Table 7-7b. Site Specific Contaminant Risk Characterization Table for the Vernon Creek Watershed.

Contaminant #	Contaminant Source Type (Hazard) & Description	Comments	Likelihood Level	Consequence Level	Risk Level	Assumptions
13	Land Ownership - privately held parcels near the Vernon Creek intake	Privately held parcels surround the water intake structure and these parcels are zoned Agricultural (A1) within the DLC. Allowable land uses of the A1 zoning designation include agriculture, range uses, etc. The parcels are currently leased for cattle grazing.	Possible	Minor	Moderate	The determination of risk takes into account that these lands are currently used for cattle grazing, and cattle are within relatively close proximity to the intake.
14	Wind Generation - One Investigative tower within the Vernon Creek watershed	Meteorological towers have little impact on source water quality. Depending on the need for tree removal, there could be some sedimentation issues and there may also be the potential for chemical contaminants originating from motorized equipment used to construct the towers.	Rare	Insignificant	Low	The risk assumes current activities associated with the investigative towers, however risk could increase with additional infrastructure.
15	Access and Recreation - MOTCA regulated recreation camp sites (at Swalwell, Island & Lost Lakes)	During site surveys, it was noted that all regulated sites were relatively clean and well maintained. Although garbage was noted, in no cases was it excessive. Erosion originating from access roads, camp site clearings and boat ramps was documented at most of the recreation sites. The erosion severity ranged from negligible to moderate, where sediment was delivered directly to adjacent lakes. At the majority of sites, sedimentation can be controlled with the use of standard erosion control techniques such as water bars, sumps, ditch/swale, etc.	Almost Certain	Insignificant	Moderate	
16	Access and Recreation - Unsanctioned campsite at Crooked Lake Dam	At the time of the site visit a small fire was burning within a fire pit and no users were present. Extensive garbage and evidence of intentional dumping was observed across the site, include garbage located directly in the over flow spillway between Crooked and Swalwell Reservoirs. Two shallow outhouse pit toilets had been erected at the site and there was extensive evidence of ATV activities, including recent trail clearing to Swalwell Reservoir that was also being utilized by cattle to access shoreline.	Almost Certain	Minor	High	
17	Access and Recreation - Motorized recreation (4x4/ATV/motorbikes) below the high water level of important creeks and/or reservoirs	Mud bogging was noted in both the shallow areas of reservoirs and in intensively used areas adjacent to source streams. However, the intensity of motorized activities below the high water level was relatively low. Other than at the Crooked Lake dam, no other sites were pinpointed as having intense activity.	Likely	Insignificant	Moderate	The risk takes into account the current levels of activity.
18	Access and Recreation - Activities of crime	Activities of crime included dumping of garbage and hazardous materials, clearing of vegetation for vehicle access, illegal drug cultivation, and abandoned vehicle dumping. Criminal activities appeared to be relatively prevalent in the Vernon Creek watershed	Almost Certain	Minor	High	
19	Access and Recreation - Abandoned vehicle and hazardous material dumping at extensive landslide on Vernon Creek canyon	Materials, including vehicles and animal parts have been intentially dumped at this site. The steep, coupled slope is already sensitive from a sedimenation perpective and the addition of dumpings is exacerbating the issue. The site is also risky from a public safety standpoint, and the slope is steep.	Almost Certain	Minor	High	
20	Stream Crossings and Roads - High risk roads	Road risk in the Vernon Creek watershed was determined based on stream crossing and culvert density, plus the vulnerability zones. Beaver Lake Road is of particular concern given its size, frequency of use and adjacency to steep, coupled slopes and Vernon Creek.	Likely	Minor	High	
21	Stream Crossings and Roads - Moderate and low risk roads	Moderate and low risk roads occur in all parts of the Vernon Creek watershed and are not of immediate concern.	Unlikely	Minor	Low	
22	Forestry - Proposed harvest	With the incorporation of proposed harvest blocks, the ECA for the entire assessment area increases from 19% to 30%. The ECA for areas above the snowline also increases from 27% to 45%. With the inclusion of the proposed blocks, there continues to be a moderate peak flow hazard, although it is approaching a high flow hazard.	Almost Certain	Minor	High	The risk pertains to increases in the peak flow hazard (i.e. wanter quantity), rather than impacts to water quality at the intake.
23	Forestry -Harvesting within sensitive Lakeshore Management Zones (LMZs)	Ecoscape is concerned that current and proposed harvesting within LMZs may result in increased access for cattle and motorized vehicles that could result in water quality impacts to the reservoirs. If increased access is realized then biological contaminants are also of concern.	Almost Certain	Moderate	Very High	The calculated risk assumes access for cattle and motorized recreation.

Table 7-7b. Site Specific Contaminant Risk Characterization Table for the Vernon Creek Watershed.

Contaminant #	Contaminant Source Type (Hazard) & Description	Comments	Likelihood Level	Consequence Level	Risk Level	Assumptions
24	Range Tenures - Cattle presence at the Vernon Creek intake	Ecoscape visited the intake on Vernon Creek on two different occasions. During the first visit in June, four cows were documented along the creeks edge using a trail that immediately parallels the creek. During the second visit, no cattle were observed, but relatively fresh feces were noted below the high water level of the holding pond and sporadically along the creeks edge. Given that there is virtually no residence time prior to contaminants moving into the intake, there is a need to entirely eliminate cattle from this area.	Almost Certain	Moderate	Very High	The likelihood of almost certain will be reduced with range improvents (i.e. fencing).
25	Range Tenures - Cattle utilizing non-status road and trails to access Vernon Creek	Cattle are using a non-status road as a movement corridor and then dropping down the steep canyon via trails to access Vernon Creek approximately 1.4 km upstream of the intake. One trail is of particular concern, as it is well defined with steep grades, especially as it approaches the creek. Certain portions of this trail have extensive erosion concerns (the worst documented in the watershed) and it also provides cattle with direct access to a rehabilitated landslide at the creek edge (approximately 1.1 km from the intake). Cattle movement across the landslide is compromising rehabilitation efforts and resulting in direct sediment and fecal input to Vernon Creek.	Almost Certain	Moderate	Very High	
26	Range Tenures - Cattle accessing Vernon Creek from Beaver Lake Main via four ephemeral creeks and drainage channels	Drainage is diverted under Beaver Lake Main via culverts and in some cases there is a defined channel from the roadway directly to Vernon Creek. Where defined channels exist, cattle (albeit, in relatively few numbers) use them as wallowing areas and movement corridors to access the main stem of Vernon Creek. These defined channels provide a direct route for sediment and fecal matter, resulting in pathogen inputs.	Likely	Moderate	High	
27	Range Tenures - High cattle densities were observed below the Swalwell Reservoir in the low lying treed area adjacent to a large floodplain.	Cattle are likely attracted to this area for its cooler temperatures and shade. There was significant substrate disturbance from cattle and a high density of fecal matter. The low lying, “swampy” area has a direct transport mechanism for pathogens into Vernon Creek, especially during high flow periods.	Almost Certain	Moderate	Very High	
28	Mining and Quarries - Three mineral and placer claims	Although these claims exist, field surveys revealed no apparent activities and to the best of our knowledge the claims are not currently active.	Unlikely	Minor	Low	

5.4 Semi - Quantitative Risk Assessment

For streams and road crossings, more data is available that allows a more precise characterization of risk at individual locations. The following sections detail the risk characterization for stream crossings and roads.

5.4.1 Overview

As previously indicated, M.J. Milne & Associates Ltd. provided road risk data and analysis for the Oyama Creek watershed and Dobson Engineering Ltd. provided stream crossing data for the Vernon Creek watershed.

5.4.2 Oyama Creek Watershed – Road Risk Results

Results of the road risk analysis are shown on Figures 7-1a and b. Roads are colour-coded by the risk rating and the rationale for each rating is provided in Appendix F. Risk ratings are not available for private roads which are largely located downstream of the DLC intake.

A total of 128 km of road was reviewed and rated in the Oyama Creek watershed. Risk ratings by road status and length are detailed in Table 7-8.

Table 7-8. Oyama Creek Watershed: Road Risk by Road Status and Length.

Risk	Road length (km) by status		
	Non-status	FSR	Licensee permit
Very high	2.0	0	0
High	3.2	1.4	0
Moderate	2.7	2.0	0.8
Low	54.7	18.5	42.7
Total	62.6	21.9	43.5

Very high risk ratings are applied to those roads where the probability of hazard occurrence and the expected effect on resources at stake are high. The very high risk rating was applied only to a non-status road OR2 (lower) on the north side of the Oyama residual and a private road (LOR1) that occurs along the assessment area boundary northwest of the intake. The very high risk rating for OR2 (lower) was driven by road location on gentle terrain above steep coupled slopes, insufficient or failing deactivation, little to no maintenance, uncontrolled drainage and drainage diversions, and evidence of past erosion and landslide events into Oyama Creek.

High risk ratings involve a combination of a high and a moderate rating (see Appendix F). High risk ratings were applied to several non-status and Forest Service Roads in the residual area. Issues include failing deactivation infrastructure, uncontrolled drainage above steep coupled slopes, past landslides on steep terrain below roads, and running surface and ditch scour related erosion with direct input of sediment to Oyama Creek or major tributaries downstream of the lakes. Case specific details are available in the Appendix F.

Moderate risk ratings involve a combination of two moderate ratings or a high and a low on the hazard or consequence side. Moderate risk roads occur in all parts of the Oyama Creek watershed and are mainly the result of insufficient water management, running surface erosion, ditch scour, and ultimately sediment input to source watercourses or fish bearing waters.

5.4.3 Vernon Watershed – Road and Stream Crossing Risk Evaluation

Risk in the Vernon Creek watershed was assessed for stream crossings, drainage culverts and roads. The following sections detail the methods and results of these analyses.

Methods

Stream Crossing and Drainage Culvert Risk

The following criteria were considered in the evaluation of stream crossing and drainage culvert risk:

1. Stream Crossing Quality Index (SCQI) – This index was used to assess sediment inputs into source streams. The results of this analysis were grouped into High, Moderate, and Low based on the output of the SCQI. All crossings that had Low to Moderate problems, or SCQI scores of 0.4 or higher were considered High, SCQI scores of 0.2 to 0.4 were considered Moderate, and SCQI scores of 0 to 0.2 were considered Low.

2. Culvert or Stream Crossing – Due to the significant number of culverts in close proximity to potentially unstable terrain, culverts were included in this analysis. Culverts and stream crossings were both considered within the index, with stream crossings given more priority or weight in the analysis than culverts.

3. Adjacency to Potentially Erodible Unstable Terrain – Terrain information discussed elsewhere in this document was also considered. The distance from a culvert or stream crossing to Slope Stability Class IV and V or Class III where soil erosion potentials were High or Very High. The distance was then categorized as follows: 0 m, 1 to 250 m, 250 m to 500 m, 500 m to 1000 m, and Greater than 1000 m.

4. Distance to the Main Stem Chanel or Reservoir – For each culvert or stream crossing assessed the distance to the main channel (i.e., that flows directly to the intake) or to the reservoir was measured and considered in the index. The distances were categorized as follows: 0-250 m, 250 – 500 m, and Greater than 500 m.

5. Vulnerability Zone – The vulnerability zone that the culvert or stream crossing occurs in was considered. To simplify the analysis, high and very high vulnerability zones were combined.

The above criteria / categories were each assigned scores (see Table 7-9 below). Higher scores reflect a greater consideration within the analysis. For each different crossing, the total score was added. The resultant range of scores for all the stream crossings was then broken down into three equal groups: High, Moderate, and Low (See Appendix E; Ecoscape Grouping). Finally, the Likelihood and Consequence for each of the three groups of stream crossings or drainage culverts were calculated to assess the risk (see Table 7-9).

Table 7-9: Vernon Creek Watershed: Stream Crossing Analysis Procedure.

Criteria	Categories	Score
Stream Crossing Quality Index (SCQI)	High (SCQI > 0.4)	5
	Moderate (SCQI of 0.2 to 0.4)	3
	Low (SCQI of 0 - 0.2)	1
Stream vs. Culvert	Stream	5
	Culvert	3
Distance to Unstable Terrain	0 m	10
	0 to 250 m	8
	250 to 500	5
	500 to 1000 m	3
	Greater than 1000 m	1
Distance to Main Stem Channel or Reservoir	0 to 250 m	5
	250 to 500 m	3
	Greater than 500 m	1
Vulnerability Zone	High or Very High	5
	Moderate	3
	Low	1

Road Risk

Road risk in the Vernon Creek watershed was also assessed using an index, because sufficient data is available to begin to better understand the risk originating from different road segments. The road risk assessment utilized the following criteria to determine risk of the different road segments.

1. Culvert / Stream Crossing density was determined across the entire watershed. Culvert / Stream crossing density is thought to increase risk associated with roads because there is a greater potential for contaminants to enter a source water stream. Culverts were included because they tend to direct water collected from roads and direct it to other locations in higher volumes than would occur naturally. These higher volumes, particularly if directed to potentially unstable or highly erodible substrates could affect water quality.

   Only culverts or stream crossings assessed during the assessment were included in the analysis. It is acknowledged that there is likely numerous other culverts that could be included, however, these culverts mostly occur in the upper watershed and are believed to have a lesser consequence on road risk than the culverts that were assessed. The following is a description of the specific GIS software analysis that was used to determine culvert density:

   > *Conceptually, a smooth, curved surface is fitted over each point in kernel density for point features. The surface value is highest*

at the location of the point and diminishes with increasing distance from the point, reaching zero at the search radius distance from the point (500 m). The volume under the surface equals the Population field value for the point or one if None is specified. The density at each output raster cell is calculated by adding the values of all the kernel surfaces where they overlay the raster cell center. The kernel function is based on the quadratic kernel function described in Silverman (1986, p. 76, equation 4.5).

If a Population field setting other than None is used, the Population field's value (the item value) determines the number of times to count the point. Thus, an item value of three would cause the point to be counted as three points. The values can be integer or floating point. If an area unit is selected, the calculated density for the cell is multiplied by the appropriate factor before it is written to the output raster. For example, if the input ground units are meters, comparing a unit scale factor of meters to kilometres will result in the values being different by a multiplier of 1,000,000 (1,000 x 1,000).

Uses are similar to those of point density, which include finding density of houses, wildlife observations, or crime reports. The Population field could be used to weigh some points more heavily than others, depending on their meaning, or to allow one point to represent several observations. For example, one address might represent a condominium with six units, or some crimes might be weighed more severely than others in determining overall crime levels.

Numerous different search radii were utilized in the analysis. In the end, a 500 m search radii was the most appropriate in our professional opinion. The resultant output was categorized at equal breaks into 3 categories, High, Moderate, and Low Culvert / Stream Crossing Density.

2. The Vulnerability Index was also overlaid across the watershed. The Very High and High Vulnerability Zones were merged together, which resulted in three specific categories.

To calculate the road risk, the resultant outputs of each analysis were overlain. The output resulted in a total of 6 different categories. Professional judgment was then used to create logical breaks to create three different road categories, High, Moderate, and Low. For each different road category, the Likelihood and Consequence were calculated using Tables 7-2 and 7-3 above.

Results

The results of the above analysis are best viewed graphically. Figure 7-2 depicts the overall risk of roads and stream crossings within the Vernon Creek watershed, while Figures 7-3 and 7-4 show only those crossings and roads that are high risk. In general, stream crossings had higher levels of risk when they were located below Swalwell Reservoir and in close proximity to the mainstem Vernon Creek channel. The majority of stream crossings located in the upper watershed area have either a moderate or low risk rating.

Two drainage culverts were also identified as having a high level of risk. The risk was higher for these culverts because of their proximity to potentially unstable terrain. The index created for the drainage culvert risk is corroborated by field surveys. For instance, in one of the culverts identified as having a high level of risk, the discharge of water and sediment from the culvert was observed to occur within 10 m from the top of bank from the Vernon creek canyon.

5.5 SWOT Analysis

The SWOT analysis provides an overview of the major factors that may influence the safety and availability of water at present and into the future. The acronym SWOT stands for Strengths, Weaknesses, Opportunities and Threats. Ecoscape relied on our experience in the watersheds and our knowledge of the issues to complete the SWOT analysis.

Table 7-10. SWOT Analysis

Strengths	Weaknesses
• Some reservoir lakes have automatic release gates that can be operated from the DLC. This system reduces operational time and enables better water conservation. • Water operators have appropriate levels of training. • Raw water quality parameters are monitored weekly at the intakes. • DLC has good working relationships with agencies and stakeholders of both watersheds. • Both intake locations are not readily accessible by the general public. • The Eldorado reservoir has the capacity to store approximately one day's water supply, which enables a temporary bypass of Vernon Creek. • There is good communication between the forest licensees and DLC prior to harvest activities. • The majority of watershed stakeholders are engaged.	• Multi-use watersheds with limited restrictions on use. • Water purveyor has no authority for enforcement. • The recreational opportunities and users within the watershed are numerous. • Reservoir storage limitations which may lead to water shortages. • Funding for enforcement, necessary assessments and general watershed protection is very limited. • Oyama and Vernon Creeks are the primary source of supply for the DLC. • Resources for infrastructure, monitoring and oversight of cattle are limited. • Range Use Plans are vague and not effective in preventing cattle from accessing source water. • The intakes are located on the mainstem of Vernon and Oyama Creek and have insufficient means to protect against trespass and vandalism.
Opportunities	**Threats**
• This assessment has served to engage and inform watershed stakeholders on ways to strengthen the source protection component. When completed, it will be widely distributed and function as a working document. • Funding sources such as Okanagan Basin Water Board help to facilitate additional assessments such as Sensitive Habitat and Inventory Mapping (SHIM), Foreshore Inventory and Mapping (FIM), a detailed Assess Management Plan, and an assessment to monitor the effectiveness of the proposed recommendations. • The Ministry of Forests and Range (MoFR) is to implement a formal plan prior to the 2010 grazing season, which mitigates risks to drinking water from range cattle accessing source waters in both the Vernon and Oyama watersheds. • Implementation of specific recommendations (Module 8 of this report) will not only achieve the intended purpose, but will act as an educational opportunity and provide funds which can be directly applied to source water protection. • The DLC may have the opportunity to increase its storage capacity at Oyama, Swalwell and Crooked Lakes.	• Sale of leased lots has the potential to further affect water quality and limits the expansion of reservoir lakes. • Cattle within very high and high vulnerability zones will result in diminished water quality and additional boil water notices. • Unsanctioned recreation has the potential of effecting water quality, especially if greater access to reservoirs is achieved. • The increasing population in the Okanagan Valley will enhance watershed activities and the demand for potable water. • Harvesting by SSSP licensees within Lakeshore Management Areas could facilitate access for cattle and recreational users. • Enhanced salvage activities due to MPB may result in moderate to high peak flow hazards. This is influenced by weather patterns, as well as harvesting schedules, replanting, etc. • Large scale or long term events such as wildfire, MPB and climate change have the potential of altering watershed hydrology and thus effecting water quality and quantity.

6.0 MODULE 8

6.1 Objectives

The two main objectives of Module 8 are 1) Recommend risk management actions to improve source water safety and sustainability; and 2) Prioritize risk management actions.

Risk management actions are presented and discussed in three categories: 1) general recommendations applicable to both watersheds; 2) hazard specific recommendations which may be general, or specific to either the Oyama or Vernon Creek watersheds; and 3) summary table of identified contaminants with specific recommendations. The recommendations are focused on risk to public health at the point of intake, and ways to reduce source water concerns.

6.2 Risk Priorities – Oyama Creek Watershed

Table 8-1 lists seven risk management actions (recommendations), which in Ecoscape's opinion, are the most important and should be carried out first in order to most effectively reduce impacts on source water in the Oyama Creek watershed.

Table 8-1. Risk Priorities in the Oyama Creek Watershed.

Hazard	**Risk Management Actions**
Cattle	Limit cattle access to very high and high vulnerability areas.
Roads	The very high risk non-status road (OR2 lower) that parallels Oyama Creek canyon above the intake should be permanently deactivated.
Harvesting in Lakeshore Management Areas	Forest harvesting should only occur within the Lakeshore Management Zone of Oyama and Damer reservoirs when the risk of wildfire and forest health factors out weigh the potential access issues and water quality impacts.
Multiple	A universal monitoring and reporting procedure should be developed so that stakeholders can notify the appropriate personnel if water quality concerns are identified.
Algae	Damer Reservoir should be either kept at a higher water level or the high point near the outflow should be dredged to prevent an isolated shallow area where algae growth is enhanced.
Sedimentation from access road and recreation site at Damer Reservoir	Use of standard erosion control techniques such as water bars, sumps, ditch/swale, etc to control erosion.
Lease Lots	Ensure there is no potential for vehicle access to residential lease lots along the road that was constructed to fight the fire in the Oyama Creek watershed.

6.3 Risk Priorities – Vernon Creek Watershed

Table 8-2 lists nine risk management actions (recommendations), which in Ecoscape's opinion, are the most important and should be carried out first in order to most effectively reduce the impacts on source water in the Vernon Creek watershed.

Table 8-2. Risk Priorities in the Vernon Creek Watershed.

Hazard	Risk Management Actions
Cattle	Limit cattle access to very high and high vulnerability zones between Swalwell Reservoir and the intake. **There should be no cattle immediately upstream of the intake.**
Terrain Instability	A detailed assessment and mapping of terrain features should be undertaken on Vernon Creek between Swalwell Reservoir and the intake.
Terrain Instability	The stream channel above the intake should be regularly monitored to look for signs of instability and/or debris jams which may affect water quality, and the intake structure itself.
Harvesting in Lakeshore Management Areas	Forest harvesting should only occur within the Lakeshore Management Zone of Swalwell and Crooked reservoirs when the risk of wildfire and forest health factors out weigh the potential access issues and water quality impacts.
Roads	A storm water management plan should be developed for Beaver Lake Main between the second cattle guard and Swalwell Reservoir.
Multiple	A universal monitoring and reporting procedure should be developed so that stakeholders can notify the appropriate personnel if water quality concerns are identified.
Roads	The non-status road that extends from Beaver Lake Main along the ridge of Vernon Creek canyon should be deactivated in a way that not only precludes recreational access, but also prevents cattle from using it as a movement corridor.
Unsanctioned Recreation	Mitigation of Crooked Lake dam site. DLC should work with MOTCA to determine how to improve conditions at this site (i.e. access prevention or re-establishment of sanctioned site).
Cattle	The high use cattle trail (contaminant #25) that extends to Vernon Creek should be accessed and mitigated for erosion concerns.

6.4 General Recommendations Applicable to Both Watersheds

General recommendations are listed in priority order (i.e. those that will be most effective at improving source water quality and quantity are listed first). After each recommendation, the suggested timeframe for completion and justification is in parentheses.

1. **Activities which generate drinking water hazards (both existing and proposed) should avoid very high and high vulnerability areas identified in each watershed.** This recommendation is most pertinent to human access, recreation, additional road development, forestry, and livestock. Future works if deemed necessary should be directed to moderate and low vulnerability areas. If avoidance is not possible, then specific mitigation strategies to protect water quality must be undertaken and coupled with monitoring, compliance and enforcement. **(Immediately; high risk reduction benefit)**

2. **All stakeholders need to work within a unified framework of decision making and assessment of risk.** For example, this assessment has generated zones of vulnerability that assume various levels of risk. If these vulnerability zones are deemed the most appropriate and agreed upon measure to assess risk, then the numerous stakeholders need to work within the defined framework (e.g. activities with a potential to affect source water should not occur in very high and high vulnerability zones without adequate levels of mitigation). If the vulnerability zones are not agreed upon, then they should be re-evaluated until consensus is achieved. **(Immediately; high risk reduction benefit)**

3. **Forested buffers surrounding reservoir lakes (including lakeshore large woody debris) are critical to adequately protect water quality, and should be measured from the proposed future high water level.** Loss of forest buffers surrounding reservoirs will increase access, most notably for recreation and cattle. It is important that the future water level of reservoirs is considered when determining buffer extents, so that protective buffers are not preemptively degraded or non-functional once reservoirs are raised. **(Immediately; need to enhance weak barriers)**

4. **Governmental agencies who promote the use of community watersheds should recognize the potential effects that their activities may have on water quality, and work to minimize the impacts.** Government agencies have A Memorandum of Understanding regarding drinking water protection. Yet it appears that provincial strategies promote development within Community watersheds (e.g. draft trails strategy for BC), without recognizing the potential impact on drinking water quality and the increased risk to public health. Funding is needed for education and watershed protection (e.g. compliance and enforcement), and funding sources should originate from the

governmental agencies promoting watershed use. **(Immediately; high risk reduction benefit)**

5. **Governmental agencies must take a leadership role to successfully facilitate an adequate level of protection.** The Drinking Water Protection Act states that agencies which oversee watershed activities are also responsible for ensuring that those activities do not affect source water quality. Therefore, numerous stakeholders are responsible for source water protection, yet no-one seems to be taking a preemptive leadership role. **(Immediately; need to enhance weak barriers)**

6. **Governmental agencies must ensure that resources are available to provide adequate levels of compliance and enforcement.** The provincial policy of multi-use Crown land is problematic for source water protection without these measures. Currently, the governmental agencies with enforcement authority include:
   - Ministry of Environment – Conservation Officers
   - Ministry of Forest & Range – Oversee cattle licensees via range use plans and can enforce compliance of mud bogging regulations; and
   - Ministry of Tourism, Culture and the Arts – Oversees sanctioned recreation sites

   Although these agencies exist, it appears that they are fairly limited in effectively protecting source water. For example, there are only a handful of conservation officers to oversee the whole Okanagan valley. There is also a long list of requests for additional recreation sites across southern BC. The combination of a limited number of sanctioned camping facilities, inadequate resources for compliance and enforcement and an ever increasing number of recreational users will result in unprecedented levels of activities such as unsanctioned camping, litter, and intentional dumping.

   There is considerable debate surrounding the effectiveness of provincial policy on source water protection. For example, the contamination of drinking water is prohibited under Section 23(1) of the Drinking Water Protection Act, however Section 23(3) states that the prohibition in subsection (1) does not apply if the introduction or activity is authorized or required under an enactment or the person is otherwise acting with lawful authority. Depending on one's interpretation, this statement essentially exempts several hazards identified in this assessment including cattle, forestry activities and even some forms of recreation. Regardless of the multi-use debate, there is little doubt that source water protection will be enhanced with a stronger component of compliance and enforcement. Therefore, additional provincial funding should be directed to on the ground source water protection, with a focus on compliance and enforcement of activities undertaken by the numerous watershed users. **(Immediately; high risk reduction benefit)**

7. **All watershed stakeholders need to acknowledge the `cost` of managing a watershed.** Watershed management is not the sole responsibility of any one stakeholder, but rather a shared responsibility among many. To effectively manage a watershed, the cost is likely more than what is currently contributed by the various stakeholders. Stakeholders should work to capitalize on the strengths of various organizations and share costs where appropriate to improve on the ground conditions within the watersheds. It may be most efficient for stakeholders to contribute to a single fund which works towards a common goal. **(Immediately; high risk reduction benefit)**

8. **A spatial dataset of existing water infrastructure (dams, ditches, pipelines, diversions, etc.) should be developed and available for use by the watershed stakeholders.** This recommendation was suggested by a planning forester and it would assist forest licensees in avoiding existing infrastructure when planning forest development activities (DLC). **(Within a year; high risk reduction benefit)**

9. **All watershed stakeholders should be present, engaged and attempt to work cooperatively**. It is critical that all major stakeholders actively participate in the process of source water protection. This recommendation specifically targets provincial agencies which oversee watershed activities. This assessment process revealed noticeable absences of certain provincial agencies. Because the activities within these watersheds are interdependent, the lack of a single agency has the potential to breakdown the process, or defeats the efforts of other stakeholders. **(Immediately; high risk reduction benefit)**

10. **Several sediment point sources were identified and should be addressed to reduce the potential affects on source water quality.** Sediment sources of concern are listed in priority order in Table 8-3 below. Typically sediment sources exist as a result of vegetation clearing and development which occurs relatively close to source watercourses. Sediment point sources were documented at forest recreation sites, commercial lease lots, and as a result of cattle access. Although individual sediment sources have little consequence, when considered cumulatively their effects begin to add up. For the most part, the sedimentation issues identified in Table 8-3 can be controlled with the use of standard erosion control techniques such as water bars, sumps, ditch/swale, etc. **(Within a year; need to reduce cumulative affects)**

Table 8-3. Sediment Sources to be Addressed in Priority Order.

Site	Erosion Severity	Sediment Delivery	Comments	Photos
Oyama Creek Watershed				
Damer Lake Recreation Site	Moderate	Evident and Direct	Erosion from access road and cleared campsites flows to lake	4824-26
Oyama Lake Lodge	Minor	Evident and Direct	Erosion from boat launch, access road	5659-77
Oyama Lake Recreation Site	Minor	Evident and Direct	Erosion from boat launch	5356-65
Vernon Creek Watershed				
Cattle Trail (contaminant #25)	Extensive	Evident and Direct	High use cattle trail to Vernon Creek	5007-09
Beaver Lake Lodge	Moderate	Evident and Direct	Erosion from boat launch, parallel access roads and trails to foreshore	5030-92
Dee Lake Lodge	Minor	Evident and Direct	Runoff from boat launch, access roads and access trails	5769-5809
Unsanctioned Campsite -Crooked Lake Dam (watershed assessment point 22)	Minor	Evident and Direct	Erosion from cleared areas and from motorized recreation	5238-64
Lost Lake Recreation Site	Minor	Evident and Direct	Runoff from cleared area travels down path to lake	5343-56
Island Lake Recreation Site	Minor	Evident and Direct	Sediment originating from access road and boat launch	5760-67
Swalwell Lake Recreation Site	Minor	Evident and Direct	Erosion from access road	5194-99

11. **Conduct finer spatial scale mapping of source water features to better identify key concerns and problem areas.** Ecoscape has identified vulnerability zones using GIS to amalgamate three general criteria (See Module 1; Table 1-4). However, this rudimentary analysis could be more informative, if it were expanded to use finer spatial scale information that is not currently available. Some of this information could be obtained with the use of methodologies such as the Sensitive Habitat Inventory and Mapping (SHIM) (Mason and Knight, 2001), and Foreshore Inventory and Mapping (FIM) (Schleppe and Mason, 2009). Additional mapping and inventory would provide a baseline understanding of current conditions and help prioritize any restoration or land use planning decisions. Funding for these projects is available from many different sources (e.g. Okanagan Basin Water Board) and

should be pursued through partnerships with relevant stakeholders. **(1-3 years; need to improve base data)**

12. **Improved communication between provincial and local governments would also benefit source water protection.** Activities within the watershed are governed by numerous jurisdictions; however their impacts are not necessarily independent of each other, and are often times cumulative. Thus when considering future works, it is critical for authorizing agencies to be aware of other existing and proposed activities and their implications on source water. **(Immediately; high risk reduction benefit)**

13. **Airphotos should be provided to DLC for the continued protection of source water.** As part of this assessment, Ecoscape will provide all digital information files to the DLC for use with ArcGis Explorer, a downloadable software that provides viewing access of GIS data. Much of the GIS information which Ecoscape has assembled is publicly available however, the 2007 orthophotos were obtained from MoE via a loan agreement. Ecoscape recommends that MoE extend this loan agreement to the DLC, so their personnel may utilize this resource to aid in the protection of their watersheds. If MoE cannot loan the airphotos, then DLC should secure sufficient budget to obtain them. **(Immediately; ease of implementation)**

14. **The DLC should invest in additional infrastructure at the water intakes to address vandalism concerns**. Thought should be given to fortification, fencing, observation (e.g. closed circuit TV) and a positive feedback loop shut down mechanism in the event of vandalism or intentional disruption of service. **(1-3 years; need to enhance weak barriers)**

15. **Ecoscape updated and refined the spatial locations of source watercourses as a part of this assessment. The DLC should distribute these updated shapefiles to pertinent stakeholders for their use.** During field surveys and desktop analysis, Ecoscape encountered watercourses not included, or not accurately represented within the provincial TRIM data. Ecoscape has attempted to update these features (i.e., streamlines, wetlands, lake high water levels, etc.). Accurate data is critical, especially within community watersheds, as stakeholders use baseline data for development planning, etc. **(Within a year; need to improve base data)**

16. **A single depository for watershed reports and associated GIS data should be created to ensure proper storage, easy accessibility and to promote the use of existing data to appropriately evaluate future changes to the watershed.** Data management for source water protection is a key concern. Spatial inventories and GIS are quickly becoming the land use management tool of choice. However, GIS data management is complicated and is often beyond the capability of many local water purveyors. This point highlights the importance of integrating data management initiatives with other agencies

better suited for management. Further, a single depository facilitates efficient access to source water information for stakeholders and others. Ecoscape understands that the Okanagan Basin Water Board has proposed a web-based Streamlined Data Reporting System which would allow the Ministry of Environment to track information such as water licensing and use (demand, supply, etc.). This venue may also be appropriate for the storage of GIS based information pertaining to specific watersheds and source water protection. **(1-3 years; improvement to resource availability)**

17. **A review of Source to Tap Assessments in the Okanagan (and abroad) should be conducted.** At this point, significant resources have been spent to asses risk in the Okanagan and in watersheds elsewhere in the province on a supplier by supplier basis. These assessments have been conducted following a similar approach, but data has been collected using a variety of different standards or methodologies. At this time, it is highly probable that a review of these Source Water Assessment documents would yield similar trends in hazards present, identified risks, and concerns raised, particularly in the Okanagan Watersheds. A review conducted now could result in more efficient use of limited funding available and allow these limited resources to be directed to the most appropriate regional watershed tasks (i.e., mapping exact locations of streams, determining where surface water bottlenecks occur, etc.). We recommend that the Interior Health Authority conduct a review of previously commissioned assessment reports to determine where and how methodologies can be improved upon to allow for long term monitoring and improved cost efficiencies. **(1-3 years; to benefit Okanagan watersheds as a whole)**

6.5 Recommendations by Hazard

The hazards with the greatest risk to source water are presented in priority order (i.e. higher risk hazards appear before lower risk hazards). Recommendations for each of the identified hazards are also listed in the order of importance. After each recommendation, the suggested timeframe for completion and justification is in parentheses.

Livestock

Livestock exists on both private and Crown land, and cattle were documented along most source watercourses. Reducing cattle access to more high and very high vulnerability areas, utilization of off channel watering, and other mechanisms will help reduce pathogen loading. Range Officers are currently working with DLC and Interior Health to address the significant concerns that occurred in the watersheds in 2009.

Ecoscape has reviewed published literature, existing planning documents and policies (e.g., LRMP), and data collected during this assessment to help prepare these recommendations. Our recommendations are based on the assumption that the risk from livestock is greatest in very high and high vulnerability zones, and diminishes with increased distance from the high water level of source watercourses. This assumption corroborates work by others who have identified stream banks and areas below the high water level (e.g., those flooded during normal years and conditions) as being the most sensitive to cattle impacts (Agouridis et al., 2005; Meays et al., 2005; Meays et al., 2006). The very high vulnerability zone is typically defined by the high water level of Oyama and Vernon Creek, where they extend between the reservoirs and the intake. The high vulnerability zones expand beyond the high water level of these creeks in the form of 50 m buffers and the inclusion of steep sloped areas. This high vulnerability zone includes the riparian communities (e.g. riparian meadows) which are also deemed as being sensitive to disturbance from cattle (Meays et al., 2006). It follows then that cattle presence within the very high and high vulnerability zones will most likely result in diminished water quality at the intakes. Our vulnerability zones and their associated risks *do not* reflect the exact risk of cattle congregating at any one location, however to accomplish this, a detailed site specific risk analysis of each location would be required.

In 2009, it was demonstrated that cattle can and do have impacts on source waters in the Oyama Creek watershed. The limited buffering capacity of Oyama and Vernon Creek below the reservoirs (i.e., travel time of 5 to 6 hours) does not provide an adequate level of protection against cattle which defecate below the high water level. Further, it has been demonstrated, at least in the Oyama Creek watershed, that current treatment systems (i.e., chlorination) are not capable of dealing with high fecal contaminant loads. Beyond the bounds of high water, risk becomes increasingly difficult to estimate, but intuitively there is an understanding that risks will diminish as distance from the high water level increases. It is probable that risk diminishes in an exponential fashion.

The key question remains, what is the minimum distance in which cattle can safely congregate from source watercourses, without causing diminished water quality at the intakes?" It follows that the answer is variable depending on factors such as slope, soils, aspect, vegetative cover and condition, stream morphology, season, sun exposure, etc. The lack of a clear methodology to answer this question, results in us relying on a combination of the best information available and our professional judgment. The following recommendations provide our best interpretation of what we believe to be the *preferred* (i.e., reduces risk to the greatest extent) and the *minimum* (i.e., reduces risk but requires substantial mitigation efforts outlined in well written, detailed Range Use Plans) distance from vulnerable source watercourses which cattle can safely congregate. Additional research is needed to define a model which more precisely identifies appropriate buffers in order to adequately mitigate risks of cattle in watersheds.

The MOFR has reviewed an earlier draft of the following recommendations, and they have provided an official response which is available in Appendix H.

General Livestock Recommendations

1. **Our *preferred* mechanism for dealing with cattle is to completely exclude them from the very high and high vulnerability zones between the intakes and the outlet of the storage reservoirs.** Cattle located within these zones without a doubt pose the greatest risk to water quality at the intakes. Because the vulnerability zones take into account the extent of the high water level and and terrain stability (slope and soil conditions), it incorporates best available site specific information as to which areas are more vulnerable to contaminants. **(Prior to the 2010 grazing season; high risk reduction benefit)**

2. **The *minimum* distance in which cattle** can safely congregate from source watercourses below the outflow of reservoir lakes is **30 m from the high water level (as defined by normal annual flows and flooding) or a 5 m offset from the Top of Bank (the portion of land that is less than 30% slope for a minimum of 15 horizontal m), which ever is greater.** The minimum distance stated above is based on previously published recommendations found in the LRMP, which suggest that cattle should be excluded from 30 m buffers surrounding source water creeks for at least 1 km upstream of an intake. The LRMP also states that corrective measures should be incorporated to increase the distance of the 30 m exclusion buffer as necessary for specific creeks. Ecoscape is of the opinion that a corrective measure is required, as 1 km above the intakes does not appear to be a sufficient distance given the significant fecal loading that occurred in the Oyama Creek watershed in 2009, from sources that were more than 1 km upstream of the intake. Coupled with this, our recommendation is also based on the fact that the travel times from the reservoir outlets to the intakes are in the order of 5 to 6 hours in both the Oyama and Venon Creek watersheds. This travel time is insufficient to reduce potential contaminant loading (i.e., Maeys *et al* (2005) found fecal density was not reduced until 17 days post placement and that there was no substantial difference in fecal density (CFU/g X 10^6) after 24 hours in deposits left in forested areas). Finally, the recommended 30 m exclusion buffer as per the LRMP does not consider topography, slope, or other terrain features. As our assessment has indicated, there are areas between the intakes and reservoirs that have highly erodible soils on steep coupled slopes. Given this, we have amended the 30 m as per the LRMP to either 5 m from the top of bank or 30 m from the high water level, whichever is greatest. This should help mitigate potential risks associated with steep slopes and highly erodible soils.

In our review of the scientific literature, we found that fecal contamination typically travels via overland flows in the order of 2 to 5 m (see summary provided in the introduction Meays *et al* (2005)) in different soil conditions). Considering cumulative impacts, which have been observed in other local watersheds (e.g., motorbikes carrying feces on tires resulting in combined sediment/fecal inputs (Laratt, 2009)), a 30 m exclusion buffer allows a safety net of approximately six times greater than that reported for typical overland flows. Further, this would allow cattle access to some riparian pasture areas while still allowing some level of risk abatement.

If the minimum exclusion buffer (30 m from the high water level or a 5 m from the Top of Bank) is selected, the recommendations below for Range Use Plans become ever more important because of the inherent risks associated with cattle in the high and very high vulnerability zones. Readers should also refer to this section because the minimum exclusion buffer relies on strict adherence to the recommendations presented for Range Use Plans. Without strict adherence, additional buffers greater than 30 m may be required.

Finally, our recommendations also rely heavily on the definition of *High Water Level*. For the purposes of this assessment, high water level refers to ***ANY*** areas inundated with water during normal operating years (i.e., 1 in 20 to 1 in 50 year events). Field determination of these areas may require professional assessment and should be accurately determined when fencing is erected. Failure to accurately determine the high water level will result in a reduced abatement of risk from cattle.

For the Vernon Creek watershed, this recommendation will result in the need for exclusion fencing from the intake along the top of bank to the outlet of the reservoir. Within the Oyama Creek watershed, this recommendation will result in exclusion fencing along the top of bank in the lower residual area (i.e., those within the lower canyon) and with fencing along a 30 m offset from the high water level in the upper areas closer to the outlet of the reservoirs. **(Prior to the 2010 grazing season; high risk reduction benefit)**

3. **Roads and unsanctioned quad paths facilitating cattle access to highly vulnerable areas should be deactivated wherever possible.** Cattle presence in highly vulnerable areas is largely correlated with human created infrastructure (e.g. roads and unsanctioned quad paths). Therefore, non-necessary roads and paths should be decommissioned wherever possible in the high and very high vulnerability areas (typically between the outflow of reservoirs and the intake). Furthermore, additional road development should not occur without consideration given to cattle utilizing the proposed road for riparian access. **Figures 7-1 b and 7-2 show high risk non status roads which should be deactivated. (Within a year; high risk reduction benefit)**

4. **A mapping initiative (GPS inventory) of fences and cattle guards should be undertaken by the Ministry of Forests & Range to assess the effectiveness of existing structures and to gain a broader understanding of how and where cattle are gaining access to source streams, diversions and reservoirs.** The target of existing infrastructure is not necessarily water quality in all cases. In fact, in some cases fencing is only present to distinguish between different pastures. Therefore the purpose of each fence should be understood, the state of repair documented, and natural features necessary for the fence to function should be determined. This effort will help focus limited funds to the most appropriate strategies and/or locations. Also, this mapping effort will provide up to date information regarding the location of the fences. Consideration should be given to development of a specific GIS database for fence lines. This database could act to hold all of the appropriate information and help facilitate long term fence line and pasture management. **(Within a year; high risk reduction benefit)**

5. **Natural barriers should also be inventoried and mapped by the Ministry of Forests & Range.** Fencing out all areas as discussed above may be an unrealistic option in the short term due to logistics and cost. Fencing and cattle exclusion often rely upon natural barriers, which help reduce costs. In these scenarios, fences are constructed to the edge of a natural barrier such as a steep slope or densely forested area, with the idea that the natural barrier will prevent further movement of cattle. Having a good understanding of the extent and location of these natural barriers is critical to ensure functionality and to prevent disturbance or elimination of the barrier. A list of natural barriers and their locations should be distributed to the various stakeholders (e.g. logging companies and MOTCA) to help ensure that proposed activities don't compromise the functionality of existing infrastructure. Detailed mapping of the natural barriers is likely best completed by the party that has identified and is utilizing the barrier (i.e., if a Range Use Plan requires a natural barrier, the developers of the Range Use Plan should map and identify the natural barriers they are relying upon). **(1-3 years; need to enhance source water barriers)**

6. **Proposed and existing fencing should also be overlaid with proposed logging in the watershed in order to determine if logging activities will impede fence locations or disrupt the necessary natural barriers upon which the strategic fencing relies.** The Ministry of Forests & Range should regularly supply the logging tenures with updated shapefiles of fencing, natural barriers, cattle guards, etc. **(Within a year; need to enhance source water barriers)**

7. **Buffers of mature forest and road deactivation should be considered around important source watercourses in high vulnerability areas to help reduce cattle access.** In our observations, cattle tend to move via roadways and to congregate in open areas around stream crossings, wetlands and

meadows, grasslands, and other areas in close proximity to forage and water. In addition, mature forests tended to reduce cattle access. Specifically, forested areas around primary reservoirs and source streams between the outlet of the reservoir and the intake have the highest priorities for maintenance of appropriate buffers and road decommissioning. **(Within a year; need to enhance source water barriers)**

8. **Cattle should be directed to strategically placed off channel watering or watering dugouts, as an alternative to source watercourses.** Off channel watering has been shown to reduce the time spent by livestock in riparian areas by more than 90% (Sheffield et al., 1997; Godwin and Miner, 1996). These features should also be spatially inventoried and monitored to evaluate effectiveness. There may be funding through AgriFlex to be used for off stream stock watering improvements (as suggested in letter from Bryn Lord). **(within 1 year; need to enhance source water barriers)**

9. **The use of range riders is encouraged to monitor livestock movement patterns and activities.** Ecoscape understands that range riders could potentially be facilitated through the Job Opportunities Program (JOP). This program creates short-term forest management job opportunities to assist laid off workers employed in the forest industry. **(prior to 2010 grazing season; need to enhance source water barriers)**

10. **A communication plan between relevant stakeholders needs to be implemented.** This may consist of determining a list of triggers that would require notification or meetings with other parties. Monitoring reports should be disseminated to relevant parties. **(prior to 2010 grazing season; high risk reduction benefit)**

11. **The MoFR has indicated that they will require cattle ranchers to keep active logs of cattle locations and numbers.** These logs will be extremely useful to help facilitate long term management of cattle in the watershed. Also, this will allow ranchers and the MoFR to better understand how changes in the watershed are affecting cattle movement patterns (i.e. certain logging cut blocks could result in changes in movement patterns). Hopefully, these logs will help both ranchers and the MoFR better understand the unique movement patterns of cattle in the watershed so that they can better predict where potential source water concerns will originate so that they can proactively adapt. **(prior to 2010 grazing season; need to enhance source water barriers)**

12. **An Adaptive Management model should be implemented.** Because the watersheds are so dynamic (ever changing roads, clearings, etc), it is likely that no two years will be alike. Further, infrastructure (e.g. fences) has been constructed (at least within the Oyama Creek watershed) which is intended to limit cattle use of riparian areas, but at this point it is not sufficient to entirely

prevent access to all very high and high vulnerability zones. Therefore, vigorous monitoring of unprotected riparian zones will be especially critical in 2010, and resultant action must promptly ensue should a problem arise. **(prior to 2010 grazing season; high risk reduction benefit)**

Recommendation for Range Use Plans

Given that the RUP is the main mechanism used to regulate range activity in riparian areas, it must provide sufficient detail to do so. **The following recommendations should be incorporated into RUPs prior to the 2010 grazing season, in order to effectively reduce the impact of cattle on source water quality.**

1. **Range Use Plans should include a map of highly sensitive riparian features.** The Very High and High Vulnerability zone include nearly all critical riparian areas. In some cases, these zones are more encompassing and include terrain features which should also be monitored. Initially, the high and very high vulnerability zones could be used as a basis to develop a riparian sensitivity map. The mapped feature should then form the basis for riparian inspections and monitoring. If these benchmark sites are functioning properly, then it is likely that other less sensitive sites are as well (Forest Practices Board, 2002).

2. **An extremely conservative stubble height approach should be undertaken.** Stubble height is a tool used to identify target utilization objectives. However, this tool does not result in reducing access to areas below the high water level. It is acknowledged that reduced densities/cattle grazing duration should correlate with reduced fecal inputs and stream sedimentation, but it will not eliminate it entirely. Giving this, an extremely conservative approach is required if this tool will be successful. Furthermore, stubble heights must be assessed in all riparian pasture areas, not just a select few. This must occur because it only takes a few cattle congregations to result in significant fecal contamination. The RUP must clearly identify all riparian pastures and assessment locations. Our figures should help the MoFR begin to ascertain the locations of key riparian pastures where stubble height measurements should be taken. Target utilization objectives (e.g. stubble heights) should be specifically stated for key riparian areas, and ranchers must be adequately trained to identify "proper functioning condition". Field days, training courses and demonstrations are all effective tools to enhance the understanding of ecology and management of riparian ecosystems (Forest Practices Board, 2002).

3. **In addition to stubble height, other conditions on the ground should be monitored to ensure proper ecosystem function.** These include channel or

stream bank condition, presence and density of fecal matter and general ground disturbance. If there are indications that ecosystem function is being affected, then range cattle should be removed from the affected area.

4. **The Range Use Plan should identify who is responsible for key components including monitoring and maintenance of infrastructure and these responsibilities must be explicitly stated.** There should also be a timeline for completion and consequences if works are not undertaken.

5. **Grazing schedules should be determined on the basis of riparian sensitivity rather than forage capacity of the uplands (Forest Practices Board, 2002).** The High and Very High vulnerability zones identify areas of greatest riparian sensitivity. The sensitivity of different riparian and terrain areas within these vulnerability zones should be assessed. The riparian sensitivity analysis should consider riparian function, condition, and ultimately assess an appropriate stubble height (i.e., allowable graze quantity) for each different riparian sensitivity area identified. Furthermore, contingencies should be in place to address unusual circumstances (e.g. particularly dry year with reductions in forage production).

6. **Range Use Plans must address the locations of natural barriers that they require for successful management.** This information must be communicated to appropriate parties and considered during other significant land use decisions (e.g., forest licensees addressing MPB concerns). A spatial GIS dataset should be developed which details the location of the proposed infrastructure and associated natural barriers. This dataset should then be shared with harvesters (and others) to ensure that future works do not compromise existing infrastructure.

7. **Use standardized cattle monitoring forms.** This would allow several entities who regularly work in the watershed to opportunistically document cattle activities. The additional data collection may allow for the identification of problems prior to water quality deterioration.

8. **The MoFR should develop a provincially recognized best management practices for ranging cattle in community watersheds.** The document should be written with sufficient detail to provide helpful guidance on ways to range cattle without affecting the water quality of source water streams and/or reservoirs.

Cattle Recommendations Specific to Oyama Creek Watershed

A phased adaptive management program is being developed for the Oyama Creek watershed through development of a comprehensive RUP. This RUP will begin to address identified cattle concerns, and stakeholders have acknowledged that an adaptive approach is required due to funding limitations. The RUP that is being prepared also requires that natural barriers to movement be maintained. Some of these barriers are vegetative (i.e., forest cover) and all forestry licensees / small scale operations may need to investigate ways to integrate these barriers into their harvest and retention plans. Relevant stakeholders should continue to work together to identify concerns and manage risks in the watershed. The cooperative involvement of the different parties will facilitate a better solution to the concerns identified and to offset costs of these programs.

- The discussion above provides our rationale and recommendations for the *preferred* and *minimum* distance in which cattle can safely congregate from vulnerable source watercourses. However, we understand that it may not be possible to complete these recommendations prior to the next grazing season. Therefore, the monitoring of key riparian areas is imperative in the meantime to mitigate repeat occurrences of contaminant loading that occurred during 2009. **Locations identified in Figures 2-9c should be included on the monitoring list, as well as any other high priority locations identified by the rancher or MOFR during their reviews of the watershed. (within 1 year; high risk reduction benefit)**

- From our review of the literature, the north fork of Oyama Creek appears to have higher *E. coli* and fecal coliforms counts (Phippen, 2008). The rationale for these higher counts is that shorter residence time in smaller lakes does not remove as many *E. coli* and coliforms. It is presumed that in the larger reservoirs, these pathogens settle out of the water column or become killed off via solar radiation before reaching the outlet. **Therefore, this sub basin area may have an increased vulnerability because of the lack of an adequate reservoir buffer (i.e., potential for an additive effect of from *E.coli* from above and below the outlet of the reservoirs). Based on this information, Ecoscape is of the opinion that the north fork of Oyama creek is a high priority for cattle exclusion.**

Cattle Recommendations Specific to Vernon Creek Watershed

Below we discuss problem locations and potential ways to exclude cattle following the *preferred* and *minimum* exclusion buffers previously outlined.

- **In the Vernon Creek watershed, a fence should be constructed along the top of bank from the intake all the way to the Swalwell reservoir.** There should be discussions as to how to best prevent cattle access in the moist forested pockets which surround Vernon Creek immediately south of the outflow of Swalwell Reservoir. There is existing fencing which excludes cattle from Beaver Lake Lodge, and it may be possible to tie into this fence. **(within 1 year; high risk reduction benefit)**

- **The non-status road which extends from Beaver Lake Main along the ridge of Vernon Creek canyon should be deactivated in a way that not only precludes recreational access, but also prevents cattle from using it as a movement corridor.** This non-status road is illustrated on Figure 7-2, and is the first high risk road upstream of the intake. Furthermore, cattle paths that extend from this non-status road into the canyon should also be assessed individually and should be decommissioned and mitigated for erosion concerns. **(within 1 year; high risk reduction benefit)**

- A total of four ephemeral tributaries with defined channels to Vernon Creek were identified along Beaver Lake Main (See Figure 2-9b for ephemeral stream locations). These tributaries act as direct inputs of sediment and fecal matter to Vernon Creek during periods of flow (typically at freshet or during large storm events). **Depending on the input of fecal matter from these areas, cattle access to these ephemeral tributaries should be eliminated using a combination of fencing and natural barriers.** Focus should be placed on initially directing cattle away from stream crossing areas associated with Beaver Lake Main. Coupled with this action, roadway drainages should also attempt to avoid direct discharge to these ephemeral channels, which will help reduce flow volumes in the small ephemeral streams and reduce the potential for sediment input to the mainstem of Vernon Creek. It may also be beneficial to lay a gravel apron upstream and downstream of the culverts, which would allow an accessible drinking point but would eliminate sedimentation from cattle wallowing (see Forest Practices Board, 2002). **(1-3 years; high risk reduction benefit)**

Terrain Stability

1. **Given the instability concerns in both watersheds, the DLC should coordinate a more detailed assessment and mapping of terrain features, with an assessment of Vernon Creek between Swalwell Reservoir and the intake being the first priority.** These assessments would serve to identify all of the locations where the streams are being impacted by slope failures, as well as to pinpoint debris jams, etc. The effectiveness of previous mitigative measures should be evaluated with recommendations for upgrades, as necessary. Appropriate sediment control measures should also be identified. These assessments could be completed as part of a modified Sensitive Habitat and Inventory Mapping project and the Okanagan Basin Water Board may act as a potential funding source. **(1-3 years; high risk reduction benefit)**

2. **The stream channels above the intakes should be regularly monitored to look for signs of instability and/or debris jams which may affect water quality, and the intake structure itself.** Monitoring details (frequency,

methods, etc.) should be individually determined based on the outcomes of the assessments described above. **(1-3 years; high risk reduction benefit)**

3. **Notify private property owner of landslides and obtain permission to trespass in order to properly inspect them.** Ecoscape identified two landslides that occur on private land upstream of the Vernon Creek intake. This property owner should be notified of these landslides and their potential to impact the water quality of Vernon Creek. **(within 1 year; high risk reduction benefit)**

4. **Unnecessary access roads and/or trails to steep coupled slopes should be deactivated and public access should be discouraged.** This recommendation specifically targets non-status roads which parallel the canyons upstream of the intakes and were determined to be high risk roads. Public access on these roads likely compounds the already existing natural instability of these areas. Figure 7-1b details those roads which have very high and high risk ratings in the Oyama Creek watershed, and Figure 7-2 illustrates high risk roads in the Vernon Creek watershed. **(within 1 year; high risk reduction benefit)**

Wildfire

1. **An Emergency Response Plan should be prepared, reviewed and updated regularly to ensure appropriate response at time of emergency.** Several of the identified hazards are classified as naturally occurring (e.g. landslides, wildfire). For these types of risks, a detailed emergency response plan is most suitable. Further, procedures should be discussed and coordinated with appropriate stakeholders to ensure a suitable response that meets the various agencies needs. **(within 1 year; high risk reduction benefit)**

2. **In particular, there is an immediate need for enhanced fire preparedness planning.** As previously discussed, a recent study suggests that Canada will likely experience significant increases in fire weather severity and fire activity. Therefore, there is an immediate need for enhanced fire preparedness planning. The planning documents could include a discussion of the backup drinking water source (e.g. availability, quality, and reliability), potential fire retardants to be used, their potential impact on water quality and post-fire rehabilitation strategies to reduce runoff and erosion (See abstracts from Wildfire and Watershed Hydrology workshop, Kelowna, June 3-4, 2009). The various watershed stakeholders, where appropriate, should be involved in the fire preparation planning to ensure that collaborative efforts are undertaken and implemented successfully. **(1-3 years; high risk reduction benefit)**

Climate Change

1. **Implement hydrometric data collection at key locations within each watershed to actively record current stream flows and to document the potentially changing hydrology that could likely result from climate change over the next 50 – 100 years.** The resulting database of hydrometric data can then be used to establish up-to-date water yields of the various supply areas within the watershed and as well as to establish discharge data of water not utilized by the DLC. This information would be informative for integrated watershed management. Finally, access to accurate hydrometric data is the first step to evaluate any potential long term limitations for water quantity. **(1-3 years; to facilitate long-term planning)**

2. **Consider implementing a decision support system for climate change adaptation.** The National Center for Atmospheric Research in Boulder, Colorado is currently working to both refine their ability to characterize future regional climate change and to develop appropriate approaches for using uncertain climate information for decision making (Miller, 2009). Early research suggests that the following key elements are necessary to design a useful system for climate change adaptation: 1) a process for identifying objectives and alternatives; 2) an integrated water resource planning and management model capable of simulating the effects of climate change on system performance; 3) multiple projections of future climate and of other key uncertain variables; and 4) methods for estimating decision performance and evaluating the desirability of the decision alternatives given the range of uncertainty about key variables.

   Although this research is new with many unanswered questions, the adoption of a risk management approach for long term planning will help to ensure that climate change plans are robust to accommodate the full range of potential changes and adaptable to new information (Miller, 2009). **(3-5 years; to facilitate long-term planning)**

Characteristics of Raw Water, Presence of Birds and Wildlife, and Algal Blooms

1. **Damer Reservoir should be either kept at a higher water level or the high point near the outflow should be dredged to prevent an isolated shallow area where algae growth is enhanced.** Near the outlet of Damer Lake, there is a highpoint of land that results in a small body of isolated water. Cattle, recreational users and their pets all have access to this small pool, which is shallow, tends to warm up quickly and is prone to algae blooms. This small pocket should either be filled with clean material, or the high point of land

should be dredged to promote adequate mixing and flushing within the larger body of the reservoir. **(Within 1 year; high risk reduction benefit)**

2. **Water quality should be a priority for watershed users and stakeholders. A universal monitoring and reporting procedure should be developed so that stakeholders can notify the appropriate personnel if concerns are identified.** It is critical that water quality issues are recognized and reported by the various watershed users, as they are often the ones to first encounter a problem. For example, if a rancher and/or cabin owner notices an algae bloom on a reservoir, how do they go about reporting the incident? A formalized monitoring/reporting procedure could also be extended to other activities which degrade source water (e.g. mud bogging). Having documentation of such events will identify trends and problem areas over time. **(Within 1 year; high risk reduction benefit)**

3. **Comprehensive water quality testing should continue at numerous locations in the watershed and prior to chlorination to pinpoint any changes to hazards which may occur.** Water quality monitoring should not be the sole responsibility of a single stakeholder. Therefore, a source water quality monitoring program should be developed by all relevant stakeholders who contribute to water quality hazards within the watersheds. By addressing the sampling requirements of all stakeholders, it is likely that a cost sharing mechanism could be easily developed that would address long term water quality trend monitoring. Further, this approach may facilitate a more collaborative environment where individual stakeholders acknowledge and accept responsibility for source water protection. **(Immediately; high risk reduction benefit)**

4. **MoE should review and finalize the provincial water quality objectives for both Oyama and Vernon Creeks.** At this point in time, the water quality data currently collected by the DLC does not allow for direct comparisons with the provincial objectives (Phippen, 2008; Einarson, 2008). An increase of one additional sampling per month would allow for the comparisons (specifically for *E. coli* and turbidity), however, as it stands the objectives are draft. The "draft" designation brings up questions regarding the definitive nature of the objectives and their likelihood to be changed in the future. The MoE should review the draft objectives put forth for both watersheds and determine if they are in fact adequate targets, and if so finalize them. Once the objectives have been finalized, the watershed stakeholders can then attempt to effectively manage the watershed in such a way as to meet those objectives. **(Within 1 year; improvements to base data)**

5. **The DLC should be responsible for enhanced water quality monitoring during and immediately following severe weather events.** Monitoring of water quality during these periods may reveal correlations that are predictive and could allow for improvements to management.

6. **The DLC should consult with an aquatic biologist to determine the most appropriate water quality sampling regime with regards to the monitoring of cyanotoxins, cyanobacteria or precursor conditions.** There is a potential for algal blooms during ice free seasons (spring – fall), and visual monitoring of reservoirs is critical to determine algal presence. Routine sampling of nutrients to determine baseline levels may also prove important to predict the potential for algal blooms. If a bloom is identified, water samples should be taken to a qualified professional for analysis.

Forestry and Mountain Pine Beetle

Ecoscape acknowledges that due to existing legislation and forestry best management practices, many of the following recommendations are already occurring. Nevertheless, we highlight them here, to emphasize their importance.

1. **Forest licensees should be diligent to reforest salvage cutblocks and deactivate access roads no longer required.** This is particularly important in very high and high vulnerability areas where there is the greatest potential for impacts to source water quality. Deactivating roads is critical because continued access increases the risks of ongoing contamination. Available funding should be focused on higher vulnerability zones first, followed by moderate and low vulnerability zones. Deactivation standards may need to be improved or changed in higher vulnerability zones where there is a need to prevent cattle and/or all terrain vehicle access. **(Immediately; high risk reduction benefit)**

2. **Forest harvesting should only occur within the 200 m Lakeshore Management Zone (LMZ) of reservoirs (Swalwell, Crooked, Oyama & Damer) when the risk of wildfire and forest health factors out weigh the potential access issues and water quality impacts.** If there is a desire to harvest with a LMZ, then risk determination should be undertaken by a representative group of individuals from the DLC, MoFR, and the major forest licensees operating within the watershed. Although there are likely multiple factors for consideration, the presence of residential structures and other types of infrastructure would most certainly elevate the risk of wildfire. If it is deemed that the risk of wildfire and forest health factors out weigh the potential access and water quality impacts, then harvesting needs to be carried out with extreme caution and disturbance should be minimized. Care should be taken to mask trail locations and debris should be used to create barriers for cattle. **(Immediately; high risk reduction benefit)**

3. **Permits issued by the SSSP within LMZs should include site specific requirements that must be undertaken to prevent access and subsequent effects on water quality.** Although the Okanagan Shuswap Forest District has recently issued a guidance document pertaining to harvesting within

LMZs, it does not provide enough detail to adequately protect the reservoirs. Site specific mitigation requirements must also be undertaken. **(Immediately; high risk reduction benefit)**

4. **Harvest activities by SSSP licensees within LMZs should be regularly monitored.** Ecoscape understands that professional foresters, which are hired to prepare prescriptions, are principally responsible for ensuring that harvest activities meet the approved prescription. However, due to the sensitivity of LMZs, we also recommend that Ministry of Forests at a minimum, conduct independent reviews to ensure that harvesting is conducted with a minimal footprint and that mitigative measures are employed to prevent cattle and all terrain vehicle access. **(Immediately; high risk reduction benefit)**

5. **In order to reduce the risk of wildfire, future harvesting and access related issues, LMZs should be replanted with a mixture of deciduous and coniferous species that are less susceptible to forest health factors and wildfire.** The intent of this recommendation is to shift from pure pine to species that are less susceptible to MPB, wildfire and future harvesting. Ecoscape understands in certain situations there may be no obligation to reforest after harvesting such as in partial harvested areas. Current legislation and policy may require modification in order to accommodate the conversion of stands to deciduous/conifer mixes to meet LMZ sensitivity and reduce the risk of wildfire. **(Immediately; high risk reduction benefit)**

6. **Retain and protect mature riparian vegetation in fan and floodplain areas of S1 – S4 streams.** Ecoscape understands that both major licensees and SSSP tenure holders operate within riparian management areas (RMAs) therefore it is essential that riparian buffers are maintained to reduce any effects on water quality. We make this recommendation to emphasize its importance; however, the retention of riparian vegetation is for the most part already occurring, as retention strategies (especially around water features) are outlined in forest stewardship plans. **(Immediately; high risk reduction benefit)**

7. **Forest licensees should work with the grazing licensees and the MoFR officers to limit cattle access to water courses and reservoirs when natural barriers may be removed during salvage harvesting**. The importance of maintaining these features cannot be overstated, especially over the short term while cattle exclusion is dependent on short segments of fence tied into natural features. As funding allows, the MoFR should GPS all cattle related features (including fences and natural barriers) and provide the forest licensees with accurate shapefiles to incorporate into their forestry development planning. **(Immediately; high risk reduction benefit)**

8. **There should be no further salvage above the snowline in the North Oyama Basin until the ECA returns to a low range (likely about 20 – 25**

years from now). This includes no operations by SSSP licensees. Exceptions may include the need to manage for wildfire or forest health factors, however, forest development which may delay a natural ECA recovery would have to be carefully justified. Any future development should be carefully reviewed and considered along with other existing watershed conditions to thoroughly evaluate the risks to water quality and quantity. **(Immediately; high risk reduction benefit)**

9. **Tolko should critically evaluate the stands proposed for salvage and only log those stands which make the most sense from a MPB perspective.** For the most part, Tolko is already meeting this recommendation with the implementation of their retention plan. The plan is designed to target retention in areas which need to be buffered from forest operations (e.g. riparian floodplains), and focuses harvest activities in areas of lower landscape sensitivity. Nevertheless, the ECA results from the Huggard based model show that the proposed scenario (Tolko's retention plan) has slightly higher ECAs than the WTP 80% + Pl, which targets greater than 80% pine and retains 10% wildlife-tree patches. Therefore, this model suggests that there **may** be further opportunities for additional retention of stands. **(Immediately; high risk reduction benefit)**

10. **No future, non forest health related forestry development beyond the current plan should be implemented until the peak flow hazard has recovered from moderate/high to low levels.** We believe this recommendation is reasonable for community watersheds, especially given the resources at stake. **(Immediately; high risk reduction benefit)**

Access and Recreation

Ministry of Tourism, Culture and the Arts (MOTCA) is responsible for the management of recreation sites and trails that were a legacy of the B.C. Forest Service and any new Partnership Agreements. Current challenges within the watersheds relate to increased recreational pressures and activities of crime. Of further concern is that motorized recreation below the high water level of source water reservoirs may be enhanced following the MPB infestation and subsequent salvage harvesting. Stakeholders must generally rely on educational efforts such as signage to inform watershed users of appropriate behavior. Although the recent announcement to license off road vehicles should help to minimize some of these risks, the cost of successful education and enforcement could be high, especially given the amount of criminal activity and inappropriate behavior observed.

1. **Recreational activities must be controlled and managed with policies of compliance and enforcement monitoring.** Poor recreational practices are far too common within the Okanagan Valley community watersheds as a

whole. Numerous activities such as "mud bogging", vehicular access, and ATV use below the high water level (or in areas that result in impacts to source streams through runoff) of watercourses are far too prevalent and highlight the need for increased enforcement and compliance monitoring. When asked, "What is the greatest threat to drinking water?" A resort owner responded "the lack of management with respect to the use of this resource as a recreation area". The current trend of reliance upon education and self regulation is not working in watersheds that are experiencing recreational demands at a level not yet seen. A combination approach consisting of education, enforcement, compliance monitoring, and access control is required. Currently, Conservation Officers are largely responsible for enforcement and there does not appear to be sufficient resources available to adequately enforce these activities. There are already moderate levels of education and access control which have been somewhat successful, but this again **highlights the importance and necessity of strict enforcement and associated consequences. (Immediately; high risk reduction benefit)**

2. **A detailed *access management plan* which prioritizes areas for access (motorized and non-motorized) and identifies other areas that could be decommissioned should be developed for both watersheds and possibly integrated with other local watersheds/water purveyors (e.g., Mission Creek Watershed/Greater Vernon Services Watersheds (Duteau))**. Broad access management has been previously addressed in the Okanagan Shuswap Land and Resource Management Plan, however the watersheds would greatly benefit from a more detailed access management plan jointly prepared and implemented by the pertinent stakeholders. The plan should be all inclusive, as every user (including livestock) depends on roads and trails for access. There are currently numerous applications to formalize land uses in the watersheds, highlighting the importance of carefully planning these activities. Motorized vehicle access to areas below the high water level of community reservoirs and dominant tributaries is a significant concern. Integration of the access management plan with forestry road construction and deactivation, proposed trail networks, crown land tenures for livestock and vulnerability zones will help control access while reducing risks. Finally, there should also be areas which are designated as non-motorized. The access management plan should flesh out optimal locations for each access type while considering factors such as watershed vulnerabilities. **(1-3 years; high risk reduction benefit)**

3. **Likely areas of unsanctioned camping should be integrated into the access management plan in order to prioritize areas of importance and to limit access to problem areas.** It is acknowledged that there will likely always be some level of unsanctioned camping. The purpose of this recommendation is to direct these activities to areas of lease risk and minimize impacts on source waters. Ongoing educational efforts will help reduce undesirable activities, as well as the promotion of public involvement, but a

level of enforcement is also likely required. **(1-3 years; high risk reduction benefit)**

4. **Off road vehicle licensing will help the general public participate in enforcement and monitoring in the watershed.** The use of off road vehicles will continue to occur within both of these watersheds and unfortunately it is often the actions of a few that is the detriment to the majority. Off road vehicle licensing is likely going to occur in the near future and is considered a key tool to help manage the poor behaviors of the few individuals. Ecoscape recommends that a portion of the money generated from licensing should be directed to source water protection programs, and that a list of off road activities deemed harmful to the environment should be distributed at the time of registration. Further, an associated series of fines and penalties for failure to avoid harmful activities should be created as an enforcement tool. Public users are highly prevalent throughout the watersheds, and they are currently an under utilized resource with regard source water protection. Giving citizens the means to participate and to take ownership of public resources will ultimately result in a greater environmental stewardship and source water protection. This type of licensing could be linked to the Report All Poachers and Polluters (RAPP) hotline at 1-877-952-7277. **(1-2 years; high risk reduction benefit)**

5. **The Ministry of Environment should designate all reservoirs as "electric motor only" due to the potential of hydrocarbon contamination originating from motor use.** The cumulative impact of hydrocarbons over time could result in a measurable deterioration of localized water quality. This recommendation is one of principle, given that reservoirs are specifically designated as a drinking water source and that viable alternatives to gas motors exist. This recommendation will further aid in the promotion of education and protection of source water. Ecoscape acknowledges that these reservoirs are large, and electric motors have other potential risks associated with them. However, we still feel that a reduction in potential for hydrocarbon contamination should be considered. **(1-3 years)**

6. **Expansion of forest recreation sites should incorporate appropriate buffers, consider surface runoff, and access.** Roads at most of the Forest Recreation sites result in direct sediment input to reservoirs. Further expansions should improve these conditions and avoid creating additional problem areas. Continued educational efforts, coupled with adequate legislation and enforcement, and careful planning will help ensure that source water is protected at these sites. **(Immediately; high risk reduction benefit)**

7. **A camp host or some other form of authority should operate at larger forest recreation sites (i.e., those with sufficient vehicle units to help offset costs).** Currently, there are no camp hosts operating in either the Oyama or Vernon Creek watersheds. The resort owners do act as overseers of the sites

on some occasions when concerns are observed, however, the presence of a regular authority would likely reduce levels of litter/intentional dumping and unsavory activities. **(Immediately; high risk reduction benefit)**

8. **Consideration should also be given to developing a back country permit program, which would require permits to access portions of the watersheds for general recreational purposes.** These permits could be administered similar to fishing or hunting licenses and would require basic knowledge of back country rules, regulations and sustainability practices (e.g. source water protection). Permitting requirements would necessitate periodic renewal with nominal fees to cover administration costs and the development of a fund that would be used for mitigation projects to offset water quality impacts by recreational users. **(1-3 years; cost benefit for source water)**

9. **Recreation/activity specific brochures (e.g. fishing, woodcutting, snowmobiling, motorized recreation) should be developed and distributed at the time of licensing and/or leasing.** These brochures should detail current legislation, potential impacts on source water, and best management practices for reducing impacts. The brochures could also be distributed by Conservation Officers or other authorities working on the ground in the watershed or via school educational programs, etc. **(1-3 years; improvement to source water barriers)**

10. **Proponents of any applications for a recreational license should provide a site appropriate management strategy and a sound business plan that demonstrates how they intend on operating their license area.** At this time, there are no active licensees in either watershed, however it is possible that applications will be put forth in the future. If this occurs, MOTCA should ensure that the applicant has a demonstrated business plan (i.e., they have the financial capability of implementing water quality mitigation strategies) and that they have developed specific approaches to mitigate the impact of their activities on water quality. Without these two fundamental components, additional risks, due to the concentration of activities, may arise. **(Immediately; improvement to source water barriers)**

Land Ownership

Land Ownership issues are governed by several different jurisdictions including RDCO and the DLC. These agencies use mechanisms of zoning, bylaws, and other powers at their discretion to govern changes in land use. Other provincial agencies also participate in land use decisions, depending upon the activities proposed (e.g., subdivisions are authorized by Ministry of Transportation, Crown leased lots are issued by the Integrated Land Management Bureau). Currently, DLC only has authority to authorize changes in land use within their municipal jurisdiction. In all other areas, the DLC must rely upon the decision of other governing bodies (e.g., Ministry of Environment issues Section 9's for Changes in and about a stream, the RDCO issues building permits for erection of structures on crown lease lots, etc.). The DLC does have the opportunity to provide comment on changes in land use by directing their responses to these different jurisdictions through established referral mechanisms. Given this, mechanisms to protect source water quality appear to be most suited through direct interactions with other governing bodies.

Table 8-4. Risk Priorities Pertaining to Land Ownership.

Hazard	Risk Management Actions
Foreshore activities (i.e. moorage construction, riparian clearing, danger tree mitigation, substrate modification, etc.)	Compliance and enforcement of existing legislation (e.g. Water Act, Riparian Areas Regulation) and best management practices should be routinely undertaken on reservoir lakes by the MOE Conservation Officer Service.
Existing structures below the high water level	The MoE should make exceptions to their policies to not issue permits to previously erected structures. Permitting is the best way to catalogue existing structures and ensure that all structures are constructed following existing legislation and standard best management practices.
Activities by lease lot owners below the high water level (i.e. use of ATVs, construction of retaining walls, groynes, moorages, etc.	Works by lease lot owners below the high water level should cease and desist. Any exceptions would require proper permitting and authorization.
Point Sediment Sources and Sewerage Systems*	Point sediment sources should be identified and mitigated within individual residential lease lots. The condition of existing sewerage systems should be evaluated for risk to water quality and improvements made accordingly.
Existing infrastructure and activities within lease lots	Regional District of Central Okanagan should revisit the recently updated by-laws and incorporate source water initiatives.

*Ecoscape did not evaluate individual point sediment sources or sewerage systems on residential lease lots because we did not have authority to access these properties.

1. **Compliance and enforcement monitoring must be consistently undertaken.** As with other activities in the watershed, a lease agreement with stipulations for source water is ineffective without proper follow up and enforcement. Without education or consequence, protection measures will not be effectively implemented and degradation of sources water will continue. **(Immediately, high risk reduction benefit)**

2. **Governmental agencies responsible for issuance of permits must be diligent to follow up and ensure that works completed conform to existing policies, bylaws, and standard best management practices.** For example, the RDCO and DLC should be conscientious to ensure that the RAR is implemented and followed for all shoreline lease and private lands. The MoE should be diligent to ensure that a Section 9 notification or authorization is obtained for any activities occurring below the high water level. As

mentioned above, routine monitoring and enforcement of regulations is required by all stakeholders who have authority to issue permits or licenses that allow further development within the watersheds. **(Immediately, high risk reduction benefit)**

3. **Cooperation and integration of source protection concerns into local government planning policies, Official Community Plans, Zoning, and bylaws is critical to the source water protection.** Significant changes in development intensity will likely increase potential source water risks (e.g., storm water / sediment loading, effluent disposal, etc.). The RDCO, MoT and DLC should incorporate vulnerability zones identified within this source assessment into land use policy and bylaw documents. **(Immediately, high risk reduction benefit)**

4. **The DLC should be given the opportunity to provide comment on all land use decisions within the assessment area through a well established referral process.** Applicants wishing to change or alter land uses should provide sufficient information to adequately assess what changes the proposed activities will have on source water quality/quantity. Applicants should also consider the vulnerability zone where activities occur, and mitigation planning should be incorporated to ensure that land use decisions do not impact source water quality. The various stakeholders who have authority to issue licenses or approvals must consider and ensure that adequate strategies are employed to protect source water. **(Immediately, high risk reduction benefit)**

5. **Additional development of private properties and expansion/sale of Crown lease lots immediately adjacent to source watercourses is not recommended.** Occupation of these areas contributes to the long term deterioration of the shoreline and will diminish water quality over time. Furthermore, privatizing of the shoreline reduces flexibility with regard to long term source water management decisions (e.g. could not boost the capacity of the reservoir by increasing the dam height, due to the loss of private lands).

6. **If Crown lease lots are to remain, the lease agreements should have detailed stipulations to ensure the protection of source water. As an example, it should be prohibited for the lessee to clear any vegetation within the 15 m riparian zone. A violation of the stipulations should result in immediate follow up, financial accountability, and if severe enough, termination of the lease. Strict enforcement will be necessary to ensure that source water is adequately protected. (Immediately, high risk reduction benefit)**

7. **The road which was built to fight the 2 km fire in the Oyama Creek watershed should be deactivated to entirely prevent vehicle access to the lease lots on Oyama Lake.** Ecoscape understands that this road was

rehabilitated and inspected in November of 2009, but we do not know if the possibility for vehicle access remains. Field assessments revealed that lease lots in the Vernon Creek watershed had a higher level of undesirable activities than those in the Oyama Creek watershed. We suspect that these observed differences are likely due to increased levels of access in the Vernon Creek watershed (lease lots on Oyama Lake are only accessible by foot and/or boat). Therefore vehicular access to lease lots on Oyama Lake is discouraged. **(Immediately, high risk reduction benefit)**

8. **The Regional District of Central Okanagan or the Integrated Land Management Bureau should develop an education program to provide resort and lease lot owners with specific strategies to lessen their impact on source waters.** Examples of information to include within the program include:
   - **a.** Plant native vegetation in disturbed shoreline and creek areas. This may be best facilitated through the Okanagan Cottage Owners Association.
   - **b.** Reduce shoreline access to one footpath rather than roadways for quads, vehicles, etc.;
   - **c.** Investigate opportunities to use a community boat launch (i.e., limit impacts to one location) and possibly small community moorages;
   - **d.** Manage invasive weeds within your lease or property;
   - **e.** Manage access of cattle and other livestock to shoreline areas within your lease or property;
   - **f.** Do not remove shoreline vegetation unless it poses an immediate and direct threat to your property. A Danger Tree Assessment should be carried out following criteria established by the Wildlife Danger Tree Committee for any proposed tree removal. Trees should only be removed if they are deemed dangerous. If removed, trees should be replaced following standard tree replacement criteria established by the Ministry of Environment and Fisheries and Oceans Canada;
   - **g.** Lease and land owners should be educated regarding the location of full pool and the high water level of reservoirs.
   - **h.** Shoreline substrates and vegetation, especially those below full pool, should not be modified and nor should substrates be imported to create `beaches`.
   - i. A Section 9 application should be obtained for *any existing structures* or proposed structures below the full pool / high water level. The MoE should make exceptions to their policies to not issue permits to previously erected structures because this will be the best way of helping catalogue and ensure that all structures are constructed following standard best management practices.

     (1-3 years, high risk reduction benefit)

9. **An additional education program should be implemented by the resorts and target their users. B**ecause of the shear number of users which frequent

these resorts on an annual basis, an educational program is critical. For example, it is likely that most users wouldn't be aware that something dumped into the reservoir at the Beaver Lake Resort will reach the intake in a short period of time (i.e., it could be as little as 5-6 hours during a normal flow period). **(1-3 years, high risk reduction benefit)**

10. **Cabin owners should continue to work with MoFR, MoTCA, range tenure licensees and also with the DLC to limit cattle and motorized recreation below the high water level of reservoir lakes.** For example, as a part of a previous agreement, the Okanagan Cottage Owners Association agreed to maintain fencing in the immediate vicinity of lease lots where salvage logging was undertaken to reduce the risk of wildfire. Cabin owners can also act as the eyes and ears of the watershed. Proper reporting procedures should be developed, so that cabin owners can notify the appropriate parties of watershed findings and activities. **(Immediately, high risk reduction benefit)**

11. **Private marinas associated with the wilderness resorts should be equipped with emergency spill containment kits, which are stocked with standard items designed for containment and absorption of hydrocarbons.** Furthermore, any sizable spills of a deleterious substance should be immediately reported to the Provincial Emergency 24 hour hotline at 1-800-663-3456 and the DLC. **(Within 1 year, high risk reduction benefit)**

12. **A designated boat fueling and maintenance area should be established.** Standard best management practices require that all fueling facilities be located at least 30 m from the high water level. A designated fueling area should be established and signage should promote use of this area for all fueling at the wilderness resorts. **(1-2 years, high risk reduction benefit)**

13. **Signage at the wilderness resorts is encouraged to foster a respect and awareness in boaters with regards to responsible boat operation and refueling.** Signage should indicate that all fueling should occur in a designated area. This concept should also be included in the resorts educational programs. **(Within 1 year, high risk reduction benefit)**

Roads and Stream Crossings

1. **Forest licensees and other pertinent stakeholders should take responsibility for maintenance and deactivation of non-status roads.** One option would be to split non-status roads among the various entities to more equitably distribute costs. The Forest Investment Account is available for work on non-status roads, as managed through the major forestry licensees. **(Within 1 year; high risk reduction benefit)**

2. **Stream crossings (either high risk or associated with high risk roads) should be monitored on a routine basis to ensure that structures are intact, functioning properly, and that mitigation efforts are in place to minimize sediment release to source streams.** Appendices F and G identify the responsible parties for the various roads in each of the watersheds. **(Immediately; high risk reduction benefit)**

3. **Roads and ditches should also be monitored, with particular focus on high risk roads and those which are in close proximity to source watercourses. (Immediately; high risk reduction benefit)**

Road Recommendations Specific to the Oyama Creek Watershed

1. **All road risk related issues in the Oyama Creek watershed can be addressed through a combination of improvements or deactivation on FSR's and other permitted roads, and preferably permanent deactivation in the case of non-status roads.** Work should be done to address the highest priorities first as determined by risk and available funds (see Appendix F). Prescriptions prepared by qualified professionals should be required in all cases and there are external sources of funding (Forest Investment Account) available for work on non-status roads in particular. **(Within 1 year; high risk reduction benefit)**

Road Recommendations Specific to the Vernon Creek Watershed

1. **The high risk non-status road that extends across the plateau and parallels the extensive landslide should be deactivated to prevent a variety of unsanctioned activities.** This access road has been the source of numerous dumping incidents (e.g. stolen vehicles, dead animal parts, etc.), has facilitated access for the cultivation of illegal substances, has acted as a movement corridor for cattle to gain easier access to Vernon Creek, and may as well compound slope stability issues via the generation of storm water. **(Within 1 year; high risk reduction benefit)**

2. **The access to unsanctioned camping around the Crooked Lake Dam should either be decommissioned, or DLC should work with MOTCA to re-establish a sanctioned recreational site.** This area contained the most significant recreational impacts and users have proven that they cannot utilize the area in a responsible manor. Further, actions at the site may also put DLC infrastructure at risk. **(Within 1 year; high risk reduction benefit)**

3. **The Ministry of Transporation and DLC should work together to review the road drainage patterns on Beaver Lake Main and a storm water**

management plan should be developed for the areas between Swalwell Reservoir and the second cattle guard. The drainage patterns of this active mainline road relies on numerous culverts that discharge significant volumes of water onto terrain that has slope stability classes of III, IV, and V. High risk drainage culverts are of greatest concern (see Figure 7-2). **(1-3 years, high risk reduction benefit)**

4. **The DLC should monitor the water quality parameters of three ephemeral streams that cross Beaver Lake Main**. Sediment, fecal matter, and other materials that enter these streams will be carried down during flow events. Thus, there is potential for concentrated discharges to areas directly above the intake (see Figure 7-2 for ephemeral stream locations). **(1-3 years, high risk reduction benefit)**

Wind Generation and Mining

1. **Wind generation and mining should follow the same standards as forestry; namely that their activities do not impact water quality, water quantity or timing of flows. (Immediately)**

2. **Stakeholders facilitating wind generation and mining claims should be diligent to inform the DLC of changes in operations which may affect source water.** At this time, operations are either inactive or investigative only, and as such, have little impacts on source water. **(Immediately)**

3. **As with other activities, the DLC should be given the opportunity to provide comment on wind generation and mining activities within the assessment area through a well established referral process.** If a referral process has yet to be established, its development should be a high priority. **(Immediately)**

6.6 Site Specific Contaminant Risk Summary

The following summary tables outline the risk documented for identified contaminants within each watershed (see Tables 8-5a and b). The tables are organized in priority order by risk (higher risk contaminants are listed first).

Table 8-5a - Risk Management Actions for Site Specific Contaminants in the Oyama Creek Watershed.

Contaminant #	Contaminant Source Type (Hazard) & Description	Comments	Risk Level	Risk Management Action	Responsible Party	Suggested Timeframe
24	Forestry -Harvesting within sensitive Lakeshore Management Zones (LMZs)	Ecoscape is concerned that current and proposed harvesting within LMZs may result in increased access for cattle and motorized vehicles that could result in water quality impacts to the reservoirs. If increased access is realized then biological contaminants are also of concern.	Very High	Forest harvesting should only occur within LMZs of reservoirs (Oyama & Damer) when the risk of wildfire and forest health factors out weigh the potential access issues and water quality impacts.	Ministry of Forests - Small Scale Salvage Program	Immediately
25	Range Tenures - High cattle density and source contaminants observed in two locations on the main channel of Oyama Creek	The first location is a low lying area and has a fence that extends across the creek. It appeared that cattle were using areas on both sides of the fence. At the second location cattle were accessing the creek from an old pathway or logging access road. At both sites there was significant stream channel bank trampling and fecal deposition below the high water level.	Very High	Fencing should be constructed to prevent access at these locations. If it cannot be completed prior to spring turnout (2010), then these sites should be closely monitored.	Ministry of Forests and Range	Immediately
26	Range Tenures - High cattle densities on the north fork of Oyama Creek, around Chatterton Lake and directly below Damer Reservoir	The north end of Chatterton Lake was heavily utilized, as cattle appeared to be congregating amongst the willows. There was extensive substrate disturbance in this location. Below Damer Lake cattle are accessing a non-status road just above Oyama Creek North. Cattle use in this area is of particular concern because the north fork of Oyama Creek typically dries up in late August and then the cattle use the creek bed as a movement corridor.	Very High	Fencing should be constructed to prevent access at these locations. If it cannot be completed prior to spring turnout (2010), then these sites should be closely monitored.	Ministry of Forests and Range	Immediately
1	Natural characteristics of raw water - north arm of Oyama creek dries up annually, providing access for wildlife, cattle and recreation	Ecsocape understands that even if this were a natural system, it is likely that the north arm of Oyama Creek would have intermittent flows.	High	Fencing should be used to prevent access of cattle to the dry creek bed.	Ministry of Forests and Range	Immediately
2	Natural characteristics of raw water - enhanced turbidity which results from the scouring of available source material as the channels fill during spring freshet	The level of snow pack influences spring freshet. Enhanced flows typically between April and mid-June.	High	There should be no further salvage above the snowline in the Oyama Creek watershed until the ECA returns to a low range (likely about 20 – 25 years from now). Exceptions may include the need to manage for wildfire or forest health factors.	Tolko, BC Timber Sales and Small Scale Salvage Program	After the proposed harvesting (summarized in Table 2-3) has been implemented.
3	Natural characteristics of raw water - north fork of Oyama Creek has high colour	Colour originates from dissolved organic matter in the water originating from soil and decaying vegetal matter. Chlorination of coloured water can produce disinfection by-products (e.g. trihalomethanes) and create difficulties in maintaining adequate levels of disinfection. Flows from the north arm of Oyama Creek are diluted with flows from Oyama Creek to reduce the levels of colour.	High	Current practices of diluting water from the north arm of Oyama Creek with water that originates from Oyama Lake should continue.	District of Lake Country	Immediately
4	Natural characteristics of raw water - peak coliform values were considerably higher along the north fork of Oyama Creek (below the lakes) than compared to the mainstem of Oyama Creek downstream of Oyama Lake (Phippen, 2008).	A reduction in coliforms did not occur downstream of High, Damer, or Chatterton Lake because the residence time of these lakes was either too short to affect coliform viability, or that there was a continual source of fecal matter in these areas (Phippen, 2008). This finding further emphasizes the importance of limiting sources of coliforms to Oyama Creek North, as additional inputs of coliforms below the lakes will have an additive affect with those already present at the outflows of High, Damer and Chatterton lakes.	High	Cattle is one source of coliforms that can be controlled. Therefore cattle presence along the north fork of Oyama Creek should be eliminated as much as possible. Ecoscape understands that DLC currently dilutes water from the north arm of Oyama Creek with water originating from Oyama Lake. This practice should continue as one means of improving water quality.	Ministry of Forests and Range, District of Lake Country	Immediately
5	Slope failure/debris flows - location, integrity and vulnerability of Oyama Creek Intake	The head pond, intake building, and access road are all built on a narrow floodplain area that occurs adjacent to the main channel. This location has experienced previous debris floods, with past evidence visible on a fan immediately upstream of the head pond. Debris flood or debris events, or materials associated with them that reach the Oyama Creek intake can be expected to damage or destroy infrastructure resulting in significant down time and loss of distribution capabilities.	High	An assessment of possible intake locations should be undertaken to determine if there are other more favorable sites.	District of Lake Country	1-3 years

Table 8-5a - Risk Management Actions for Site Specific Contaminants in the Oyama Creek Watershed.

Contaminant #	Contaminant Source Type (Hazard) & Description	Comments	Risk Level	Risk Management Action	Responsible Party	Suggested Timeframe
6	Human Access - integrity and vulnerability of Oyama Creek Intake	The location of the intake, adjacent to private property, likely provides a reduction in access by the general public. Nevertheless, a non-status road along the north side of the canyon does facilitate all terrain vehicle access if one is determined, and the intake is certainly accessible by foot. Therefore, public access and/or vandalism at the intake is a very real possibility.	High	Thought should be given to fortification, fencing, observation (e.g. closed circuit TV) and a shut down mechanism in the event of vandalism or intentional disruption of service.	District of Lake Country	1-3 years
9	Access and Recreation - the presence of wildlife (including birds, mammals and fish) has resulted in excellent sport fishing and hunting opportunities	Hunting and fishing activities can result in all three contaminant types originating from roads (sedimenation), human and pet waste and trace chemical releases from motorized vehicles.	High	Additional education (watershed signage, pamplets, and stakeholder word of mouth) that informs watershed users of source waters and appropriate behaviors.	All Stakeholders	Immediately
11	Algae - Documented algae near the outflow of Damer Lake	Algal blooms are most likely to occur during summer months when water temperatures are warmer and water volumes are low due to high peak demands. Nutrients can occur naturally but can also be significantly altered by anthropogenic influences such as faulty septic systems, livestock, fire retardants, agricultural runoff, and landslide events resulting from poor storm runoff or road construction on both sanctioned and non sanctioned roads.	High	Damer Reservoir should be either kept at a higher water level or the high point near the outflow should be dredged to prevent an isolated shallow area where algae growth is enhanced.	District of Lake Country	Within a year
20	Access and Recreation - Activities of crime	Activities of crime included dumping of garbage and hazardous materials, clearing of vegetation for vehicle access, illegal drug cultivation, and abandoned vehicle dumping. Criminal activities were less than what was observed in the Vernon Creek watershed, but were still documented.	High	There should be additional resources put forth to deal with activities of crime, and watershed users should consistently report them.	Ministry of Environment, Local Police	Immediately
21	Stream Crossings and Roads - Very High and High Risk roads	Very high and high risk ratings were applied to several non-status and Forest Service Roads in the residual area. Issues include failing deactivation infrastructure, uncontrolled drainage above steep coupled slopes, past landslides on steep terrain below roads, and running surface and ditch scour related erosion with direct input of sediment to Oyama Creek or major tributaries downstream of the lakes.	High	Very high and high risk roads should be addressed through a combination of improvements or deactivation on FSR's and other permitted roads, and preferably permanent deactivation in the case of non-status roads. Prescriptions prepared by qualified professionals should be required in all cases.	Permitted road users (Tolko, BC Timber Sales) Forest Investment Account (for non-status roads)	Within 1-3 years
23	Forestry - Proposed harvest	With the additional proposed harvest, the ECAs are projected to increase to 49.2 and 51.7%, for moderate and full attack levels, respectively. These projections suggest that the peak flow hazard will increase from the middle of the moderate range to the cusp of the high range for the watershed as a whole. In the Oyama Lake Basin, where the majority of the harvesting is planned, the projected ECAs for both the moderate and full attack levels are within the high peak flow hazard range.	High	There should be no further salvage above the snowline in the Oyama Creek watershed until the ECA returns to a low range (likely about 20 – 25 years from now). Exceptions may include the need to manage for wildfire or forest health factors.	Tolko and BC Timber Sales	After the proposed harvesting (summarized in Table 2-3) has been implemented.
27	Range Tenures - Cattle congregating in a moist pocket with ground water seepage along a fence that is approximately 5 m from the Oyama Creek	It is possible that feces from this moist pocket would be transported to the creek, especially during spring freshet. Cattle fences should be set back from the creeks at least 20 to 50 m depending on the slopes and characteristics of the particular sites.	High	The fence should be moved away from the creek to the top of ridge. Moving the fence back would substantially reduce fecal inputs and will likely require less maintenance as blow down would be reduced near the top of the ridge.	Ministry of Forests and Range	Within a year
7	Slope failure/debris flows - Evidence of three previous landslides upstream of intake	The canyon upstream of the intake has a slope stability class of IV and a soil erosion potential that ranges from high to very high. The cause of the documented landslides is not known for certain, and given their size, they do not continue to pose a threat. Overall landslide hazard index for the Oyama Creek watershed is ranked as low (Dobson Engineering Ltd., 1998).	Moderate	Ecoscape understands that these landslides are no longer a significant threat. Alternatively, efforts should be directed at deactivating the non-status road (OR2 lower) that parallels Oyama Creek canyon to ensure that flows originating from this road do not contribute to future landslides.	Permitted road users (Tolko, BC Timber Sales) Forest Investment Account (for non-status roads)	Within 1-3 years

Table 8-5a - Risk Management Actions for Site Specific Contaminants in the Oyama Creek Watershed.

Contaminant #	Contaminant Source Type (Hazard) & Description	Comments	Risk Level	Risk Management Action	Responsible Party	Suggested Timeframe
8	Natural characteristics of raw water - wildlife (including birds and mammals) are capable of carrying and disseminating fecal coliforms and *E. coli*	All warm-blooded wildlife species (including birds and mammals) are capable of carrying and disseminating fecal coliforms and *E. coli* and their presence in the watershed results in a basal level of risk.	Moderate	Comprehensive water quality testing should continue at numerous locations in the watershed to pinpoint any changes to background levels.	District of Lake Country	Immediately
12	Moutain Pine Beetle - Oyama Creek watershed has extensive stands of lodgepole pine, which are highly susceptible to MPB	The potential of MPB infestation in the Oyama Creek watershed can estimated based on the availability of mature lodgepole pine. In 2006, approximately 45% of the area above the snowline was previously logged and about 45% of the remaining area was composed of more than 70% lodgepole pine . It was speculated that the MPB infestation would be severe and will likely have a significant impact on peak flows and the water quality at the intake (Dobson Engineering Ltd., 2008).	Moderate	Major and minor licensees should critically evaluate the stands proposed for salvage and only log those stands which make the most sense from a MPB perspective.	Tolko, BC Timber Sales & Small Scale Salvage Program	Immediately
13	Land Ownership - commerical lease lot (Oyama Lake Wilderness Fishing Resort)	The facility currently has a total of thirteen cabins, a main lodge and small store, a workshop/sawmill, and a number of camp sites. The septic system has been updated within the last several years. Documented a minor sediment point source from boat launch and access road. Small marina and additional floating structures. Increased risk due to intensity of use.	Moderate	An education program should be developed to provide resort and lease lot owners with specific strategies to lessen their impact on source waters.	Okanagan Cabin Owners Association	Within a year
14	Land Ownership - 13 residential lease lots on Oyama Reservoir	The lots are only accessible by foot and/or boat. Most, if not all are equipped with pit outhouses. Very little foreshore disturbance was documented and the majority of existing moorages are small (<24 m^2). There is concern that a road built to fight the Oyama fire could be used for future access to lease lots.	Moderate	An education program should be developed to provide resort and lease lot owners with specific strategies to lessen their impact on source waters.	Okanagan Cabin Owners Association	Within a year
17	Access and Recreation - MOTCA regulated recreation camp sites (at Oyama, Streak, High and Damer Lakes),	During site surveys, it was noted that all regulated sites were relatively clean and well maintained. Although garbage was noted, in no cases was it excessive. Erosion originating from access roads, camp site clearings and boat ramps was documented at most of the recreation sites. The erosion severity ranged from negligible to moderate, where sediment was delivered directly to adjacent lakes. At the majority of sites, sedimentation can be controlled with the use of standard erosion control techniques such as water bars, sumps, ditch/swale, etc.	Moderate	Sediment point sources originating from access roads and boat launches were identified and should be addressed to reduce the potential affects on source water quality. The Damer Lake site had moderate levels of erosion, while the Oyama Lake site has minor erosion.	MoTCA	Within a year
18	Access and Recreation - Motorized recreation (4x4/ATV/motorbikes) below the high water level of important creeks and/or reservoirs	Mud bogging was noted in both the shallow areas of reservoirs and in heavily used areas adjacent to source streams. However, the intensity of motorized activities below the high water level was relatively low. No sites were pinpointed as having intense activity.	Moderate	Efforts should be made to prevent additional access points to reservoirs and source water streams.	All Stakeholders	Immediately
10	Wildfire Potential - 2 km wildfire occurred within 50 m of the Oyama Reservoir (June 11th, 2009)	More than 2 months after the fire, it was noted that fire retardant remained at the site covering the remaining standing trees, downed vegetation and soils. An ephemeral drainage also flowed from the burned area into the Oyama Reservoir. The most likely result of enhanced nutrients is the increased potential for algal blooms. Given the adjacency of lease lots, there is also concern that lease lot owners may use a road which was built fight the fire to access their lots.	Low	The road which was built to fight the 2 km fire in the Oyama Creek watershed should be deactivated to entirely prevent vehicle access to the lease lots on Oyama Lake. Ecoscape understands that this road was rehabilitated and inspected in November of 2009, but we do not know if the possibility for vehicle access remains.	Ministry of Forests	Within a year
15	Land Ownership - Three privately held parcels near the Oyama Creek intake	The water intake and associated infrastructure occurs on two privately held parcels of land owned by the DLC and access to the intake requires the use of various easement roads across private lands. Due to the adjacency of these parcels to the intake, future changes in land use and/or zoning must be carefully considered.	Low	Cooperation and integration of source protection concerns into local government planning policies, Official Community Plans, Zoning, and bylaws is critical to the source water protection.	District of Lake Country	Immediately

Table 8-5a - Risk Management Actions for Site Specific Contaminants in the Oyama Creek Watershed.

Contaminant #	Contaminant Source Type (Hazard) & Description	Comments	Risk Level	Risk Management Action	Responsible Party	Suggested Timeframe
16	Wind Generation - Four Investigative towers within the Oyama Creek watershed	Meteorological towers have little impact on source water quality. Depending on the need for tree removal, there could be some sedimentation issues and there may also be the potential for chemical contaminants originating from motorized equipment used to construct the towers.	Low	Wind generation should follow the same standards as forestry; namely that their activities do not impact water quality, water quantity or timing of flows.	Integrated Land Management Bureau and private wind generation and mining licensees	Immediately
19	Access and Recreation - "The lookout"	Access to this site appears to have been blocked in at least two locations, but ATV access around roadblocks is still possible. The biggest concern observed in this location was a substantial number of shotgun shells (i.e., in excess of 100), which appear to have been fired out over the Oyama Creek canyon in the approximate vicinity of the intake. Unsanctioned camping is also occurring at this location.	Low	Continue efforts to block motorized activity at his location.	MoTCA and District of Lake Country	Within a year
22	Stream Crossings and Roads - Moderate and low risk roads	Moderate risk roads occur in all parts of the Oyama Creek watershed and are mainly the result of insufficient water management, running surface erosion, ditch scour, and ultimately sediment input to source watercourses or fish bearing waters. Low risk roads are not an issue.	Low	Lower risk road should continued to be monitored to ensure crossing functionality.	Permitted road users (Tolko, BC Timber Sales) Forest Investment Account (for non-status roads)	Annually

Table 8-5b - Risk Management Actions for Site Specific Contaminants in the Vernon Creek Watershed.

Contaminant #	Contaminant Source Type (Hazard) & Description	Comments	Risk Level	Risk Management Action	Responsible Party	Suggested Timeframe
2	Slope failure/debris flows - location, integrity and vulnerability of Vernon Creek Intake	The holding pond and intake building are located on the main channel of Vernon Creek within a steep, well-incised canyon with highly erodible soils. Given that landslides have interrupted service in the past, it is really a matter of when, and not if water quality at the intake will be affected. The presence of numerous unstable, steep coupled slopes pose a significant risk, if not the primary risk to water quality and infrastructure at the intake.	Very High	An assessment of possible intake locations should be undertaken to determine if there are other more favorable sites.	District of Lake Country	Within a year
5	Slope failure/debris flows - Evidence of seven landslides upstream of the Vernon Creek intake	The canyon upstream of the intake has a slope stability class of V and a soil erosion potential of very high. The soils in this portion of Vernon Creek developed on glaciofluvial and glaciolacustrine materials that are highly erodible. Previous studies have concluded that these landslides are the principal sediment sources within the Vernon Creek watershed.	Very High	A detailed assessment and mapping of terrain features should be undertaken between Swalwell Reservoir and the intake. Macintosh Properties should be notified of the landslides within their property and permission should be granted to inspect them.	District of Lake Country	1 - 3 years
23	Forestry -Harvesting within sensitive Lakeshore Management Zones (LMZs)	Ecoscape is concerned that current and proposed harvesting within LMZs may result in increased access for cattle and motorized vehicles that could result in water quality impacts to the reservoirs. If increased access is realized then biological contaminants are also of concern.	Very High	Forest harvesting should only occur within LMZs of reservoirs (Swalwell and Crooked) when the risk of wildfire and forest health factors out weigh the potential access issues and water quality impacts.	Ministry of Forests - Small Scale Salvage Program	Immediately
24	Range Tenures - Cattle presence at the Vernon Creek intake	Ecoscape visited the intake on Vernon Creek on two different occasions. During the first visit in June, four cows were documented along the creeks edge using a trail that immediately parallels the creek. During the second visit, no cattle were observed, but relatively fresh feces were noted below the high water level of the holding pond and sporadically along the creeks edge. Given that there is virtually no residence time prior to contaminants moving into the intake, there is a need to entirely eliminate cattle from this area.	Very High	Fencing should be used to entirely eliminate cattle from the Vernon Creek intake.	Macintosh Properties, Eldorado Ranch Ltd. District of Lake Country & Ministry of Forests & Range	Immediately
25	Range Tenures - Cattle utilizing non-status road and trails to access Vernon Creek	Cattle are using a non-status road as a movement corridor and then dropping down the steep canyon via trails to access Vernon Creek approximately 1.4 km upstream of the intake. One trail is of particular concern, as it is well defined with steep grades, especially as it approaches the creek. Certain portions of this trail have extensive erosion concerns (the worst documented in the watershed) and it also provides cattle with direct access to a rehabilitated landslide at the creek edge (approximately 1.1 km from the intake). Cattle movement across the landslide is compromising rehabilitation efforts and resulting in direct sediment and fecal input to Vernon Creek.	Very High	A fence should be constructed along the top of bank from the intake all the way to Swalwell Reservoir in order to exclude cattle from the Vernon Creek canyon.	Ministry of Forests & Range	1 - 3 years
27	Range Tenures - High cattle densities were observed below the Swalwell Reservoir in the low lying treed area adjacent to a large floodplain.	Cattle are likely attracted to this area for its cooler temperatures and shade. There was significant substrate disturbance from cattle and a high density of fecal matter. The low lying, “swampy” area has a direct transport mechanism for pathogens into Vernon Creek, especially during high flow periods.	Very High	A fence should be constructed along the top of bank from the intake all the way to Swalwell Reservoir in order to exclude cattle from the Vernon Creek canyon.	Ministry of Forests & Range	1 - 3 years
1	Natural characteristics of raw water - enhanced turbidity which results from the scouring of available source material as the channels fill during spring freshet	The level of snow pack influences spring freshet. Enhanced flows typically between April and mid-June.	High	There should be no further salvage above the snowline until the ECA returns to a low range. Exceptions may include the need to manage for wildfire or forest health factors.	Tolko and Small Scale Salvage Program	After the proposed harvesting (summarized in Table 2-6) has been implemented.
4	Human Access - integrity and vulnerability of Vernon Creek Intake	From a trespass/vandalism perspective, the Vernon Creek intake is fairly isolated, however the intake can also be accessed on foot by descending into the canyon from the upper plateau. Therefore, the intake location is as such that the general public will not happen upon it, but if the intention is for trespass/vandalism, it is very possible.	High	Thought should be given to fortification, fencing, observation (e.g. closed circuit TV) and a shut down mechanism in the event of vandalism or intentional disruption of service.	District of Lake Country	1-3 years

Table 8-5b - Risk Management Actions for Site Specific Contaminants in the Vernon Creek Watershed.

Contaminant #	Contaminant Source Type (Hazard) & Description	Comments	Risk Level	Risk Management Action	Responsible Party	Suggested Timeframe
7	Access and Recreation - the presence of wildlife (including birds, mammals and fish) has resulted in excellent sport fishing and hunting opportunities	Hunting and fishing activities can result in all three contaminant types originating from roads (sedimenation), human and pet waste and trace chemical releases from motorized vehicles.	High	Additional education (watershed signage, pamplets, and stakeholder word of mouth) that informs watershed users of source waters and appropriate behaviors.	All Stakeholders	Immediately
16	Access and Recreation - Unsanctioned campsite at Crooked Lake Dam	At the time of the site visit a small fire was burning within a fire pit and no users were present. Extensive garbage and evidence of intentional dumping was observed across the site, include garbage located directly in the over flow spillway between Crooked and Swalwell Reservoirs. Two shallow outhouse pit toilets had been erected at the site and there was extensive evidence of ATV activities, including recent trail clearing to Swalwell Reservoir that was also being utilized by cattle to access shoreline.	High	The access to unsanctioned camping around the Crooked Lake Dam should either be decommissioned, or DLC should work with MoTCA to re-establish a sanctioned recreational site.	District of Lake Country, MoTCA	Within a year (high priority)
18	Access and Recreation - Activities of crime	Activities of crime included dumping of garbage and hazardous materials, clearing of vegetation for vehicle access, illegal drug cultivation, and abandoned vehicle dumping. Criminal activities appeared to be relatively prevalent in the Vernon Creek watershed	High	There should be additional resources put forth to deal with activities of crime, and watershed users should consistently report them.	Ministry of Environment, Local Police	Immediately
19	Access and Recreation - Abandoned vehicle and hazardous material dumping at extensive landslide on Vernon Creek canyon	Materials, including vehicles and animal parts have been intentially dumped at this site. The steep, coupled slope is already sensitive from a sedimenation perpective and the addition of dumpings is exacerbating the issue. The site is also risky from a public safety standpoint, as the slope is steep.	High	The high risk non-status road that extends across the plateau and parallels the extensive landslide should be deactivated to prevent a variety of unsanctioned activities.	Tolko via the Forest Investment Account (for non-status roads)	Within a year (high priority)
20	Stream Crossings and Roads - High risk roads	Road risk in the Vernon Creek watershed was determined based on stream crossing and culvert density, plus the vulnerability zones. Beaver Lake Road is of particular concern given its size, frequency of use and adjacency to steep, coupled slopes and Vernon Creek.	High	Very high and high risk roads should be addressed through a combination of improvements or deactivation on FSR's and other permitted roads, and preferably permanent deactivation in the case of non-status roads. Prescriptions prepared by qualified professionals should be required in all cases.	Tolko, Ministry of Transporation, Forest Investment Account (for non-status roads)	Within 1-3 years
22	Forestry - Proposed harvest	With the incorporation of proposed harvest blocks, the ECA for the entire assessment area increases from 19% to 30%. The ECA for areas above the snowline also increases from 27% to 45%. With the inclusion of the proposed blocks, there continues to be a moderate peak flow hazard, although it is approaching a high flow hazard.	High	There should be no further salvage above the snowline until the ECA returns to a low range. Exceptions may include the need to manage for wildfire or forest health factors.	Tolko	After proposed harvesting has been implemented
26	Range Tenures - Cattle accessing Vernon Creek from Beaver Lake Main via ephemeral creeks and drainage channels	Drainage is diverted under Beaver Lake Main via culverts and in some cases there is a defined channel from the roadway directly to Vernon Creek (See Figure 2-9b). Where defined channels exist, cattle (albeit, in relatively few numbers) use them as wallowing areas and movement corridors to access the main stem of Vernon Creek. These defined channels provide a direct route for sediment and fecal matter, resulting in pathogen inputs.	High	A gravel apron should be laid up and down stream of the Beaver Lake Main crossings to allow for an accessible drinking point, but would eliminate sedimentation from cattle wallowing (see Forest Practices Board, 2002). Fencing should be constructed to prevent cattle from using the ephemeral creeks as movement corridors to Vernon Creek.	Ministry of Forests and Range	Immediately
3	Slope failure/debris flows -a steep, coupled slope with soft material immediately adjacent to the screening shack and head pond	The steep, coupled slope is located on the northwest corner of the holding pond. A narrow trail extends across this slope and provides access to the upper portions of the pond. During the summer of 2009, works were undertaken to stabilize the trail with the use of a wooden walkway. Nevertheless, sedimentation is probable at this site.	Moderate	A professional assessment should be undertaken to prescribe mitigative measures to prevent sedimenation at this site.	District of Lake Country	1 - 3 years
6	Natural characteristics of raw water -wildlife (including birds and mammals) are capable of carrying and disseminating fecal coliforms and *E. coli*	All warm-blooded wildlife species (including birds and mammals) are capable of carrying and disseminating fecal coliforms and *E. coli* and their presence in the watershed results in a basal level of risk.	Moderate	Comprehensive water quality testing should continue at numerous locations in the watershed to pinpoint any changes to background levels.	District of Lake Country	Immediately

Table 8-5b - Risk Management Actions for Site Specific Contaminants in the Vernon Creek Watershed.

Contaminant #	Contaminant Source Type (Hazard) & Description	Comments	Risk Level	Risk Management Action	Responsible Party	Suggested Timeframe
8	Moutain Pine Beetle - Vernon Creek watershed has extensive stands of lodgepole pine, which are highly susceptible to MPB	The potential of MPB infestation in the Vernon Creek watershed can estimated based on the availability of mature lodgepole pine. In 2006, approximately 45% of the area above the snowline was previously logged and about 45% of the remaining area was composed of more than 70% lodgepole pine . It was speculated that the MPB infestation would be severe and will likely have a significant impact on peak flows and the water quality at the intake (Dobson Engineering Ltd., 2008).	Moderate	Major and minor licensees should critically evaluate the stands proposed for salvage and only log those stands which make the most sense from a MPB perspective.	Tolko & Small Scale Salvage Program	Immediately
9	Land Ownership - commerical lease lot (Beaver Lake Mountain Resort)	The facility has a total of 22 cabins, some on septic and others are equipped with outhouses. There is a petting zoo, a general store, numerous camp sites, and a marina. In addition, many of the cabins have their own moorages. The boat launch has a moderate level of sedimentation flowing directly to Swalwell Reservoir.	Moderate	The sedimentation associated with the boat launch should be controlled with the use of standard erosion control techniques such as water bars, sumps, ditch/swale, etc.	Okanagan Cabin Owners Association	Within a year
10	Land Ownership - commerical lease lot (Dee Lake Wilderness Resort)	The resort has full service cottages, log cabins, camping and RV facilities, lodge units and a store and office. Some of the facilities are on septic, while others utilize outhouses. There is a boat launch and individual moorages.	Moderate	Minor erosion was documented at this site and should be controlled with the use of standard erosion control techniques such as water bars, sumps, ditch/swale, etc.	Okanagan Cabin Owners Association	Within a year
11	Land Ownership - 15 residential lease lots (Crooked Lake)	Documented concerns at residential lease lots include vegetation clearing, retaining walls, groynes, substrate importation, burning below the HWL, moorages > 24 m^2, and sediment point sources.	Moderate	An education program should be developed to provide resort and lease lot owners with specific strategies to lessen their impact on source waters (also applies to contaminants 10 & 11).	Okanagan Cabin Owners Association	Within a year
12	Land Ownership - 27 residential lease lots (Swalwell Reservoir)	Documented concerns at residential lease lots include vegetation clearing, retaining walls, groynes, substrate importation, burning below the HWL, moorages > 24 m^2, and sediment point sources.	Moderate	An education program should be developed to provide resort and lease lot owners with specific strategies to lessen their impact on source waters.	Okanagan Cabin Owners Association	Within a year
13	Land Ownership - privately held parcels near the Vernon Creek intake	Privately held parcels surround the water intake structure and these parcels are zoned Agricultural (A1) within the DLC. Allowable land uses of the A1 zoning designation include agriculture, range uses, etc. The parcels are currently leased for cattle grazing.	Moderate	Cooperation and integration of source protection concerns into local government planning policies, Official Community Plans, Zoning, and bylaws is critical to the source water protection.	District of Lake Country	Immediately
15	Access and Recreation - MOTCA regulated recreation camp sites (at Swalwell, Island & Lost Lakes)	During site surveys, it was noted that all regulated sites were relatively clean and well maintained. Although garbage was noted, in no cases was it excessive. Erosion originating from access roads, camp site clearings and boat ramps was documented at most of the recreation sites. The erosion severity ranged from negligible to moderate, where sediment was delivered directly to adjacent lakes. At the majority of sites, sedimentation can be controlled with the use of standard erosion control techniques such as water bars, sumps, ditch/swale, etc.	Moderate	Sediment point sources originating from access roads and boat launches were identified and should be addressed to reduce the potential affects on source water quality. The sites at Lost, Island and Swallwell all had minor erosion.	MoTCA	Within a year
17	Access and Recreation - Motorized recreation (4x4/ATV/motorbikes) below the high water level of important creeks and/or reservoirs	Mud bogging was noted in both the shallow areas of reservoirs and in intensively used areas adjacent to source streams. However, the intensity of motorized activities below the high water level was relatively low. Other than at the Crooked Lake dam, no other sites were pinpointed as having intense activity.	Moderate	Efforts should be made to prevent additional access points to reservoirs and source water streams.	All Stakeholders	Immediately
14	Wind Generation - One Investigative tower within the Vernon Creek watershed	Meteorological towers have little impact on source water quality. Depending on the need for tree removal, there could be some sedimentation issues and there may also be the potential for chemical contaminants originating from motorized equipment used to construct the towers.	Low	Wind generation should follow the same standards as forestry; namely that their activities do not impact water quality, water quantity or timing of flows.	Integrated Land Management Bureau and private wind generation and mining licensees	Immediately

Table 8-5b - Risk Management Actions for Site Specific Contaminants in the Vernon Creek Watershed.

Contaminant #	Contaminant Source Type (Hazard) & Description	Comments	Risk Level	Risk Management Action	Responsible Party	Suggested Timeframe
21	Stream Crossings and Roads - Moderate and low risk roads	Moderate and low risk roads occur in all parts of the Vernon Creek watershed and are not of immediate concern.	Low	Lower risk road should continued to be monitored to ensure crossing functionality.	Tolko, Ministry of Transportation, District of Lake Country, Forest Investment Account (for non-status roads)	Annually
28	Mining and Quarries - Three mineral and placer claims	Although these claims exist, field surveys revealed no apparent activities and to the best of our knowledge the claims are not currently active.	Low	Mining should follow the same standards as forestry; namely that their activities do not impact water quality, water quantity or timing of flows.	Integrated Land Management Bureau and private wind generation and mining licensees	Immediately

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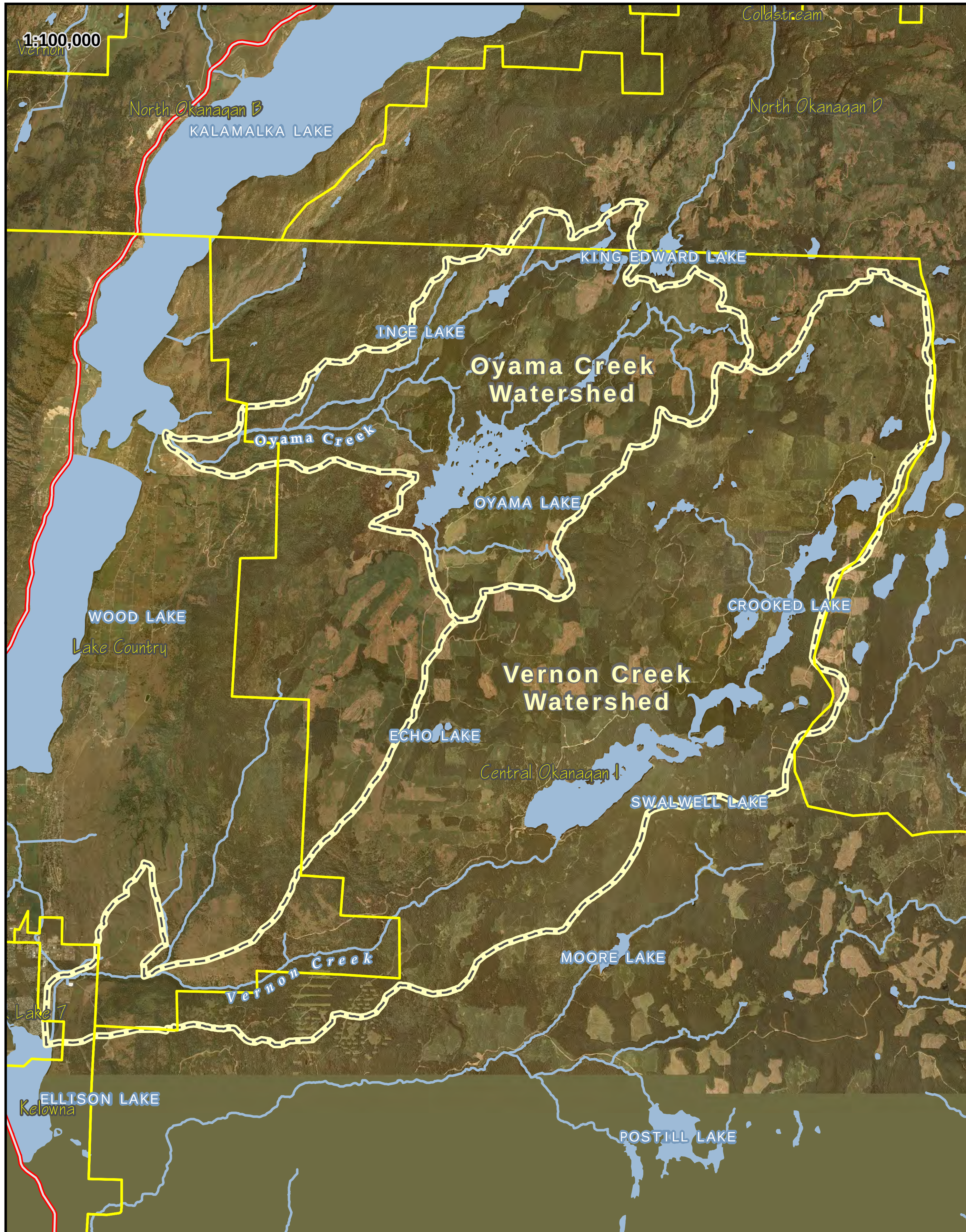


FIGURE 1-1

Regional Location and Watershed Boundary

Project:	Watershed Assessment
Location:	District of Lake Country
Project No.:	09-367 and 09-415
Prepared for:	District of Lake Country
Prepared by:	Ecoscape Environmental Consultants Ltd.
Drawn by:	Robert Wagner
Checked by:	Mary Ann Olson-Russello
Projection:	NAD83-UTM Zone 11
Date:	June 11, 2010

N W E S

LEGEND

City

Municipal Boundary

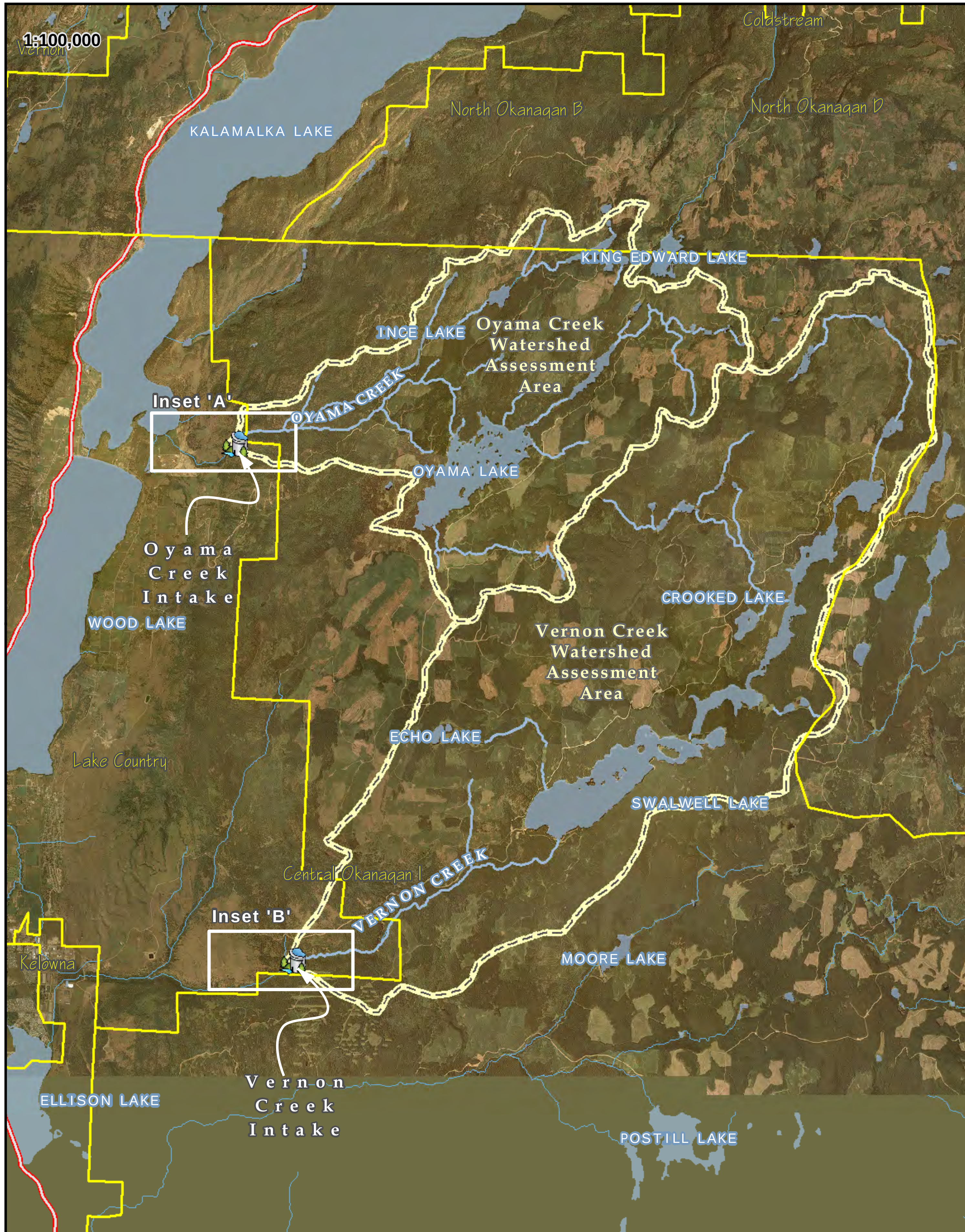
Assessment Area

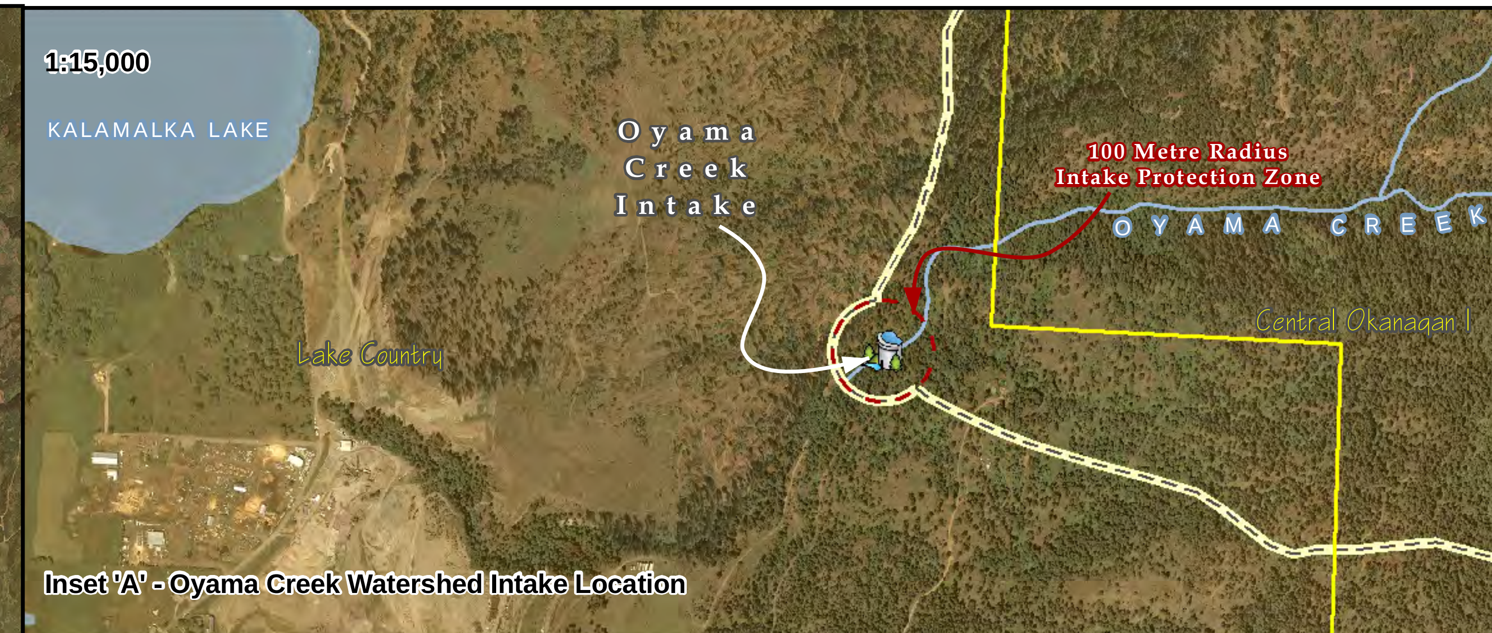
Major Highway

Streams and Rivers

Lake

ECOSCAPE Environmental Consultants Ltd.





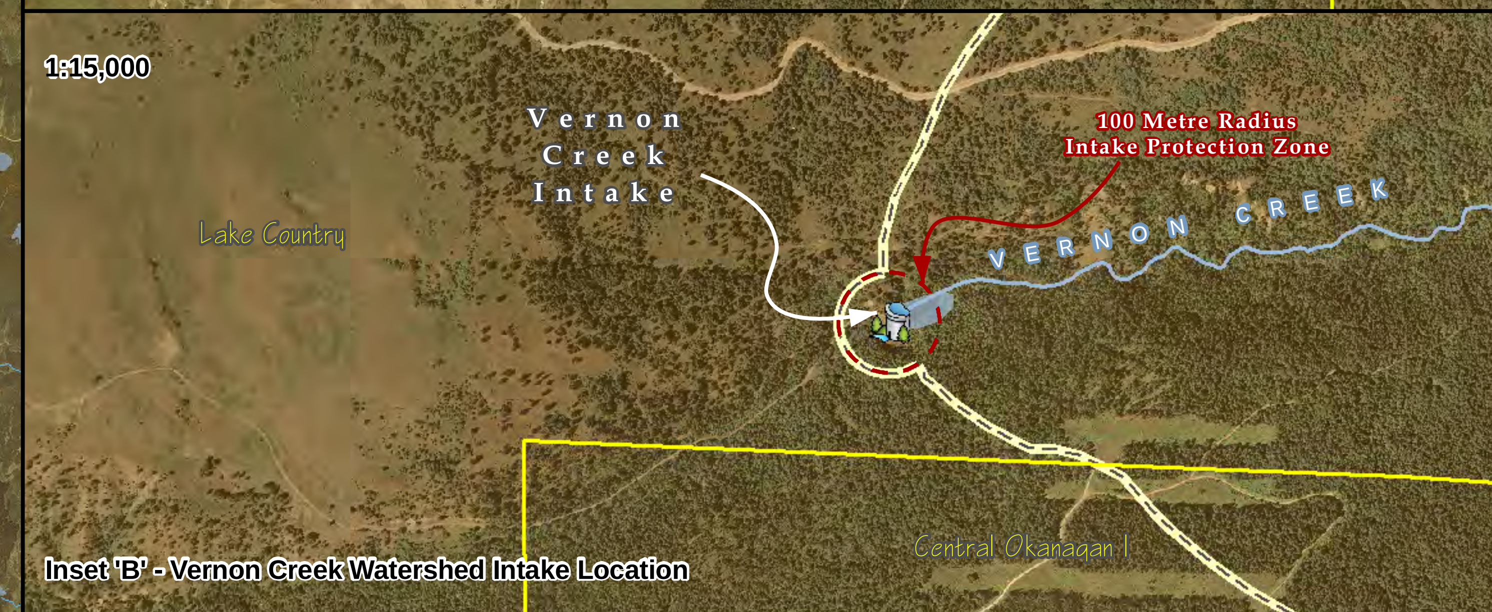


FIGURE 1-2

Intake Location and Contributing Watershed (Assessment Area)

Project:	Watershed Assessment
Location:	District of Lake Country
Project No.:	09-367 and 09-415
Prepared for:	District of Lake Country
Prepared by:	Ecoscape Environmental Consultants Ltd.
Drawn by:	Robert Wagner
Checked by:	Mary Ann Olson-Russello
Projection:	NAD83-UTM Zone 11
Date:	June 11, 2010

N W E S

LEGEND

- Municipal Boundary
- Assessment Area
- Major Highway
- Lake
- Streams and Rivers
- Intake
- Intake Protection Zone

ECOSCAPE
Environmental Consultants Ltd.

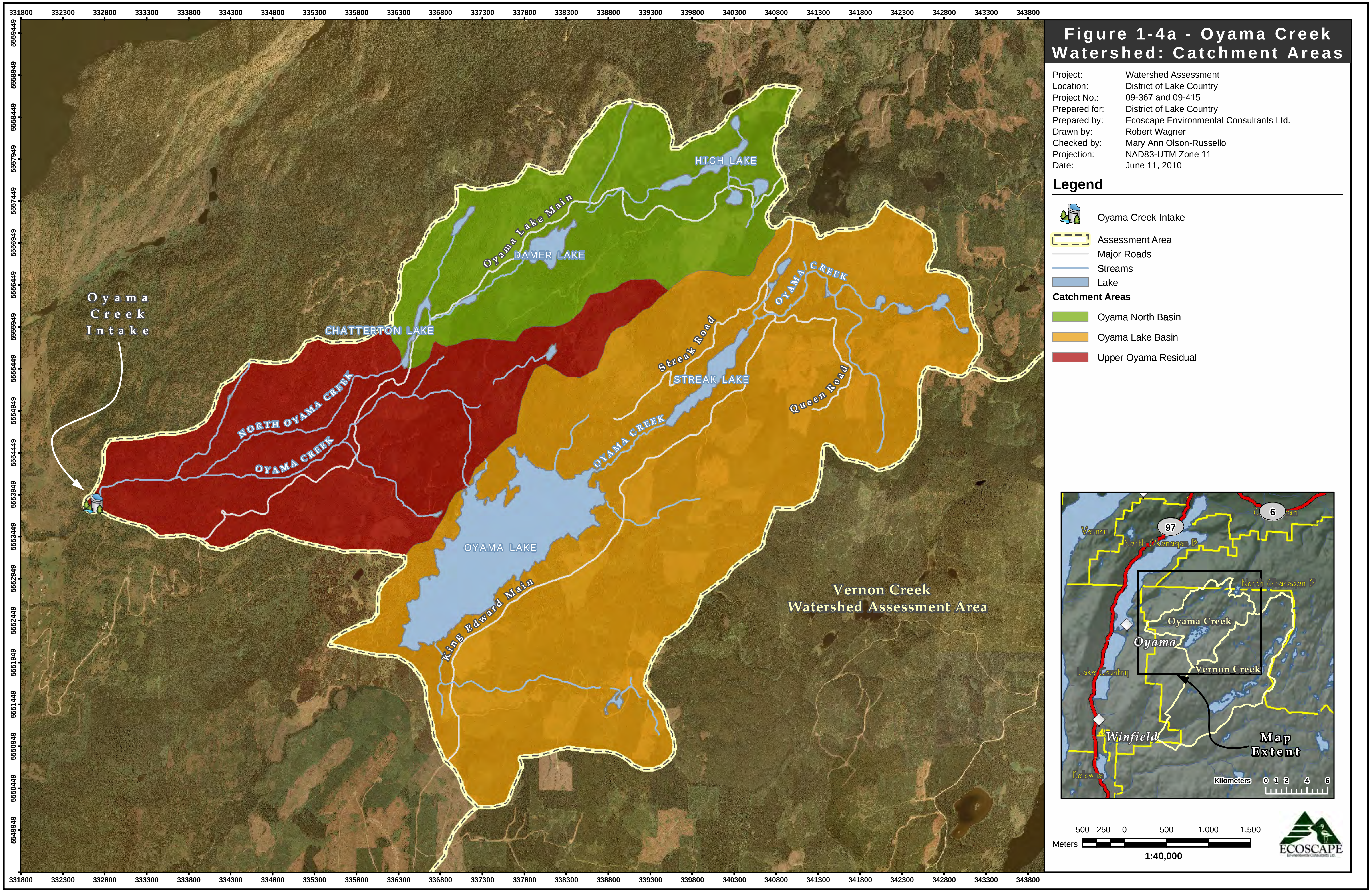


Figure 1-4a - Oyama Creek Watershed: Catchment Areas

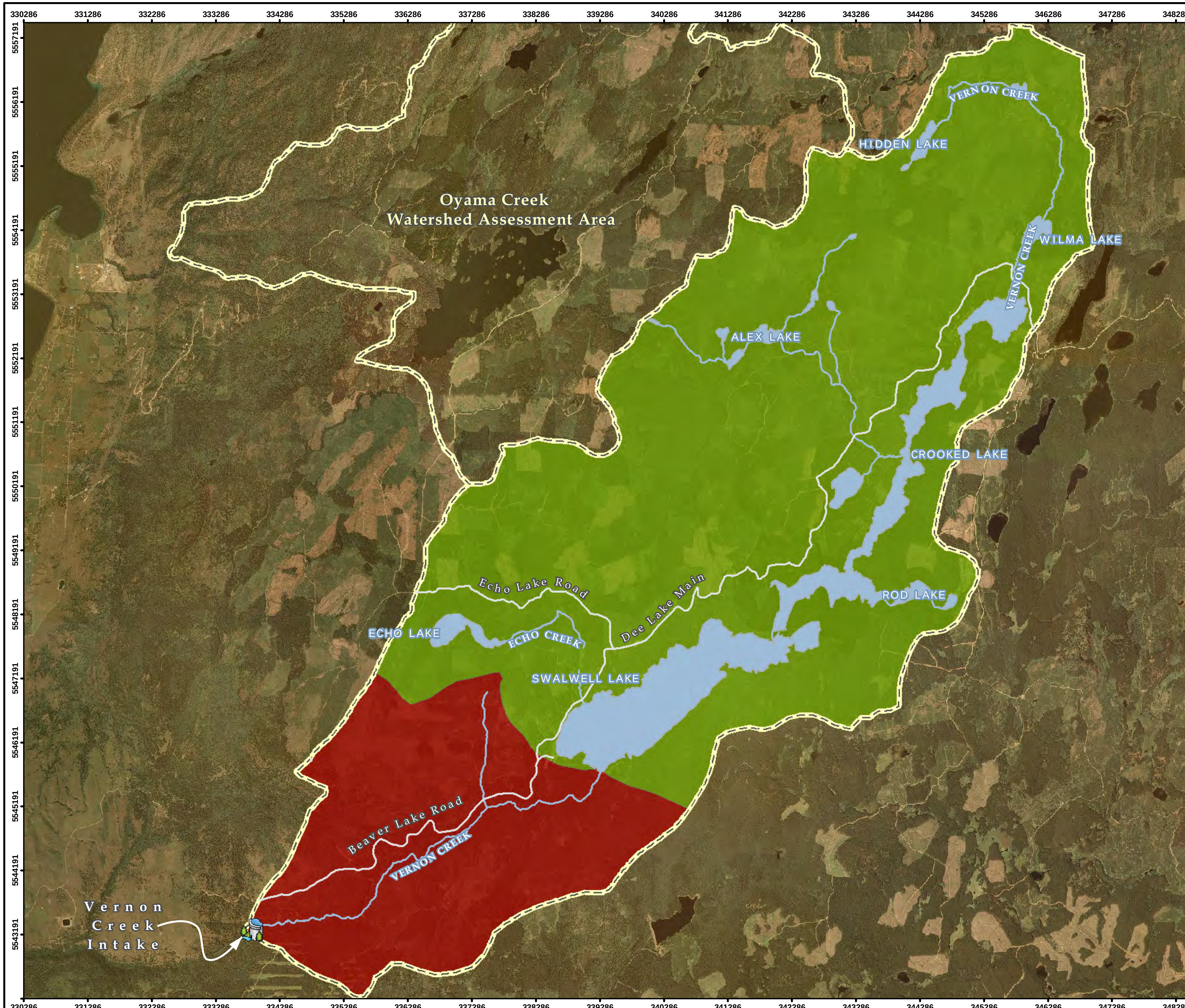


Figure 1-4b - Vernon Creek Watershed: Catchment Areas

Project:	Watershed Assessment
Location:	District of Lake Country
Project No.:	09-367 and 09-415
Prepared for:	District of Lake Country
Prepared by:	Ecoscape Environmental Consultants Ltd.
Drawn by:	Robert Wagner
Checked by:	Mary Ann Olson-Russello
Projection:	NAD83-UTM Zone 11
Date:	June 11, 2010

Legend

- Vernon Creek Intake
- Assessment Area
- Major Roads
- Streams
- Lake

Catchment Areas

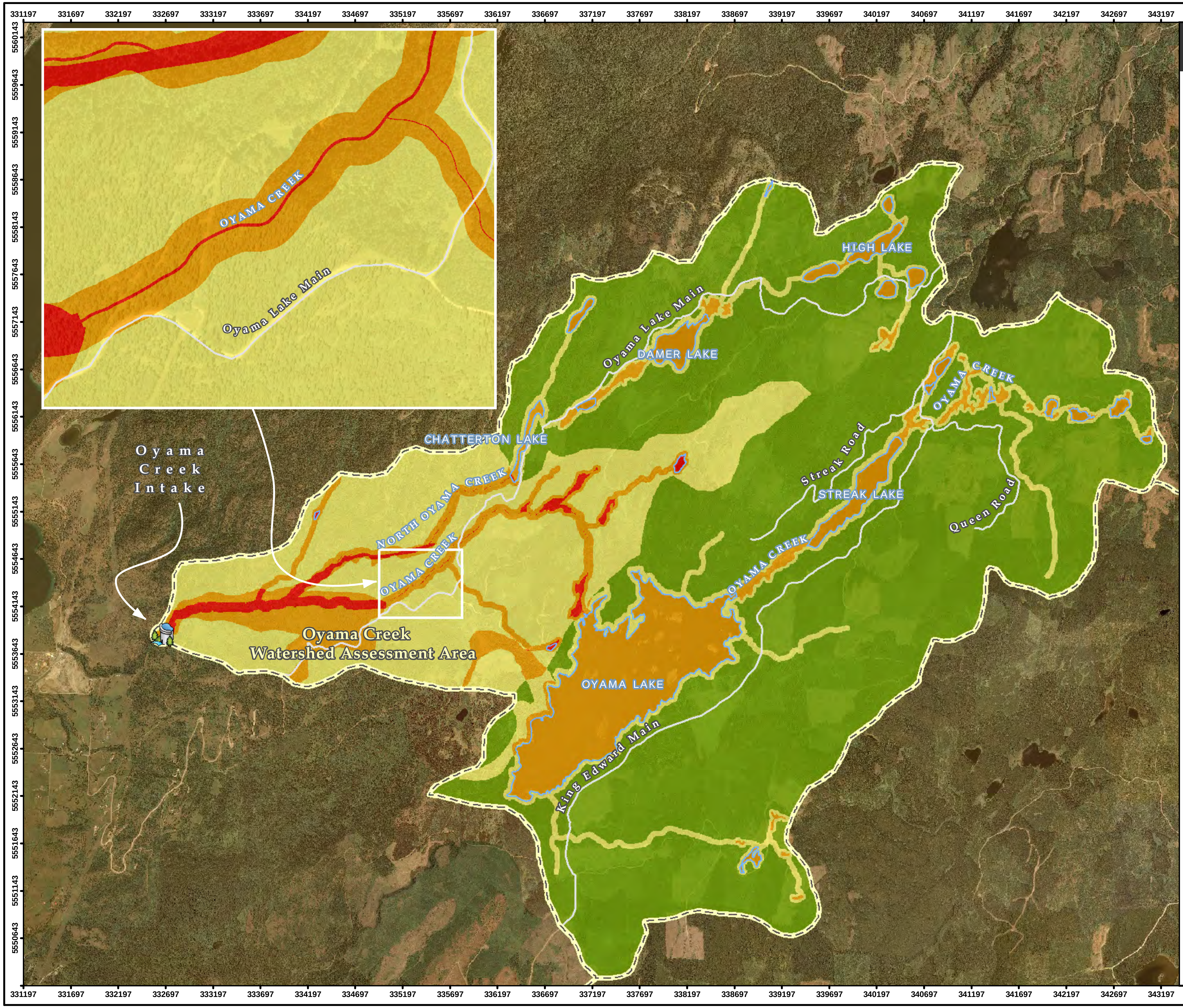
- Vernon Creek Basin
- Upper Vernon Residual

Meters 1,000 500 0 1,000 2,000

1:60,000

ECOSCAPE Environmental Consultants Ltd.

Figure 1-6a - Oyama Creek Watershed: Vulnerability



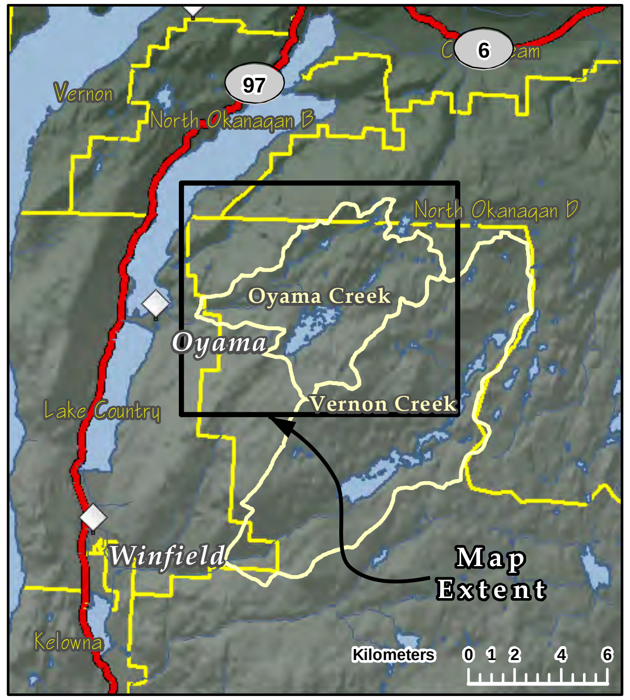
Project: Watershed Assessment
Location: District of Lake Country
Project No.: 09-367 and 09-415
Prepared for: District of Lake Country
Prepared by: Ecoscape Environmental Consultants Ltd.
Drawn by: Robert Wagner
Checked by: Mary Ann Olson-Russello
Projection: NAD83-UTM Zone 11
Date: June 11, 2010

Legend

Oyama Creek Intake
Assessment Area
Major Roads
Lake

Vulnerability Rating

Very High
High
Moderate
Low



Meters
500 250 0 500 1,000 1,500
1:40,000

ECOSCAPE
Environmental Consultants Ltd.

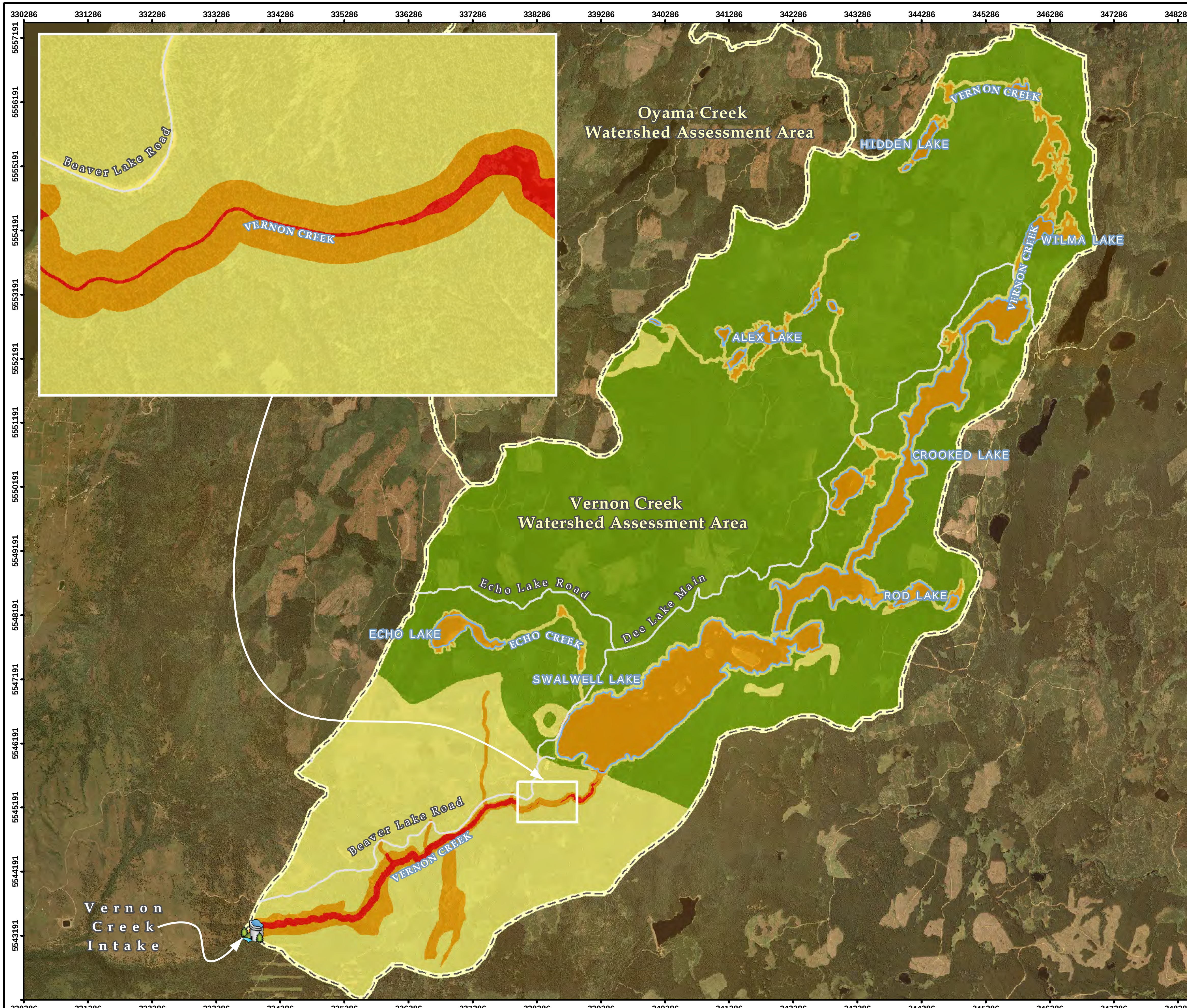


Figure 1-6b - Vernon Creek Watershed: Vulnerability

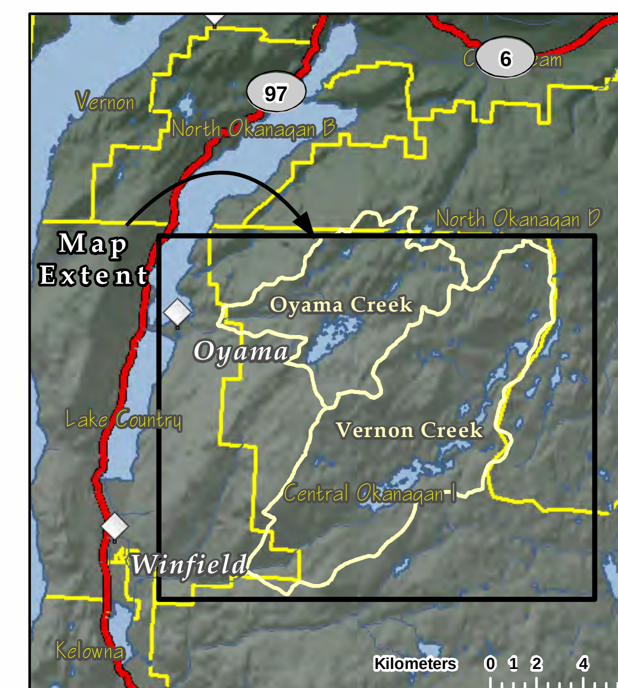
Project:	Watershed Assessment
Location:	District of Lake Country
Project No.:	09-367 and 09-415
Prepared for:	District of Lake Country
Prepared by:	Ecoscape Environmental Consultants Ltd.
Drawn by:	Robert Wagner
Checked by:	Mary Ann Olson-Russello
Projection:	NAD83-UTM Zone 11
Date:	June 11, 2010

Legend

- Vernon Creek Intake
- Assessment Area
- Major Roads
- Lake

Vulnerability Rating

- Very High
- High
- Moderate
- Low



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1:60,000

ECOSCAPE

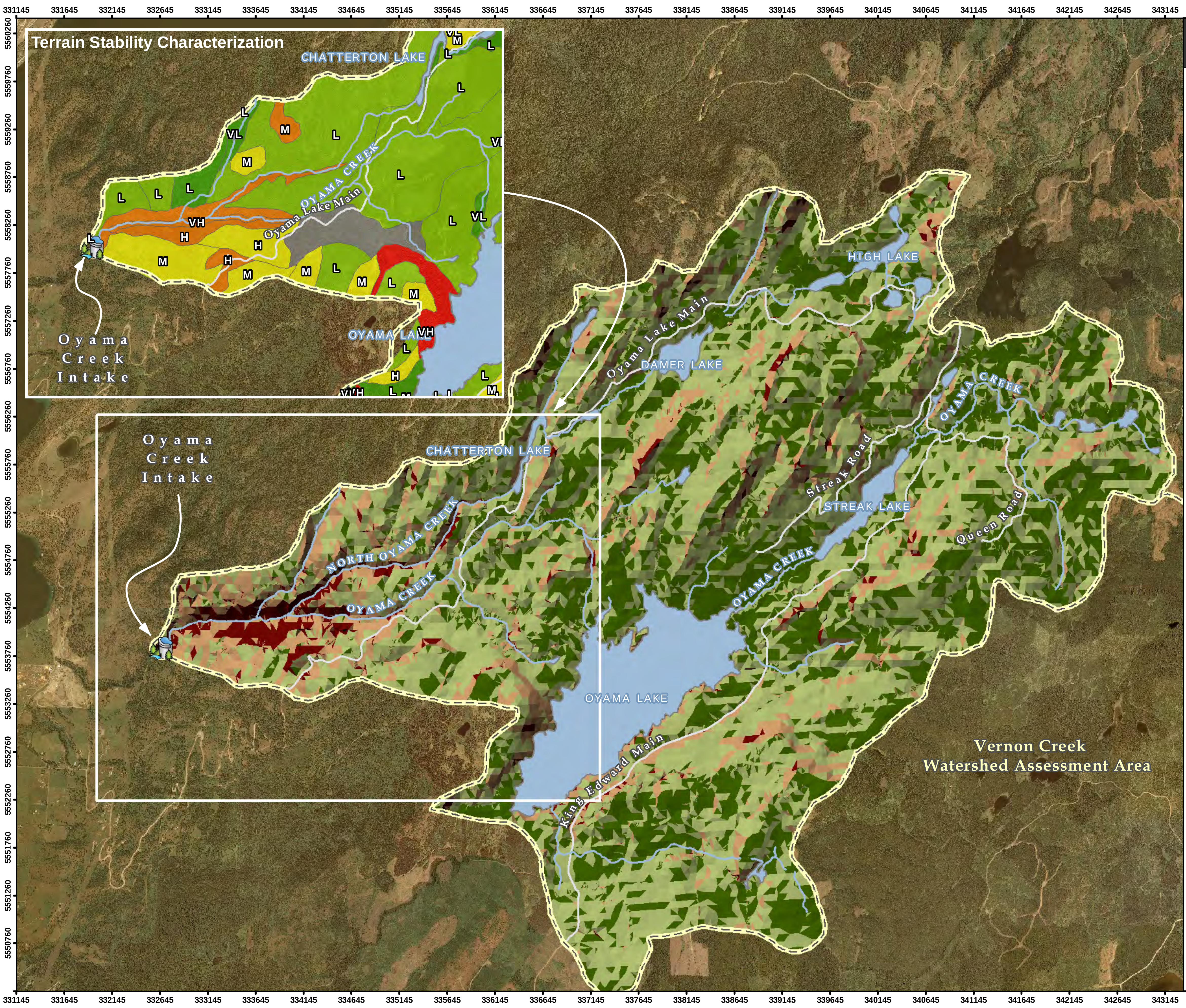


Figure 1-9a - Oyama Creek Watershed: Slope Analysis

Project:	Watershed Assessment
Location:	District of Lake Country
Project No.:	09-367 and 09-415
Prepared for:	District of Lake Country
Prepared by:	Ecoscape Environmental Consultants Ltd.
Drawn by:	Robert Wagner
Checked by:	Mary Ann Olson-Russello
Projection:	NAD83-UTM Zone 11
Date:	June 11, 2010

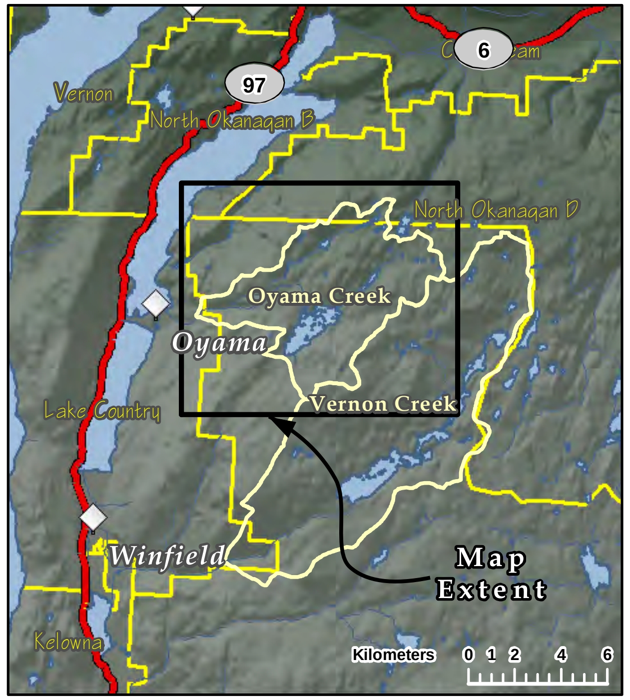
Legend

- Oyama Creek Intake
- Assessment Area
- Major Roads
- Streams
- Lake

Slope (percent)
- 0 to 10%
- 11 to 30%
- 31 to 60%
- Greater than 60%

Slope Stability Class
- V
- IV
- III
- II
- I
- Unclassified

Soil Erosion Potential
- "VH" Very High
- "H" High
- "M" Moderate
- "L" Low
- "VL" Very Low



Meters 500 250 0 500 1,000 1,500

1:40,000

ECOSCAPE Environmental Consultants Ltd.

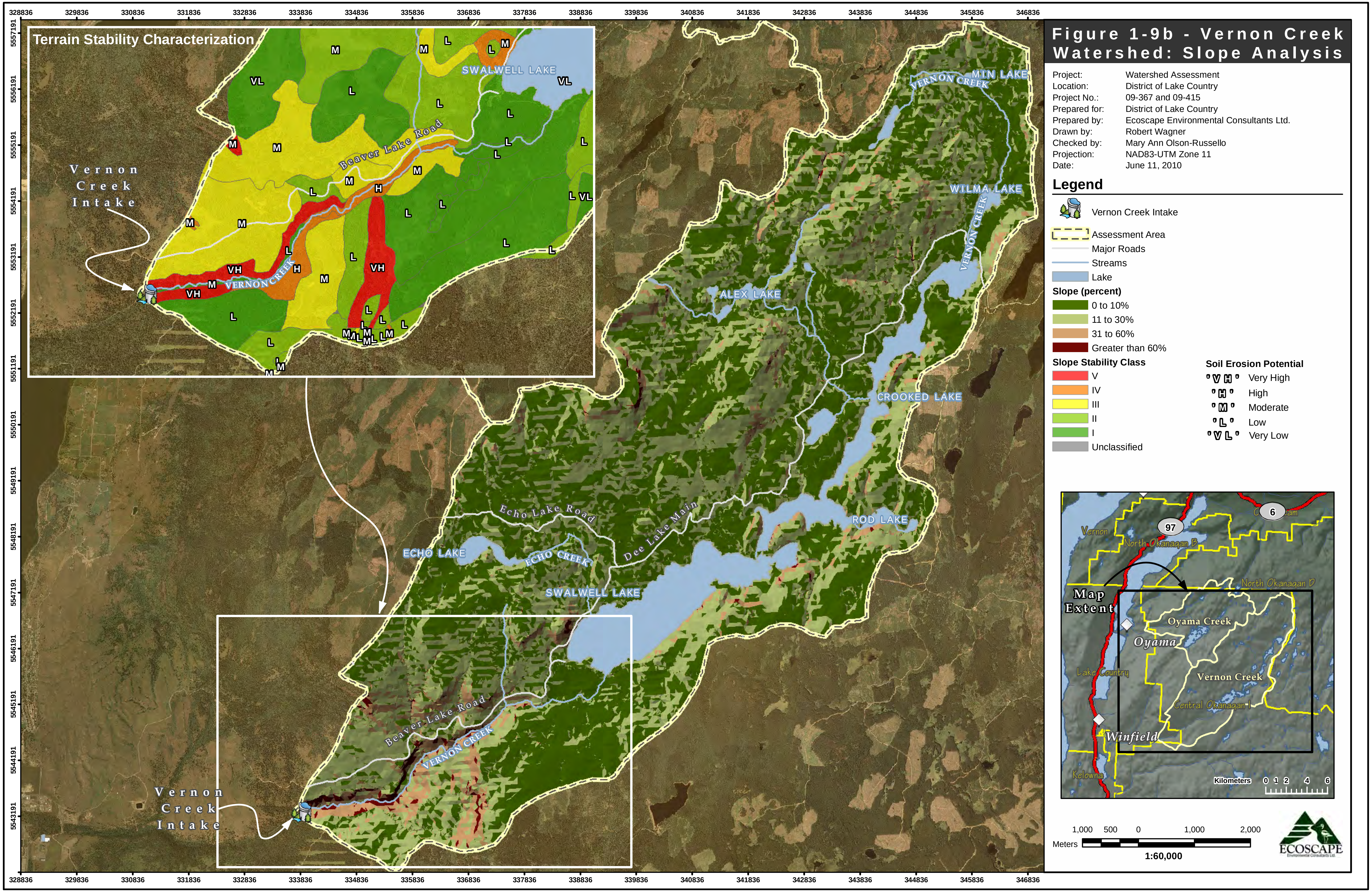
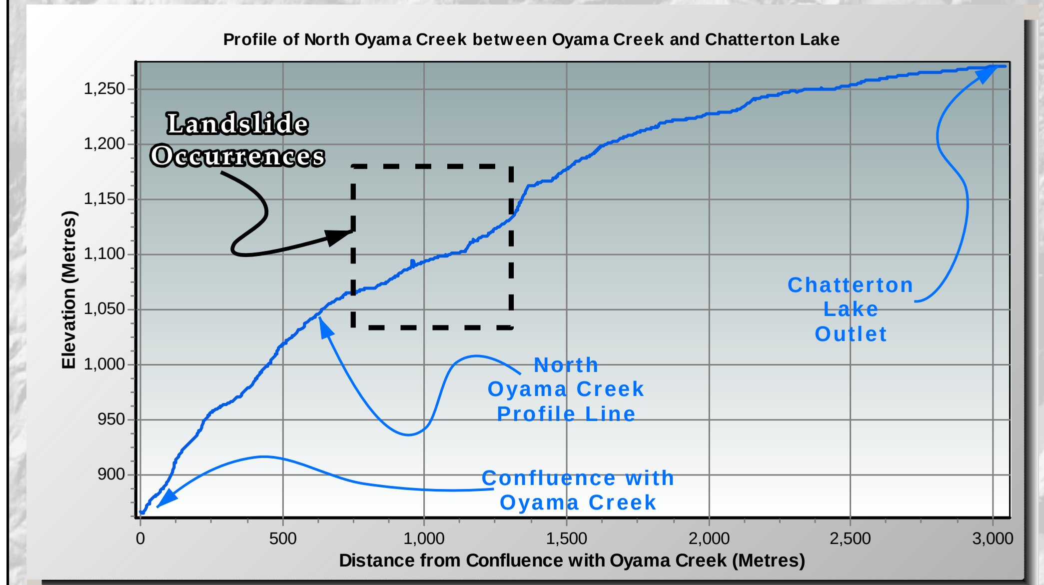
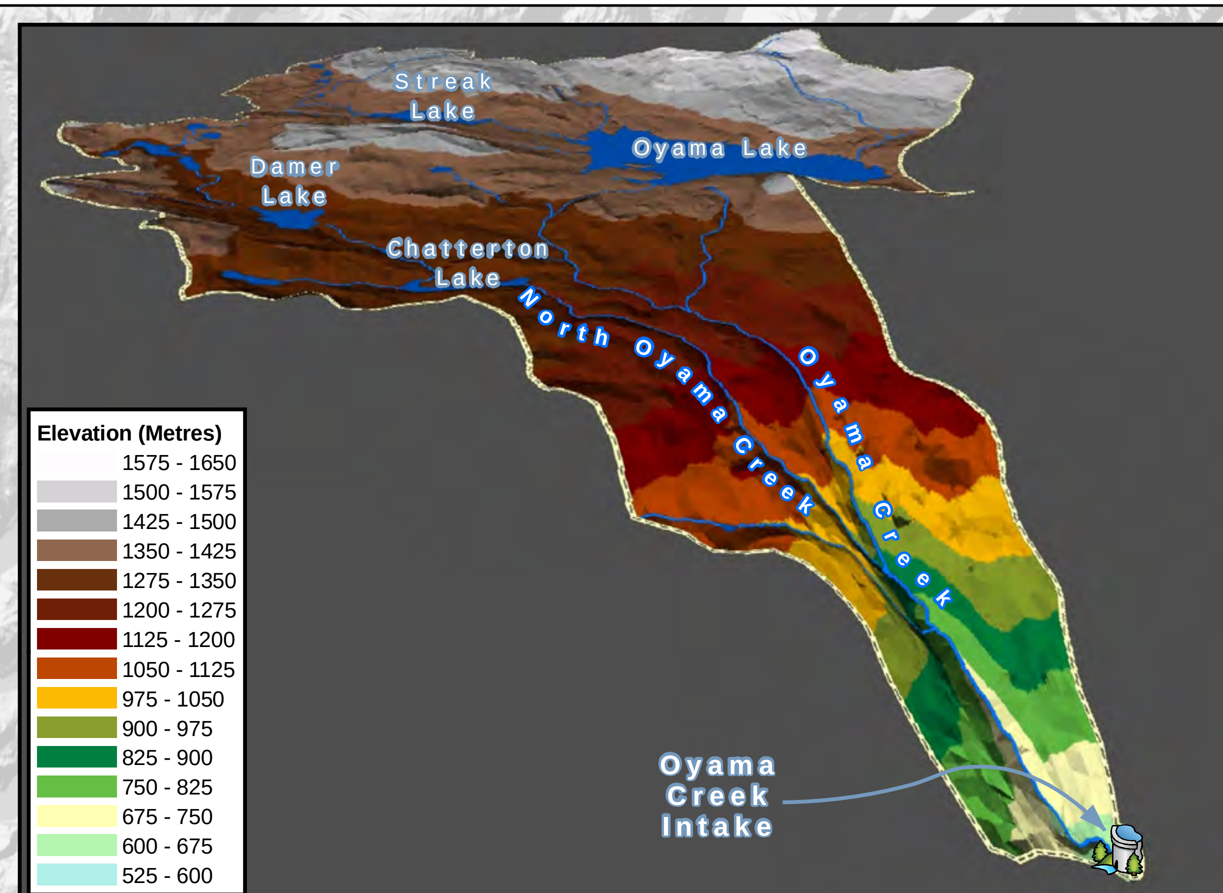


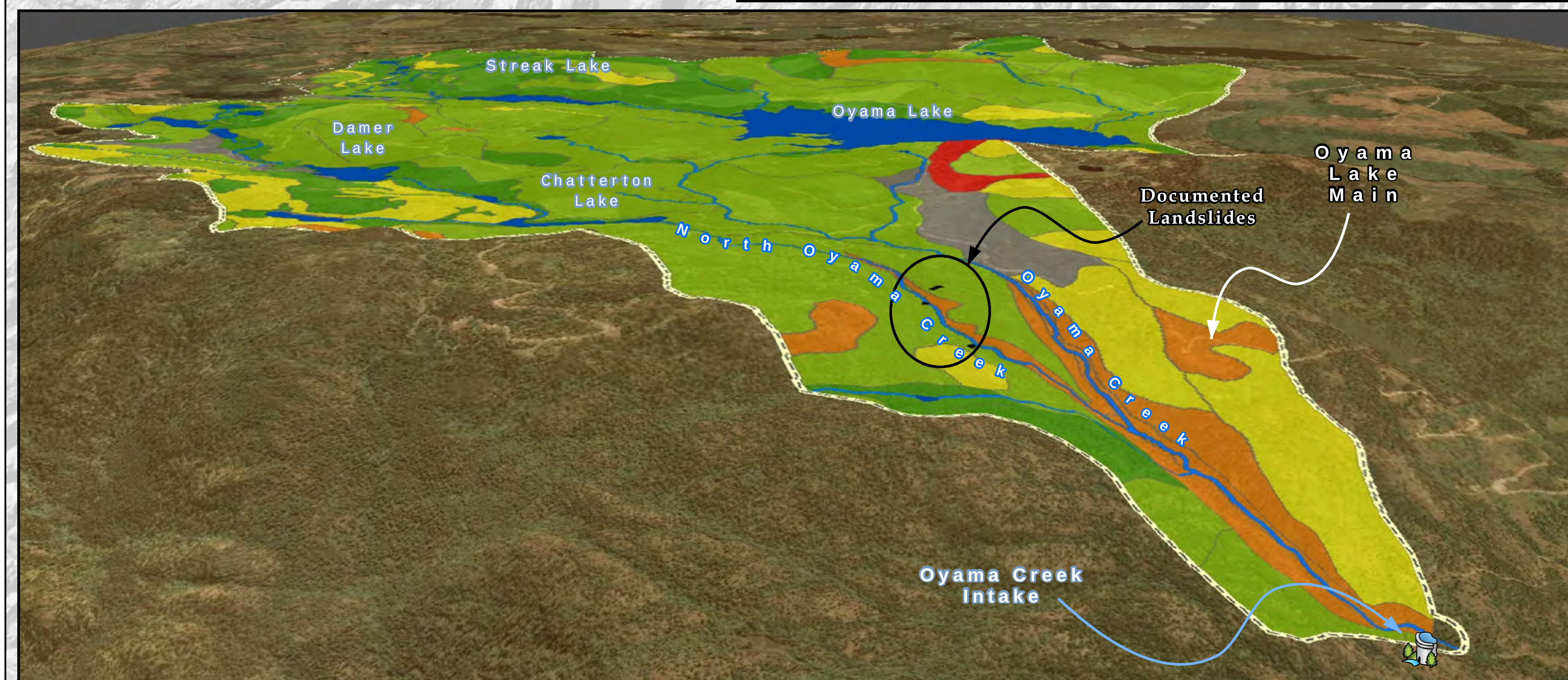
Figure 1-9b - Vernon Creek Watershed: Slope Analysis
Project: Watershed Assessment
Location: District of Lake Country
Project No.: 09-367 and 09-415
Prepared for: District of Lake Country
Prepared by: Ecoscape Environmental Consultants Ltd.
Drawn by: Robert Wagner
Checked by: Mary Ann Olson-Russello
Projection: NAD83-UTM Zone 11
Date: June 11, 2010
Legend
Vernon Creek Intake
Assessment Area
Major Roads
Streams
Lake
Slope (percent)
0 to 10%
11 to 30%
31 to 60%
Greater than 60%
Slope Stability Class
V
IV
III
II
I
Unclassified
Soil Erosion Potential
VH Very High
H High
M Moderate
L Low
VL Very Low
Terrain Stability Characterization
Vernon Creek Intake
Beaver Lake Road
Vernon Creek
Swalwell Lake
Echo Lake Road
Echo Lake
Echo Creek
Dee Lake Main
Alex Lake
Crooked Lake
Rod Lake
Wilma Lake
Min Lake
Map Extent
Oyama Creek
Oyama
Vernon Creek
Lake Country
Central Okanagan I
Winfield
Kelowna
North Okanagan B
North Okanagan D
Vernon
97
6
Kilometers 0 1 2 4 6
Meters 1,000 500 0 1,000 2,000
1:60,000
ECOSCAPE
Environmental Consultants Ltd.

Figure 1-10a - Oyama Creek Watershed: Landslides

Project:	Watershed Assessment
Location:	District of Lake Country
Project No.:	09-367 and 09-415
Prepared for:	District of Lake Country
Prepared by:	Ecoscape Environmental Consultants Ltd.
Drawn by:	Robert Wagner
Checked by:	Mary Ann Olson-Russello
Projection:	NAD83-UTM Zone 11
Date:	June 11, 2010







Legend

- Oyama Creek Intake
- Assessment Area
- Documented Landslides
- Streams
- Lakes

Slope Stability Class

- V
- IV
- III
- II
- I
- Unclassified

Note:
Elevation has been exaggerated 2:1 for visual effect.

Landslide locations provided by M. J. Miline and Associates Ltd.

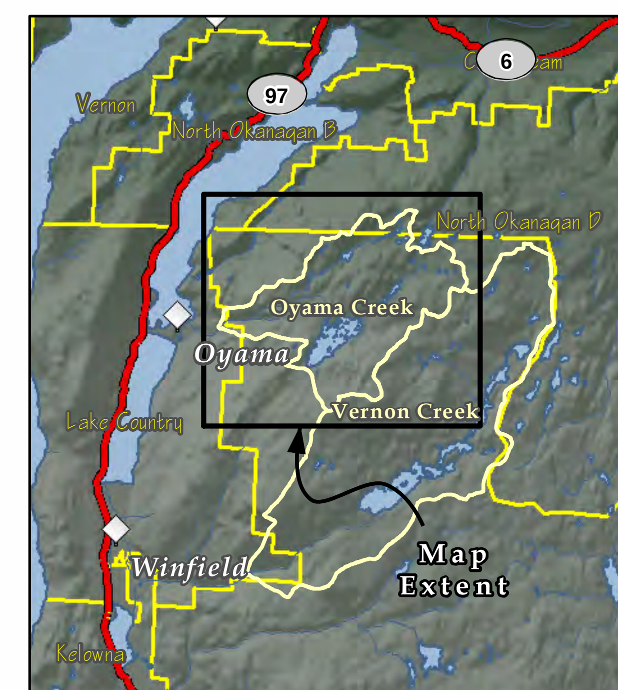


Figure 1-10b - Vernon Creek Watershed: Landslides

Project:	Watershed Assessment
Location:	District of Lake Country
Project No.:	09-367 and 09-415
Prepared for:	District of Lake Country
Prepared by:	Ecoscape Environmental Consultants Ltd.
Drawn by:	Robert Wagner
Checked by:	Mary Ann Olson-Russello
Projection:	NAD83-UTM Zone 11
Date:	June 11, 2010

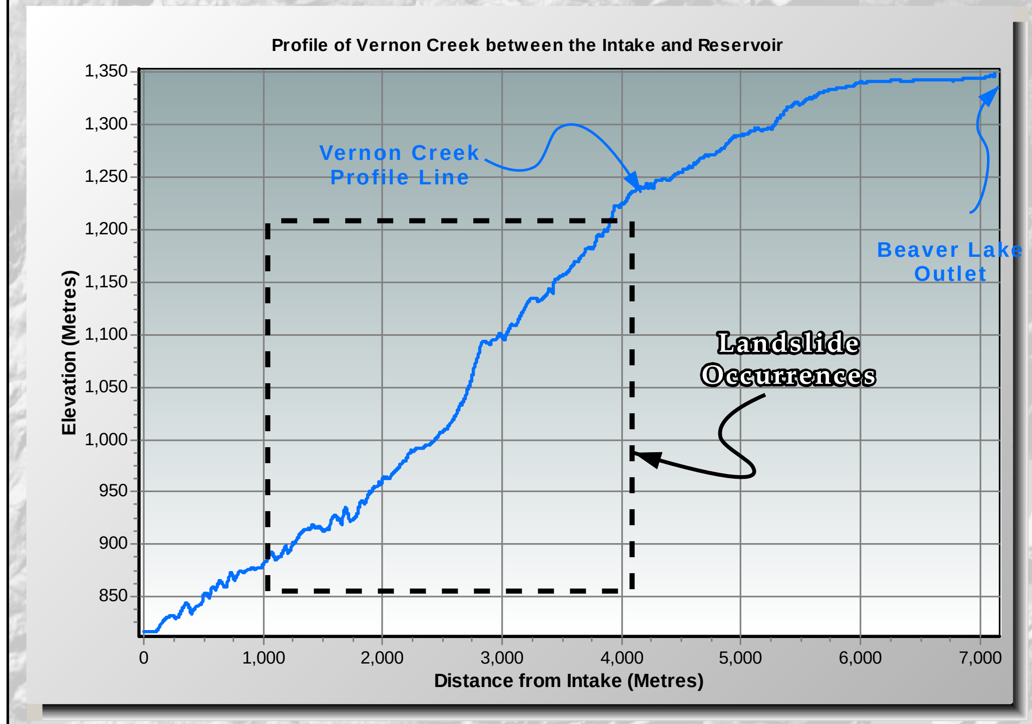
Legend

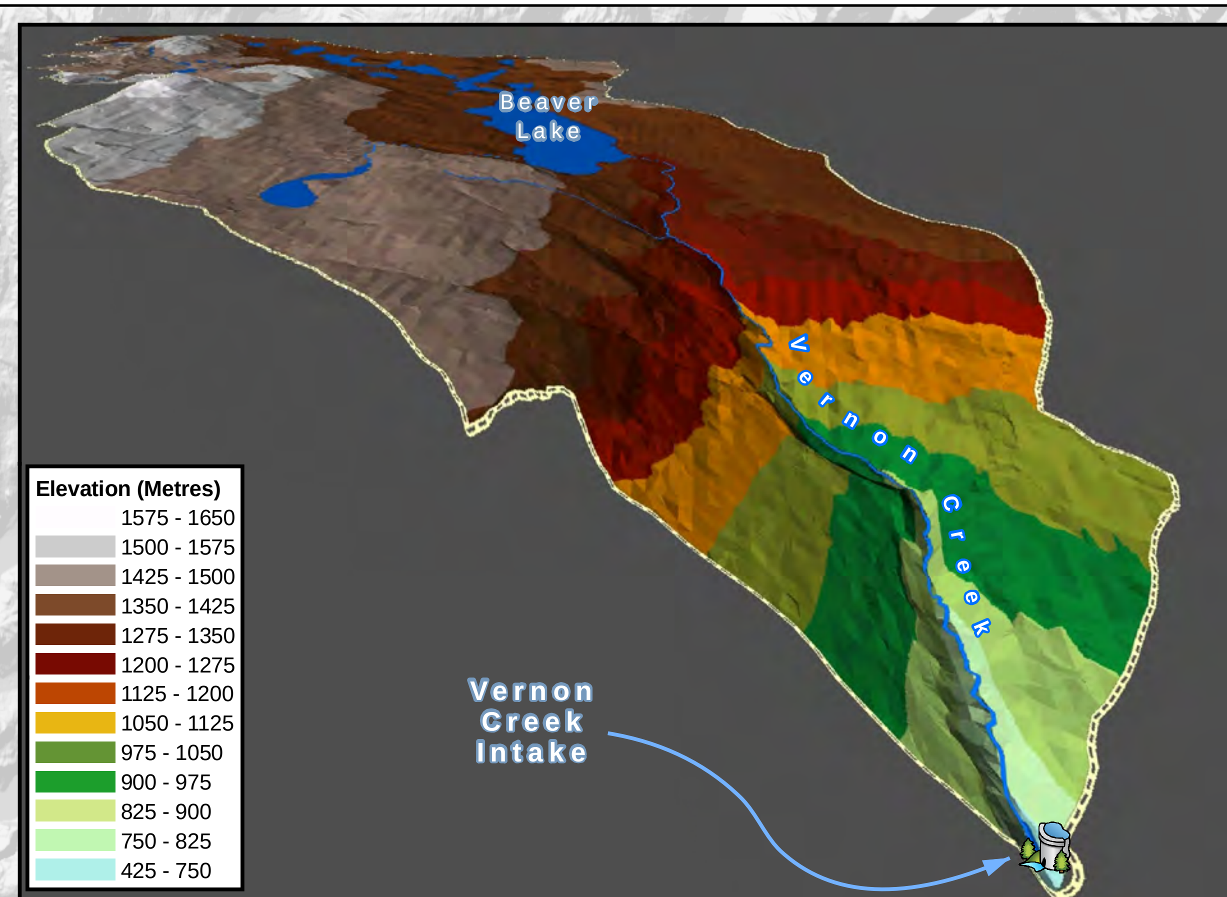
- Vernon Creek Intake
- Assessment Area
- Documented Landslides
- Streams
- Lakes

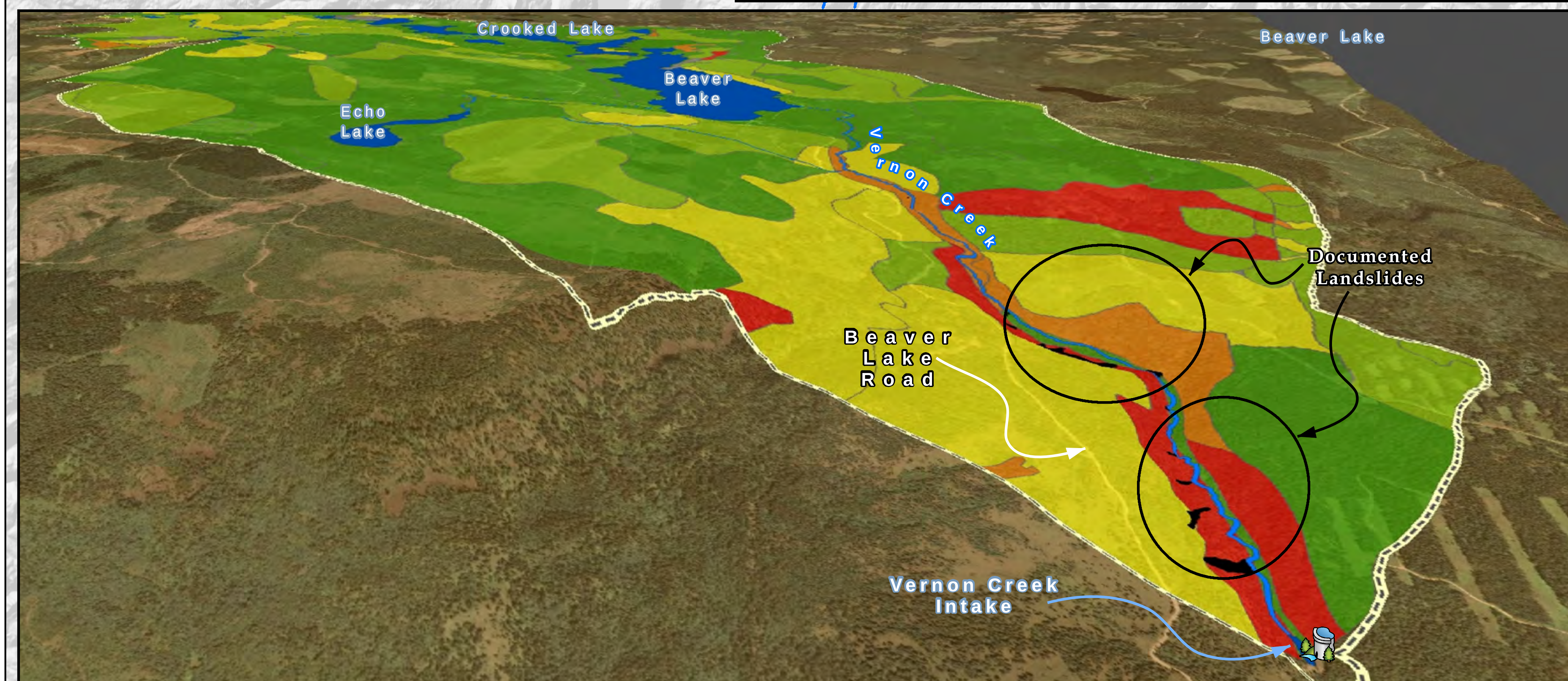
Slope Stability Class

- V
- IV
- III
- II
- I
- Unclassified

Note:
Elevation has been exaggerated 2:1 for visual effect.







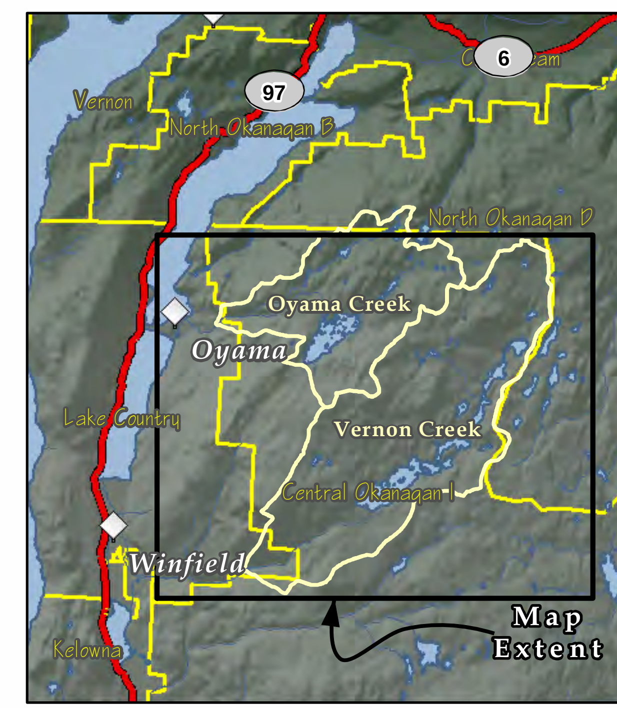
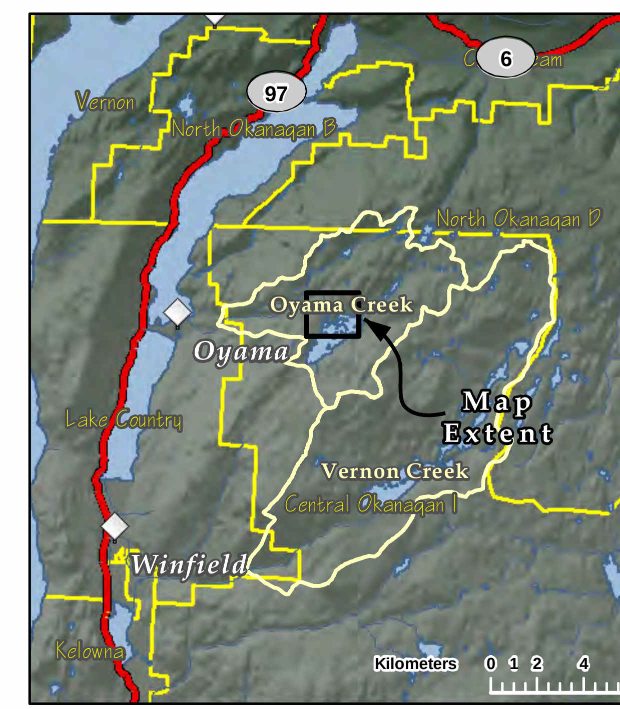


Figure 1-11 - Oyama Creek Watershed: Wildfire Extent

Project:	Watershed Assessment
Location:	District of Lake Country
Project No.:	09-367 and 09-415
Prepared for:	District of Lake Country
Prepared by:	Ecoscape Environmental Consultants Ltd.
Drawn by:	Robert Wagner
Checked by:	Mary Ann Olson-Russello
Projection:	NAD83-UTM Zone 11
Date:	June 11, 2010

Legend

- Crown Lease Lots (RDC O Parcels)
- Roads
- Streams
- Lake
- Approximate Fire Extent (April 30, 2009)



Meters 100 50 0 100 200 300

1:7,500

ECOSCAPE Environmental Consultants Ltd.

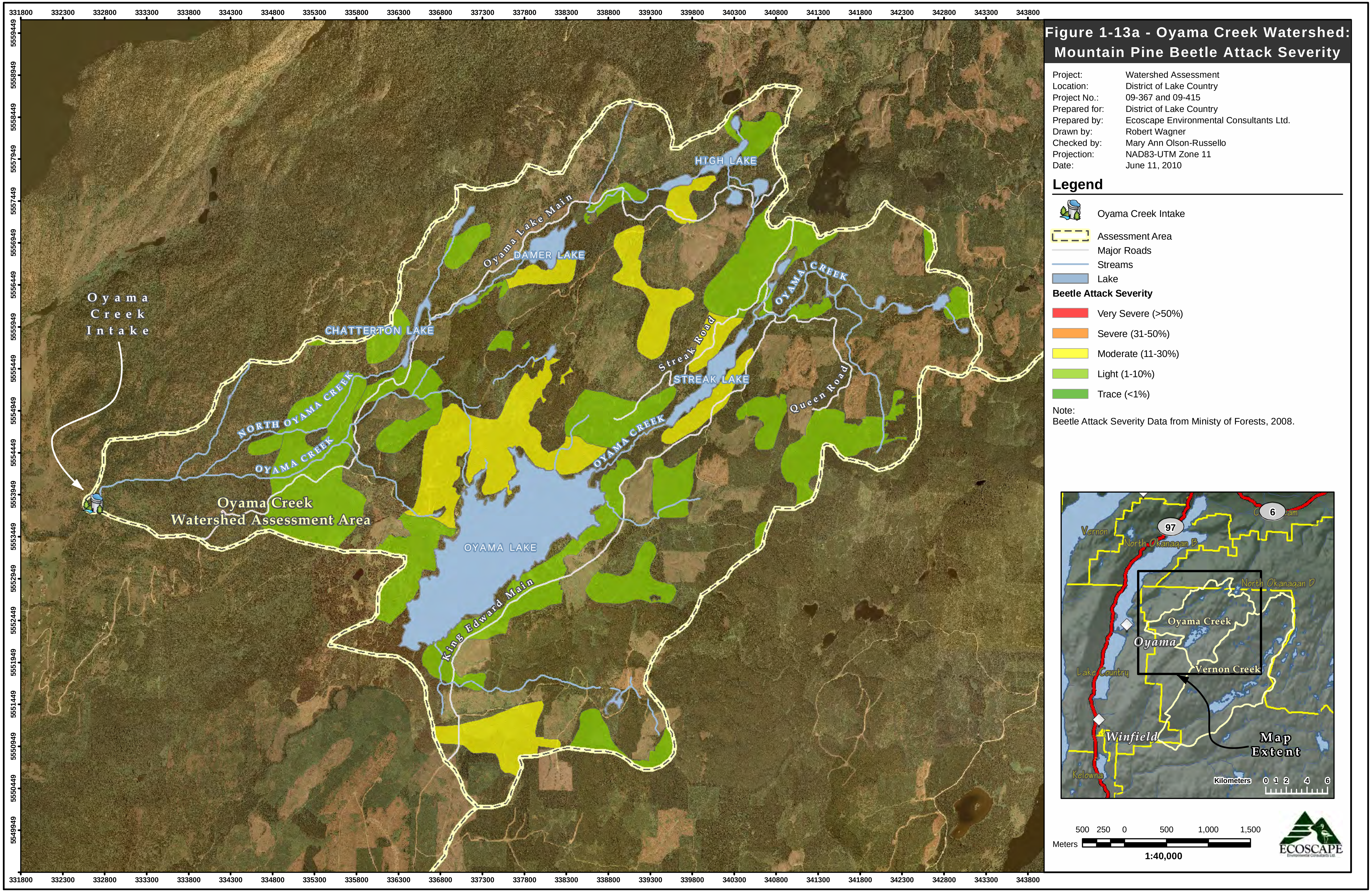
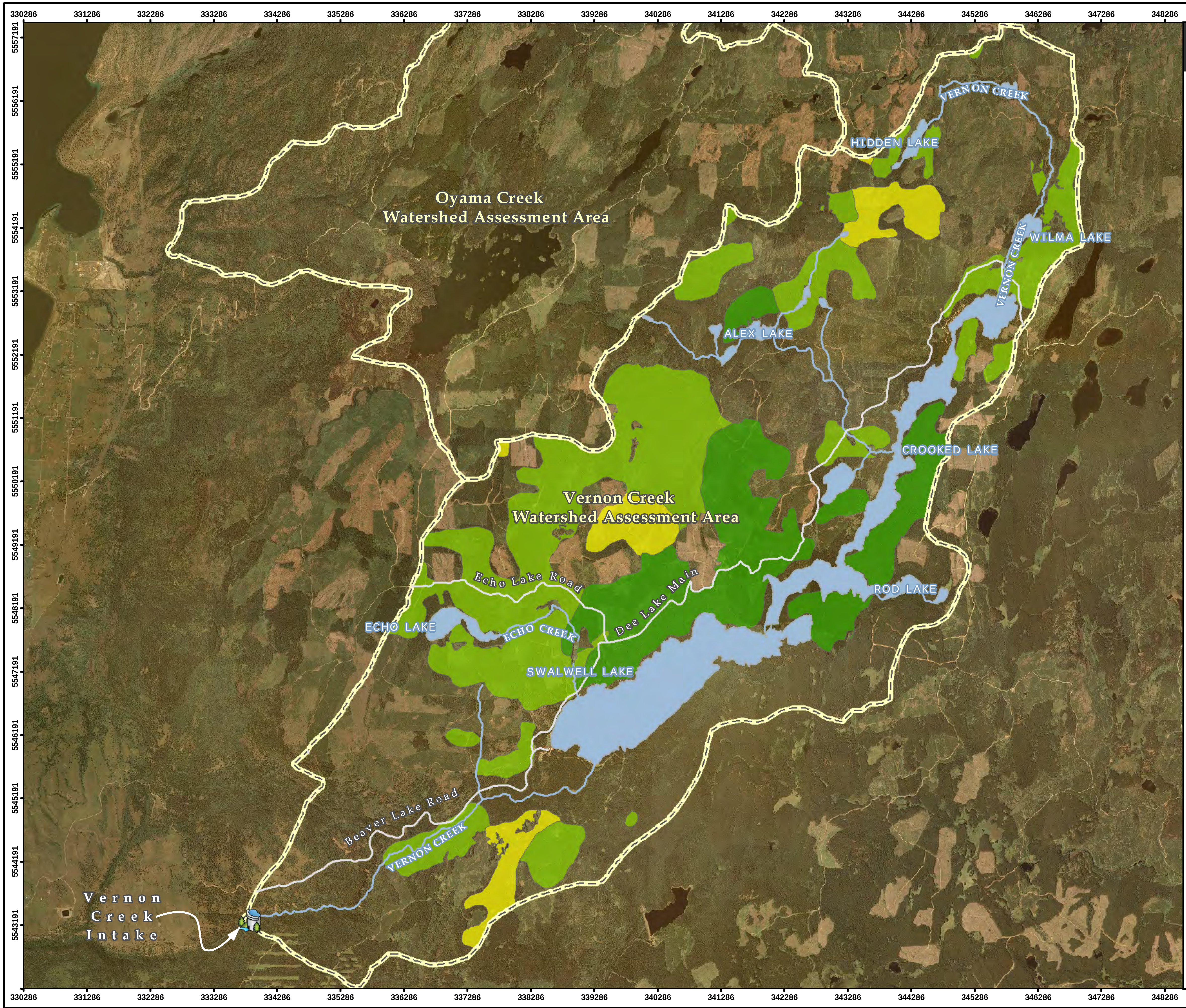


Figure 1-13a - Oyama Creek Watershed:
Mountain Pine Beetle Attack Severity
Project: Watershed Assessment
Location: District of Lake Country
Project No.: 09-367 and 09-415
Prepared for: District of Lake Country
Prepared by: Ecoscape Environmental Consultants Ltd.
Drawn by: Robert Wagner
Checked by: Mary Ann Olson-Russello
Projection: NAD83-UTM Zone 11
Date: June 11, 2010
Legend
Oyama Creek Intake
Assessment Area
Major Roads
Streams
Lake
Beetle Attack Severity
Very Severe (>50%)
Severe (31-50%)
Moderate (11-30%)
Light (1-10%)
Trace (<1%)
Note:
Beetle Attack Severity Data from Ministy of Forests, 2008.
Oyama Creek Intake
Oyama Creek Watershed Assessment Area
HIGH LAKE
DAMER LAKE
Oyama Lake Main
CHATTERTON LAKE
NORTH OYAMA CREEK
OYAMA CREEK
STREAK LAKE
Streak Road
Queen Road
OYAMA LAKE
King Edward Main
Vernon
North Okanagan B
North Okanagan D
97
6
Oyama Creek
Oyama
Vernon Creek
Lake Country
Winfield
Kelowna
Map Extent
Kilometers 0 1 2 4 6
Meters 500 250 0 500 1,000 1,500
1:40,000
ECOSCAPE

Figure 1-13b - Vernon Creek Watershed: Mountain Pine Beetle Attack Severity



Project:	Watershed Assessment
Location:	District of Lake Country
Project No.:	09-367 and 09-415
Prepared for:	District of Lake Country
Prepared by:	Ecoscape Environmental Consultants Ltd.
Drawn by:	Robert Wagner
Checked by:	Mary Ann Olson-Russello
Projection:	NAD83-UTM Zone 11
Date:	June 11, 2010

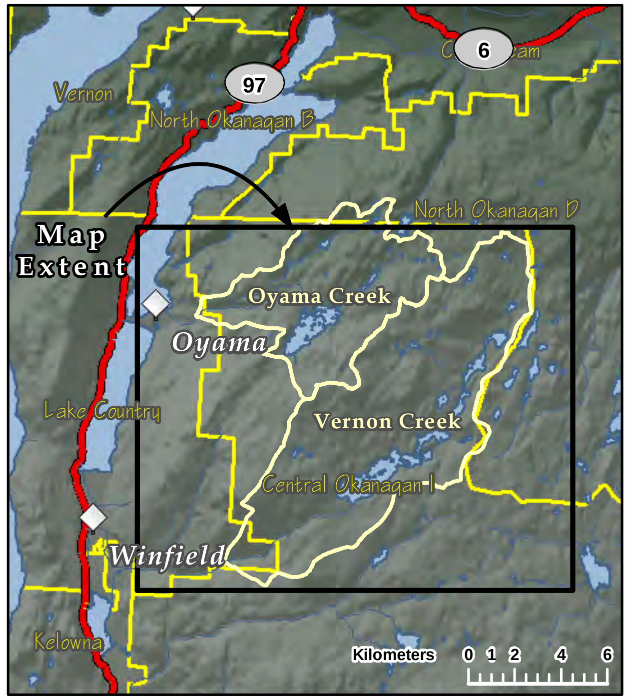
Legend

Vernon Creek Intake
Assessment Area
Major Roads
Streams
Lake

Beetle Attack Severity

Very Severe (>50%)
Severe (31-50%)
Moderate (11-30%)
Light (1-10%)
Trace (<1%)

Note:
Beetle Attack Severity Data from Ministy of Forests, 2008.



1,000 500 0 1,000 2,000
Meters

1:60,000

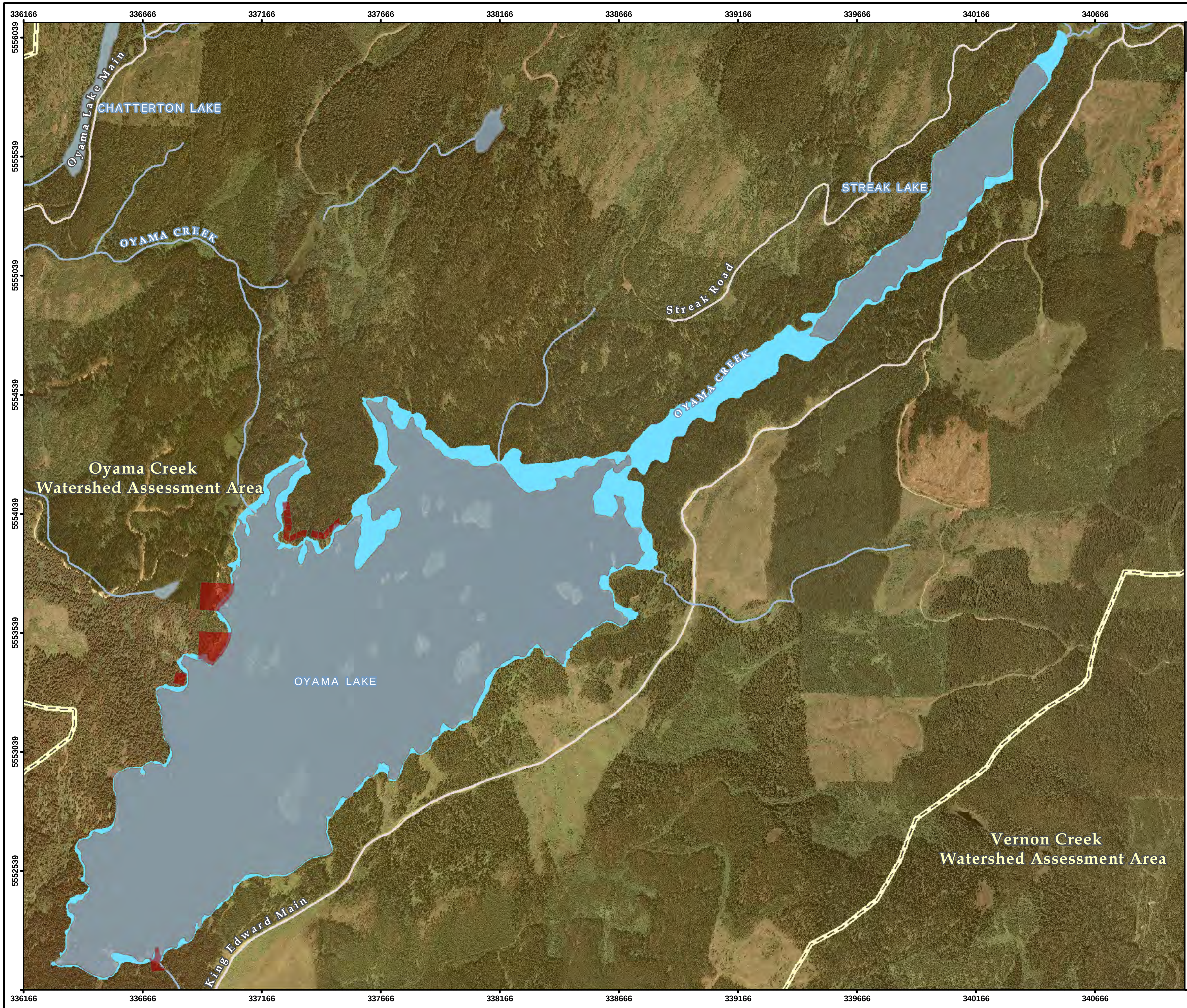
ECOSCAPE

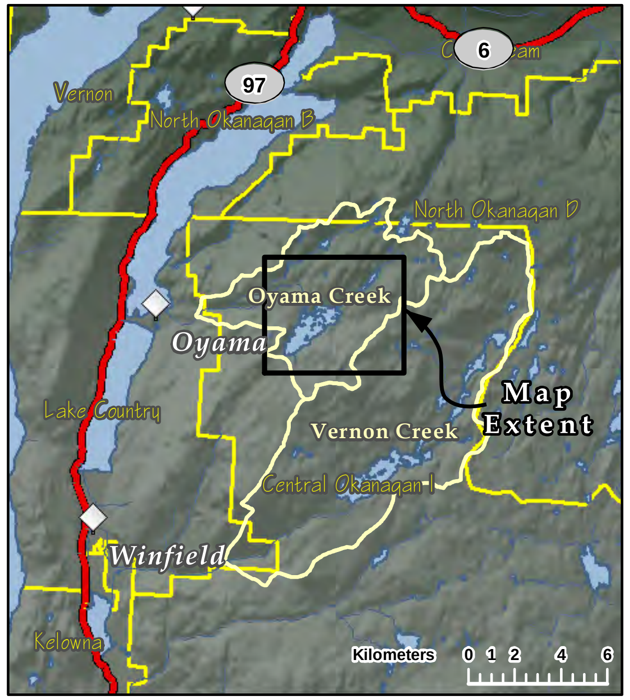
Figure 1-14a - Oyama Lake and Streak Lake Proposed Inundation Area

Project:	Watershed Assessment
Location:	District of Lake Country
Project No.:	09-367 and 09-415
Prepared for:	District of Lake Country
Prepared by:	Ecoscape Environmental Consultants Ltd.
Drawn by:	Robert Wagner
Checked by:	Mary Ann Olson-Russello
Projection:	NAD83-UTM Zone 11
Date:	June 11, 2010

Legend

- Oyama Creek Intake
- Assessment Area
- Major Roads
- Streams
- Lake
- Proposed Inundation Area
- District of Lake Country Parcels
- Regional District of Central Okanagan Parcels





200 100 0 200 400 600

Meters

1:16,000

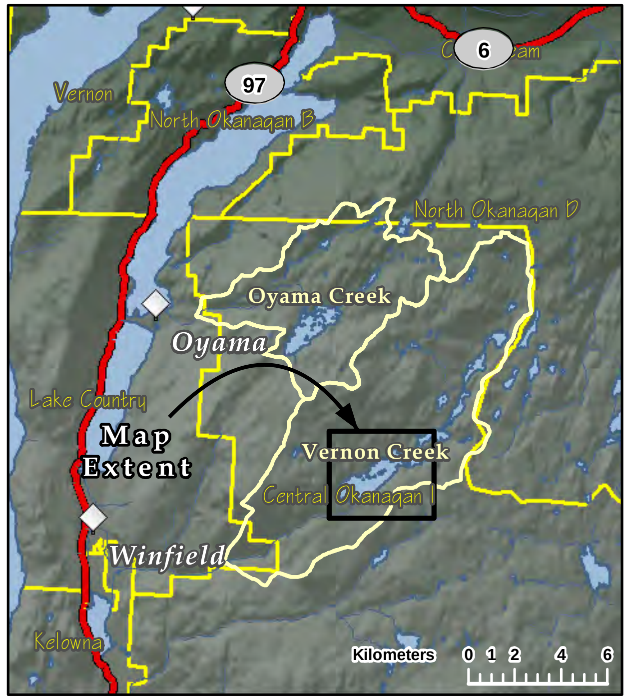
ECOSCAPE

Figure 1-14b - Swalwell Lake Proposed Inundation Area

Project:	Watershed Assessment
Location:	District of Lake Country
Project No.:	09-367 and 09-415
Prepared for:	District of Lake Country
Prepared by:	Ecoscape Environmental Consultants Ltd.
Drawn by:	Robert Wagner
Checked by:	Mary Ann Olson-Russello
Projection:	NAD83-UTM Zone 11
Date:	June 11, 2010

Legend

- Vernon Creek Intake
- Assessment Area
- Major Roads
- Streams
- Lake
- Proposed Inundation Area
- Regional District of Central Okanagan Parcels



Meters 250 125 0 250 500

1:15,000

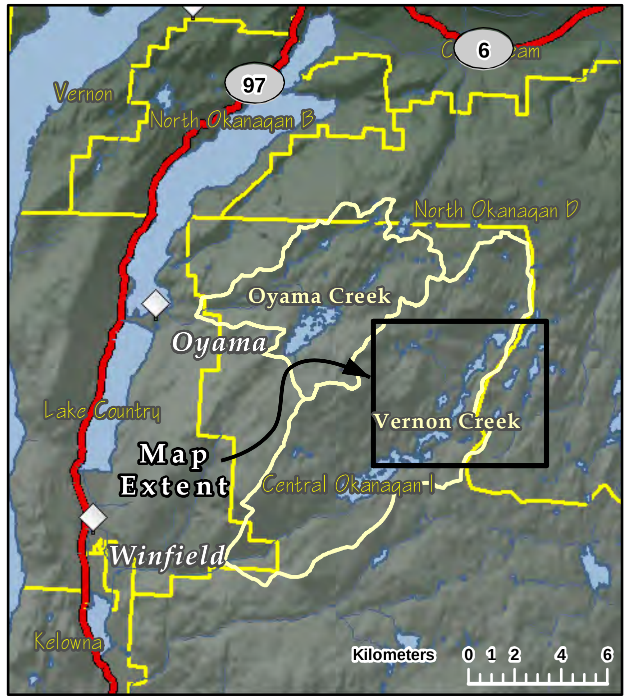
ECOSCAPE Environmental Consultants Ltd.

Figure 1-14c - Crooked Lake Proposed Inundation Area

Project:	Watershed Assessment
Location:	District of Lake Country
Project No.:	09-367 and 09-415
Prepared for:	District of Lake Country
Prepared by:	Ecoscape Environmental Consultants Ltd.
Drawn by:	Robert Wagner
Checked by:	Mary Ann Olson-Russello
Projection:	NAD83-UTM Zone 11
Date:	June 11, 2010

Legend

- Vernon Creek Intake
- Assessment Area
- Major Roads
- Streams
- Lake
- Proposed Inundation Area
- District of Lake Country Parcels
- Regional District of Central Okanagan Parcels



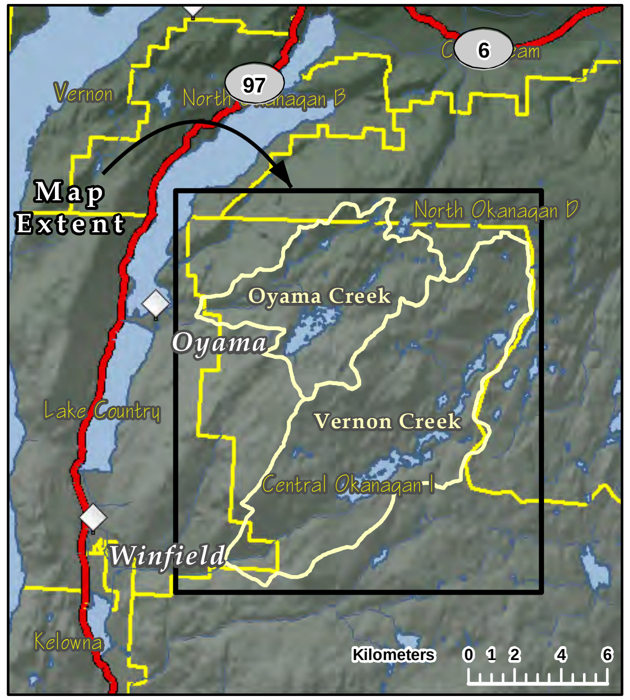
250 125 0 250 500 750 1,000
Meters
1:25,000

Figure 2-1 - Watershed Assessment Points

Project:	Watershed Assessment
Location:	District of Lake Country
Project No.:	09-367 and 09-415
Prepared for:	District of Lake Country
Prepared by:	Ecoscape Environmental Consultants Ltd.
Drawn by:	Robert Wagner
Checked by:	Mary Ann Olson-Russello
Projection:	NAD83-UTM Zone 11
Date:	June 11, 2010

Legend

- Intake
- Assessment Area
- Major Roads
- Streams
- Lake
- Watershed Assessment Point



1,000 500 0 1,000 2,000
Meters
1:70,000

ECOSCAPE
Environmental Consultants Ltd.

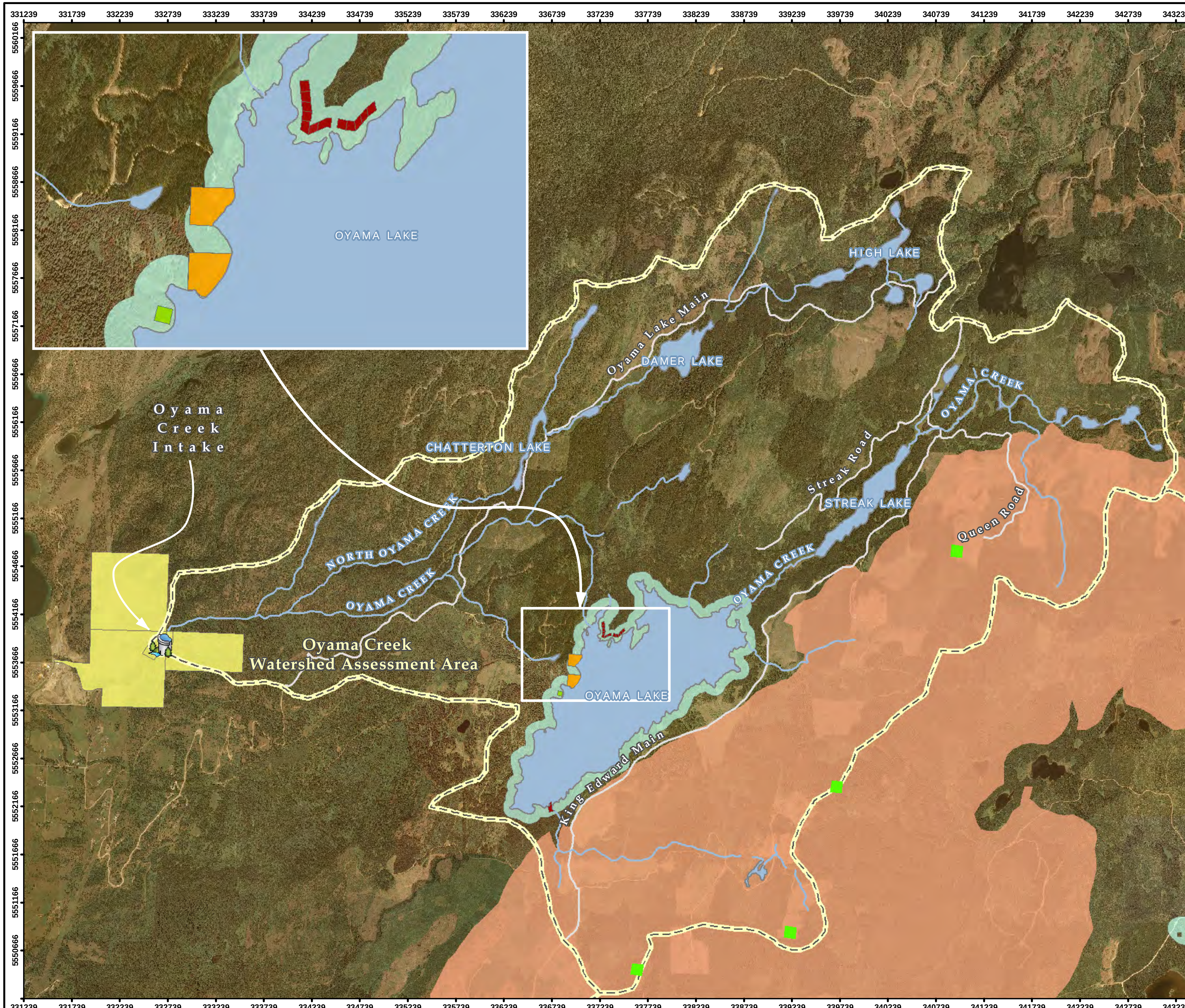


Figure 2-2a - Oyama Creek Watershed: Land Jurisdiction and Zoning

Project:	Watershed Assessment
Location:	District of Lake Country
Project No.:	09-367 and 09-415
Prepared for:	District of Lake Country
Prepared by:	Ecoscape Environmental Consultants Ltd.
Drawn by:	Robert Wagner
Checked by:	Mary Ann Olson-Russello
Projection:	NAD83-UTM Zone 11
Date:	June 11, 2010

Legend

- Oyama Creek Intake
- Assessment Area
- Major Roads
- Streams
- Lake
- Potential Meteorological Tower Locations
- Wind Power Investigative Use Permit Boundary

Regional District of Central Okanagan Parcels

Zoning

- C8
- P2
- RU7
- CL8

District of Lake Country Parcels

Zoning

- A1
- RLP

500 250 0 500 1,000 1,500
Meters
1:40,000

ECOSCAPE Environmental Consultants Ltd.

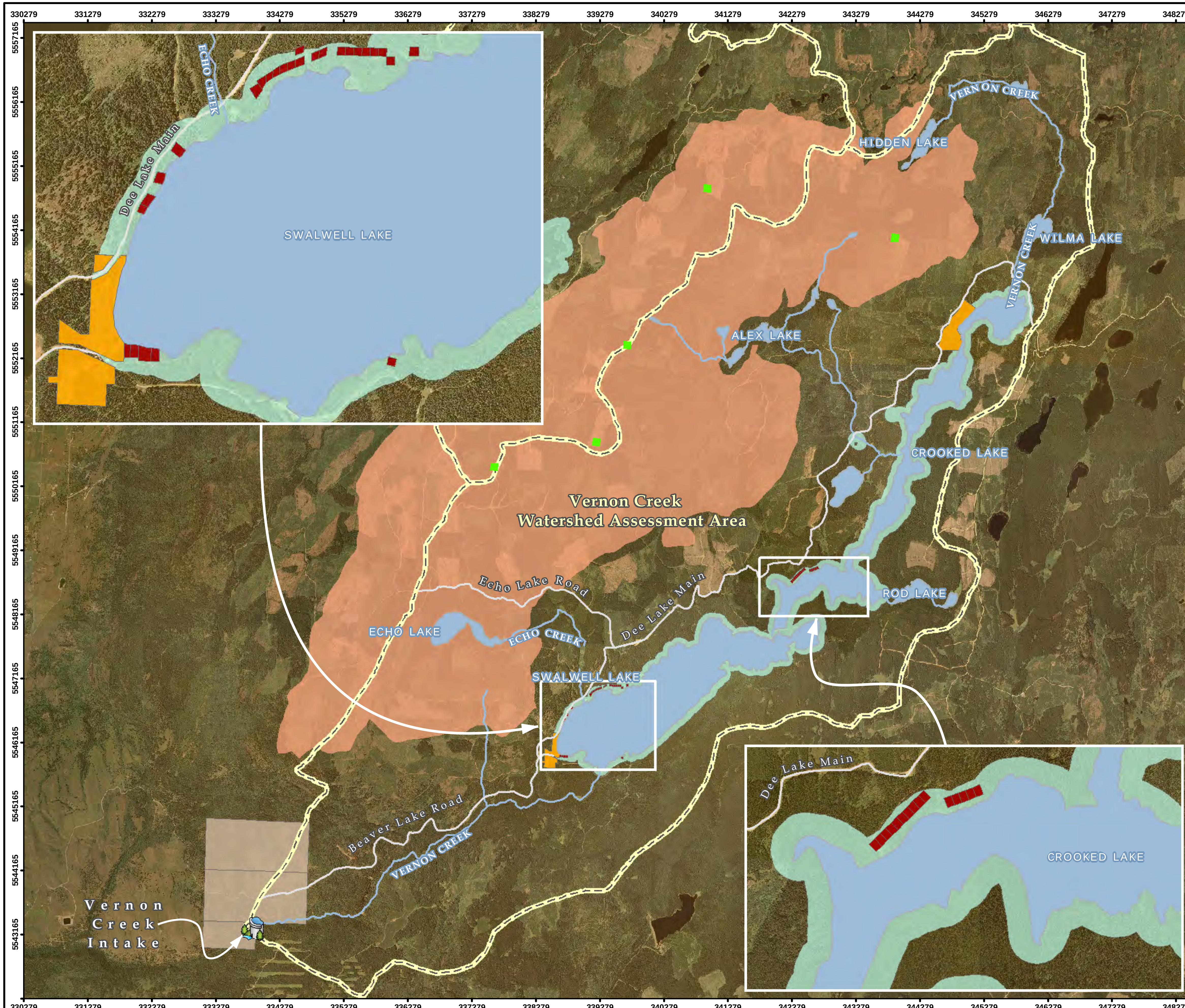


Figure 2-2b - Vernon Creek Watershed: Land Jurisdiction and Zoning

Project:	Watershed Assessment
Location:	District of Lake Country
Project No.:	09-367 and 09-415
Prepared for:	District of Lake Country
Prepared by:	Ecoscape Environmental Consultants Ltd.
Drawn by:	Robert Wagner
Checked by:	Mary Ann Olson-Russello
Projection:	NAD83-UTM Zone 11
Date:	June 11, 2010

Legend

- Vernon Creek Intake
- Assessment Area
- Major Roads
- Streams
- Lake
- Potential Meteorological Tower Locations
- Wind Power Investigative Use Permit Boundary

Regional District of Central Okanagan Parcels

Zoning

- C8
- P2
- RU7
- CL8

District of Lake Country Parcels

Zoning

- A1
- RLP

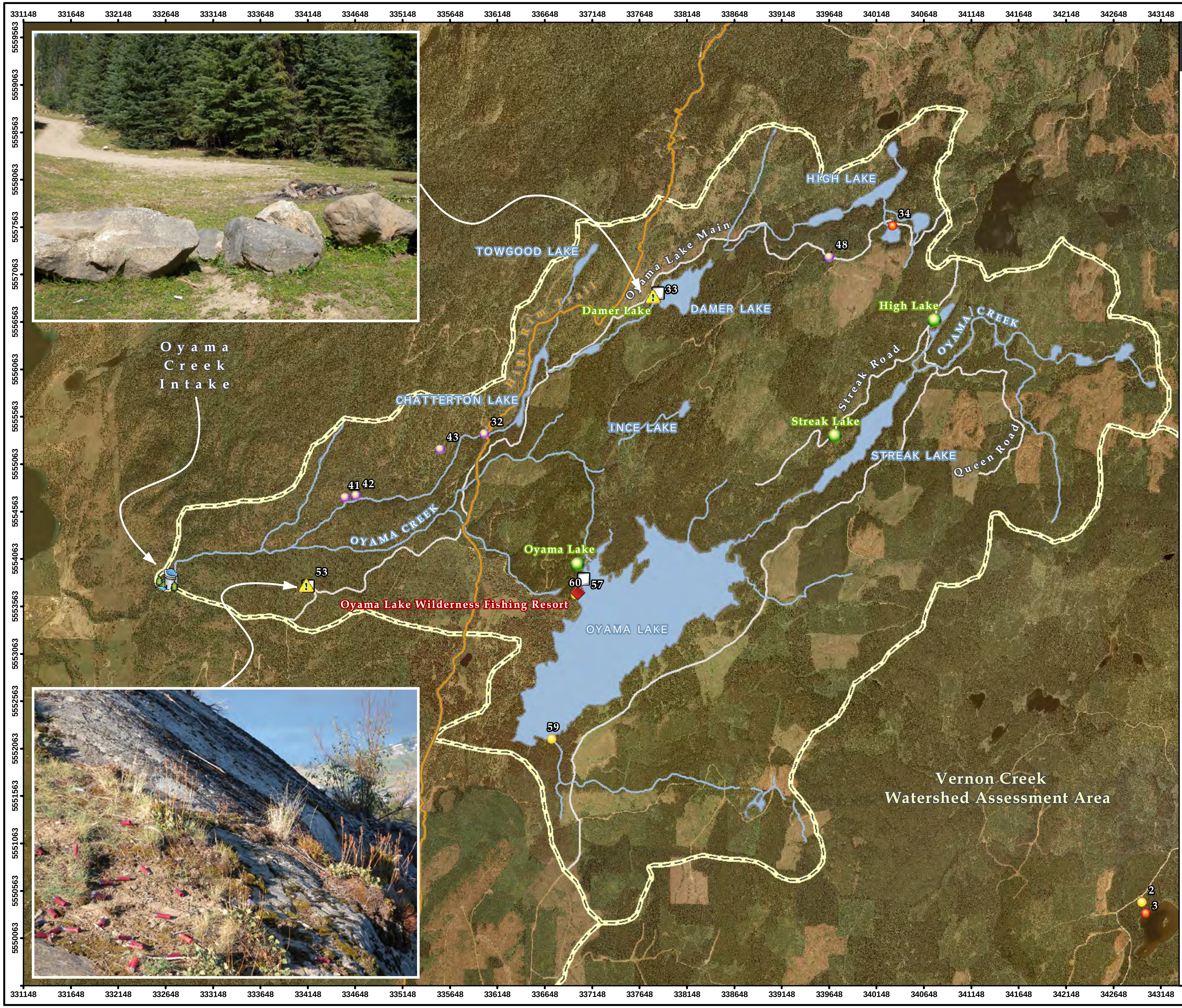
Meters 1,000 500 0 1,000 2,000

1:60,000

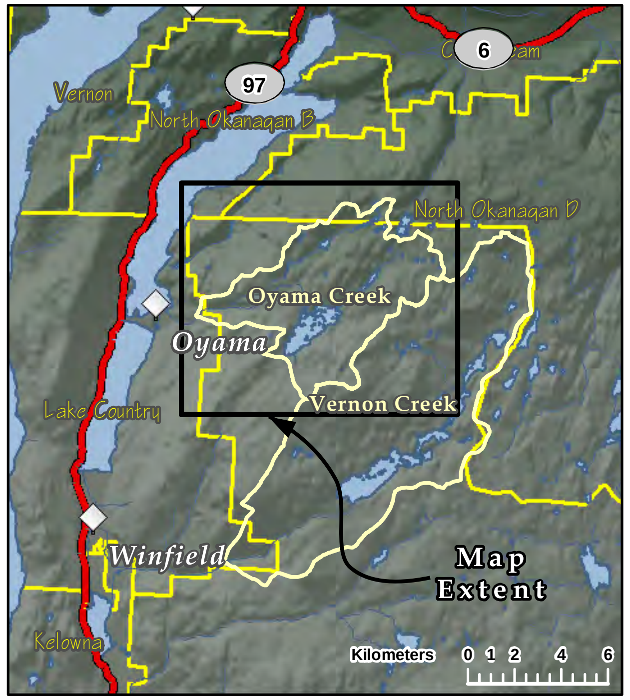
ECOSCAPE Environmental Consultants Ltd.

Figure 2-3a - Oyama Creek Watershed: Recreation

Project:	Watershed Assessment
Location:	District of Lake Country
Project No.:	09-367 and 09-415
Prepared for:	District of Lake Country
Prepared by:	Ecoscape Environmental Consultants Ltd.
Drawn by:	Robert Wagner
Checked by:	Mary Ann Olson-Russello
Projection:	NAD83-UTM Zone 11
Date:	June 11, 2010



Legend



Meters 500 250 0 500 1,000 1,500

1:40,000

ECOSCAPE

Figure 2-3b - Vernon Creek Watershed: Recreation

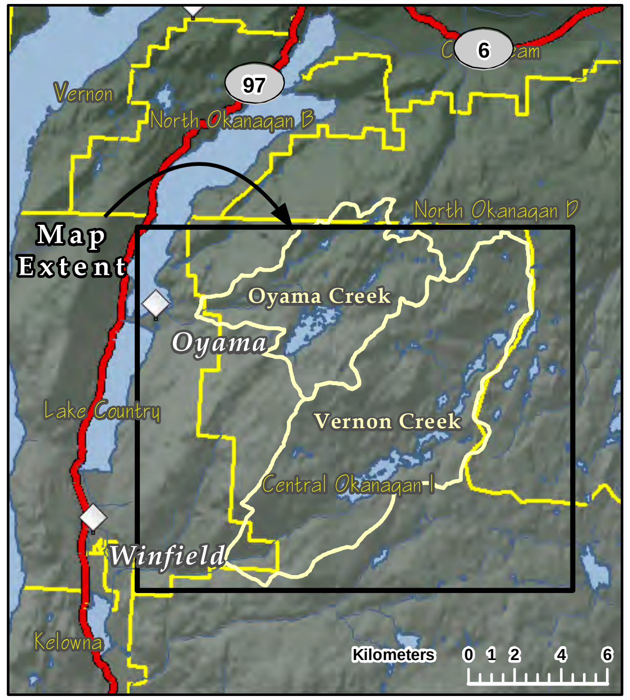
Project: Watershed Assessment
Location: District of Lake Country
Project No.: 09-367 and 09-415
Prepared for: District of Lake Country
Prepared by: Ecoscape Environmental Consultants Ltd.
Drawn by: Robert Wagner
Checked by: Mary Ann Olson-Russello
Projection: NAD83-UTM Zone 11
Date: June 11, 2010

Legend

- Vernon Creek Intake
- Assessment Area
- Major Roads
- Streams
- Lake
- Recreation Site
- Commercial Recreation Site
- High Rim Trail
- Unsanctioned Crooked Lake Dam Site

Watershed Assessment Points

- Sanctioned Camping
- Unsanctioned Camping
- Motorized Recreation
- Multiple Recreational Uses



1,000 500 0 1,000 2,000
Meters
1:60,000

ECOSCAPE
Environmental Consultants Ltd.

Figure 2-4 - Vernon Creek Watershed: Drainage and Stream Crossing Points

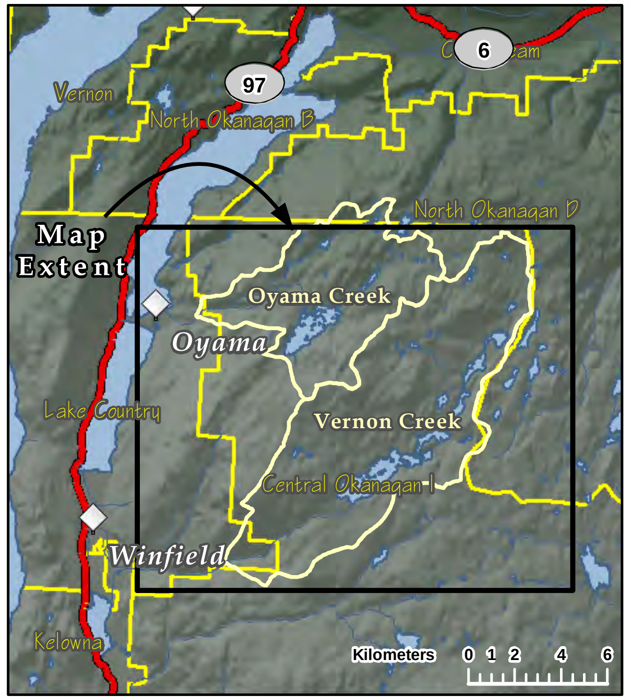
Project:	Watershed Assessment
Location:	District of Lake Country
Project No.:	09-367 and 09-415
Prepared for:	District of Lake Country
Prepared by:	Ecoscape Environmental Consultants Ltd.
Drawn by:	Robert Wagner
Checked by:	Mary Ann Olson-Russello
Projection:	NAD83-UTM Zone 11
Date:	June 11, 2010

Legend

- Vernon Creek Intake
- Assessment Area
- Major Roads
- Streams
- Lake

Stream Crossing Assessment Point Type

- Drainage Culvert
- Stream Crossing



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ECOSCAPE

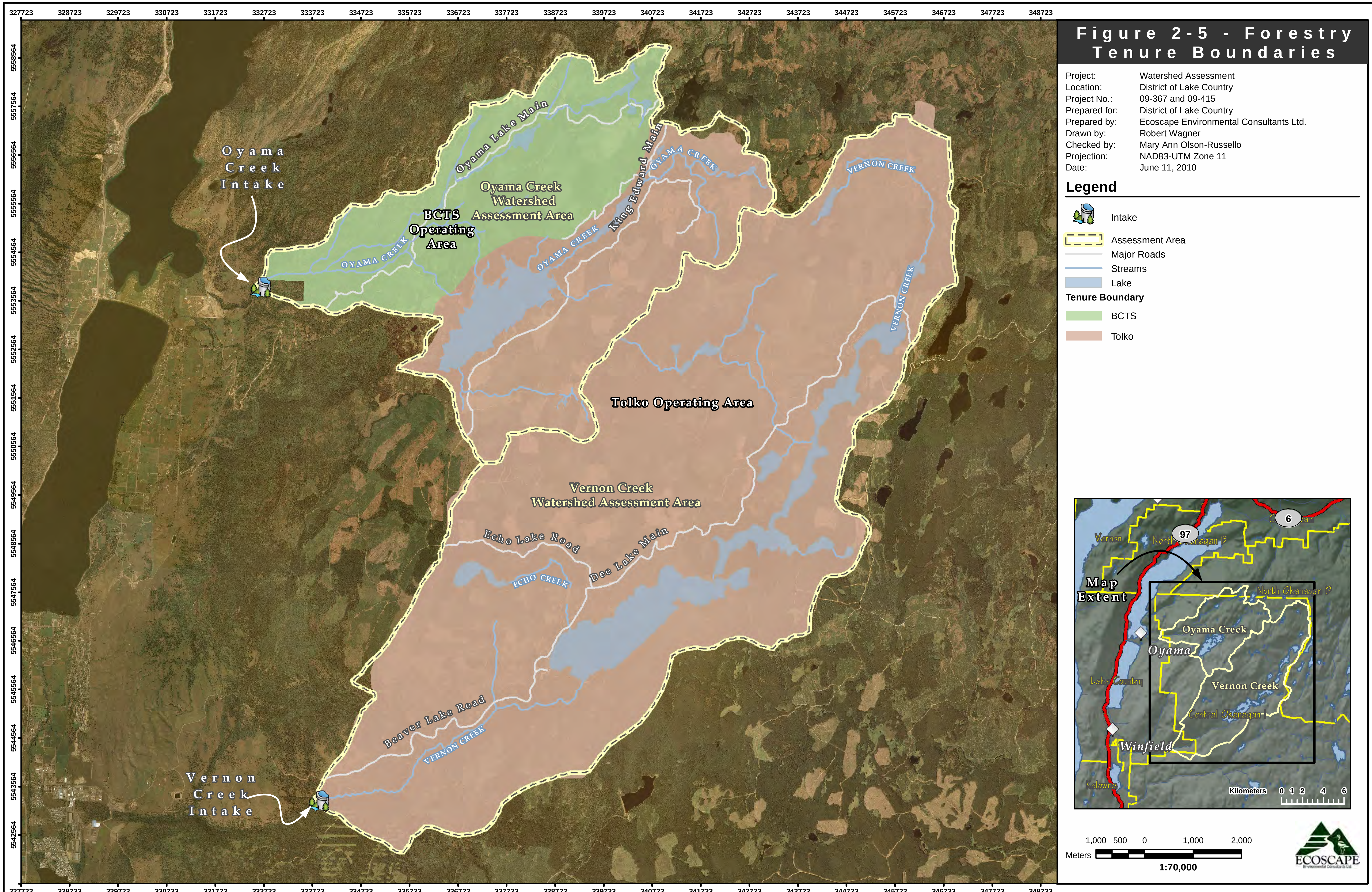
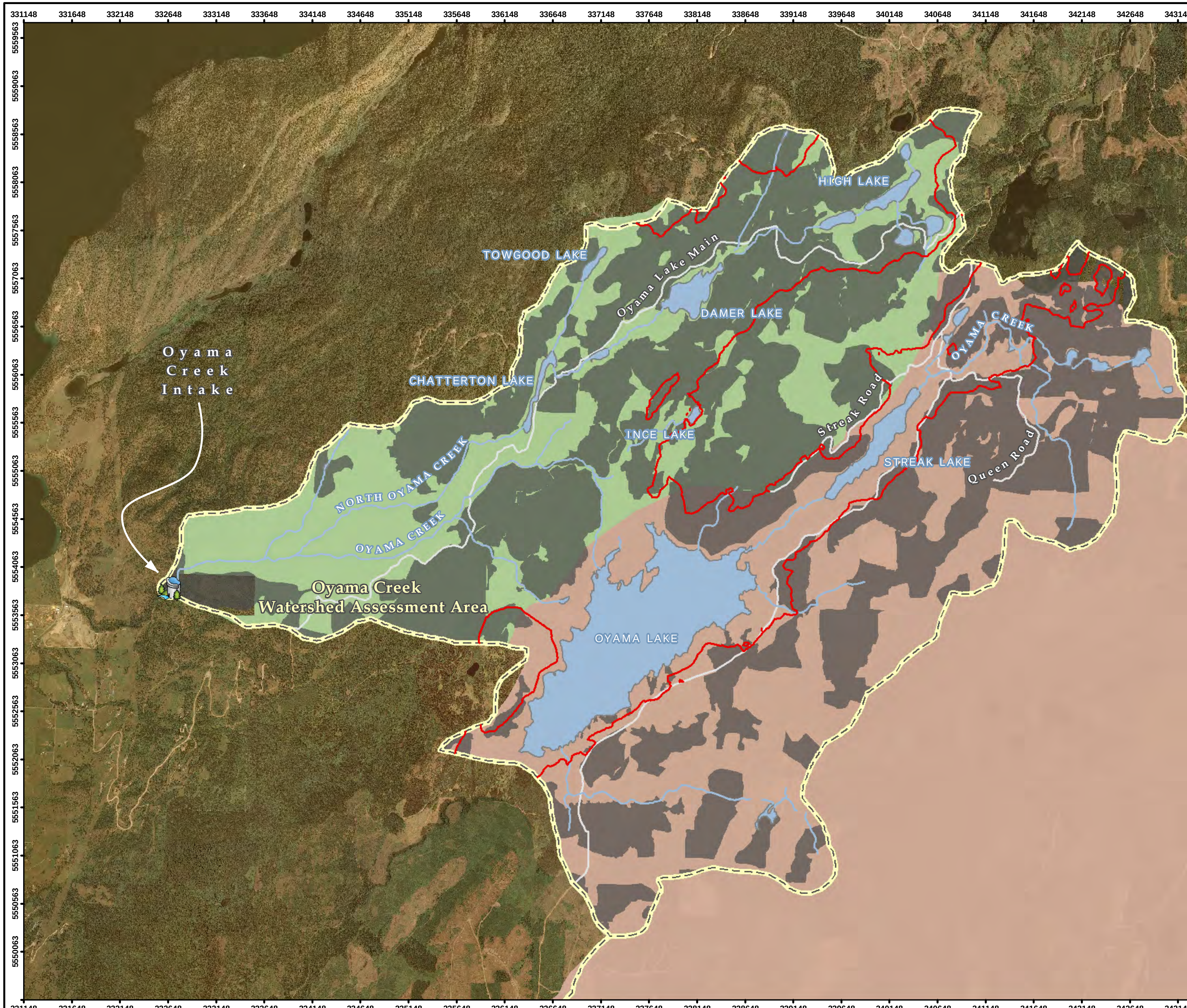


Figure 2-5 - Forestry Tenure Boundaries

Project:	Watershed Assessment
Location:	District of Lake Country
Project No.:	09-367 and 09-415
Prepared for:	District of Lake Country
Prepared by:	Ecoscape Environmental Consultants Ltd.
Drawn by:	Robert Wagner
Checked by:	Mary Ann Olson-Russello
Projection:	NAD83-UTM Zone 11
Date:	June 11, 2010

Figure 2-6a - Oyama Creek Watershed: Harvested Blocks

Project:	Watershed Assessment
Location:	District of Lake Country
Project No.:	09-367 and 09-415
Prepared for:	District of Lake Country
Prepared by:	Ecoscape Environmental Consultants Ltd.
Drawn by:	Robert Wagner
Checked by:	Mary Ann Olson-Russello
Projection:	NAD83-UTM Zone 11
Date:	June 11, 2010

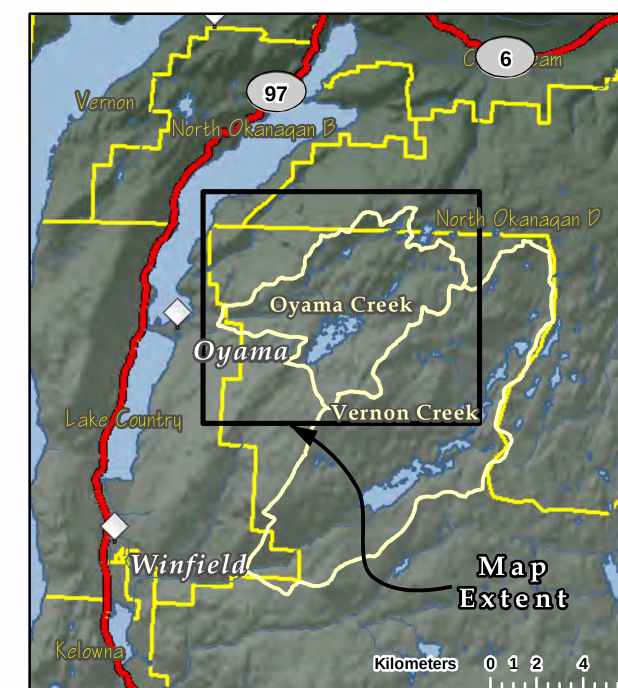


Legend

- Oyama Creek Intake
- Assessment Area
- Major Roads
- Streams
- Lake
- Snowline Elevation (H45)
- Previously Harvested

Tenure Boundary

- BCTS
- Tolko



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ECOSCAPE Environmental Consultants Ltd.

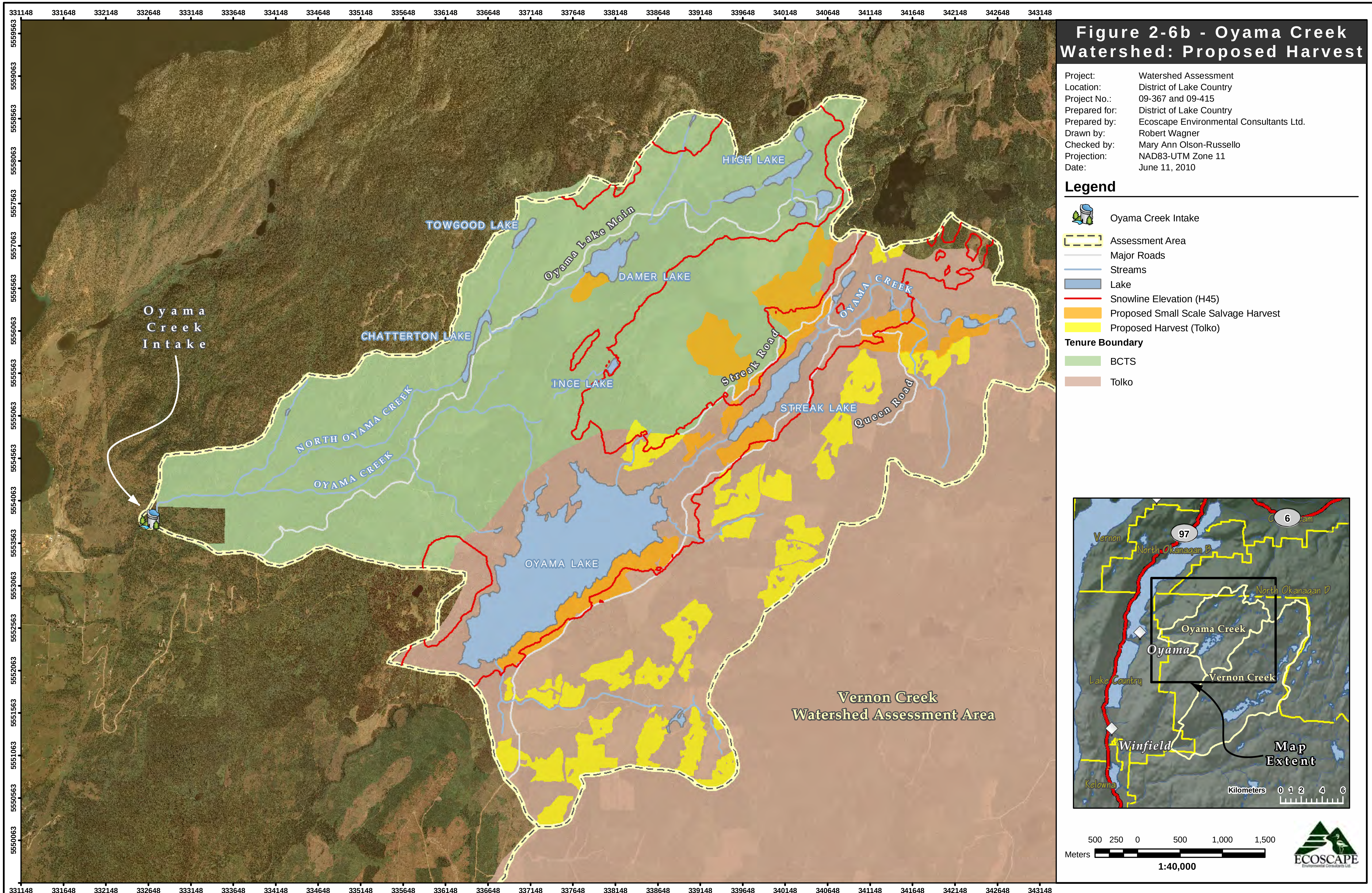


Figure 2-6b - Oyama Creek Watershed: Proposed Harvest
Project: Watershed Assessment
Location: District of Lake Country
Project No.: 09-367 and 09-415
Prepared for: District of Lake Country
Prepared by: Ecoscape Environmental Consultants Ltd.
Drawn by: Robert Wagner
Checked by: Mary Ann Olson-Russello
Projection: NAD83-UTM Zone 11
Date: June 11, 2010
Legend
Oyama Creek Intake
Assessment Area
Major Roads
Streams
Lake
Snowline Elevation (H45)
Proposed Small Scale Salvage Harvest
Proposed Harvest (Tolko)
Tenure Boundary
BCTS
Tolko
Oyama Creek Intake
TOWGOOD LAKE
Oyama Lake Main
DAMER LAKE
HIGH LAKE
CHATTERTON LAKE
INCE LAKE
NORTH OYAMA CREEK
OYAMA CREEK
Streak Road
STREAK LAKE
Queen Road
OYAMA LAKE
Vernon Creek Watershed Assessment Area
Vernon
North Okanagan B
North Okanagan D
97
6
Oyama Creek
Oyama
Vernon Creek
Lake Country
Winfield
Kelowna
Map Extent
Kilometers 0 1 2 4 6
Meters 500 250 0 500 1,000 1,500
1:40,000
ECOSCAPE

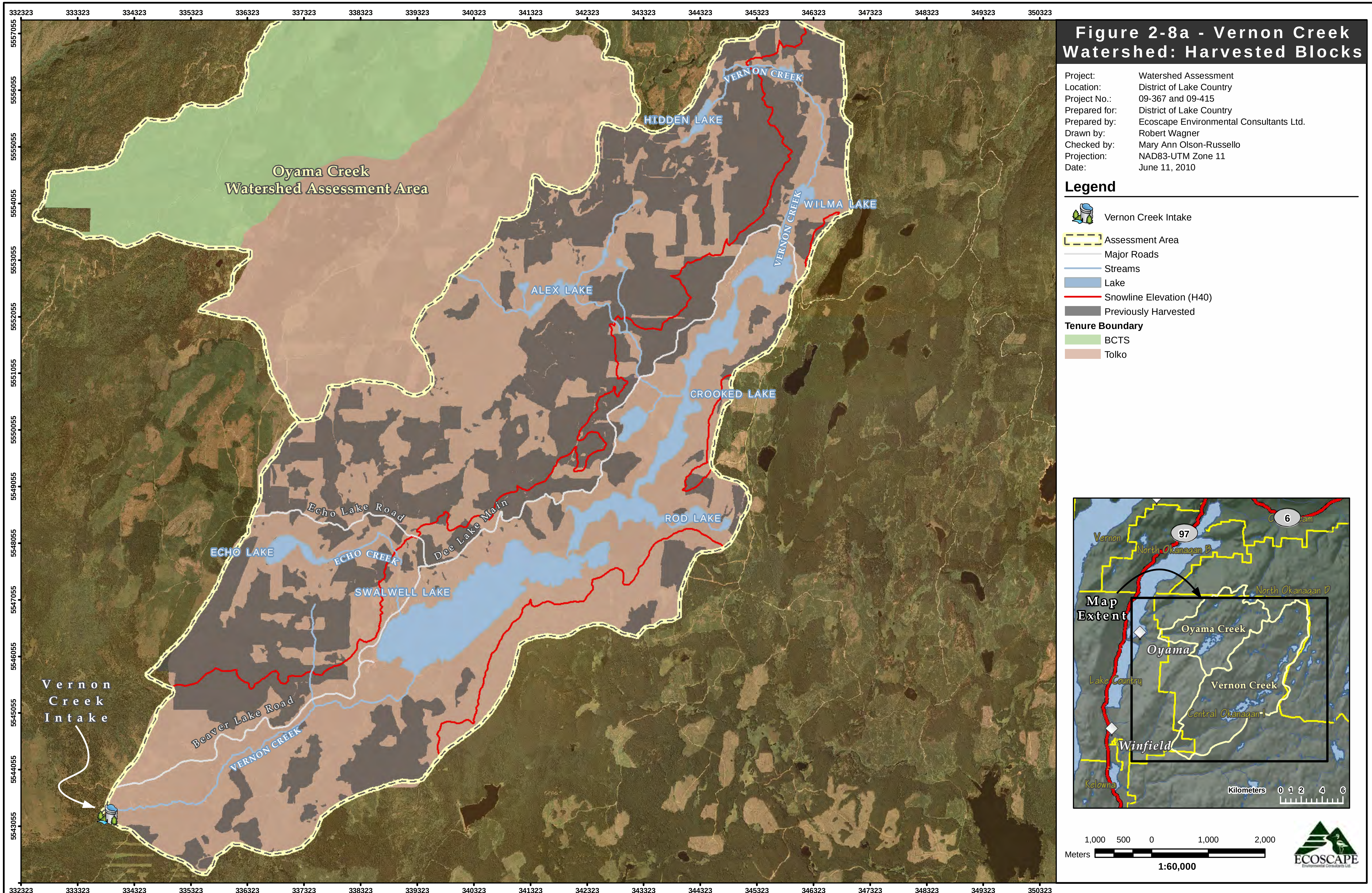


Figure 2-8a - Vernon Creek Watershed: Harvested Blocks
Project: Watershed Assessment
Location: District of Lake Country
Project No.: 09-367 and 09-415
Prepared for: District of Lake Country
Prepared by: Ecoscape Environmental Consultants Ltd.
Drawn by: Robert Wagner
Checked by: Mary Ann Olson-Russello
Projection: NAD83-UTM Zone 11
Date: June 11, 2010
Legend
Vernon Creek Intake
Assessment Area
Major Roads
Streams
Lake
Snowline Elevation (H40)
Previously Harvested
Tenure Boundary
BCTS
Tolko
Oyama Creek Watershed Assessment Area
HIDDEN LAKE
VERNON CREEK
WILMA LAKE
ALEX LAKE
CROOKED LAKE
ROD LAKE
ECHO LAKE
ECHO CREEK
Echo Lake Road
Dee Lake Main
SWALWELL LAKE
Beaver Lake Road
Vernon Creek Intake
Map Extent
Vernon
North Okanagan B
North Okanagan D
97
6
Oyama Creek
Oyama
Vernon Creek
Lake Country
Central Okanagan I
Winfield
Kelowna
Kilometers 0 1 2 4 6
Meters 1,000 500 0 1,000 2,000
1:60,000
ECOSCAPE Environmental Consultants Ltd.
332323 333323 334323 335323 336323 337323 338323 339323 340323 341323 342323 343323 344323 345323 346323 347323 348323 349323 350323
5557055 5556055 5555055 5554055 5553055 5552055 5551055 5550055 5549055 5548055 5547055 5546055 5545055 5544055 5543055

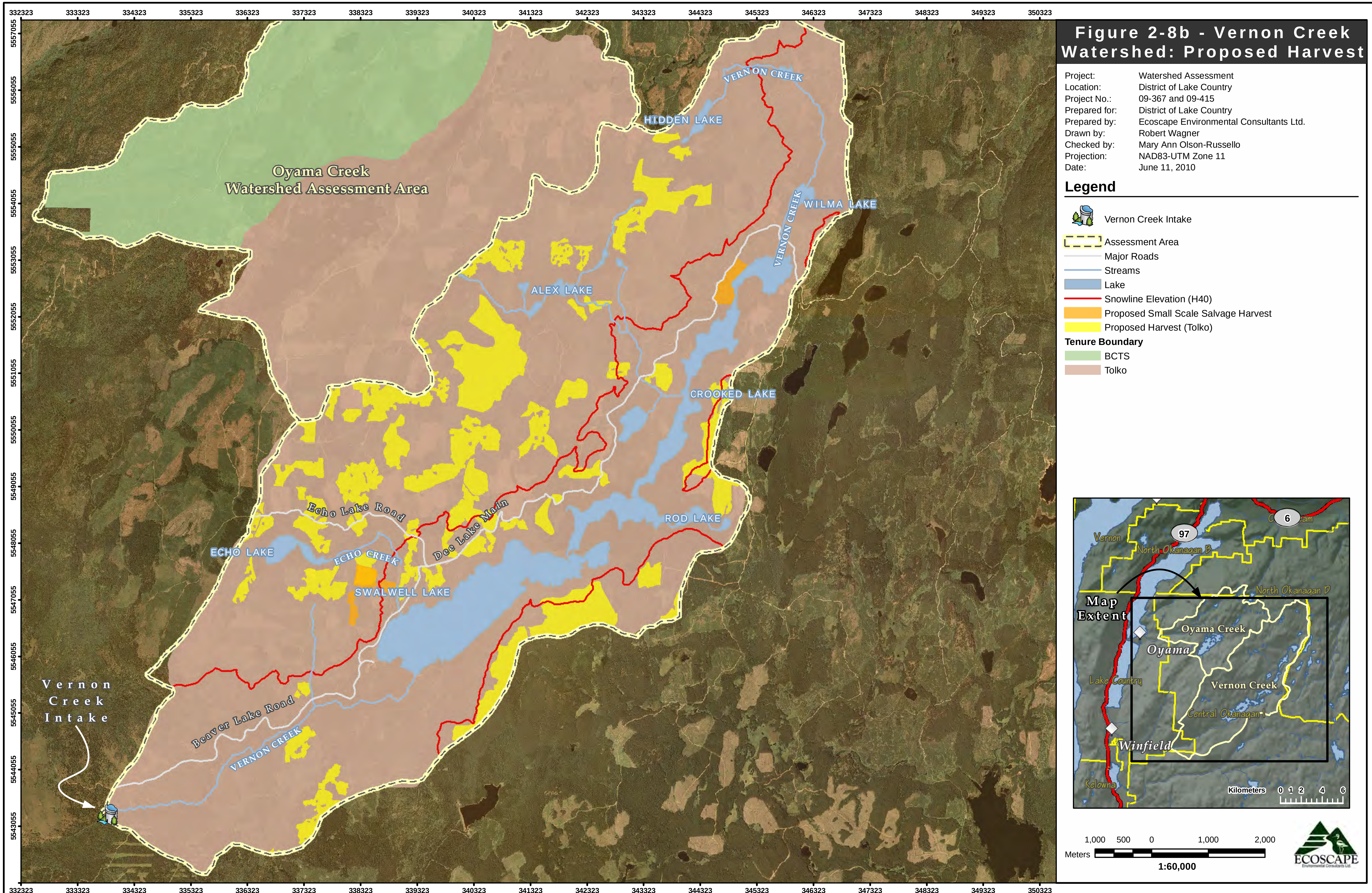


Figure 2-8b - Vernon Creek Watershed: Proposed Harvest

Figure 2-9a -Range Tenure Boundaries and Private Pasture Lands

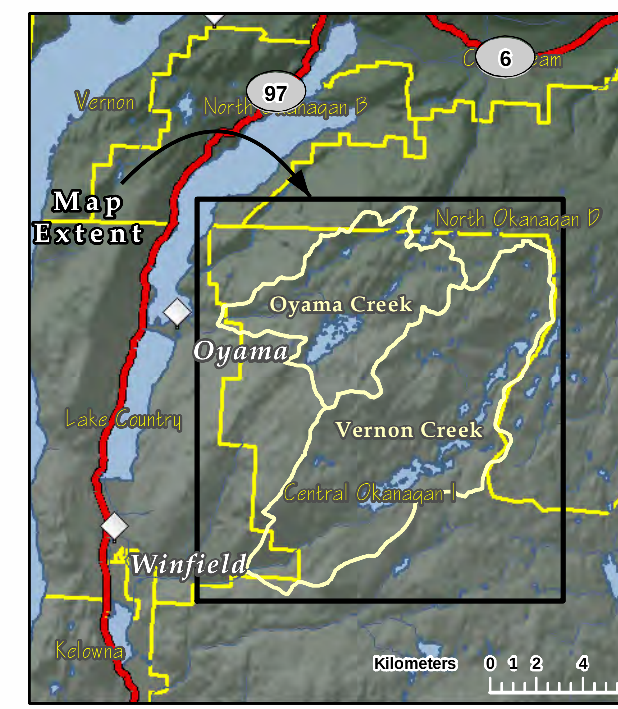
Project:	Watershed Assessment
Location:	District of Lake Country
Project No.:	09-367 and 09-415
Prepared for:	District of Lake Country
Prepared by:	Ecoscape Environmental Consultants Ltd.
Drawn by:	Robert Wagner
Checked by:	Mary Ann Olson-Russello
Projection:	NAD83-UTM Zone 11
Date:	June 11, 2010

Legend

- Vernon Creek Intake
- Assessment Area
- Major Roads
- Streams
- Lake
- Private Pasture Land

Range Tenure Holder

- Coldstream Ranch (2002) Ltd.
- David Allingham
- Eldorado Ranch Ltd.
- George Holt



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ECOSCAPE Environmental Consultants Ltd.

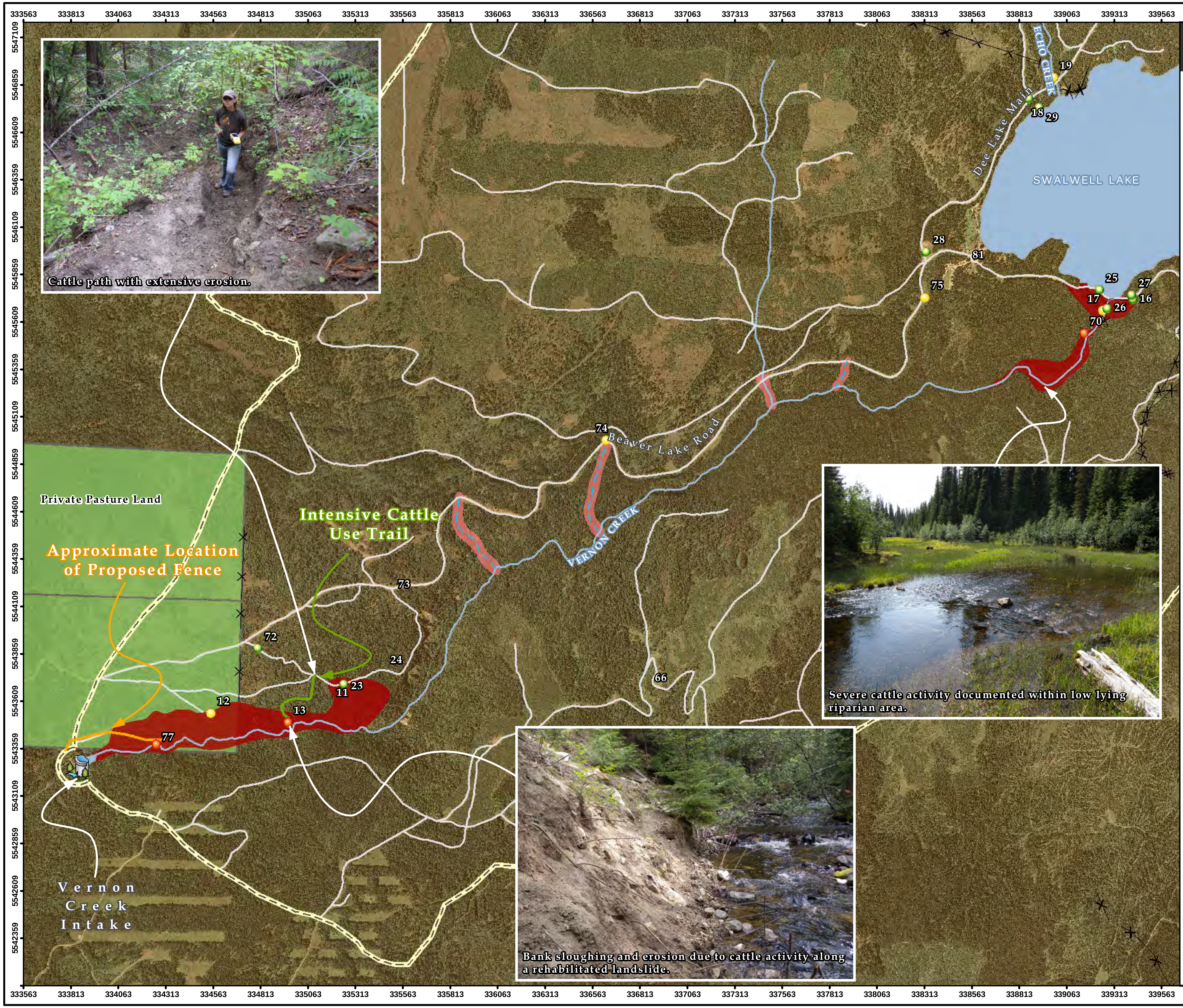


Figure 2-9b - Vernon Creek Watershed: Intensive Cattle Use Areas

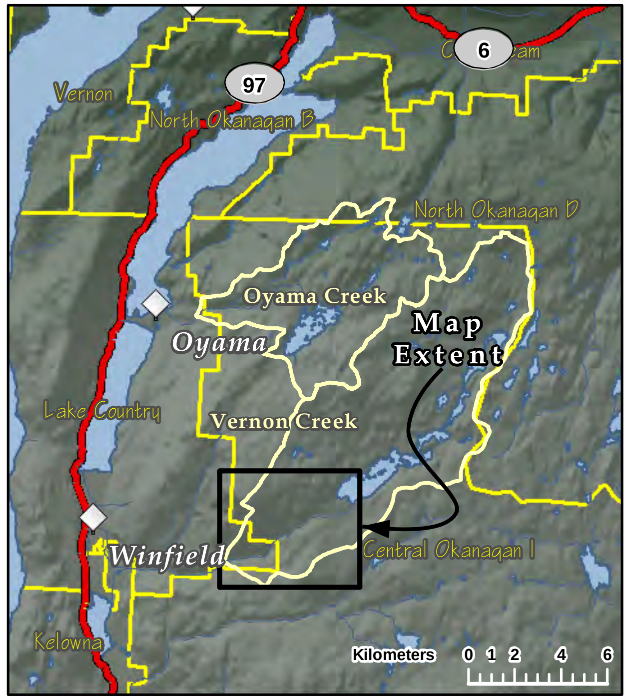
Project:	Watershed Assessment
Location:	District of Lake Country
Project No.:	09-367 and 09-415
Prepared for:	District of Lake Country
Prepared by:	Ecoscape Environmental Consultants Ltd.
Drawn by:	Robert Wagner
Checked by:	Mary Ann Olson-Russello
Projection:	NAD83-UTM Zone 11
Date:	June 11, 2010

Legend

- Vernon Creek Intake
- Assessment Area
- Major Roads
- Streams
- Ephemeral Streams (Airphoto/DEM Interpretation)
- Lake
- Approximate Location of Proposed Fence
- Intensive Cattle Use Area
- Cattle Access Via Ephemeral Streams
- Intensive Cattle Use Trail
- Private Pasture Land

Documented Cattle Presence

- High Severity
- Moderate Severity
- Low Severity



Meters 250 125 0 250 500 750 1,000

1:20,000

ECOSCAPE Environmental Consultants Ltd.

Figure 2-9c - Oyama Creek Watershed: Intensive Cattle Use Areas

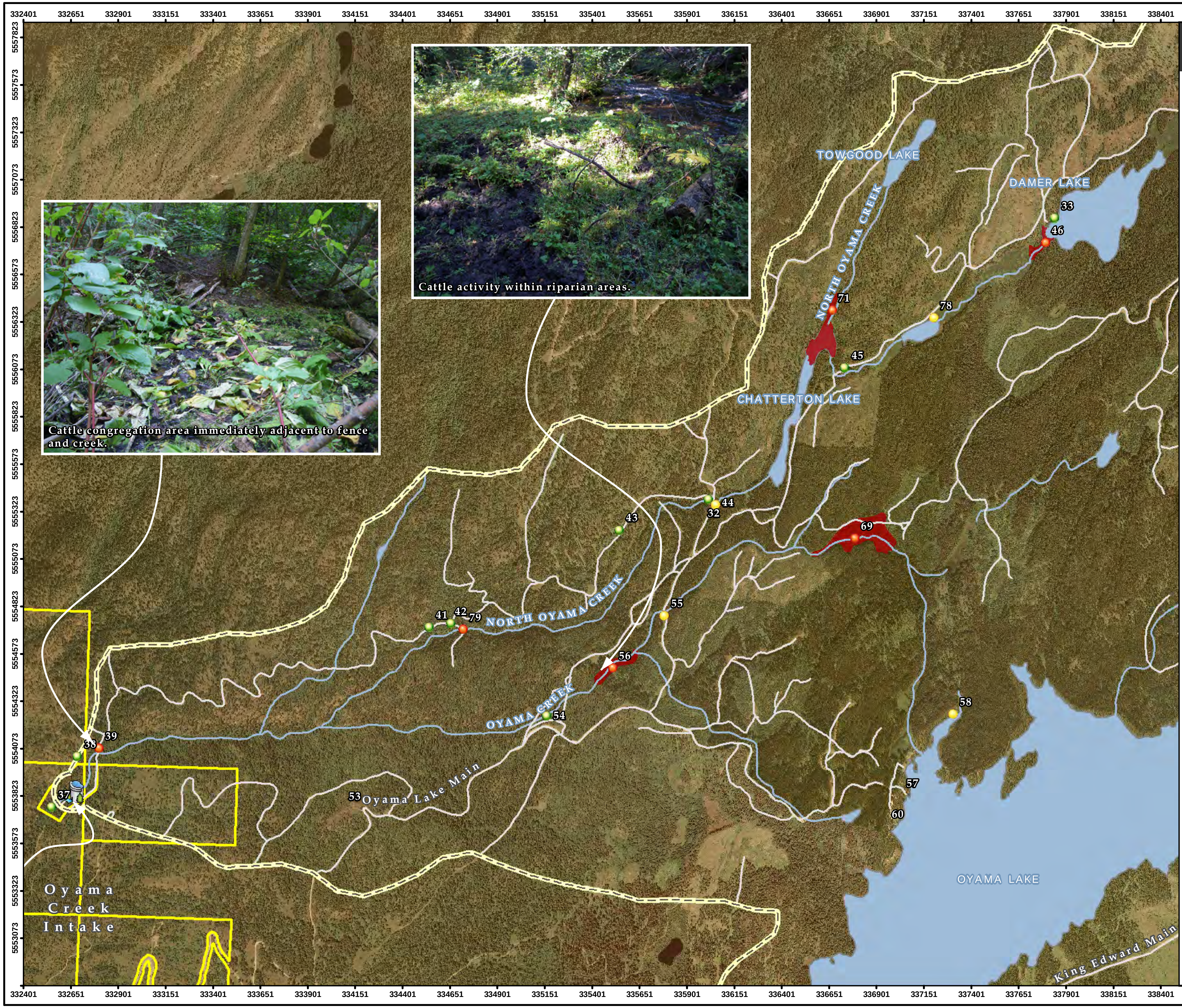
Project:	Watershed Assessment
Location:	District of Lake Country
Project No.:	09-367 and 09-415
Prepared for:	District of Lake Country
Prepared by:	Ecoscape Environmental Consultants Ltd.
Drawn by:	Robert Wagner
Checked by:	Mary Ann Olson-Russello
Projection:	NAD83-UTM Zone 11
Date:	June 11, 2010

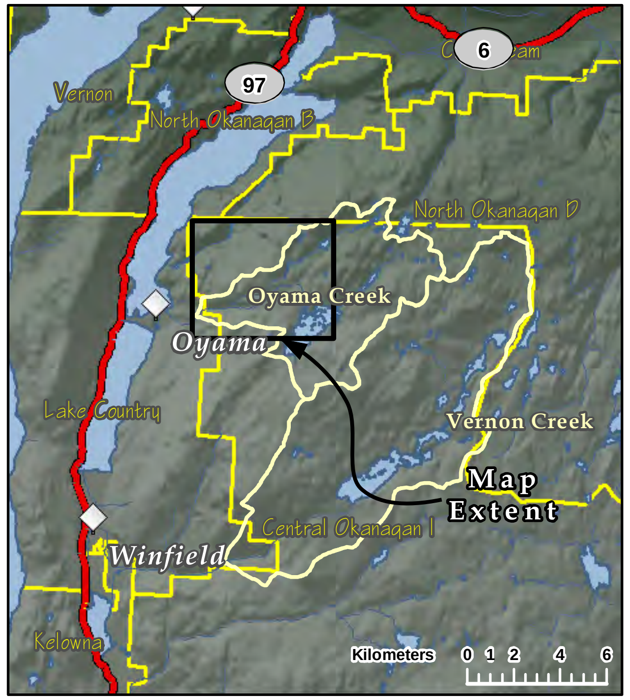
Legend

- Oyama Creek Intake
- Assessment Area
- Major Roads
- Streams
- Lake
- Intensive Cattle Use Area

Documented Cattle Presence

- High
- Moderate
- Low





250 125 0 250 500 750
Meters
1:20,000

ECOSCAPE Environmental Consultants Ltd.

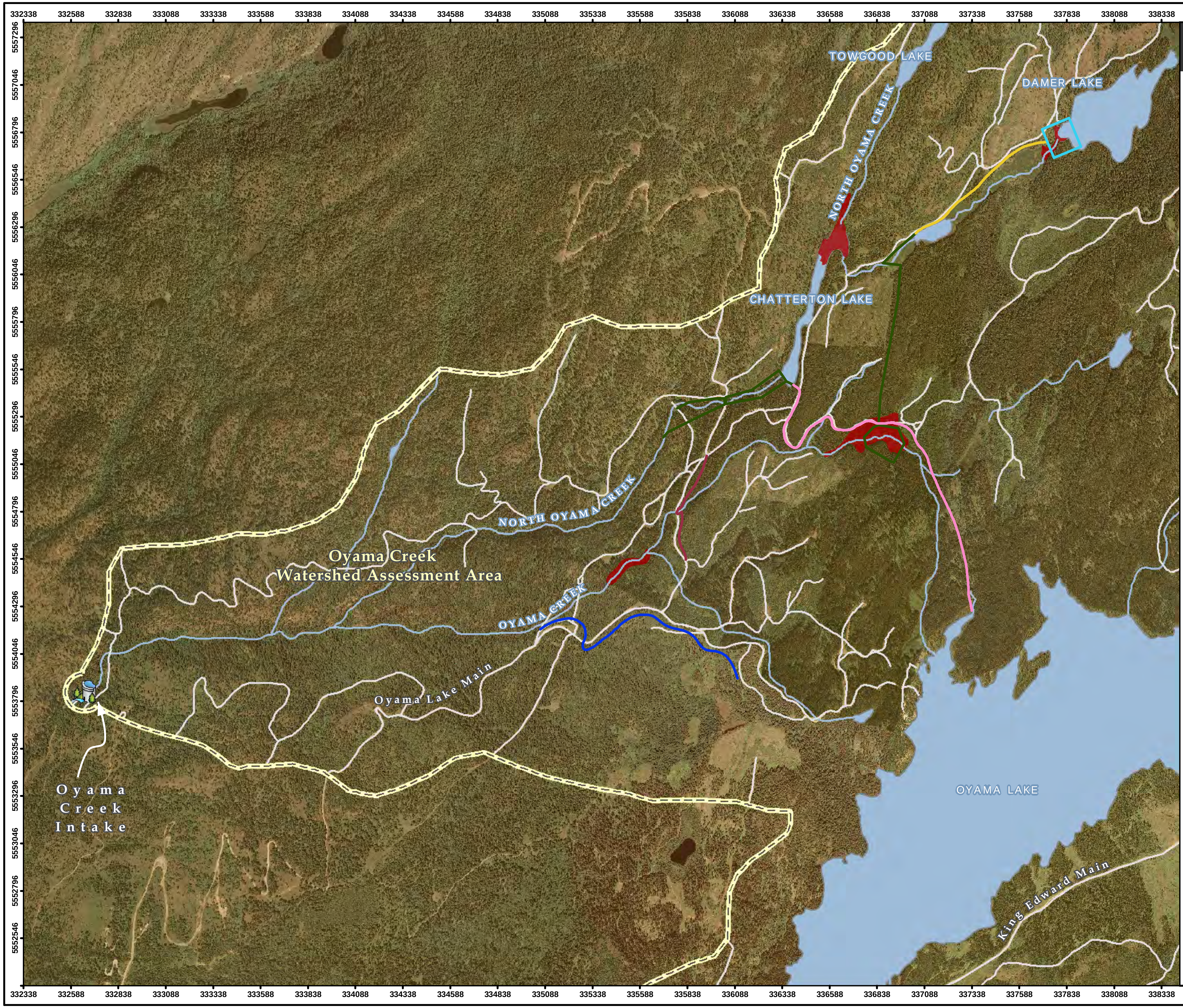


Figure 2-9d - Oyama Creek Watershed: MoFR Proposed Mitigative Fencing

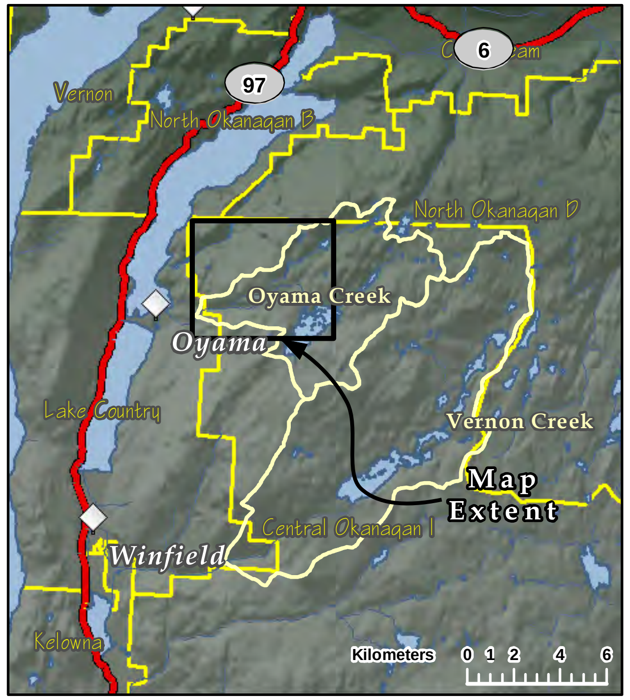
Project:	Watershed Assessment
Location:	District of Lake Country
Project No.:	09-367 and 09-415
Prepared for:	District of Lake Country
Prepared by:	Ecoscape Environmental Consultants Ltd.
Drawn by:	Robert Wagner
Checked by:	Mary Ann Olson-Russello
Projection:	NAD83-UTM Zone 11
Date:	June 11, 2010

Legend

- Oyama Creek Intake
- Assessment Area
- Major Roads
- Streams
- Lake

Mitigative Fencing

- Rebuilt existing fences completed Sept. / Oct. 2009 JOP
- New construction +/- 50 metres completed Sept. 2009 JOP
- New construction in progress Oct. / Nov. 2009 under CRIRRP
- New construction in progress Oct. / Nov. 2009 under remedial JOP
- Phase 1 proposed: outlet of Damer Lake tentative spring 2010
- Phase 2 proposed: link Ince Lake existing fence to (proposed) Damer outlet fence (2010?)



Meters 250 125 0 250 500 750

1:20,000

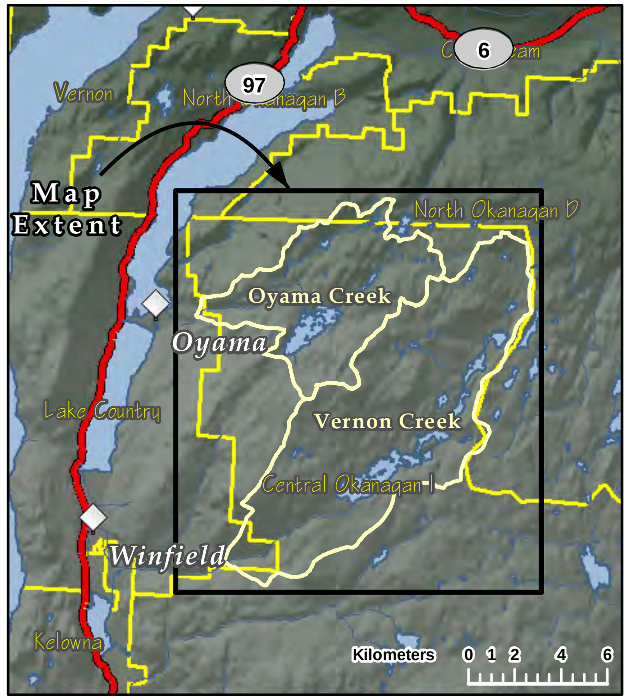
ECOSCAPE

Figure 2-10 - Mineral and Placer Claims

Project:	Watershed Assessment
Location:	District of Lake Country
Project No.:	09-367 and 09-415
Prepared for:	District of Lake Country
Prepared by:	Ecoscape Environmental Consultants Ltd.
Drawn by:	Robert Wagner
Checked by:	Mary Ann Olson-Russello
Projection:	NAD83-UTM Zone 11
Date:	June 11, 2010

Legend

Vernon Creek Intake
Assessment Area
Major Roads
Streams
Lake
Mineral and Placer Claims



1,000 500 0 1,000 2,000
Meters
1:70,000

ECOSCAPE
Environmental Consultants Ltd.

Figure 7-1a - Oyama Creek Watershed: Road Risk

Project:	Watershed Assessment
Location:	District of Lake Country
Project No.:	09-367 and 09-415
Prepared for:	District of Lake Country
Prepared by:	Ecoscape Environmental Consultants Ltd.
Drawn by:	Robert Wagner
Checked by:	Mary Ann Olson-Russello
Projection:	NAD83-UTM Zone 11
Date:	June 11, 2010

Legend

- Oyama Creek Intake
- Assessment Area
- Major Roads
- Streams
- Lake

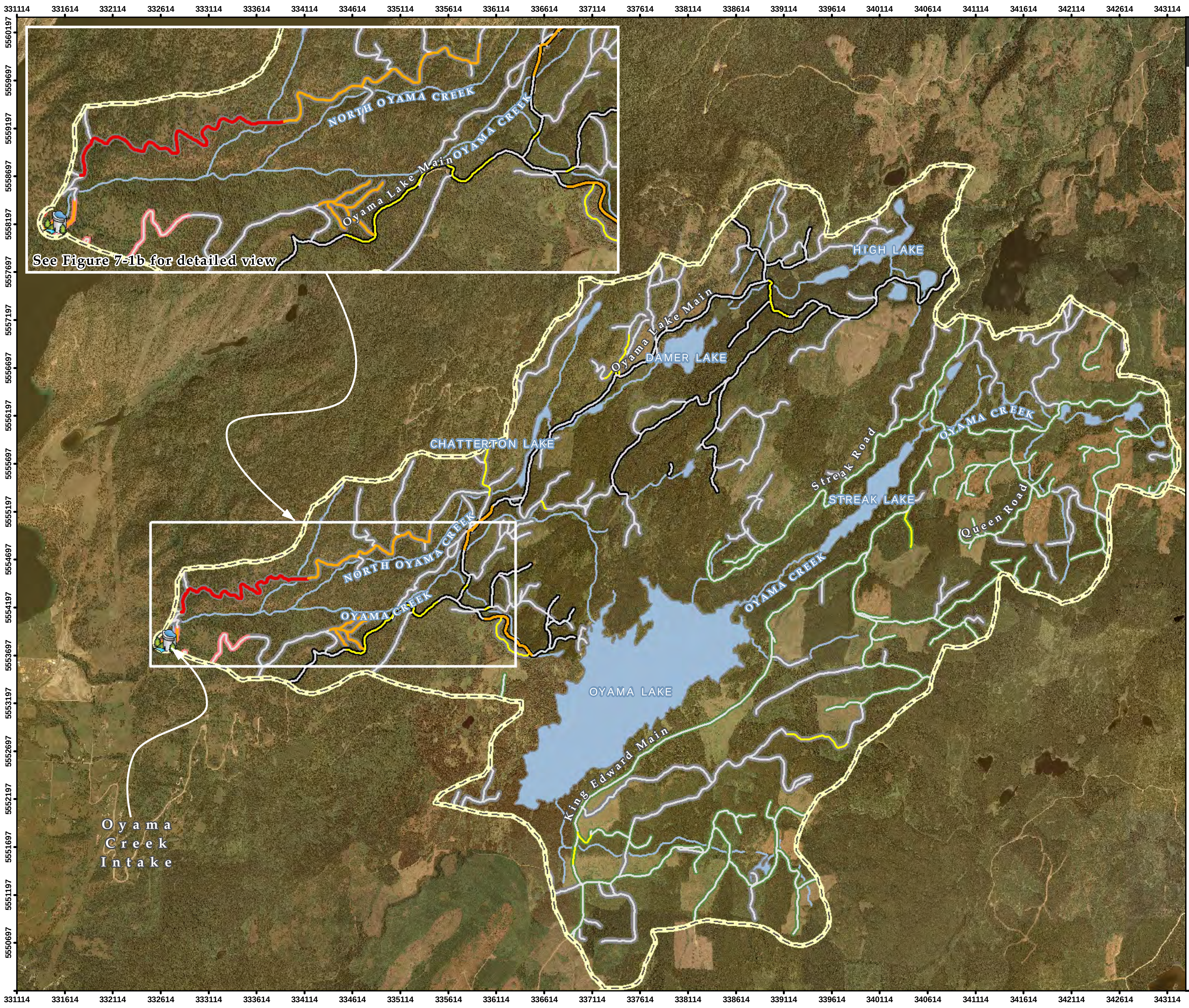
Road Risk Rating

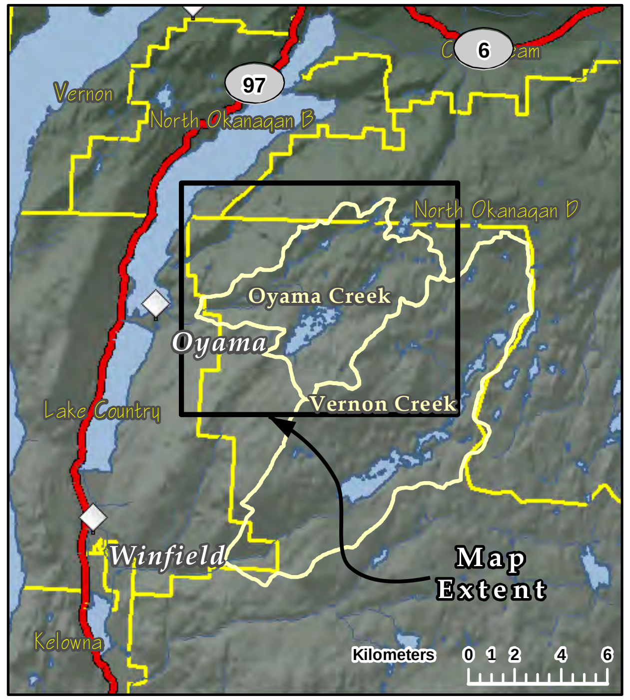
- Very High
- High
- Moderate
- Low

Responsible Party

- BC Timber Sales
- Tolko
- Private
- Non-Status Road

Note:
Road Risk data provided by M.J. Milne & Associates Ltd.





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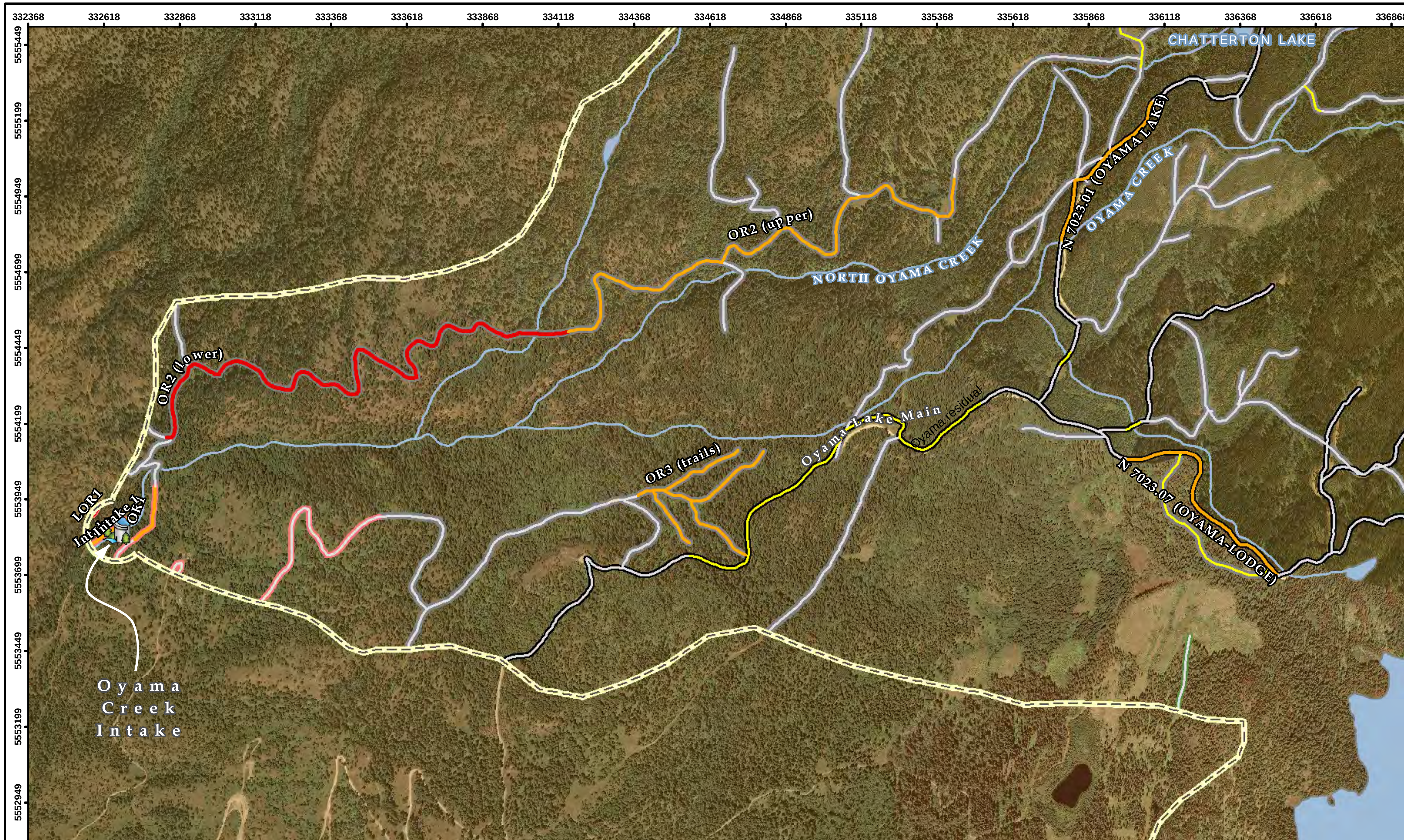
ECOSCAPE
Environmental Consultants Ltd.

Figure 7-1b - Oyama Creek Watershed: Very High and High Road Risk



Project: Watershed Assessment
Location: District of Lake Country
Project No.: 09-367 and 09-415
Prepared for: District of Lake Country
Prepared by: Ecoscape Environmental Consultants Ltd.
Drawn by: Robert Wagner
Checked by: Mary Ann Olson-Russello
Projection: NAD83-UTM Zone 11
Date: June 11, 2010

Legend

- Oyama Creek Intake
- Assessment Area
- Major Roads
- Streams
- Lake

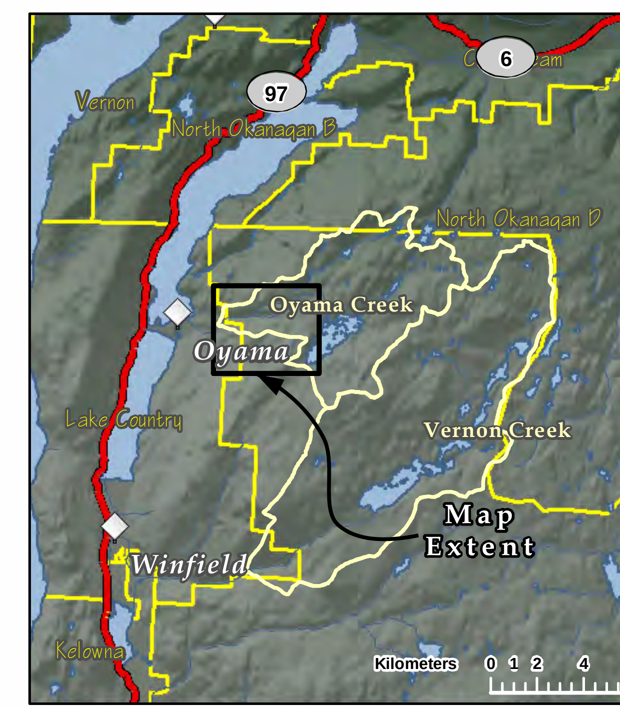
Road Risk

- Very High
- High
- Moderate
- Low

Responsible Party

- BC Timber Sales
- Tolko
- Private
- Non-Status Road

Note:
Road Risk data provided by M.J. Milne & Associates Ltd.



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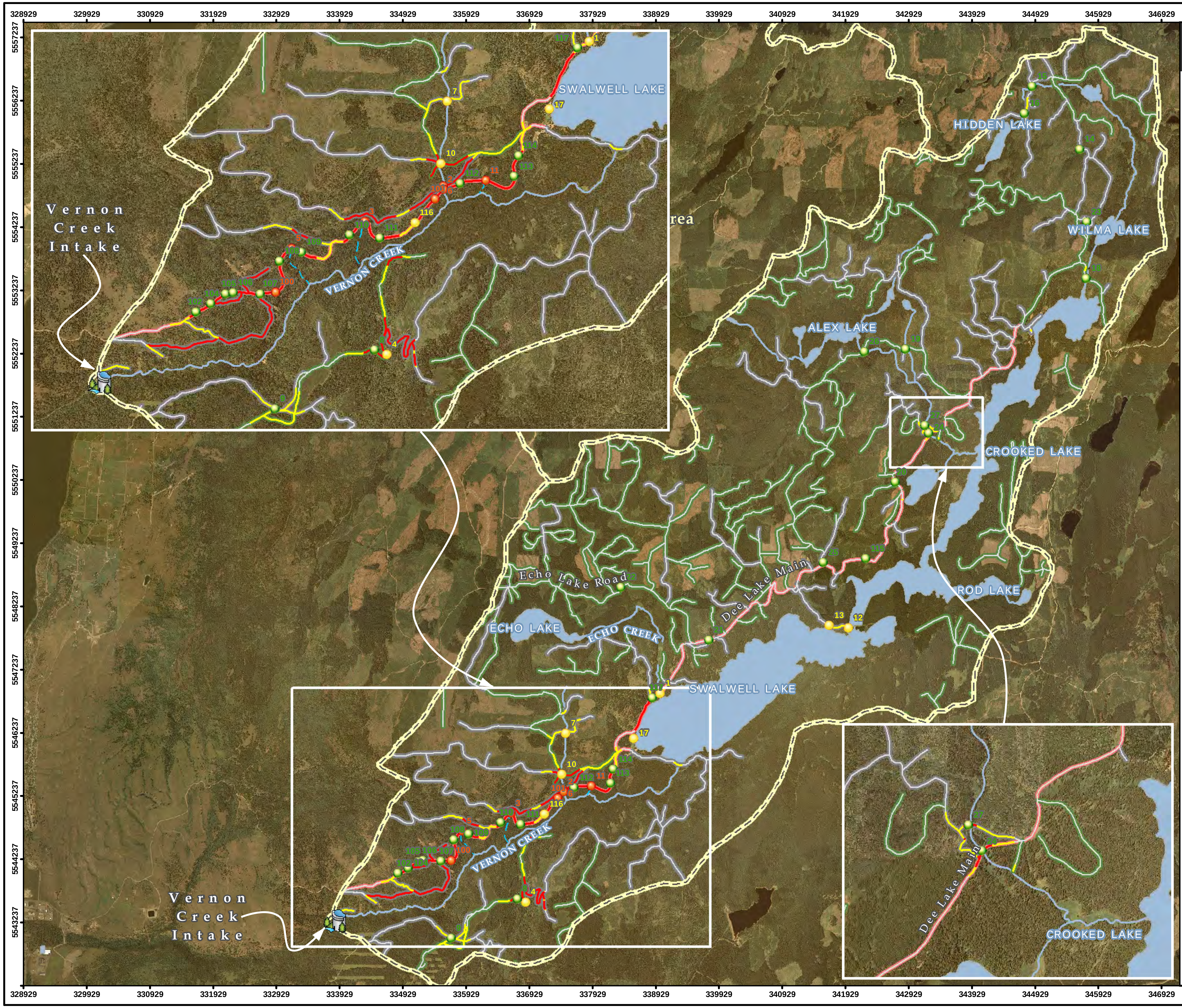
Oyama Creek Watershed Road Risk

Road	Responsible Party	Basin	Comments	Length (m)	Hazard	Resource at Stake	Probability of Hazard Occurance	Effect on Resource at Stake	Risk
OR2 (lower)	Non-status	Oyama residual	Deactivation insufficient or failing as a result of ATV and range use. Drainage uncontrolled above steep coupled slope.	2025.219	Road erosion, landslide, debris flow or flood on mainstem	Water quality, District intake infrastructure	H	H	VH
LOR1	Private	Oyama residual	Uncontrolled drainage onto steep coupled slopes, multiple landslides into Oyama Creek, increasing likelihood of debris flood or flood related damage.	43.942	Landslides, increased sediment load on mainstem channel, road erosion.	Public safety on fan, private land, private road infrastructure	H	H	VH
N 7023.01 (OYAMA LAKE)	BCTS	Oyama residual	Long downhill approach, surface erosion, sediment input to Oyama Creek. Structure is sufficient.	592.947	Surface erosion, sediment input mainstem channel.	Water quality	H	M	H
N 7023.07 (OYAMA-LODGE)	BCTS	Oyama residual	Erosion on steep grades close to stream, sediment input to main Oyama Creek tributary. Road too close to stream, should be relocated.	775.047	Road erosion, sediment input to streams	Water quality, road infrastructure	H	M	H
OR3 (trails)	Non-status	Oyama residual	Deactivation failing or insufficient, diversions above steep coupled slopes, fill in draws.	1275.004	Landslide, road erosion	Water quality	M	H	H
OR2 (upper)	Non-status	Oyama residual	Deactivation failing, limited runoff but drainage becoming uncontrolled above steep coupled slope	1907.589	Road erosion, landslide, possible debris flow or debris flood on mainstem	Water quality, District intake infrastructure	M	H	H
OR1	Private	Oyama residual	Light pullback done with waterbars, insufficient to achieve low risk situation, fill in draws, limited runoff but moving water.	203.116	Landslide in mainstem	Water quality, District intake infrastructure	M	H	H
Intake 1	Private	Oyama residual	Road and crossing built on floodplain, potential to divert flows with avulsion resulting in road erosion.	151.866	Road erosion, increased sediment load on mainstem channel.	Public safety on fan, private land, private road infrastructure	M	H	H

ECOSCAPE Environmental Consultants Ltd.

Figure 7-2 - Vernon Creek Watershed: Road and Stream Crossing Risk

Project:	Watershed Assessment
Location:	District of Lake Country
Project No.:	09-367 and 09-415
Prepared for:	District of Lake Country
Prepared by:	Ecoscape Environmental Consultants Ltd.
Drawn by:	Robert Wagner
Checked by:	Mary Ann Olson-Russello
Projection:	NAD83-UTM Zone 11
Date:	June 11, 2010



Legend

- Vernon Creek Intake
- Assessment Area
- Streams
- Ephemeral Streams (Airphoto/DEM Interpretation)
- Lake

Road Risk Rating
- High
- Moderate
- Low

Responsible Party
- Tolko
- Public Roads
- Non-status Roads

Stream/Culvert Crossing Risk
- High
- Moderate
- Low

1,000 500 0 1,000 2,000
Meters
1:60,000

ECOSCAPE Environmental Consultants Ltd.

Figure 7-3 - Vernon Creek Watershed: High Stream Crossing Risk

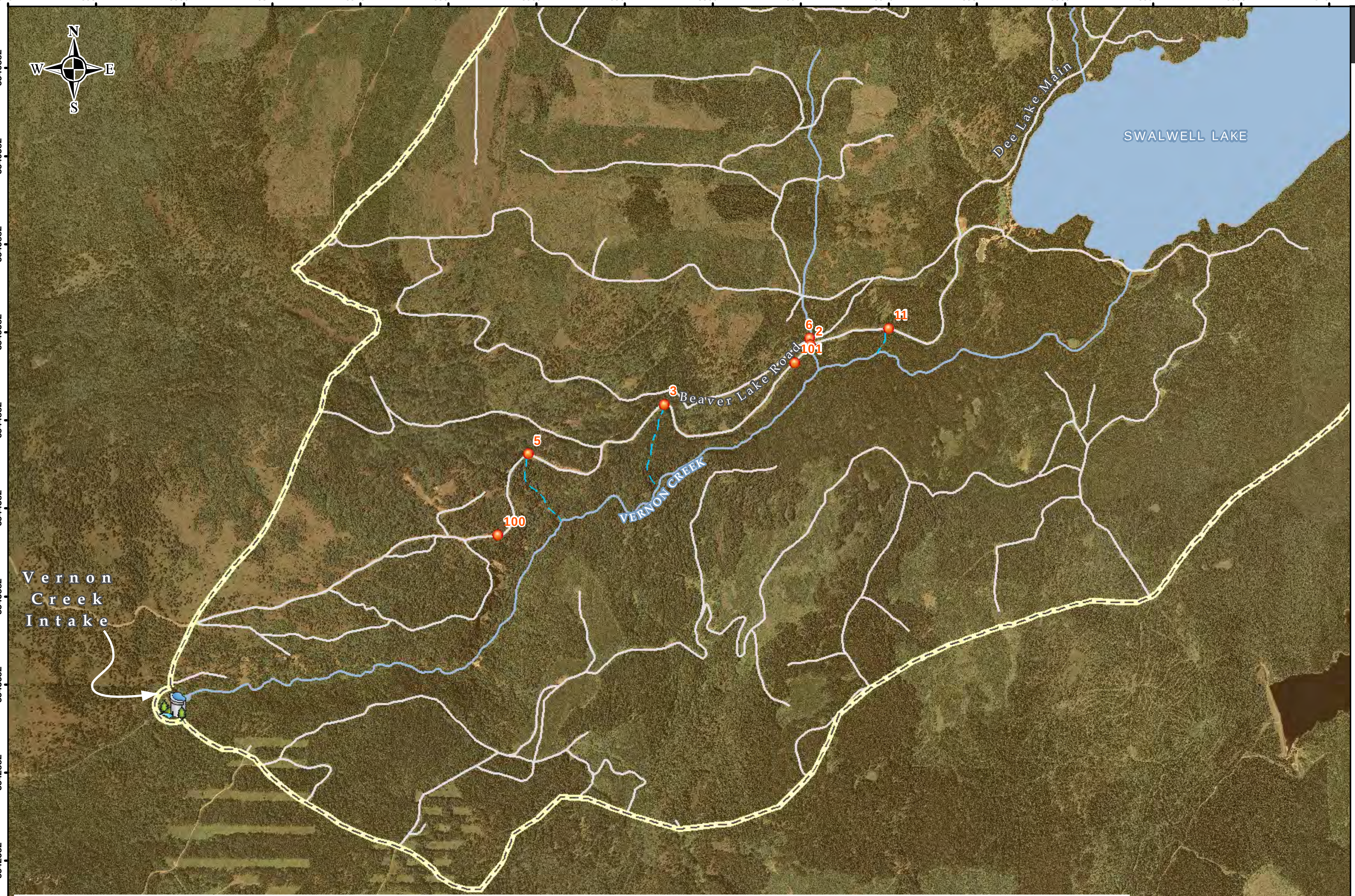
Project:	Watershed Assessment
Location:	District of Lake Country
Project No.:	09-367 and 09-415
Prepared for:	District of Lake Country
Prepared by:	Ecoscape Environmental Consultants Ltd.
Drawn by:	Robert Wagner
Checked by:	Mary Ann Olson-Russello
Projection:	NAD83-UTM Zone 11
Date:	June 11, 2010

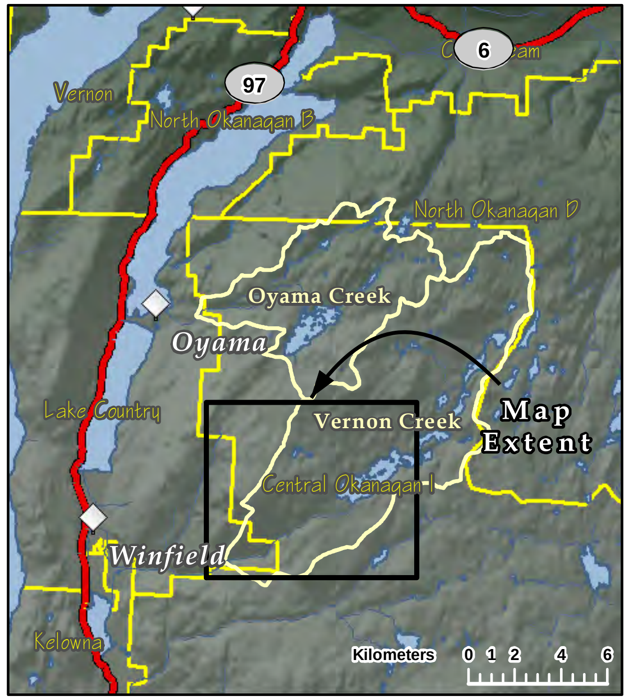
Legend

Vernon Creek Intake
Assessment Area
Roads
Streams
Ephemeral Streams (Airphoto/DEM Interpretation)
Lake

Stream/Culvert Crossing Risk

High





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Vernon Creek Watershed: High Risk Stream Crossings and Drainage.							
Stream Crossing	Crossing Comment	Sediment Delivery Score	Sediment Delivery Interpretation	Ecoscape Grouping	Liklihood	Consequence	Risk
2	Fill erosion. Regularly monitor and implement erosion control measures	0.64	Moderate	High	Likely	Minor	High
3	Fill erosion at outlet, cattle crossing. Implement erosion control measures	0.53	Low to Moderate	High	Likely	Minor	High
5	Implement erosion control measures	0.43	Low to Moderate	High	Likely	Minor	High
6	Outer plounge, scour. Regularly monitor	0.20	Slight	High	Likely	Minor	High
11	Intermitant flows	0.18	Very Minor	High	Likely	Minor	High
Drainage Culvert							
100	Significant water movement along rear ditch, defined outflow channel 30 m from top of bank. Clean out top end of culvert	0.40	Low to Moderate	High	Likely	Minor	High
101	Poorly defined channel all the way to creek, approx 100 m	0.40	Low to Moderate	High	Likely	Minor	High

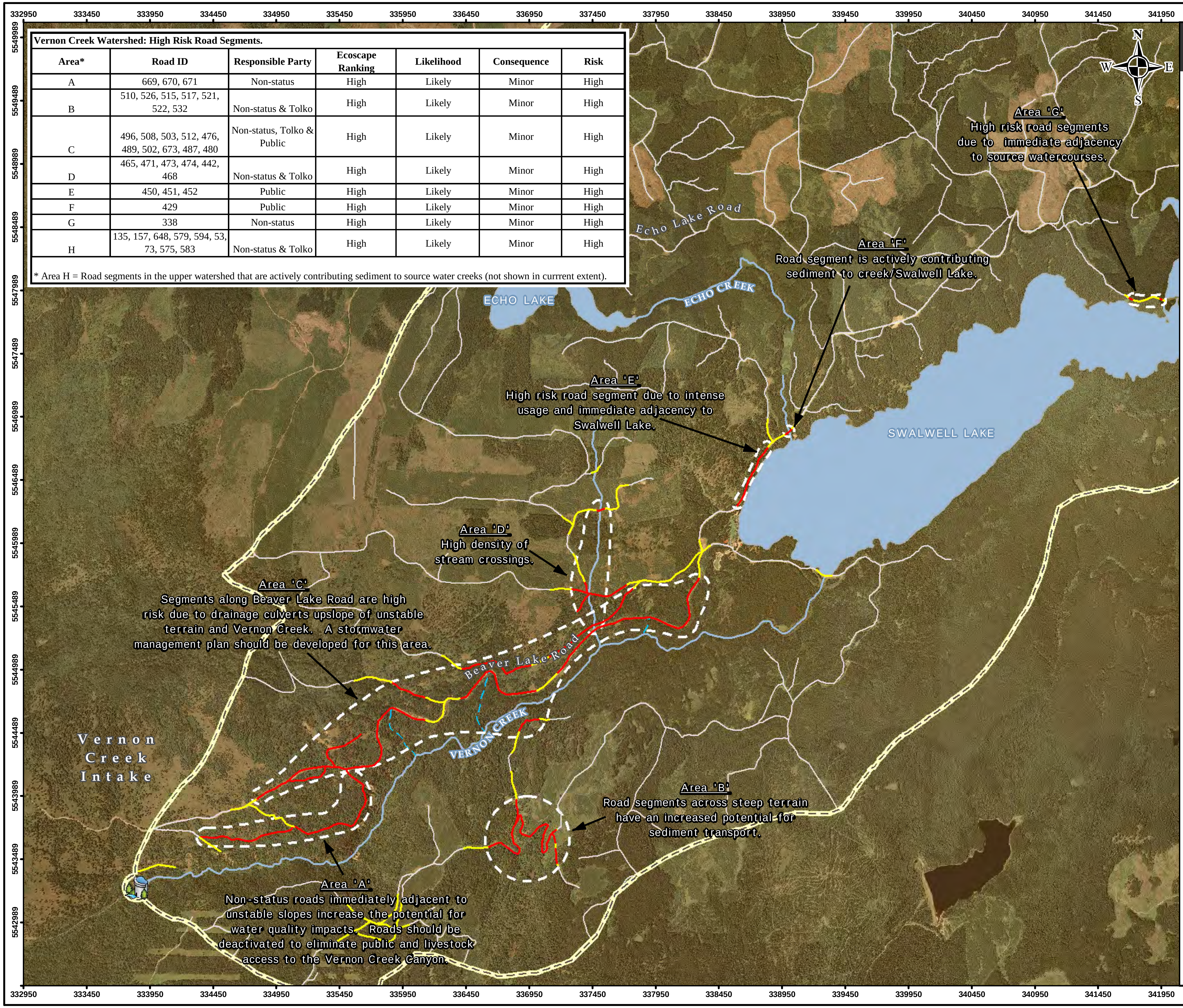
Figure 7-4 - Vernon Creek Watershed: High Road Risk

Project:	Watershed Assessment
Location:	District of Lake Country
Project No.:	09-367 and 09-415
Prepared for:	District of Lake Country
Prepared by:	Ecoscape Environmental Consultants Ltd.
Drawn by:	Robert Wagner
Checked by:	Mary Ann Olson-Russello
Projection:	NAD83-UTM Zone 11
Date:	June 11, 2010

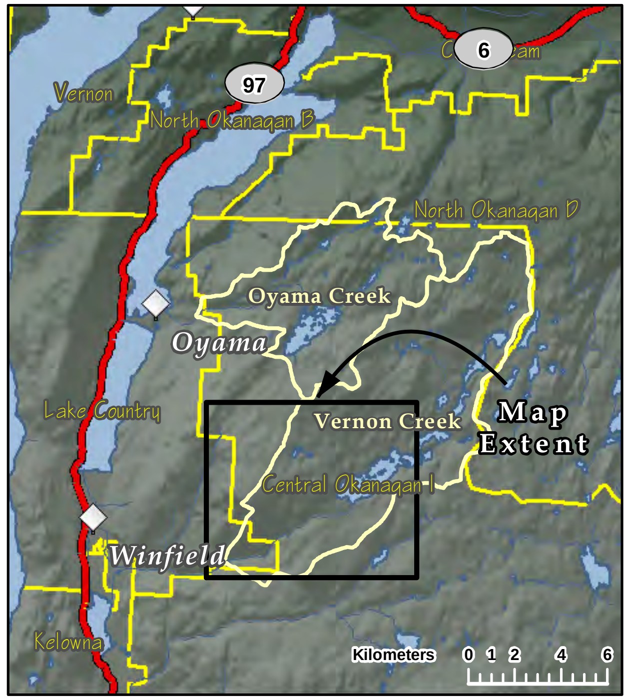
Vernon Creek Watershed: High Risk Road Segments.

Area*	Road ID	Responsible Party	Ecoscape Ranking	Likelihood	Consequence	Risk
A	669, 670, 671	Non-status	High	Likely	Minor	High
B	510, 526, 515, 517, 521, 522, 532	Non-status & Tolko	High	Likely	Minor	High
C	496, 508, 503, 512, 476, 489, 502, 673, 487, 480	Non-status, Tolko & Public	High	Likely	Minor	High
D	465, 471, 473, 474, 442, 468	Non-status & Tolko	High	Likely	Minor	High
E	450, 451, 452	Public	High	Likely	Minor	High
F	429	Public	High	Likely	Minor	High
G	338	Non-status	High	Likely	Minor	High
H	135, 157, 648, 579, 594, 53, 73, 575, 583	Non-status & Tolko	High	Likely	Minor	High

* Area H = Road segments in the upper watershed that are actively contributing sediment to source water creeks (not shown in currrent extent).



Legend



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ECOSCAPE Environmental Consultants Ltd.

APPENDIX A

STAKEHOLDER QUESTIONNAIRE AND RESPONSE

Dear Stakeholder,

Please complete the following questionnaire. Responses will be considered in the preparation of the Source Water Protection document. It is purely optional to include your name and contact information however, by doing so you may be contacted for further clarification.

---

1. What is your connection/interest in the Oyama and Vernon Creek watersheds? Are you affiliated with one or both watersheds? If one, which one?

- Manage the range program for the Okanagan Shuswap Forest District (grazing licensees in both watersheds
- I am a planning forester with BC Timber Sales. BCTS has operations in the Oyama Creek watershed and to a much lesser degree, in the Vernon Creek watershed.
- I am a co-owner of Dee Lake Wilderness Resort Ltd. in the Vernon Creek watershed.
- I am the small scale salvage coordinator for Okanagan Shuswap F.D. We have significant interest from salvagers in both watersheds, and much of the area of interest is within Lakeshore Management Zones, as these are the main areas that are not being harvested by major licensees.
- Range tenure holder – Vernon Creek watershed
- Provided potable water for 450 customers (homes), school (Peter Greer) Clearwater subdivision.
- Own a leasehold lot on Swalwell.
- Tolko Ind. Ltd. Forest Licensee with active operations; timber harvesting, road construction, maintenance and deactivation and silviculture operations in both watersheds.
- Oyama Creek runs through Pier Mac property for approx. 2 km. We have 2 water licenses. The Oyama water district has an easement on our property to transfer water to their systems.

2. What do you see as the greatest threat to drinking water quality for each respective watershed?

- Oyama and Vernon Creek watersheds – no one threat but a combination of all.
- Unmanaged cattle that get into creeks; roads where the ditches and culverts are not properly maintained; off road motor bike and ATV users; improperly deactivated roads without adequate or enough waterbars.
- The uncontrolled proliferation of wandering cattle. The lack of management with respect to the use of this resource as a recreation asset.
- I am not a hydrologist, but these CWS's have so many different and extensive uses. I think cumulative impacts from all the uses present a large threat. Between harvest of

MPB and associated roads, cabins on reservoir lakes, cattle and mud bogging – I don't know which is the greatest threat.

- Irresponsible use
- Lack of coordinated plan of protection.
- Contamination due to cattle grazing, logging and ATV usage.
- Sediment production into streams and contamination from animals and humans – mainly livestock grazing, sediment from various sources including old non-status forestry roads, recreation/ATV's, livestock watering, etc.
- All uses below the reservoirs where impacts are directly connected to intakes.
- Water contamination - human, livestock, forestry

3. In your opinion, what are the most important steps that should be undertaken to successfully protect source water?

- Collaborative approach to planning and resolution of issues. The source water assessment report should be used to both identify areas of risk and then identify the recommendation to mitigate the risk. It seems that CWS's should be viewed as a single entity with several users and therefore a single funding source should be allocated to improvements to mitigate water quality concerns.
- Exclusion of cattle, or at least better control of cattle movement within the watershed. Better control of motor bike and ATV users in the watershed.
- Eliminate access of the cattle to this area. Manage and monitor use by the public. Convert the leases to freehold
- Good evaluation of risks. Good cattle management practices to keep cows out of streams/reservoirs. Better management of human impacts – recreation of all types. Good forestry practices to manage cattle movement, sediment inputs, etc. Restricting watershed access is a interesting idea, but won't go over well with public, and hard to do with all the potential access routes, also hard with active logging to put in a gate.
- Everyone putting forth honest effort, public awareness
- What we are doing now
- Educate the public and all stakeholders as to best practices that will protect the water supply. Coordinate efforts, as started today, to work towards a common purpose.
- Identify issues in the watersheds that effect water quality (inventory). Create list of point sources of contamination. Identify solutions to address issues, who, funding options, partnerships
- Keep livestock from having access to the creek – fencing. Make sure all run off water is contained from running into the creek. Divert water into troughs (with salt blocks nearby) for cattle. No sewer seepage into watershed – potable water/sewersystems mandatory for cabin owners?

4. In your role as a watershed stakeholder, how can you best assist in source water protection?

- Ensuring that all harvest activities adhere to the rules and regulation found in FRPA and the BCTS Forest Stewardship Plan
- Participate as a member of a committee involved in all aspects of the use, development, zoning and management of the watershed.
- I can help to manage what harvesting activities take place under small scale salvage. I would like to gain a better understanding of what the biggest risks (related to salvage) are, and how I can help to manage those risks. While I don't prepare harvest plans myself, I can influence what goes into them, and what we approve.
- Monitoring and communication from others in the watershed and action when we are informed.
- Follow-up on the suggestions outlined in my source water protection study.
- I would like guidance as to how to further protect the watersheds. The O.C.O.A. and resort owners have published a brochure to help educate the public but agencies should work together to establish guidelines and promote good stewardship. Perhaps individual site visits, by request, would be beneficial.
- Provide resource use/inventory data. Partner with water purveyors to address sediment issues that are in our area of responsibility. Work with stakeholders to plan and implement harvesting and road building to address water quality issues and livestock access to water or seepage areas. Would be nice to have a spatial data set of the infrastructure in the watersheds (dams, ditches, pipelines, diversions, intakes….) So we can ensure we don't impact these through our operations.

5. Please provide anything in addition that should be considered in the preparation of Source Water Protection Plans for the Oyama and Vernon Creek watersheds.

- Establish a committee involved in all aspects of the use, development, zoning and management of the watershed. Increase controlled campsites and recreation areas. Improve the main road structure with dust control measures. Establish hydro to facilitate the elimination of generators, fuel storage and state of the art wastewater treatment.
- Could natural barriers be inventoried and mapped?
- Have my well protection study and would like to discuss the implementation of the remaining steps and ways that Alto can contribute.
- Impacts of MPB and various salvage harvesting scenarios. Who has responsibility for what sediment sources? Range/recreation issues that affect water quality. Sources of funding for any recommended works.

6. Contact Information (optional):

i. **Name:**
ii. **Organization:**
iii. **Phone:**
iv. **Email:**

APPENDIX B

STAKEHOLDER MEETING MINUTES

District of Lake Country
Municipal Office
10150 Bottom Wood Lake Road, Lake Country, British Columbia V4V 2M1
Telephone: 250-766-5650 Fax: 250-766-0116

VERNON/OYAMA CREEK WATERSHEDS STAKEHOLDERS

MINUTES

Date: Wednesday, September 23, 2009

Time: 8:30 a.m.

Place: Council Chambers, Municipal Hall
10150 Bottom Wood Lake Road

Staff: Jack Allingham, Utilities Manager (Chair)
Sean Lefebvre, Operations Manager
Patti Hansen, Water Quality
Deb Youngest, Recording Secretary

Present: Councillor Barb Leamont
Brian Bedard, BC Timber Sales
Brad Allingham, rancher
Dave Allingham, rancher
Larry Fallis, Alto Utilities
Kevin Bennett, Eldorado Ranch
Tracey Mitchell, OK Cottage Owners Association
Russ Meldrum, OK Cottage Owners Association
Ron Smith, ILMB
Ivor Norland, Interior Health
Jason Schleppe, Ecoscape
Deanna Drouillard, Oyama Lake Resort
Bryn Lord, Interior Health
Mary Ann Olson-Russello, Ecoscape)
Lloyd Manchester, OK Cottage Owners Association
Jody McCall, Coldstream Ranch
Nick Babty, Coldstream Ranch
Terry Brown, Dee Lake Resort
Nick Imthorne, cabin owner
George Holt, rancher
Harold Waters, Tolko
Katherine Ladyman, Ministry of Forests
Wesley Miles, RDCO
Margaret Bakelaar, RDCO
Heather Schellenberg, Pier Mac
Rob Dinwoodie, Ministry of Forests

The meeting was called to order at 8:30 a.m. by Jack Allingham.

1. Agenda & Opening Remarks

Leamont/Fallis
That the Watershed Stakeholders' Meeting Agenda for September 23, 2009 be adopted.
Carried.

The Chair noted that the meeting was part of the Oyama and Vernon Creek Watershed Assessment process, and its purpose was to elicit feedback from stakeholders in the watersheds as part of that process. Around-the-table introductions were made.

2. Source Water Assessment General Process

The Chair noted that the Watershed Assessment and Protection Plan is a requirement set out by Interior Health (IH) as a Condition on the District's Permit to Operate, and must meet the parameters as set out by IH. The consulting firm Ecoscape has been retained to carry out the assessment. Funding has been provided from within the District's budget coupled with grant funding from the Okanagan Basin Water Board.

3. SWA methodology & hazard overview (Ecoscape - Jason Schleppe)

Jason Schleppe of Ecoscape Consulting gave a PowerPoint presentation, highlighting:

- The objective of source water protection is to ensure a reliable source of safe drinking water. Source protection is an important part of the Multi Barrier Approach to water quality.
- The Watershed Assessment and Protection Plan objectives are based on Modules 1, 2, 7 and 8 of the source protection guidelines:
    - Module 1- Delineate and characterize the physical characteristics of the watersheds, such as the multiple water sources and water supply infrastructure.
    - Module 2 – Identify potential contaminants, whether inherent biophysical risks or anthropogenic risks.
    - Module 7 – Risk analysis to characterize risks based on a combination of likelihood (probability) and consequence (severity of effect).
    - Module 8 - Generate recommendations based on information gathered and assessed in Modules 1, 2 and 7.
- Examples of source water hazards include:
    - Fecal material (cattle, wildlife, human, domestic pets)
    - Sediment and released organics (roads, forestry, landslides)
    - Trace chemicals (private use, recreational use, industry)
    - Turbidity/release of pathogens (4x4 vehicles, recreation)
    - Clearing of riparian land
- Source water contaminants fall into three main categories:
    - Biological (i.e. fecal matter, parasites)
    - Physical (i.e. sediment)

- Chemical (i.e. pesticides, hydrocarbons)

- Degree of risk is influenced by the location in the watershed where hazards or activities are located. Risk varies over time and space.
- GIS Spatial Analysis enables the mapping of more susceptible areas in order to categorize areas by "watershed vulnerability," as well as identifying and mapping locations of hazards.
- Factors affecting watershed vulnerability include:
  - Proximity to water (main creek, reservoir, above vs. below high water mark)
  - Terrain stability/potential for erosion adjacent to a watercourse
  - Proximity to an intake
  - Elevation within the watershed

The presentation concluded with a demonstration of the GIS system to show the ability of spatial mapping to indicate areas of vulnerability and location of hazards in a fine spatial scale.

4. Forestry open discussion

Issues discussed included:

- Increased potential for risk resulting from increased accessibility to the watershed via forestry road networks.
- The importance of road decommissioning as a way to reduce the risks associated with increased access to the watershed.
- The issue of the "breached barrier":
  - When harvesting activities breach natural barriers to pasture access, cattle can gain continued access to creeks and reservoirs.
  - The burden of responsibility for mitigative measures (i.e. fencing) has fallen to the range tenures.
  - The issue could be addressed at the harvesting stage by leaving "retention strips" and other natural barriers more effectively.
  - The need to seek opportunities for range tenures and forest companies to work together, i.e. to identify natural barriers to cattle movement, use GIS to map the information and thus enabling forestry licensees to incorporate it into their harvesting plans.
- Issues related to wildfire management:
  - the need to balance protection of the watershed and its hydrology against the need for wildfire planning activities.
  - concerns related to the potential for introduction of high-nutrient substances such as fire retardant into shallow or "seep" zones.
- Issues related to coarse woody debris left by harvesting and salvage logging. It was recommended that there should be variability in debris and some open

areas maintained, to ensure that cattle can access cut areas in order to avoid situations where cattle are forced to seek alternative water sources such as main creeks and reservoirs.

- Whether selective harvesting would better enable faster hydrological recovery of the watershed than "clear cutting" and the need to incorporate the most up-to-date information and modeling available in the watershed assessments.

5. Recreation open discussion

Jason Schleppe introduced this discussion by noting that the watersheds are identified by LRMP as "multi-use." Various recreational activities take place within the watersheds, with much of the access resulting from forestry activities. It was noted that recreation in the Vernon and Oyama Creek watersheds is less extensive than in other regional watersheds, likely as a result of less access (fewer roads and trails).

Issues related to recreational access were visually demonstrated by photos taken within the watershed, indicating vandalism, garbage, the results of mud-bogging adjacent to a lake, and cattle accessing the shoreline via a 4x4/quad trail.

Discussion ensued on the following points:

- Concerns related to "partying" and the frequent efforts of cabin owners to clean up the results.
- Gates tend to be ineffective access control measures as they are easily torn down and expensive to replace; boulder placement is more effective for access control but prevents all access.
- Concerns that "recreation damage" is being singled out more dramatically than damages caused by other watershed uses such as forestry or ranching.
- Debate on points related to the designation of the watersheds as "for the purpose of providing irrigation water" versus "drinking water reservoirs.":
    - If the watershed were for irrigation only, the consequence of recreational impacts on water quality would be diminished.
    - The watershed was originally established as an irrigation watershed; the majority of the water licences held by the District on the upper lakes are for irrigation supply, with about 20% for drinking water.
    - During the 1960's the water system was rehabilitated and drinking water systems were established at the request of community residents.
    - Whereas the original intent may have been irrigation, the costs involved in cutting the watershed off from domestic use would be substantial.
- The lack of accountability of recreational users. It was noted that a key recommendation made for SEKID was the need for a licensing and regulation system for people using the watershed.

6. Private holdings and lease lots open discussion

The Utility Manager noted that within the Vernon Creek and Oyama watersheds, there are three resorts, two large private owners, and fifty-one leased recreational lots.

The location of various private holdings was reviewed on the GIS system, and risks related to private land use were visually demonstrated by photos of substrate modification, dock-building, clearing of riparian areas, and burning activities in the foreshore, activities that lead to potential sources of sediment. Discussion ensued on the following points:

- Private landholders and leased lot holders as stewards in the watershed; the importance and desirability of "eyes and ears" in the watershed, given the limitations on funding for enforcement/conservation officers.
- Issues of risk characterization with respect to the possibility of raising the level of the lakes (i.e. damage to riparian areas). It was noted that should an application to raise lake levels proceed, it would involve a full environmental assessment. For the purpose of the watershed assessment a rough model indicating potential contour elevations will be included as a flagging tool only.
- Questions related to the standard for sewage disposal on crown lease lots. It was noted that detailed study has been performed and the results of several studies are readily available.
- How a Cottage Zoning Bylaw with a focus on retaining rustic qualities could serve to address concerns with "development" and its consequences within the watershed. It was noted that RDCO has recently drafted such a bylaw.
- Questions related to the assumptions being made regarding private land use (i.e. whether it is assumed that private landholders are using pesticides, intend to pave driveways, etc.). It was noted that risks within each vulnerability zone will be characterized generically, and while some categorization will occur, the assessment is considered a "first step" - an information-gathering phase in which potential concerns are identified, which will enable the generation of useful and applicable recommendations on how to move forward.
- The need for the assessment to be transparent and evidence-based, incorporating work done to date, identifying and quantifying risk – the intention that this process should put people on the same page rather than point fingers at particular land uses or land users.
- Questions related to how and where water sampling was performed, with what result, particularly with respect to Dee Lake. The Water Quality Technician explained the nutrient sampling program. It was suggested that any sampling done on Dee Lake may have been "grab samples" taken by the Ministry of Environment.
- It was suggested that resort- and cabin-owners not be placed in the same category as recreational day-users, and that the role of the leaseholders as stewards of the watershed should be recognized.

7. Cattle tenures (Ministry of Forests, followed by open discussion)

Issues related to cattle tenures were visually demonstrated by photos taken within the watershed, indicating cattle presence at a main creek, fecal material in the water, and sediment access paths created by cattle trampling.

Rob Dinwoodie, Ministry of Forests, spoke at length with respect to:

- The number of cattle present in the watershed (from June through October, 800 cow/calf pairs present in the Vernon Creek watershed and 150 cow/calf pairs in the Oyama Creed Watershed).
- Range tenures, grazing licenses, range use plans, and issues that may arise when tenures occur within a community watershed.
- Mitigative actions may include salt locations, pasture use, infrastructure maintenance, fencing.
- Infrastructure that exists was installed for the purpose of livestock management; while in some cases it does also serve as a means of source protection, this is not always the case.
- Funding has been obtained to enable the placement of fencing in the Oyama Lake watershed, and recent approval has also been received for fencing in the Beaver Lake area. Buffer areas, riparian pastures, "meadow complexes" are valuable filtering tools that enable sediment and fecal material to be removed before water reaches a reservoir.

Further points of discussion included:

- Cattle presence has been noted along length of creek.
- Impact of cow at intake is very different than impact of cows far from creek; the need to seek creative ways to use natural barriers as well as fencing to keep cows in areas of reduced risk.
- How Mountain Pine Beetle has changed the landscape; many barriers to cattle movement have been lost as a result.
- The importance of risk-rating sites in the assessment in order to identify the highest priority areas so these may be addressed first.
- The need for further funding to enable more thorough mapping of actual locations of creeks, fencing and so forth, as existing mapping is not accurate.
- The need to ensure that recent improvements to fencing are included in the mapping, and a notation of works underway be included in the assessment.
- Issues related to the loss of buffer zones between population and range boundary, including the problem of "quad trails" opening up routes for cattle movement.
- Possible methods for keeping cows off private or leased lands. It was noted that private landholders adjacent to crown range tenures have an obligation to fence out cattle.
- Appropriate avenues to follow when cattle activities may impact a drinking water source (i.e. a cattle pond in close proximity to a drinking water well).

8. Other concerns & General comments

Final comments included:

- A question regarding the feasibility of building a downstream dam and flooding the natural canyon, creating something new rather than trying to "fix something that is broken." This comment was followed by discussion of cost/benefit analysis and the need to ensure that the expansion of public infrastructure is done in a cost-effective manner.
- Discussion of the importance of source water protection; ensuring water is protected at the source reduces the potential for contaminated water entering the system (which raises the "duty of care" and increases costs related to treatment).
- Discussion of current economic conditions and funding, including a consideration of the question as to whether, due to lack of funding, a higher level of risk is acceptable.
- Discussion of the importance of protecting water quality in the area between where water leaves the lake and where it enters the intake, and the purpose of identifying "vulnerability zones" as an attempt to identify where most efforts should be directed.

9. Wrap-up/timelines

The Utility Manager stated that a Draft report would be prepared, and would be followed by a second stakeholders' meeting and then a public open house. The tentative schedule is set as:

- Draft report – November 2009
- Second stakeholders' meeting – Late November/December. At least 3 weeks lead time between the issuance of the draft report and the scheduling of this meeting.
- Public open house – January 2010
- Final report – no later than March 31, 2010

It was determined that the stakeholders' meeting should take place during daytime hours, and that the public open house should span the afternoon and evening.

The Utility Manager adjourned the meeting at 12:00 noon.

District of Lake Country
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VERNON/OYAMA CREEK WATERSHEDS STAKEHOLDERS

MINUTES

Date: Wednesday, January 27, 2010

Time: 8:30 a.m.

Place: Council Chambers, Municipal Hall
10150 Bottom Wood Lake Road

Staff: Jack Allingham, Utilities Manager (Chair)
Mark Koch, Development Services
Patti Hansen, Water Quality
Shane Cote, Planning
Deb Youngest, Recording Secretary

Present: Councillor Barb Leamont
Brian Bedard, BC Timber Sales
Brad Allingham, rancher
Dave Allingham, rancher
Russ Meldrum, OK Cottage Owners Association
Ron Smith, ILMB
Ivor Norland, Interior Health
Jason Schleppe, Ecoscape
Bryn Lord, Interior Health
Mary Ann Olson-Russello, Ecoscape
Lloyd Manchester, OK Cottage Owners Association
Nick Babty, Coldstream Ranch
George Holt, rancher
Harold Waters, Tolko
Katherine Ladyman, Ministry of Forests
Margaret Bakelaar, RDCO
Heather Schellenberg, Pier Mac
Rob Dinwoodie, Ministry of Forests
Carmen Stanyk, Lake Country Environmental Society
Ray Crampton, Ministry of Forests
Jeff Jaccobi, Ministry of Tourism
Wade Anderson, Ministry of Tourism
Sylve Petchkar, Ministry of Environment
Rick Simpson, OFGC
Bruce Williams, Dee Lake Resort
Connie Kruger, GVWS
Pat Whittingham, OFGC

The meeting was called to order at 8:40 a.m. by Jack Allingham.

1. Agenda & Opening Remarks

The Chair noted that the meeting was part of the Oyama and Vernon Creek Watershed Assessment process, as a follow up to the Stakeholder's meeting in September 2009.

2. Source Water Assessment Overview (Ecoscape - Jason Schleppe)

Jason Schleppe offered a Powerpoint presentation to summarize the works done on the Source Water Assessment to date. The overview covered points including the multi-jurisdictional, multi-stakeholder nature of the process, the importance of source protection as part of a multi-barrier source-to-tap approach, the potential hazards to water quality, factors that influence risk and vulnerability, and a summary of risks and recommendations.

The GIS mapping of vulnerability zones was reviewed, and discussion was held on the potential for this information to be made available to all stakeholders. The Chair noted that it was the District's intention to make this information accessible.

3. SWA General Recommendations (Ecoscape - Jason Schleppe)

Jason Schleppe of Ecoscape Consulting gave a PowerPoint presentation, listing general and stakeholder-related recommendations as follows:

General Recommendations

- Add more detailed fine-scale mapping to increase accuracy of vulnerability zones
- Mitigation of sediment point sources is desirable
- Forest buffers, a critical factor in the maintenance of water quality, should be measured from the proposed high water line of reservoirs should they be raised.

Stakeholder-related Recommendations

- All stakeholders need to be engaged and involved
- Agencies promoting or authorizing use of the watershed need to ensure adequate funding is set aside for water source protection
- Stakeholders must work within a unified framework of risk assessment
- Agencies need to take the leadership role in source water protection including compliance, enforcement and monitoring
- Stakeholders working cooperatively towards common goals will reduce overall watershed management costs.

Comments and points of discussion included:

A concern that the draft report did not contain a cumulative impact analysis. It was noted that while cumulative impacts may play a role in vulnerability, the source water assessment is not, and is not intended to be, a cumulative impact assessment or environmental assessment, but rather a "health risk assessment."

A notation that the assessment defined "watershed" as "watershed above the intake(s) only." It was confirmed that for the purposes of the report, "watershed" was defined as the 100-metre radius around the intake, and above.

A consideration for the differing levels of complexity that various stakeholders may have when managing activity within a vulnerability zone Jason Schleppe indicated that there would be an attempt to ensure that the final report makes the definitions very clear with respect to how they should be applied, noting that recommended mitigation measures to reduce risk for each of the various areas are specific.

4. Forestry open discussion

Patti Hansen reviewed the District's position with respect to forestry activities in the watershed, noting the desire that Equivalent Cut block Area (ECA) should not exceed 50% without significant consideration of potential consequences. Five considerations for all cut blocks regardless of size should include:

- All streams should be treated as fish bearing
- The area should be left in a state that maintains water quality for the long term
- All roads must meet current standards
- All accesses should be completely rehabilitated
- Existing buffers should be maintained.

Discussion of the ECA ensued, with points of note including the consequences of vegetation loss during times of peak flows, and the impact of both economic factors and natural factors such as pine beetle. It was confirmed that this ECA limitation was desirable for the entire watershed, not only the higher elevations. The role of the ECA as a "flag" to inform the process of understanding and predicting risks and vulnerabilities.

A comment was raised with respect to seeing this process come to a conclusion, with the Chair noting that the assessment itself will be concluded by the end of March 2010, and will provide a "base from which to move forward."

A point was raised regarding the potential for the use of selective logging or other alternatives to clear cutting in certain more sensitive areas. Some discussion ensued on forestry best practices, the existence and adherence to rules and regulations directing forest management, the impact of pine beetle on harvesting techniques, and the role of wildfire mitigation plans. Potential negative impacts of selective logging (i.e. increasing access via skid-trails, likelihood of remaining trees being blown down) were noted.

The issue of pine beetle kill and over mature forest in certain management zones and buffer zones was discussed, noting that the desire to minimize impacts on water quality are considered when creating salvage plans for these areas.

Jason Schleppe summarized the recommendations for high to very-high risk areas:

- Avoidance of harvesting around source streams and reservoirs except where fire risk outweighs harvest risk.
- Site-specific assessments should be done to address issues of access to reservoirs once harvesting activities are complete
- Replanting efforts around reservoirs should focus on deciduous trees, spruce and fir.

- Mature riparian vegetation in fan/flood plain areas should be retained
- Licensees should work with cattle tenure holders to ensure natural barriers to cattle movement are included in retention plans.

5. Cattle Tenures Open Discussion

Patti Hansen presented the District's position that cattle should be excluded from all high risk areas, including around reservoirs, watercourses, tributaries, and riparian areas below the dam but above the intake.

Jason Schleppe summarized the key recommendations with respect to cattle use:

- Range use plans (RUP) can incorporate ideas for mitigation of cattle impacts, including off-channel watering, range riders, observation logs, etc.
- Cattle should be completely excluded below the high water line or from any reservoir or stream space between the reservoir outlet and the intake, as these are the most critical areas.
- Adaptive management planning is key.

Discussion followed on the role of the RUP as the main tool for both scheduling of use and determining type of use. It was noted that in the past, RUPs were tailored towards resource management rather than a water protection orientation.

Recent cattle management efforts and challenges were discussed, noting that there is a learning curve both for the managers and for the cattle themselves.

6. Private holdings and lease lots open discussion

Patti Hansen presented the District's position that private owners should strive to meet the same requirements as are demanded of adjacent crown lands, that government authorities should exercise their influence to educate landowners and assist them in meeting these requirements, that the District continues to oppose the sale of leased lots to private individuals, and that the District continues to consider public health and safety as the primary concern, seeking to maintain the "status quo." This was clarified to note that the District does not oppose activities that have historically been occurring within the watersheds, but does oppose new construction, access and recreational uses from being added. The District does not have a firmly defined position with respect to the operation of wilderness resorts, and wishes to get more information and develop a closer working relationship with these stakeholders in order to develop a position.

Jason Schleppe noted that "private lands" include freehold lands, leased lands, and wilderness resort properties, indicating that differing zoning and allowable land uses applied to these three types of private lands. It was further noted that risk has to be based on "worst case scenarios" and the key recommendations were presented as:

- Land use policy documents should incorporate identified Vulnerability Zones.
- The sale of lease lots to private landowners is not recommended, and it is further noted that renewed leases should contain specific conditions to ensure that source water protection occurs. The importance of planning for future water needs, including the possibility of raising the reservoirs to accommodate these needs, was stressed as a main basis for recommending against the conversion of leased land to private holdings.

- Compliance and enforcement of existing legislation should be performed.
- Development of specific education programs to inform leaseholders and patrons of wilderness resorts about risks to water quality should be undertaken.

Discussion ensued with respect to the impact of various activities such as ice fishing, unsanctioned camping, as well as various considerations specific to best-practices operation of wilderness resorts stressing that many positive actions could be performed by operators of wilderness resorts which were constrained by the inability to obtain financing for such improvements to lease-held lands.

There was further discussion on concerns made by leasehold cabin owners, including a note that very few cabins would be affected by raising the reservoirs but a parallel concern with the potential environmental effects that a changed high water mark may have. It was stressed that certain negative activities that have occurred are the exception and are opposed by the majority of cabin owners, and that "having all leases pulled" would be an inappropriate response.

Issues of compliance and enforcement with respect to deterring cattle and public access to these private lands were discussed

It was noted that "vulnerability zones" were useful as guidelines when considering any type of permitting requirements, particularly since there is no Official Community Plan in place for these areas. Consideration of the suitability of pursuing adoption of an OCP (by Central Okanagan Regional District with the permission of the province) included points that OCPs can be restrictive, there potential for adding too many "levels of bureaucracy," and the potential to use bylaws and zoning in conjunction with compliance and enforcement to guide development on private and leasehold lands. It was noted that human behavior can be difficult to control and manage.

7. Recreation Open Discussion

Patti Hansen presented the District's position that recreation should be excluded from high risk areas around the upland reservoirs, water courses, tributaries and riparian areas below the dam but upstream of the intake, and that all recreational activities should be limited to "low impact" activity.

Jason Schleppe summarized the key recommendations with respect to recreation within the watershed:

- Recreation must be monitored and controlled with compliance and enforcement activities.
- Access Management Planning is required; stakeholder buy-in to an AMP is desirable.
- Boating on reservoir lakes should be "electric motor only"
- Educational programs should be developed to inform users of the sensitivity of the watershed and the consequences of their actions

There was discussion on the best way to manage and mitigate risks, given the inherent difficulty in managing and modifying human behavior, particularly when considering dispersed or non-sanctioned activities that were not representative of "recreational use." It was requested that this differentiation be made clearer in the report.

The pros and cons of "access restrictions," "education" and "enforcement" were considered and it was clarified that the District's position on recreation within the watershed refers to recreation taking place in the "high vulnerability/high risk" zones.

8. Other concerns & General comments

Other comments included:

- A comment that public education into the potential effect of trihalomethanes could have on human health was made, noting that decomposing logs in the lake could be a factor in trihalomethane levels.
- A suggestion that the water system intakes be moved in closer proximity to the dams, to reduce the extent of the "between dam and intake" high vulnerability zone.
- A comment on the ongoing challenge of finding funding for improvements.

9. Wrap-up/timelines

Stakeholders were encouraged to provide written comments to Ecoscape to assist in the preparation of the next draft report. It was asked that comments should relate to specific paragraphs or pages, noting some existing limitations related to budget for making broad changes in the scope or direction of the report.

The Public Open House is tentatively scheduled for March 24th

Prior to finalizing the date of the Open House, the draft must go before Council, tentatively planned for March 2nd. The draft will be distributed to stakeholders ideally one week prior to the date it is scheduled to go to Council.

The Chair adjourned the meeting at 12:15 p.m.

Point Number	Cattle Presence	Cow Fecal Density Category	Cattle Fecal Density	Cattle Proximity	Cattle Erosion	Cattle Erosion Category	Cattle Sediment Delivery	Cattle Vegetation Disturbance	Cattle Aggregation	Cattle Stream Length Impacted Category	Cattle Actual Stream Length Impacted	Cattle Guards Present	Cattle Exclusion Fencing Present	Quality Cattle Severity	Cattle Photo Numbers	Cattle Comments	Motorized Recreation Present
1	Yes	1-5	5	Above	Yes	Negligeable	No delivery	Yes	Yes		0	No	No	Low	5336-37	opening, intense grazing	Yes
2	Yes	1-5	1	Above	Yes	Negligeable	No delivery	No	No		0	No	No	Low	5349	fecal matter only	No
3	Yes	1-5	1	Below	Yes	Negligeable	Evident and Dirct	No	No	10 - 20 metres	10	No	No	Low	5349	path from road to the foreshore of Lost Lake facilitates access	No
4	Yes	1-5	4	Above	Yes	Negligeable	Evident and Direct	Yes	No	10 - 20 metres	10	No	No	Low	5363	Cattle utilizing main road, sediment delivery to creek which flows to Crooked Lake 800 m away	No
5	Yes	1-5	1	Above	No	No Erosion Evident	No delivery	No	No		0	No	No	Low		Fecal matter only	No
6	Yes	1-5	3	Above	Yes	Negligeable	Weakly Filtered	Yes	Yes		0	No	No	Low	5810-17	Fecal matter and vegetation disturbance	No
7	Yes	1-5	1	Above	Yes	Negligeable	No delivery	Yes	Yes		0	No	Yes	Low	5818--20	Cattle fencing at this location	No

Point Number	Non Motorized Recreation Present	Sanctioned Camping Present	Un - sanctioned Camping Present	ATV Vehicles Present	Vehicle Access	Motor Boat Access	Snow - mobile Access	Other Motorized Vehicle Presence	Motoized Vehicle Comments	Motorized Type	Motorized Other Type	Motorized Vehicle Disturbance Category	Motorized Vehicle Acutal	Motorized Vehicle Disturbance Comment	Motorized Vehicle Proximity	Motorized Vehicle Proximity Comment	Motorized Vehicle Garbage Present
1	No	No	Yes	No	Yes	No	No			Sac. Road		11-50 square metres	0		Above		No
2	No	Yes	No	No	No	No	No						0				No
3	No	No	Yes	No	No	No	No						0				No
4	No	No	No	No	No	No	No						0				No
5	No	Yes	No	No	No	No	No						0				No
6	No	No	Yes	No	No	No	No						0				No
7	No	No	No	No	No	No	No						0				No

Point Number	Motorized Vehicle Erosion	Motorized Vehicle Erosion Catetory	Motorized Vehicle Sediment Delivery	Motorized Vehicle Erosion Comment	Motorized Vehicle Barriers Present	Motorized Vehicle Barriers Functioning	Motorized Vehicle Barriers Comment	Motorized Vehicle Photo Numbers	Motorized Vehicle Qualitative Severity	Motorized Vehicle Comment	Non-Motorized Hiking Present	Non Motorized Biking Present	Non Motorized Skiing Present	Non Motorized Fishing Present	Other Non Motorized Activities Present	Non Motorized Comment	Non Motorized Type
1	No	Negligeable	No delivery		No	No					No	No	No	No			
2	No				No	No					No	No	No	No			
3	No				No	No					No	No	No	No			
4	No				No	No					No	No	No	No			
5	No				No	No					No	No	No	No			
6	No				No	No					No	No	No	No			
7	No				No	No					No	No	No	No			

Appendix C - Oyama and Vernon Creek Watershed Assessment Points

Point Number	Non Motorized Other Types	Non Motorized Other Comments	Non Motorized Disturbance Catetgory	Non Motorized Disturbance Actual	Non Motorized Disturbance Comment	Non Motorized Proximity	Non Motorized Proximity Comment	Non-motorized Garbage Present	Non Motorized Erosion	Non Motorized Erosion Category	Non Motorized Sediment Delivery	Non Motorized Erosion Comment	Non Motorized Barriers Present	Non Motorized Barriers Functioning	Non Motorized Barrier Comment	Non Motorized Photo Numbers
1				0				No	No				No	No		
2				0				No	No				No	No		
3				0				No	No				No	No		
4				0				No	No				No	No		
5				0				No	No				No	No		
6				0				No	No				No	No		
7				0				No	No				No	No		

Appendix C - Oyama and Vernon Creek Watershed Assessment Points

Point Number	Non Motorized Qualitative Severity	Non Motorized Comments	Sanctioned Camping # of Sites	Sanctioned Camp - ground	Sanctioned Resort	Sanctioned Cabins	Other Sanctioned Activities	Sanctioned Camping Comments	Sanctioned Camping Disturbance Category	Sanctioned Camping Acutal Disturbance	Sanctioned Camping Disturbance Comment	Sanctioned Camping Proximity	Sanctioned Camping Proximity Comment	Sanctioned Camping Gargbage Present	Sanctioned Camping Erosion Present	Santioned Camping Erosion Category
1			0	No	No	No				0				No	No	
2			1	Yes	No	No		1 picnic table, outhouse and parking for multiple vehicles	< 10 square metres	0		Above	100 m from Lost Lake	Yes	Yes	Minor Erosion
3			0	No	No	No				0				No	No	
4			0	No	No	No				0				No	No	
5			7	Yes	No	No		Extends across a sizeable area	> 50 sqaure metres	1000		Above	30 metres from Crooked Chain (Island Lake)	Yes	Yes	Minor
6			0	No	No	No				0				No	No	
7			0	No	No	No				0				No	No	

Point Number	Sanctioned Camping Sediment Delivery	Sanctioned Camping Erosion Comment	Sanctioned Camping Barriers Present	Sanctioned Camping Barriers Functioning	Sanctioned Camping Barriers Comment	Sanctioned Camping Photos	Sanctioned Camping Qualitative Severity	Sanctioned Camping Comment	Sanctioned Camping Vegetation Clearing	Sanctioned Camping Linear Corridors	Sanctioned Camping Other Disturbances Comment	Sanctioned Camping Porta Potties	Sanctioned Camping Wash - rooms	Sanctioned Camping Outhouses	Sanctioned Camping Boat Ramp	Sanctioned Camping Other Facilities	Sanctioned Camping Number of Facilities Category
1			No	No					No	No		No	No	No	No		
2	Evident and Direct	runoff from cleared area travels down path to lake	No	No	Only barriers consist of signage for anglers	5343-56	Low		No	Yes		No	No	Yes	No	picnic table	1
3			No	No					No	No		No	No	No	No		
4			No	No					No	No		No	No	No	No		
5	Evident and Direct	Sediment originating from access road and boat launch	Yes	Yes	Community Watershed signage, no cutting trees	5760-67	Low	unsanctioned camping on the access road to Sanctioned site	Yes	Yes		No	No	Yes	Yes	7 picnic tables,	2 - 5
6			No	No					No	No		No	No	No	No		
7			No	No					No	No		No	No	No	No		

Point Number	Sanctioned Camping Facilities Distance Category	Sanctioned Camping Facilities Comment	Un - sanctioned Camping Sites Number	Un - sanctioned Tenting	Un - sanctioned Campers	Other Types of Un - sanctioned Camping	Un - sanctioned # Firepit	Un - sanctioned Comments	Un - sanctioned Disturbance Category	Un - sanctioned Disturbance Extent	Un - sanctioned Disturbance Comment	Un - sanctioned Proximity	Un - sanctioned Proximity Comment	Un - sanctioned Garbage Present	Un - sanctioned Erosion Present	Un - sanctioned Erosion Category
1			1	Yes	Yes		1	opening along road	< 10 square metres	3	little disturbance, only firpit remains	Above	300 m from Crooked Lake	Yes	No	Negligeable
2	100 metres	Photo 5346 shows outhouse	0	No	No		0			0				No	No	
3			1	Yes	No		1	walking and ATV use only	< 10 square metres	3	single firepit adjacent to Lost Lake	Above	5 m from Crooked Lake	Yes	Y	Minor
4			0	No	No		0			0				No	No	
5	10 - 20 metres		0	No	No		0			0				No	No	
6			3	Yes	Yes		5		< 10 square metres	10	USA camping adjacent to road.	Above	300 m to lake	No	No	No Erosion Evident
7			3	Yes	Yes		5		< 10 square metres	0		Above		No	No	

Point Number	Un - sanctioned Sediment Delivery	Un - sanctioned Erosion Comment	Un - sanctioned Barriers Present	Un - sanctioend Barriers Functioning	Un - sancationed Barriers Comment	Un - sanctioned Qualitative Severity	Un - sanctioned Linear Corridors	Un - sanctioned Vegetation Clearing	Un - sanctioned Sediment Delivery	Un - sanctioned Other Disturbances Comment	Un - sanctioned Comments	Un - sacntioned Photos
1	No delivery	runoff to accumulate on adjacent road	No	No		Low	No	No	No		clearing in forest facilitated an unsanctioned campsite	5336-37
2			No	No			No	No	No			
3	Evident and Dirct	sediment from USA site meets up with path and has direct input to Lost Lake	No	No		Low	Yes	Yes	Yes		vegetation clearing is minimal, see photo 5357 for example of vegetation disturbance	5357
4			No	No			No	No	No			
5			No	No			No	No	No			
6	No delivery	No concerns	No	No		Low	Yes	No	No		Camping within non-forested area adjacent to road and lake	5810-17
7			No	No		Low	Yes	No	No			

Point Number	Cattle Presence	Cow Fecal Density Category	Cattle Fecal Density	Cattle Proximity	Cattle Erosion	Cattle Erosion Category	Cattle Sediment Delivery	Cattle Vegetation Disturbance	Cattle Aggregation	Cattle Stream Length Impacted Category	Cattle Actual Stream Length Impacted	Cattle Guards Present	Cattle Exclusion Fencing Present	Quality Cattle Severity	Cattle Photo Numbers	Cattle Comments	Motorized Recreation Present
8	Yes	1-5	5	Below	Yes	Negligeable	Evident and Direct	Yes	Yes	> 10 metres	50	No	No	Moderate	5821-28	Catttle congregating in the moist areas along the creek	No
9	Yes	6-10	6	Below	Yes	Minor Erosion	Evident and Direct	Yes	Yes	> 10 metres	20	No	No	Moderate	5839-42	Cattle accessing creek at road/stream intersection. Cattle prints and fecal matter below HWL	No
10	Yes	1-5	5	Below	Yes	Minor Erosion	Evident and Direct	Yes	Yes	> 10 metres	20	No	No	Moderate	5844	Cattle prints and fecal matter below HWL of Hidden Lake	No
11	No		0		No			No	No		0	No	No				Yes
12	Yes	1-5	5	Above	Yes	Negligeable	No delivery	Yes	Yes		0	No	No	Moderate		High density cattle across this whole area	No
13	Yes	1 - 5	5	Below	Yes	Extensive Erosion	Evident and Direct	No	Yes	> 10 metres	50	No	No	High	5007-9	High use trail to water with extensive erosion, cattle disturbing bank along landslide	No

Point Number	Non Motorized Recreation Present	Sanctioned Camping Present	Un - sanctioned Camping Present	ATV Vehicles Present	Vehicle Access	Motor Boat Access	Snow - mobile Access	Other Motorized Vehicle Presence	Motoized Vehicle Comments	Motorized Type	Motorized Other Type	Motorized Vehicle Disturbance Category	Motorized Vehicle Acutal	Motorized Vehicle Disturbance Comment	Motorized Vehicle Proximity	Motorized Vehicle Proximity Comment	Motorized Vehicle Garbage Present
8	No	No	No	No	No	No	No						0				No
9	No	No	No	No	No	No	No						0				No
10	No	No	Yes	Yes	Yes	Yes	Yes			Sac. Road			0		Above		Yes
11	No	No	No	Yes	Yes	No	Yes		non-status road	Sac. Road			0		Above	On ridge above canyon	Yes
12	No	No	No	No	No	No	No						0				No
13	No	No	No	No	No	No	No						0				No

Point Number	Motorized Vehicle Erosion	Motorized Vehicle Erosion Catetory	Motorized Vehicle Sediment Delivery	Motorized Vehicle Erosion Comment	Motorized Vehicle Barriers Present	Motorized Vehicle Barriers Functioning	Motorized Vehicle Barriers Comment	Motorized Vehicle Photo Numbers	Motorized Vehicle Qualitative Severity	Motorized Vehicle Comment	Non-Motorized Hiking Present	Non Motorized Biking Present	Non Motorized Skiing Present	Non Motorized Fishing Present	Other Non Motorized Activities Present	Non Motorized Comment	Non Motorized Type
8	No				No	No					No	No	No	No			
9	No				No	No					No	No	No	No			
10	Yes	Minor Erosion	Evident and Direct	boat launch	No	No					No	No	No	No			
11	Yes	Minor Erosion	Indirect andfiltered	runoff from sanct road	Yes	No	Road has since been blocked by DLC, but not successfully	4952-54	Moderate	Should prevent access due to adjacent steep, coupled slopes	No	No	No	No			
12	No				No	No					No	No	No	No			
13	No				No	No					No	No	No	No			

Point Number	Non Motorized Other Types	Non Motorized Other Comments	Non Motorized Disturbance Catetgory	Non Motorized Disturbance Actual	Non Motorized Disturbance Comment	Non Motorized Proximity	Non Motorized Proximity Comment	Non-motorized Garbage Present	Non Motorized Erosion	Non Motorized Erosion Category	Non Motorized Sediment Delivery	Non Motorized Erosion Comment	Non Motorized Barriers Present	Non Motorized Barriers Functioning	Non Motorized Barrier Comment	Non Motorized Photo Numbers
8				0				No	No				No	No		
9				0				No	No				No	No		
10				0				No	No				No	No		
11				0				No	No				No	No		
12				0				No	No				No	No		
13				0				No	No				No	No		

Point Number	Non Motorized Qualitative Severity	Non Motorized Comments	Sanctioned Camping # of Sites	Sanctioned Camp - ground	Sanctioned Resort	Sanctioned Cabins	Other Sanctioned Activities	Sanctioned Camping Comments	Sanctioned Camping Disturbance Category	Sanctioned Camping Acutal Disturbance	Sanctioned Camping Disturbance Comment	Sanctioned Camping Proximity	Sanctioned Camping Proximity Comment	Sanctioned Camping Gargbage Present	Sanctioned Camping Erosion Present	Santioned Camping Erosion Category
8			0	No	No	No				0				No	No	
9			0	No	No	No				0				No	No	
10			0	No	No	No				0				No	No	
11			0	No	No	No				0				No	No	
12			0	No	No	No				0				No	No	
13			0	No	No	No				0				No	No	

Point Number	Sanctioned Camping Sediment Delivery	Sanctioned Camping Erosion Comment	Sanctioned Camping Barriers Present	Sanctioned Camping Barriers Functioning	Sanctioned Camping Barriers Comment	Sanctioned Camping Photos	Sanctioned Camping Qualitative Severity	Sanctioned Camping Comment	Sanctioned Camping Vegetation Clearing	Sanctioned Camping Linear Corridors	Sanctioned Camping Other Disturbances Comment	Sanctioned Camping Porta Potties	Sanctioned Camping Wash - rooms	Sanctioned Camping Outhouses	Sanctioned Camping Boat Ramp	Sanctioned Camping Other Facilities	Sanctioned Camping Number of Facilities Category
8			No	No					No	No		No	No	No	No		
9			No	No					No	No		No	No	No	No		
10			No	No					No	No		No	No	No	No		
11			No	No					No	No		No	No	No	No		
12			No	No					No	No		No	No	No	No		
13			No	No					No	No		No	No	No	No		

Point Number	Sanctioned Camping Facilities Distance Category	Sanctioned Camping Facilities Comment	Un - sanctioned Camping Sites Number	Un - sanctioned Tenting	Un - sanctioned Campers	Other Types of Un - sanctioned Camping	Un - sanctioned # Firepit	Un - sanctioned Comments	Un - sanctioned Disturbance Category	Un - sanctioned Disturbance Extent	Un - sanctioned Disturbance Comment	Un - sanctioned Proximity	Un - sanctioned Proximity Comment	Un - sanctioned Garbage Present	Un - sanctioned Erosion Present	Un - sanctioned Erosion Category
8			0	No	No		0			0				No	No	
9			0	No	No		0			0				No	No	
10			1	Yes	Yes		1	Campsite adjacent to lake	< 10 square metres	5	Very little impact	Above	15 m to lake	Yes	No	
11			0	No	No		0			0				No	No	
12			0	No	No		0			0				No	No	
13			0	No	No		0			0				No	No	

Point Number	Un - sanctioned Sediment Delivery	Un - sanctioned Erosion Comment	Un - sanctioned Barriers Present	Un - sanctioend Barriers Functioning	Un - sancationed Barriers Comment	Un - sanctioned Qualitative Severity	Un - sanctioned Linear Corridors	Un - sanctioned Vegetation Clearing	Un - sanctioned Sediment Delivery	Un - sanctioned Other Disturbances Comment	Un - sanctioned Comments	Un - sacntioned Photos
8			No	No			No	No	No			
9			No	No			No	No	No			
10			No	No		Low	No	No	No		Single firepit 15 m from lake's edge	5843-50
11			No	No			No	No	No			
12			No	No			No	No	No			
13			No	No			No	No	No			

Point Number	Cattle Presence	Cow Fecal Density Category	Cattle Fecal Density	Cattle Proximity	Cattle Erosion	Cattle Erosion Category	Cattle Sediment Delivery	Cattle Vegetation Disturbance	Cattle Aggregation	Cattle Stream Length Impacted Category	Cattle Actual Stream Length Impacted	Cattle Guards Present	Cattle Exclusion Fencing Present	Quality Cattle Severity	Cattle Photo Numbers	Cattle Comments	Motorized Recreation Present
16	Yes	1-5	1	Above	No	No Erosion Evident	No delivery	Yes	No		0	No	No	Low	5114-15	Cattle foraging in cleared area	No
17	Yes	6-10	6	Below	Yes	Minor Erosion	Weakly Filtered	Yes	Yes	> 10 metres	25	No	No	Moderate	5123	Cattle presence at the spillway and long creek	Yes
18	Yes	1-5	3	Above	No	No Erosion Evident	No delivery	No	No		0	Yes	Yes	Low	5145-8	Non - functional cattle guard and downed fence	No
19	Yes	6-10	6	Below	Yes	Minor Erosion	Evident and Direct	No	Yes	> 10 metres	40	No	No	Moderate	5169-5177	Cattle wallowing in creek	No
20	No		0		No			No	No		0	No	No				Yes
21	Yes	1-5	2	Above	No	No Erosion Evident	No delivery	Yes	No		0	No	No	Low		Cattle using road as movement corridor	Yes
22	Yes	6-10	6	Above	No	No Erosion Evident	No delivery	No	No		0	No	No	Low	5238-64	Have access to below HWL, but evidence minimal at this location	Yes

Point Number	Non Motorized Recreation Present	Sanctioned Camping Present	Un - sanctioned Camping Present	ATV Vehicles Present	Vehicle Access	Motor Boat Access	Snow - mobile Access	Other Motorized Vehicle Presence	Motoized Vehicle Comments	Motorized Type	Motorized Other Type	Motorized Vehicle Disturbance Category	Motorized Vehicle Acutal	Motorized Vehicle Disturbance Comment	Motorized Vehicle Proximity	Motorized Vehicle Proximity Comment	Motorized Vehicle Garbage Present
16	No	No	Yes	No	No	No	No						0				No
17	No	No	No	Yes	No	No	Yes		At spillway	Mud Bogging	Some mud bogging in low lying areas adjacent to creek	< 10 square metres	5		Below	Activity within floodplain areas	Yes
18	No	No	No	No	No	No	No						0				No
19	No	No	No	No	No	No	No						0				No
20	No	Yes	No	Yes	Yes	Yes	Yes		Boat launch at this site	Sac. Road		11-50 square metres	20	Motorized access to recreation site	Above	Within 10 m to lake	Yes
21	No	No	Yes	Yes	Yes	No	Yes		ATV use of this road, road is poorly maintained	Off Road/Trail		< 10 square metres	0	Some off road 4x4 adjacent to road	Above	Within 50 m to lake	Yes
22	No	No	Yes	Yes	Yes	No	Yes		ATV crossing below dam at Crooked lake	Off Road/Trail	Mud bogging	11-50 square metres	11	Off Road/Trail	Below	ATV activity throughout camping area and below HWL	Yes

Point Number	Motorized Vehicle Erosion	Motorized Vehicle Erosion Catetory	Motorized Vehicle Sediment Delivery	Motorized Vehicle Erosion Comment	Motorized Vehicle Barriers Present	Motorized Vehicle Barriers Functioning	Motorized Vehicle Barriers Comment	Motorized Vehicle Photo Numbers	Motorized Vehicle Qualitative Severity	Motorized Vehicle Comment	Non-Motorized Hiking Present	Non Motorized Biking Present	Non Motorized Skiing Present	Non Motorized Fishing Present	Other Non Motorized Activities Present	Non Motorized Comment	Non Motorized Type
16	No				No	No					No	No	No	No			
17	Yes	Negligeable	Weakly Filtered	Some motorized activity in floodplain	Yes	Yes	Boulders block access to further down the creek	5120-22	Low	Most of access is blocked	No	No	No	No			
18	No				No	No					No	No	No	No			
19	No				No	No					No	No	No	No			
20	Yes	Minor Erosion	Evident and Direct	Erosion originating from access road and boat launch	No	No	Water bars may be useful to redirect flows		Low		No	No	No	No			
21	Yes	Negligeable	Indirect andfiltered	Some erosion from road	No	No			Low	Poor condition of road limits motorized access	No	No	No	No			
22	Yes	Minor Erosion	Evident and Direct	Fire burning upon arrival, garbage extensive, no ethic at this site	No	No	Access road is poorly maintained	5238-64	High	Site should be better monitored	No	No	No	No			

Point Number	Non Motorized Other Types	Non Motorized Other Comments	Non Motorized Disturbance Catetgory	Non Motorized Disturbance Actual	Non Motorized Disturbance Comment	Non Motorized Proximity	Non Motorized Proximity Comment	Non-motorized Garbage Present	Non Motorized Erosion	Non Motorized Erosion Category	Non Motorized Sediment Delivery	Non Motorized Erosion Comment	Non Motorized Barriers Present	Non Motorized Barriers Functioning	Non Motorized Barrier Comment	Non Motorized Photo Numbers
16				0				No	No				No	No		
17				0				No	No				No	No		
18				0				No	No				No	No		
19				0				No	No				No	No		
20				0				No	No				No	No		
21				0				No	No				No	No		
22				0				No	No				No	No		

Point Number	Non Motorized Qualitative Severity	Non Motorized Comments	Sanctioned Camping # of Sites	Sanctioned Camp - ground	Sanctioned Resort	Sanctioned Cabins	Other Sanctioned Activities	Sanctioned Camping Comments	Sanctioned Camping Disturbance Category	Sanctioned Camping Acutal Disturbance	Sanctioned Camping Disturbance Comment	Sanctioned Camping Proximity	Sanctioned Camping Proximity Comment	Sanctioned Camping Gargbage Present	Sanctioned Camping Erosion Present	Santioned Camping Erosion Category
16			0	No	No	No				0				No	No	
17			0	No	No	No				0				No	No	
18			0	No	No	No				0				No	No	
19			0	No	No	No				0				No	No	
20			10	Yes	No	No	Trailers, tents	Campground not full during assessment	11-50 square metres	25	Site is in good condition	Above	Less than 100 m from HWL	Yes	Yes	Minor Erosion
21			0	No	No	No				0				No	No	
22			0	No	No	No				0				No	No	

Point Number	Sanctioned Camping Sediment Delivery	Sanctioned Camping Erosion Comment	Sanctioned Camping Barriers Present	Sanctioned Camping Barriers Functioning	Sanctioned Camping Barriers Comment	Sanctioned Camping Photos	Sanctioned Camping Qualitative Severity	Sanctioned Camping Comment	Sanctioned Camping Vegetation Clearing	Sanctioned Camping Linear Corridors	Sanctioned Camping Other Disturbances Comment	Sanctioned Camping Porta Potties	Sanctioned Camping Wash - rooms	Sanctioned Camping Outhouses	Sanctioned Camping Boat Ramp	Sanctioned Camping Other Facilities	Sanctioned Camping Number of Facilities Category
16			No	No					No	No		No	No	No	No		
17			No	No					No	No		No	No	No	No		
18			No	No					No	No		No	No	No	No		
19			No	No					No	No		No	No	No	No		
20	Evident and Direct	From access road	No	No		5194-99	Low	Access road/boat launch contributes sediment to lake	Yes	Yes		No	No	Yes	Yes		2 outhouses
21			No	No					No	No		No	No	No	No		
22			No	No					No	No		No	No	No	No		

Point Number	Sanctioned Camping Facilities Distance Category	Sanctioned Camping Facilities Comment	Un - sanctioned Camping Sites Number	Un - sanctioned Tenting	Un - sanctioned Campers	Other Types of Un - sanctioned Camping	Un - sanctioned # Firepit	Un - sanctioned Comments	Un - sanctioned Disturbance Category	Un - sanctioned Disturbance Extent	Un - sanctioned Disturbance Comment	Un - sanctioned Proximity	Un - sanctioned Proximity Comment	Un - sanctioned Garbage Present	Un - sanctioned Erosion Present	Un - sanctioned Erosion Category
16			1	Yes	Yes		1	Camper unlikely, as access is now blocked	< 10 square metres	10	Little impact, some garbage	Above	Within 50 to water	Yes	No	No Erosion Evident
17			0	No	No		0			0				No	No	
18			0	No	No		0			0				No	No	
19			0	No	No		0			0				No	No	
20	> 20 metres	good condition	0	No	No		0			0				No	No	
21			2	Yes	Yes		4	Along road and lake	< 10 square metres	5	Minimal impact, but garbage left behind	Above	Within 10 m of lake	Yes	Yes	Negligeable
22			10	Yes	Yes		15	Extensive garbage and disregard	> 50 sqaure metres	300	Unsanctioned sites extend into trees, large site	Above	Within 10 m of crooked lake dam	Yes	Yes	Minor Erosion

Point Number	Un - sanctioned Sediment Delivery	Un - sanctioned Erosion Comment	Un - sanctioned Barriers Present	Un - sanctioend Barriers Functioning	Un - sancationed Barriers Comment	Un - sanctioned Qualitative Severity	Un - sanctioned Linear Corridors	Un - sanctioned Vegetation Clearing	Un - sanctioned Sediment Delivery	Un - sanctioned Other Disturbances Comment	Un - sanctioned Comments	Un - sacntioned Photos
16	No delivery	No significant erosion from USA at this location	Yes	Yes	Lock gate, fire pit is old	Low	No	Yes	No		Old evidence of camping at this location, no longer a problem?	5116-7
17			No	No			No	No	No			
18			No	No			No	No	No			
19			No	No			No	No	No			
20			No	No			No	No	No			
21	Indirect andfiltered	No significant erosion from USA at this location	No	No		Moderate	Yes	Yes	Yes		Disregard along this road, USA left with garbage	5200-17
22	Evident and Direct	Erosion from cleared areas	No	No	Need a barrier at this location	High	Yes	Yes	Yes	Disregard at this location	Site should be either changed to sanctioned with road improvements, or access must be blocked	5238-64

Point Number	Cattle Presence	Cow Fecal Density Category	Cattle Fecal Density	Cattle Proximity	Cattle Erosion	Cattle Erosion Category	Cattle Sediment Delivery	Cattle Vegetation Disturbance	Cattle Aggregation	Cattle Stream Length Impacted Category	Cattle Actual Stream Length Impacted	Cattle Guards Present	Cattle Exclusion Fencing Present	Quality Cattle Severity	Cattle Photo Numbers	Cattle Comments	Motorized Recreation Present
23	Yes	1-5	4	Above	No	Negligeable	No delivery	No	No		0	No	No	Low		Cattle using the non-status road as movement corridor	Yes
24	No		0		No			No	No		0	No	No				No
25	Yes	1-5	1	Above	No	No Erosion Evident	No delivery	No	No		0	No	No	Low	5072	Cattle feces adjacent to reservoir	Yes
26	Yes	1-5	3	Above	Yes	Negligeable	Evident and Direct	Yes	No	1-5 metres	1	No	No	Low	5074-5078	Access to the creek is minimal at this location	No
27	Yes	1-5	1	Above	No	No Erosion Evident	No delivery	Yes	No	No Impact	0	No	No	Low	5079-5081	Cattle activity around little pond not directly connected to reservoir	No
28	Yes	1-5	2	Above	No	No Erosion Evident	No delivery	No	No		0	No	No	Low		Evidence of cattle within clearing	Yes
29	Yes	1-5	1	Below	Yes	Negligeable	Evident and Direct	Yes	No	6-10 metres	10	No	No	Low	5161	Cattle evidence at lake edge	No

Point Number	Non Motorized Recreation Present	Sanctioned Camping Present	Un - sanctioned Camping Present	ATV Vehicles Present	Vehicle Access	Motor Boat Access	Snow - mobile Access	Other Motorized Vehicle Presence	Motoized Vehicle Comments	Motorized Type	Motorized Other Type	Motorized Vehicle Disturbance Category	Motorized Vehicle Acutal	Motorized Vehicle Disturbance Comment	Motorized Vehicle Proximity	Motorized Vehicle Proximity Comment	Motorized Vehicle Garbage Present
23	No	No	Yes	Yes	Yes	No	Yes		Motorized vehicles using the non-status road	Off Road/Trail	4x4 activity	< 10 square metres	0	Off Road/Trail	Above	On ridge above canyon, 250 m from creek	Yes
24	No	No	Yes	No	No	No	No						0				No
25	Yes	No	Yes	Yes	Yes	No	No		A fence reduces 4x4 access, but ATVs still use this area	Off Road/Trail		< 10 square metres	10	Some activity off the road	Above	Road is less than 10 m in some locations	No
26	No	No	No	No	No	No	No						0				No
27	No	No	No	No	No	No	No						0				No
28	No	No	Yes	Yes	Yes	No	Yes		Clearing adjacent to road, used for motorized activities	Off Road/Trail		> 50 sqaure metres	3000		Above	250 m from Lake	No
29	No	No	No	No	No	No	No						0				No

Point Number	Motorized Vehicle Erosion	Motorized Vehicle Erosion Catetory	Motorized Vehicle Sediment Delivery	Motorized Vehicle Erosion Comment	Motorized Vehicle Barriers Present	Motorized Vehicle Barriers Functioning	Motorized Vehicle Barriers Comment	Motorized Vehicle Photo Numbers	Motorized Vehicle Qualitative Severity	Motorized Vehicle Comment	Non-Motorized Hiking Present	Non Motorized Biking Present	Non Motorized Skiing Present	Non Motorized Fishing Present	Other Non Motorized Activities Present	Non Motorized Comment	Non Motorized Type
23	Yes	Minor Erosion	Indirect andfiltered	roadway erosion	Yes	No	Road access blocked by DLC, but has since been damaged and not functional	5067, 5069	Moderate	Should prevent access at this location	No	No	No	No			
24	No				No	No					No	No	No	No			
25	Yes	Negligeable	Weakly Filtered	Erosion from road at this location is minimal	Yes	Yes	Locked gate blocks some access, but open gate along side		Low		Yes	No	No	No		Road used as walking trail for campers	
26	No				No	No					No	No	No	No			
27	No				No	No					No	No	No	No			
28	Yes	Negligeable	No delivery		No	No			Low	Central location for 4x4 activity, but not affecting source water	No	No	No	No			
29	No				No	No					No	No	No	No			

Point Number	Non Motorized Other Types	Non Motorized Other Comments	Non Motorized Disturbance Catetgory	Non Motorized Disturbance Actual	Non Motorized Disturbance Comment	Non Motorized Proximity	Non Motorized Proximity Comment	Non-motorized Garbage Present	Non Motorized Erosion	Non Motorized Erosion Category	Non Motorized Sediment Delivery	Non Motorized Erosion Comment	Non Motorized Barriers Present	Non Motorized Barriers Functioning	Non Motorized Barrier Comment	Non Motorized Photo Numbers
23				0				No	No				No	No		
24				0				No	No				No	No		
25		Minimal to no disturbance from non-motorized recreation		0		Above	Less than 10 m to lake	No	No				No	No		
26				0				No	No				No	No		
27				0				No	No				No	No		
28				0				No	No				No	No		
29				0				No	No				No	No		

Point Number	Non Motorized Qualitative Severity	Non Motorized Comments	Sanctioned Camping # of Sites	Sanctioned Camp - ground	Sanctioned Resort	Sanctioned Cabins	Other Sanctioned Activities	Sanctioned Camping Comments	Sanctioned Camping Disturbance Category	Sanctioned Camping Acutal Disturbance	Sanctioned Camping Disturbance Comment	Sanctioned Camping Proximity	Sanctioned Camping Proximity Comment	Sanctioned Camping Gargbage Present	Santioned Camping Erosion Present	Santioned Camping Erosion Category
23			0	No	No	No				0				No	No	
24			0	No	No	No				0				No	No	
25	Low		0	No	No	No				0				No	No	
26			0	No	No	No				0				No	No	
27			0	No	No	No				0				No	No	
28			0	No	No	No				0				No	No	
29			0	No	No	No				0				No	No	

Point Number	Sanctioned Camping Sediment Delivery	Sanctioned Camping Erosion Comment	Sanctioned Camping Barriers Present	Sanctioned Camping Barriers Functioning	Sanctioned Camping Barriers Comment	Sanctioned Camping Photos	Sanctioned Camping Qualitative Severity	Sanctioned Camping Comment	Sanctioned Camping Vegetation Clearing	Sanctioned Camping Linear Corridors	Sanctioned Camping Other Disturbances Comment	Sanctioned Camping Porta Potties	Sanctioned Camping Wash - rooms	Sanctioned Camping Outhouses	Sanctioned Camping Boat Ramp	Sanctioned Camping Other Facilities	Sanctioned Camping Number of Facilities Category
23			No	No					No	No		No	No	No	No		
24			No	No					No	No		No	No	No	No		
25			No	No					No	No		No	No	No	No		
26			No	No					No	No		No	No	No	No		
27			No	No					No	No		No	No	No	No		
28			No	No					No	No		No	No	No	No		
29			No	No					No	No		No	No	No	No		

Point Number	Sanctioned Camping Facilities Distance Category	Sanctioned Camping Facilities Comment	Un - sanctioned Camping Sites Number	Un - sanctioned Tenting	Un - sanctioned Campers	Other Types of Un - sanctioned Camping	Un - sanctioned # Firepit	Un - sanctioned Comments	Un - sanctioned Disturbance Category	Un - sanctioned Disturbance Extent	Un - sanctioned Disturbance Comment	Un - sanctioned Proximity	Un - sanctioned Proximity Comment	Un - sanctioned Garbage Present	Un - sanctioned Erosion Present	Un - sanctioned Erosion Category
23			1	Yes	Yes		1	Camping along road	< 10 square metres	5	Garbage left behind	Above	On ridge above canyon	Yes	Yes	Minor Erosion
24			1	Yes	Yes		1	clearing adjacent to road used for camping	< 10 square metres	10	Could be minimal disturbance, but lots of garbage left behink	Above	On ridge above canyon, 200 m from creek	Yes	No	No Erosion Evident
25			1	Yes	No		2	access unknown	< 10 square metres	10	Old firepits encountered adjacent to dam	Above	Within 5 m of HWL	No	No	No Erosion Evident
26			0	No	No		0			0				No	No	
27			0	No	No		0			0				No	No	
28			4	Yes	Yes		4	Firepits within cleared area	> 50 sqaure metres	0	Unsact Camping likely affiliated with motorized activities	Above	250 m to lake	Yes	Yes	Negligeable
29			0	No	No		0			0				No	No	

Point Number	Un - sanctioned Sediment Delivery	Un - sanctioned Erosion Comment	Un - sanctioned Barriers Present	Un - sanctioend Barriers Functioning	Un - sancationed Barriers Comment	Un - sanctioned Qualitative Severity	Un - sanctioned Linear Corridors	Un - sanctioned Vegetation Clearing	Un - sanctioned Sediment Delivery	Un - sanctioned Other Disturbances Comment	Un - sanctioned Comments	Un - sacntioned Photos
23	Indirect andfiltered	roadway erosion	Yes	No	Road blocked by DLC, but nonfuntional	Low	No	No	Yes		Access should be blocked, due to disregard, intentional dumping, garbage, etc.	5068
24	No delivery	Significant garbage left behind	Yes	No	Road has since been blocked by DLC, but access continues	Low	No	Yes	No		Likely clearing of vegetation to be used in campfires	4972
25	No delivery		Yes	Yes	Fence likely reduces access, firpits appear to be old	Low	No	Yes	No		Minimal impact from unsanctioned camping activity at this location	5071
26			No	No			No	No	No			
27			No	No			No	No	No			
28	No delivery	Erosion originating from clearing and from motorized activities	No	No		Low	No	No	No			5133-5144
29			No	No			No	No	No			

Point Number	Cattle Presence	Cow Fecal Density Category	Cattle Fecal Density	Cattle Proximity	Cattle Erosion	Cattle Erosion Category	Cattle Sediment Delivery	Cattle Vegetation Disturbance	Cattle Aggregation	Cattle Stream Length Impacted Category	Cattle Actual Stream Length Impacted	Cattle Guards Present	Catlle Exclusion Fencing Present	Quality Cattle Severity	Cattle Photo Numbers	Cattle Comments	Motorized Recreation Present
30	Yes	1-5	2	Above	Yes	Negligeable	Indirect & Filtered	No	No		0	No	No	Low		Cattle are hanging out in the 4x4 area	Yes
32	Yes	1-5	2	Above	No	Negligeable	No delivery	No	No		0	Yes	Yes	Low	4792-95	Fencing around creek	Yes
33	Yes	1-5	2	Above	No	Negligeable	No delivery	No	No		0	No	No	Low	4822	Cattle at Recreation site	Yes
34	Yes	1-5	2	Below	Yes	Minor Erosion	Evident and Direct	No	Yes	1-5 metres	5	No	No	Moderate	4855-56	Cattle access to below HWL, numerous footprints in mud	No
35	Yes	1-5	4	Below	Yes	Negligeable	Weakly Filtered	Yes	Yes	> 10 metres	15	No	No	Moderate	4889-4898	Riparian pasture with low stubble heights, entrance trail with erosion, but filtered by vegetation	No
36	Yes	1-5	1	Above	No	Negligeable	No delivery	No	No		0	Yes	Yes	Low	4904-4909	Cattle guard not functioning	No
37	Yes	1-5	1	Below	No	Negligeable	Evident and Direct	No	No	1-5 metres	1	No	Yes	Low	4987	Old feces, historic cattle presnce	No

Point Number	Non Motorized Recreation Present	Sanctioned Camping Present	Un - sanctioned Camping Present	ATV Vehicles Present	Vehicle Access	Motor Boat Access	Snow - mobile Access	Other Motorized Vehicle Presence	Motoized Vehicle Comments	Motorized Type	Motorized Other Type	Motorized Vehicle Disturbance Category	Motorized Vehicle Acutal	Motorized Vehicle Disturbance Comment	Motorized Vehicle Proximity	Motorized Vehicle Proximity Comment	Motorized Vehicle Garbage Present
30	No	No	Yes	Yes	Yes	No	Yes		Clearing adjacent to road, which is used for mud bogging	Off Road/Trail		> 50 sqaure metres	150	Sediment production	Above	Relatively close proximity to ephemeral creek	Yes
32	No	No	No	Yes	Yes	No	Yes	main road	stream crossing	Sac. Road			0		Above		No
33	Yes	Yes	Yes	Yes	Yes	No	Yes	Easy vehicle access	Access road erosion issues	Sac. Road			0		Above	Access road is less than 25 m to lake	No
34	No	No	Yes	No	No	No	No						0				No
35	No	No	No	No	No	No	No						0				No
36	No	No	No	No	No	No	No						0				No
37	No	No	No	No	No	No	No						0				No

Point Number	Motorized Vehicle Erosion	Motorized Vehicle Erosion Catetory	Motorized Vehicle Sediment Delivery	Motorized Vehicle Erosion Comment	Motorized Vehicle Barriers Present	Motorized Vehicle Barriers Functioning	Motorized Vehicle Barriers Comment	Motorized Vehicle Photo Numbers	Motorized Vehicle Qualitative Severity	Motorized Vehicle Comment	Non-Motorized Hiking Present	Non Motorized Biking Present	Non Motorized Skiing Present	Non Motorized Fishing Present	Other Non Motorized Activities Present	Non Motorized Comment	Non Motorized Type
30	Yes	Minor Erosion	Indirect andfiltered		No	No			Moderate	Central location for 4x4 activity	No	No	No	No			
32	Yes	Minor Erosion	No delivery	Mini cattle guards to capture flows from road	Yes	Yes	good fencing, culverts	4784-85	Low	Stream crossing appears well protected	No	No	No	No			
33	No	Minor Erosion	Weakly Filtered	Erosion originating from access road, needs sump or water bars	Yes	Yes	Boulders block access to dam		Low		Yes	No	No	No		High Rim Trail	
34	No				No	No					No	No	No	No			
35	No				No	No					No	No	No	No			
36	No				No	No					No	No	No	No			
37	No				No	No					No	No	No	No			

Point Number	Non Motorized Other Types	Non Motorized Other Comments	Non Motorized Disturbance Catetgory	Non Motorized Disturbance Actual	Non Motorized Disturbance Comment	Non Motorized Proximity	Non Motorized Proximity Comment	Non-motorized Garbage Present	Non Motorized Erosion	Non Motorized Erosion Category	Non Motorized Sediment Delivery	Non Motorized Erosion Comment	Non Motorized Barriers Present	Non Motorized Barriers Functioning	Non Motorized Barrier Comment	Non Motorized Photo Numbers
30				0				No	No				No	No		
32				0				No	No				No	No		
33				0		Above	300 m from Damer Lake	No	No				No	No		
34				0				No	No				No	No		
35				0				No	No				No	No		
36				0				No	No				No	No		
37				0				No	No				No	No		

Appendix C - Oyama and Vernon Creek Watershed Assessment Points

Point Number	Non Motorized Qualitative Severity	Non Motorized Comments	Sanctioned Camping # of Sites	Sanctioned Camp - ground	Sanctioned Resort	Sanctioned Cabins	Other Sanctioned Activities	Sanctioned Camping Comments	Sanctioned Camping Disturbance Category	Sanctioned Camping Acutal Disturbance	Sanctioned Camping Disturbance Comment	Sanctioned Camping Proximity	Sanctioned Camping Proximity Comment	Sanctioned Camping Gargbage Present	Sanctioned Camping Erosion Present	Santioned Camping Erosion Category
30			0	No	No	No				0				No	No	
32			0	No	No	No				0				No	No	
33			2	Yes	No	No	2 Vehicle units,	Small site	11-50 square metres	0	Significant Clearing associated with Rec. Site	Above	Less than 50 m from lake	No	Yes	Moderate Erosion
34			0	No	No	No				0				No	No	
35			0	No	No	No				0				No	No	
36			0	No	No	No				0				No	No	
37			0	No	No	No				0				No	No	

Point Number	Sanctioned Camping Sediment Delivery	Sanctioned Camping Erosion Comment	Sanctioned Camping Barriers Present	Sanctioned Camping Barriers Functioning	Sanctioned Camping Barriers Comment	Sanctioned Camping Photos	Sanctioned Camping Qualitative Severity	Sanctioned Camping Comment	Sanctioned Camping Vegetation Clearing	Sanctioned Camping Linear Corridors	Sanctioned Camping Other Disturbances Comment	Sanctioned Camping Porta Potties	Sanctioned Camping Wash - rooms	Sanctioned Camping Outhouses	Sanctioned Camping Boat Ramp	Sanctioned Camping Other Facilities	Sanctioned Camping Number of Facilities Category
30			No	No					No	No		No	No	No	No		
32			No	No					No	No		No	No	No	No		
33	Evident and Direct	Erosion from cleared campsites flows to lake	No	No		4824-26	Low	Low impact site, with some erosion concerns	Yes	Yes		No	No	Yes	No	Oly linear corridor is access road to campsite	1
34			No	No					No	No		No	No	No	No		
35			No	No					No	No		No	No	No	No		
36			No	No					No	No		No	No	No	No		
37			No	No					No	No		No	No	No	No		

Point Number	Sanctioned Camping Facilities Distance Category	Sanctioned Camping Facilities Comment	Un - sanctioned Camping Sites Number	Un - sanctioned Tenting	Un - sanctioned Campers	Other Types of Un - sanctioned Camping	Un - sanctioned # Firepit	Un - sanctioned Comments	Un - sanctioned Disturbance Category	Un - sanctioned Disturbance Extent	Un - sanctioned Disturbance Comment	Un - sanctioned Proximity	Un - sanctioned Proximity Comment	Un - sanctioned Garbage Present	Un - sanctioned Erosion Present	Un - sanctioned Erosion Category
30			0	Yes	Yes		5		> 50 sqaure metres	150	Firepits within cleared area	Above		Yes	Yes	Minor Erosion
32			0	No	No		0			0				No	No	
33	> 20 metres	low risk	10	Yes	Yes	large clearing, good vehicle acccess	10	Some firepits below hwl	11-50 square metres	25	USA presence, need more Rec sites?	Above	5-10 m from lake	Yes	Yes	Moderate Erosion
34			1	Yes	Yes		1	Firepit adjacent to lake	< 10 square metres	3	Minimal	Above	Site within 5 m to lake	Yes	Yes	Minor Erosion
35			0	No	No		0			0				No	No	
36			0	No	No		0			0				No	No	
37			0	No	No		0			0				No	No	

Point Number	Un - sanctioned Sediment Delivery	Un - sanctioned Erosion Comment	Un - sanctioned Barriers Present	Un - sanctioend Barriers Functioning	Un - sancationed Barriers Comment	Un - sanctioned Qualitative Severity	Un - sanctioned Linear Corridors	Un - sanctioned Vegetation Clearing	Un - sanctioned Sediment Delivery	Un - sanctioned Other Disturbances Comment	Un - sanctioned Comments	Un - sacntioned Photos
30	Indirect andfiltered	Erosion originating from clearing and from motorized activities	No	No		Moderate	No	Yes	Yes		Classified as moderate severity due to number of firepits, but not affecting sourcewater	5180-5193
32			No	No			No	No	No			
33	Evident and Direct	4830	No	No		Moderate	Yes	Yes	Yes		Recommend additional sactioned camping at this site	4822-40
34	Weakly filtered	There is vegeative buffer between USA site and waters edge	No	No		Low	No	Yes	Yes	Minor sediment concerns	Vegetative buffer between campsite and lake	4857-60
35			No	No			No	No	No			
36			No	No			No	No	No			
37			No	No			No	No	No			

Point Number	Cattle Presence	Cow Fecal Density Category	Cattle Fecal Density	Cattle Proximity	Cattle Erosion	Cattle Erosion Category	Cattle Sediment Delivery	Cattle Vegetation Disturbance	Cattle Aggregation	Cattle Stream Length Impacted Category	Cattle Actual Stream Length Impacted	Cattle Guards Present	Cattle Exclusion Fencing Present	Quality Cattle Severity	Cattle Photo Numbers	Cattle Comments	Motorized Recreation Present
38	Yes	6-10	6	Above	No	Negligeable	Indirect & Filtered	Yes	No	No Impact	0	No	Yes	Low	4993-4997	Off channel water, fencing appears to prevent access to intake and creek	No
39	Yes	1-5	4	Above	Yes	Minor Erosion	Weakly Filtered	Yes	Yes	6-10 metres	6	No	Yes	High	5002-5008	Wet low area with wallow, potential for transport to creek during runoff, 5 m from creek	No
41	Yes	1-5	3	Above	No	No Erosion Evident	No delivery	No	Yes	No Impact	0	No	Yes	Low	5028-9	Gate across rd, cattle along fence	Yes
42	Yes	Greater than 10	15	Above	No	No Erosion Evident	No delivery	Yes	Yes	No Impact	0	No	No	Low	4765-67	Off channel watering, 35 m from creek, high cattle use	Yes
43	Yes	6-10	6	Above	No	No Erosion Evident	No delivery	Yes	Yes	No Impact	0	No	No	Low	4779-4781	Possible water dugout, good location for off channel watering, shrubs for shade, 170 m from ck	Yes
44	Yes	1-5	5	Above	Yes	Negligeable	Indirect & Filtered	Yes	Yes	No Impact	0	Yes	Yes	Moderate	4796-4798	Wallow area 15 m from creek, potential transport during high flows periods only	No

Point Number	Non Motorized Recreation Present	Sanctioned Camping Present	Un - sanctioned Camping Present	ATV Vehicles Present	Vehicle Access	Motor Boat Access	Snow - mobile Access	Other Motorized Vehicle Presence	Motoized Vehicle Comments	Motorized Type	Motorized Other Type	Motorized Vehicle Disturbance Category	Motorized Vehicle Acutal	Motorized Vehicle Disturbance Comment	Motorized Vehicle Proximity	Motorized Vehicle Proximity Comment	Motorized Vehicle Garbage Present
38	No	No	No	No	No	No	No						0				No
39	No	No	No	No	No	No	No						0				No
41	No	No	No	Yes	Yes	No	Yes		Possible access for 4x4, ATV and snowmobile	Sac. Road		< 10 square metres	6	Erosion from road running down to steep coupled slope	Above	50 m to creek	No
42	No	No	No	Yes	Yes	No	Yes		Nonstatus road, relatively little motorized activity	Sac. Road			0	roadway use	Above	35 m to creek	No
43	No	No	No	Yes	Yes	No	Yes		Possible access for 4x4, ATV and snowmobile	Sac. Road			0	roadway use	Above	170 m to creek	No
44	No	No	No	No	No	No	No						0				No

Point Number	Motorized Vehicle Erosion	Motorized Vehicle Erosion Catetory	Motorized Vehicle Sediment Delivery	Motorized Vehicle Erosion Comment	Motorized Vehicle Barriers Present	Motorized Vehicle Barriers Functioning	Motorized Vehicle Barriers Comment	Motorized Vehicle Photo Numbers	Motorized Vehicle Qualitative Severity	Motorized Vehicle Comment	Non-Motorized Hiking Present	Non Motorized Biking Present	Non Motorized Skiing Present	Non Motorized Fishing Present	Other Non Motorized Activities Present	Non Motorized Comment	Non Motorized Type
38	No				No	No					No	No	No	No			
39	No				No	No					No	No	No	No			
41	Yes	Minor Erosion	Indirect andfiltered	Water bars to direct runoff	Yes	No	Water bars to direct runoff, dlc maintained	5011-5014	Moderate	Runoff may affect steep slopes below	No	No	No	No			
42	No	No Erosion Evident	No delivery	Water bars at various locations along nonstatus road	Yes	No	Water bars to direct drainage, not to prevent access		Low		No	No	No	No			
43	No	No Erosion Evident	No delivery		No	No		4779-4781	Low	Sanctioned road only, no extreme 4x4ing	No	No	No	No			
44	No				No	No					No	No	No	No			

Point Number	Non Motorized Other Types	Non Motorized Other Comments	Non Motorized Disturbance Catetgory	Non Motorized Disturbance Actual	Non Motorized Disturbance Comment	Non Motorized Proximity	Non Motorized Proximity Comment	Non-motorized Garbage Present	Non Motorized Erosion	Non Motorized Erosion Category	Non Motorized Sediment Delivery	Non Motorized Erosion Comment	Non Motorized Barriers Present	Non Motorized Barriers Functioning	Non Motorized Barrier Comment	Non Motorized Photo Numbers
38				0				No	No				No	No		
39				0				No	No				No	No		
41				0				No	No				No	No		
42				0				No	No				No	No		
43				0				No	No				No	No		
44				0				No	No				No	No		

Point Number	Non Motorized Qualitative Severity	Non Motorized Comments	Sanctioned Camping # of Sites	Sanctioned Camp - ground	Sanctioned Resort	Sanctioned Cabins	Other Sanctioned Activities	Sanctioned Camping Comments	Sanctioned Camping Disturbance Category	Sanctioned Camping Acutal Disturbance	Sanctioned Camping Disturbance Comment	Sanctioned Camping Proximity	Sanctioned Camping Proximity Comment	Sanctioned Camping Gargbage Present	Sanctioned Camping Erosion Present	Santioned Camping Erosion Category
38			0	No	No	No				0				No	No	
39			0	No	No	No				0				No	No	
41			0	No	No	No				0				No	No	
42			0	No	No	No				0				No	No	
43			0	No	No	No				0				No	No	
44			0	No	No	No				0				No	No	

Point Number	Sanctioned Camping Sediment Delivery	Sanctioned Camping Erosion Comment	Sanctioned Camping Barriers Present	Sanctioned Camping Barriers Functioning	Sanctioned Camping Barriers Comment	Sanctioned Camping Photos	Sanctioned Camping Qualitative Severity	Sanctioned Camping Comment	Sanctioned Camping Vegetation Clearing	Sanctioned Camping Linear Corridors	Sanctioned Camping Other Disturbances Comment	Sanctioned Camping Porta Potties	Sanctioned Camping Wash - rooms	Sanctioned Camping Outhouses	Sanctioned Camping Boat Ramp	Sanctioned Camping Other Facilities	Sanctioned Camping Number of Facilities Category
38			No	No					No	No		No	No	No	No		
39			No	No					No	No		No	No	No	No		
41			No	No					No	No		No	No	No	No		
42			No	No					No	No		No	No	No	No		
43			No	No					No	No		No	No	No	No		
44			No	No					No	No		No	No	No	No		

Point Number	Sanctioned Camping Facilities Distance Category	Sanctioned Camping Facilities Comment	Un - sanctioned Camping Sites Number	Un - sanctioned Tenting	Un - sanctioned Campers	Other Types of Un - sanctioned Camping	Un - sanctioned # Firepit	Un - sanctioned Comments	Un - sanctioned Disturbance Category	Un - sanctioned Disturbance Extent	Un - sanctioned Disturbance Comment	Un - sanctioned Proximity	Un - sanctioned Proximity Comment	Un - sanctioned Garbage Present	Un - sanctioned Erosion Present	Un - sanctioned Erosion Category
38			0	No	No		0			0				No	No	
39			0	No	No		0			0				No	No	
41			0	No	No		0			0				No	No	
42			0	No	No		0			0				No	No	
43			0	No	No		0			0				No	No	
44			0	No	No		0			0				No	No	

Point Number	Un - sanctioned Sediment Delivery	Un - sanctioned Erosion Comment	Un - sanctioned Barriers Present	Un - sanctioend Barriers Functioning	Un - sancationed Barriers Comment	Un - sanctioned Qualitative Severity	Un - sanctioned Linear Corridors	Un - sanctioned Vegetation Clearing	Un - sanctioned Sediment Delivery	Un - sanctioned Other Disturbances Comment	Un - sanctioned Comments	Un - sacntioned Photos
38			No	No			No	No	No			
39			No	No			No	No	No			
41			No	No			No	No	No			
42			No	No			No	No	No			
43			No	No			No	No	No			
44			No	No			No	No	No			

Point Number	Cattle Presence	Cow Fecal Density Category	Cattle Fecal Density	Cattle Proximity	Cattle Erosion	Cattle Erosion Category	Cattle Sediment Delivery	Cattle Vegetation Disturbance	Cattle Aggregation	Cattle Stream Length Impacted Category	Cattle Actual Stream Length Impacted	Cattle Guards Present	Cattle Exclusion Fencing Present	Quality Cattle Severity	Cattle Photo Numbers	Cattle Comments	Motorized Recreation Present
45	Yes	1-5	2	Above	No	No Erosion Evident	No delivery	No	No	No Impact	0	Yes	Yes	Low		Nonfunctional cattle guard, fence needs repair	No
46	Yes	6-10	6	Below	Yes	Minor Erosion	Evident and Direct	Yes	Yes	> 10 metres	50	No	No	High	5066-5067	Cattle at the outflow of Damer Lake below HWL	No
47	Yes	1-5	4	Below	Yes	Minor Erosion	Evident and Direct	Yes	Yes	1-5 metres	4	Yes	Yes	Moderate	4867-4868	Cattle using defined trail to creek at stream/road crossing, fencing	No
48	Yes	1-5	1	Below	Yes	Negligeable	Indirect & Filtered	Yes	No	1-5 metres	5	No	No	Low	4872-4876	Cattle wallow area within a wetland adjacent to rd, no direct impact to creek (>400 m)	Yes
49	Yes	1-5	3	Below	No	No Erosion Evident	No delivery	No	No	1-5 metres	1	No	No	Low	4921	small drainage with bridge, cattle accessing water at crossing	No
50	Yes	1-5	2	Below	Yes	Negligeable	Evident and Direct	Yes	Yes	1-5 metres	3	No	No	Moderate	4930-4936	Cattle trail from road to access creek, sediment disturbance from cattle	No
51	Yes	1-5	2	Above	No			No	No		0	No	Yes	Low	4946-48	Cattle fencing	No

Point Number	Non Motorized Recreation Present	Sanctioned Camping Present	Un - sanctioned Camping Present	ATV Vehicles Present	Vehicle Access	Motor Boat Access	Snow - mobile Access	Other Motorized Vehicle Presence	Motoized Vehicle Comments	Motorized Type	Motorized Other Type	Motorized Vehicle Disturbance Category	Motorized Vehicle Acutal	Motorized Vehicle Disturbance Comment	Motorized Vehicle Proximity	Motorized Vehicle Proximity Comment	Motorized Vehicle Garbage Present
45	No	No	No	No	No	No	No						0				No
46	No	No	No	No	No	No	No						0				No
47	No	No	No	No	No	No	No						0				No
48	No	No	No	Yes	Yes	No	Yes		Possible access for 4x4, ATV and snowmobile	Mud Bogging	ATV bogging in wetland	11-50 square metres	40	wetland not connected to creek	Below		No
49	No	No	No	No	No	No	No						0				No
50	No	No	No	No	No	No	No						0				No
51	No	No	No	No	No	No	No						0				No

Point Number	Motorized Vehicle Erosion	Motorized Vehicle Erosion Catetory	Motorized Vehicle Sediment Delivery	Motorized Vehicle Erosion Comment	Motorized Vehicle Barriers Present	Motorized Vehicle Barriers Functioning	Motorized Vehicle Barriers Comment	Motorized Vehicle Photo Numbers	Motorized Vehicle Qualitative Severity	Motorized Vehicle Comment	Non-Motorized Hiking Present	Non Motorized Biking Present	Non Motorized Skiing Present	Non Motorized Fishing Present	Other Non Motorized Activities Present	Non Motorized Comment	Non Motorized Type
45	No				No	No					No	No	No	No			
46	No				No	No					No	No	No	No			
47	No				No	No					No	No	No	No			
48	No	Negligeable	Indirect andfiltered		No	No		4878-4880	Low	Not affecting source water, because not connected to creek	No	No	No	No			
49	No				No	No					No	No	No	No			
50	No				No	No					No	No	No	No			
51	No				No	No					No	No	No	No			

Point Number	Non Motorized Other Types	Non Motorized Other Comments	Non Motorized Disturbance Catetgory	Non Motorized Disturbance Actual	Non Motorized Disturbance Comment	Non Motorized Proximity	Non Motorized Proximity Comment	Non-motorized Garbage Present	Non Motorized Erosion	Non Motorized Erosion Category	Non Motorized Sediment Delivery	Non Motorized Erosion Comment	Non Motorized Barriers Present	Non Motorized Barriers Functioning	Non Motorized Barrier Comment	Non Motorized Photo Numbers
45				0				No	No				No	No		
46				0				No	No				No	No		
47				0				No	No				No	No		
48				0				No	No				No	No		
49				0				No	No				No	No		
50				0				No	No				No	No		
51				0				No	No				No	No		

Point Number	Non Motorized Qualitative Severity	Non Motorized Comments	Sanctioned Camping # of Sites	Sanctioned Camp - ground	Sanctioned Resort	Sanctioned Cabins	Other Sanctioned Activities	Sanctioned Camping Comments	Sanctioned Camping Disturbance Category	Sanctioned Camping Acutal Disturbance	Sanctioned Camping Disturbance Comment	Sanctioned Camping Proximity	Sanctioned Camping Proximity Comment	Sanctioned Camping Gargbage Present	Sanctioned Camping Erosion Present	Santioned Camping Erosion Category
45			0	No	No	No				0				No	No	
46			0	No	No	No				0				No	No	
47			0	No	No	No				0				No	No	
48			0	No	No	No				0				No	No	
49			0	No	No	No				0				No	No	
50			0	No	No	No				0				No	No	
51			0	No	No	No				0				No	No	

Point Number	Sanctioned Camping Sediment Delivery	Sanctioned Camping Erosion Comment	Sanctioned Camping Barriers Present	Sanctioned Camping Barriers Functioning	Sanctioned Camping Barriers Comment	Sanctioned Camping Photos	Sanctioned Camping Qualitative Severity	Sanctioned Camping Comment	Sanctioned Camping Vegetation Clearing	Sanctioned Camping Linear Corridors	Sanctioned Camping Other Disturbances Comment	Sanctioned Camping Porta Potties	Sanctioned Camping Wash - rooms	Sanctioned Camping Outhouses	Sanctioned Camping Boat Ramp	Sanctioned Camping Other Facilities	Sanctioned Camping Number of Facilities Category
45			No	No					No	No		No	No	No	No		
46			No	No					No	No		No	No	No	No		
47			No	No					No	No		No	No	No	No		
48			No	No					No	No		No	No	No	No		
49			No	No					No	No		No	No	No	No		
50			No	No					No	No		No	No	No	No		
51			No	No					No	No		No	No	No	No		

Point Number	Sanctioned Camping Facilities Distance Category	Sanctioned Camping Facilities Comment	Un - sanctioned Camping Sites Number	Un - sanctioned Tenting	Un - sanctioned Campers	Other Types of Un - sanctioned Camping	Un - sanctioned # Firepit	Un - sanctioned Comments	Un - sanctioned Disturbance Category	Un - sanctioned Disturbance Extent	Un - sanctioned Disturbance Comment	Un - sanctioned Proximity	Un - sanctioned Proximity Comment	Un - sanctioned Garbage Present	Un - sanctioned Erosion Present	Un - sanctioned Erosion Category
45			0	No	No		0			0				No	No	
46			0	No	No		0			0				No	No	
47			0	No	No		0			0				No	No	
48			0	No	No		0			0				No	No	
49			0	No	No		0			0				No	No	
50			0	No	No		0			0				No	No	
51			0	No	No		0			0				No	No	

Point Number	Un - sanctioned Sediment Delivery	Un - sanctioned Erosion Comment	Un - sanctioned Barriers Present	Un - sanctioend Barriers Functioning	Un - sancationed Barriers Comment	Un - sanctioned Qualitative Severity	Un - sanctioned Linear Corridors	Un - sanctioned Vegetation Clearing	Un - sanctioned Sediment Delivery	Un - sanctioned Other Disturbances Comment	Un - sanctioned Comments	Un - sacntioned Photos
45			No	No			No	No	No			
46			No	No			No	No	No			
47			No	No			No	No	No			
48			No	No			No	No	No			
49			No	No			No	No	No			
50			No	No			No	No	No			
51			No	No			No	No	No			

Point Number	Cattle Presence	Cow Fecal Density Category	Cattle Fecal Density	Cattle Proximity	Cattle Erosion	Cattle Erosion Category	Cattle Sediment Delivery	Cattle Vegetation Disturbance	Cattle Aggregation	Cattle Stream Length Impacted Category	Cattle Actual Stream Length Impacted	Cattle Guards Present	Cattle Exclusion Fencing Present	Quality Cattle Severity	Cattle Photo Numbers	Cattle Comments	Motorized Recreation Present
53	No		0		No			No	No		0	No	No				Yes
54	Yes	1-5	0	Below	Yes	Negligeable	Evident and Direct	No	No	1-5 metres	5	No	No	Low	5307-8	Cattle accessing creek at stream crossing	No
55	Yes	1-5	2	Below	Yes	Minor Erosion	Evident and Direct	Yes	Yes	6-10 metres	10	Yes	No	Moderate	5312-18	Cattle accessing creek from road, well defined cattle trail and feces to the HWL	No
56	Yes	6-10	10	Below	Yes	Moderate Erosion	Evident and Direct	Yes	Yes	> 10 metres	100	No	No	High	5330-5337	Cattle accessing the creek from well defined trail, lots of evidence of wallowing	No
57	No		0		No			No	No		0	No	No				Yes
58	Yes	6-10	6	Below	Yes	Minor Erosion	Evident and Direct	Yes	Yes	> 10 metres	30	No	No	Moderate	5405-10	Cattle accessing the lake via fire access road and trail to lease lot cabins	No

Point Number	Non Motorized Recreation Present	Sanctioned Camping Present	Un - sanctioned Camping Present	ATV Vehicles Present	Vehicle Access	Motor Boat Access	Snow - mobile Access	Other Motorized Vehicle Presence	Motoized Vehicle Comments	Motorized Type	Motorized Other Type	Motorized Vehicle Disturbance Category	Motorized Vehicle Acutal	Motorized Vehicle Disturbance Comment	Motorized Vehicle Proximity	Motorized Vehicle Proximity Comment	Motorized Vehicle Garbage Present
53	No	No	Yes	Yes	Yes	No	No		Access partially blocked	Off Road/Trail		< 10 square metres	0	Shot gun shells >100	Above	A "lookout" point over Oyama Creek	Yes
54	No	No	No	No	No	No	No						0				No
55	No	No	No	No	No	No	No						0				No
56	No	No	No	No	No	No	No						0				No
57	No	Yes	No	Yes	Yes	Yes	Yes		boat launch at this recreation site, motorized destination	Sac. Road		< 10 square metres	10	clearing with possible erosion concerns	Above	Within 10 m of HWL and boat launch to HWL	Yes
58	No	No	No	No	No	No	No						0				No

Point Number	Motorized Vehicle Erosion	Motorized Vehicle Erosion Catetory	Motorized Vehicle Sediment Delivery	Motorized Vehicle Erosion Comment	Motorized Vehicle Barriers Present	Motorized Vehicle Barriers Functioning	Motorized Vehicle Barriers Comment	Motorized Vehicle Photo Numbers	Motorized Vehicle Qualitative Severity	Motorized Vehicle Comment	Non-Motorized Hiking Present	Non Motorized Biking Present	Non Motorized Skiing Present	Non Motorized Fishing Present	Other Non Motorized Activities Present	Non Motorized Comment	Non Motorized Type
53	Yes	Negligeable	No delivery		Yes	No	boulder to block access, needs additional barrier to prevent ATV access	5280-92	Low	Lead shots if being used could access creek below	No	No	No	No			
54	No				No	No					No	No	No	No			
55	No				No	No					No	No	No	No			
56	No				No	No					No	No	No	No			
57	Yes	Minor Erosion	Evident and Direct	Originates from cleared rec site and boat launch	Yes	Yes	signage	5356-5365	Low		No	No	No	No			
58	No				No	No					No	No	No	No			

Point Number	Non Motorized Other Types	Non Motorized Other Comments	Non Motorized Disturbance Catetgory	Non Motorized Disturbance Actual	Non Motorized Disturbance Comment	Non Motorized Proximity	Non Motorized Proximity Comment	Non-motorized Garbage Present	Non Motorized Erosion	Non Motorized Erosion Category	Non Motorized Sediment Delivery	Non Motorized Erosion Comment	Non Motorized Barriers Present	Non Motorized Barriers Functioning	Non Motorized Barrier Comment	Non Motorized Photo Numbers
53				0				No	No				No	No		
54				0				No	No				No	No		
55				0				No	No				No	No		
56				0				No	No				No	No		
57				0				No	No				No	No		
58				0				No	No				No	No		

Point Number	Non Motorized Qualitative Severity	Non Motorized Comments	Sanctioned Camping # of Sites	Sanctioned Camp - ground	Sanctioned Resort	Sanctioned Cabins	Other Sanctioned Activities	Sanctioned Camping Comments	Sanctioned Camping Disturbance Category	Sanctioned Camping Acutal Disturbance	Sanctioned Camping Disturbance Comment	Sanctioned Camping Proximity	Sanctioned Camping Proximity Comment	Sanctioned Camping Gargbage Present	Sanctioned Camping Erosion Present	Santioned Camping Erosion Category
53			0	No	No	No				0				No	No	
54			0	No	No	No				0				No	No	
55			0	No	No	No				0				No	No	
56			0	No	No	No				0				No	No	
57			4	Yes	No	No	approx 4	compact,cle an	< 10 square metres	0		Above		Yes	Yes	Minor Erosion
58			0	No	No	No				0				No	No	

Point Number	Sanctioned Camping Sediment Delivery	Sanctioned Camping Erosion Comment	Sanctioned Camping Barriers Present	Sanctioned Camping Barriers Functioning	Sanctioned Camping Barriers Comment	Sanctioned Camping Photos	Sanctioned Camping Qualitative Severity	Sanctioned Camping Comment	Sanctioned Camping Vegetation Clearing	Sanctioned Camping Linear Corridors	Sanctioned Camping Other Disturbances Comment	Sanctioned Camping Porta Potties	Sanctioned Camping Wash - rooms	Sanctioned Camping Outhouses	Sanctioned Camping Boat Ramp	Sanctioned Camping Other Facilities	Sanctioned Camping Number of Facilities Category
53			No	No					No	No		No	No	No	No		
54			No	No					No	No		No	No	No	No		
55			No	No					No	No		No	No	No	No		
56			No	No					No	No		No	No	No	No		
57	Evident and Direct	erosion from boat launch	Yes	Yes	signaage	5356-5365	Low		Yes	Yes		No	No	Yes	Yes		1
58			No	No					No	No		No	No	No	No		

Point Number	Sanctioned Camping Facilities Distance Category	Sanctioned Camping Facilities Comment	Un - sanctioned Camping Sites Number	Un - sanctioned Tenting	Un - sanctioned Campers	Other Types of Un - sanctioned Camping	Un - sanctioned # Firepit	Un - sanctioned Comments	Un - sanctioned Disturbance Category	Un - sanctioned Disturbance Extent	Un - sanctioned Disturbance Comment	Un - sanctioned Proximity	Un - sanctioned Proximity Comment	Un - sanctioned Garbage Present	Un - sanctioned Erosion Present	Un - sanctioned Erosion Category
53			1	Yes	No	only access by ATV, or park at road and walk	1	Lookout point, not a lot of camping	< 10 square metres	5	Mostly garbage, intentional dumping	Above	On plateau above canyon	Yes	No	Negligeable
54			0	No	No		0			0				No	No	
55			0	No	No		0			0				No	No	
56			0	No	No		0			0				No	No	
57	> 20 metres	Outhouse more than 20 m from lake	0	No	No		0			0				No	No	
58			0	No	No		0			0				No	No	

Point Number	Un - sanctioned Sediment Delivery	Un - sanctioned Erosion Comment	Un - sanctioned Barriers Present	Un - sanctioend Barriers Functioning	Un - sancationed Barriers Comment	Un - sanctioned Qualitative Severity	Un - sanctioned Linear Corridors	Un - sanctioned Vegetation Clearing	Un - sanctioned Sediment Delivery	Un - sanctioned Other Disturbances Comment	Un - sanctioned Comments	Un - sacntioned Photos
53	No delivery	No issue	Yes	No	Access barrier only	Low	No	No	No		Garbage and left over casings are unsightly	5280-92
54			No	No			No	No	No			
55			No	No			No	No	No			
56			No	No			No	No	No			
57			No	No			No	No	No			
58			No	No			No	No	No			

Point Number	Cattle Presence	Cow Fecal Density Category	Cattle Fecal Density	Cattle Proximity	Cattle Erosion	Cattle Erosion Category	Cattle Sediment Delivery	Cattle Vegetation Disturbance	Cattle Aggregation	Cattle Stream Length Impacted Category	Cattle Actual Stream Length Impacted	Cattle Guards Present	Cattle Exclusion Fencing Present	Quality Cattle Severity	Cattle Photo Numbers	Cattle Comments	Motorized Recreation Present
59	No		0		No			No	No		0	No	No				No
60	No		0		No			No	No		0	No	No				No
61	Yes	1-5	2	Below	Yes	Minor Erosion	Weakly Filtered	Yes	No	6-10 metres	0	No	No	Low	p5 upstream		No
62	Yes	1-5	4	Below	Yes	Minor Erosion	Evident and Direct	Yes	Yes	> 10 metres	25	No	No	Moderate	p8	Cattle trails downstream	No
63	Yes	1-5	3	Below	Yes	Moderate Erosion	Evident and Direct	Yes	No	> 10 metres	0	No	No	Moderate	p18, 19	Stream widening due to cattle	No
64	Yes	1-5	3	Below	Yes	Moderate Erosion	Evident and Direct	Yes	No	> 10 metres	0	No	No	Moderate	p24	Cattle trample causing channelizatiion	No
65	Yes	1-5	3	Below	Yes	Moderate Erosion	Evident and Direct	Yes	No	> 10 metres	40	No	No	Moderate	p25, 26	Cattle trampling causing channelizatiion	No
66	No		0		No			No	No		0	No	No				Yes
68	Yes	1-5	4	Below	Yes	Negligeable	Evident and Direct	Yes	Yes	> 10 metres	20	No	No	Moderate	5814	Cattle below HWL of Wilma Lake	No
69	Yes	Greater than 10	12	Below	Yes	Moderate Erosion	Evident and Direct	Yes	Yes	> 10 metres	500	No	Yes	High	5343-50	Fencing crosses the creek, cattle on both sides of creek, crossing in numerous locations	No

Point Number	Non Motorized Recreation Present	Sanctioned Camping Present	Un - sanctioned Camping Present	ATV Vehicles Present	Vehicle Access	Motor Boat Access	Snow - mobile Access	Other Motorized Vehicle Presence	Motoized Vehicle Comments	Motorized Type	Motorized Other Type	Motorized Vehicle Disturbance Category	Motorized Vehicle Acutal	Motorized Vehicle Disturbance Comment	Motorized Vehicle Proximity	Motorized Vehicle Proximity Comment	Motorized Vehicle Garbage Present
59	No	Yes	No	No	No	Yes	No						0				No
60	No	Yes	No	No	No	No	No						0				No
61	No	No	No	No	No	No	No						0				No
62	No	No	No	No	No	No	No						0				No
63	No	No	No	No	No	No	No						0				No
64	No	No	No	No	No	No	No						0				No
65	No	No	No	No	No	No	No						0				No
66	No	No	No	Yes	Yes	No	Yes		Road rutted from 4x4 activity, no delivery, steep slope below	Off Road/Trail		> 50 sqaure metres	0	p1 to p5	Above		No
68	No	No	No										0				
69	No	No	No										0				

Point Number	Motorized Vehicle Erosion	Motorized Vehicle Erosion Catetory	Motorized Vehicle Sediment Delivery	Motorized Vehicle Erosion Comment	Motorized Vehicle Barriers Present	Motorized Vehicle Barriers Functioning	Motorized Vehicle Barriers Comment	Motorized Vehicle Photo Numbers	Motorized Vehicle Qualitative Severity	Motorized Vehicle Comment	Non-Motorized Hiking Present	Non Motorized Biking Present	Non Motorized Skiing Present	Non Motorized Fishing Present	Other Non Motorized Activities Present	Non Motorized Comment	Non Motorized Type
59	No				No	No					No	No	No	No			
60	No				No	No					No	No	No	No			
61	No				No	No					No	No	No	No			
62	No				No	No					No	No	No	No			
63	No				No	No					No	No	No	No			
64	No				No	No					No	No	No	No			
65	No				No	No					No	No	No	No			
66	No				No	No		p1-5	Low		No	No	No	No			
68																	
69																	

Point Number	Non Motorized Other Types	Non Motorized Other Comments	Non Motorized Disturbance Catetgory	Non Motorized Disturbance Actual	Non Motorized Disturbance Comment	Non Motorized Proximity	Non Motorized Proximity Comment	Non-motorized Garbage Present	Non Motorized Erosion	Non Motorized Erosion Category	Non Motorized Sediment Delivery	Non Motorized Erosion Comment	Non Motorized Barriers Present	Non Motorized Barriers Functioning	Non Motorized Barrier Comment	Non Motorized Photo Numbers
59				0				No	No				No	No		
60				0				No	No				No	No		
61				0				No	No				No	No		
62				0				No	No				No	No		
63				0				No	No				No	No		
64				0				No	No				No	No		
65				0				No	No				No	No		
66				0				No	No				No	No		
68				0												
69				0												

Point Number	Non Motorized Qualitative Severity	Non Motorized Comments	Sanctioned Camping # of Sites	Sanctioned Camp - ground	Sanctioned Resort	Sanctioned Cabins	Other Sanctioned Activities	Sanctioned Camping Comments	Sanctioned Camping Disturbance Category	Sanctioned Camping Acutal Disturbance	Sanctioned Camping Disturbance Comment	Sanctioned Camping Proximity	Sanctioned Camping Proximity Comment	Sanctioned Camping Gargbage Present	Sanctioned Camping Erosion Present	Santioned Camping Erosion Category
59			0	No	No	Yes		Small boarded up cabin	< 10 square metres	10	minimal, but cabin close to creek	Above	Cabin is within 10 m to creek	No	Yes	Negligeable
60			13	No	Yes	Yes		One residence and 13 cabins	11-50 square metres	0	cabins amongst treees	Above	Some cabins as close as 15 m to lake	No	Yes	Minor Erosion
61			0	No	No	No				0				No	No	
62			0	No	No	No				0				No	No	
63			0	No	No	No				0				No	No	
64			0	No	No	No				0				No	No	
65			0	No	No	No				0				No	No	
66			0	No	No	No				0				No	No	
68			0							0						
69			0							0						

Point Number	Sanctioned Camping Sediment Delivery	Sanctioned Camping Erosion Comment	Sanctioned Camping Barriers Present	Sanctioned Camping Barriers Functioning	Sanctioned Camping Barriers Comment	Sanctioned Camping Photos	Sanctioned Camping Qualitative Severity	Sanctioned Camping Comment	Sanctioned Camping Vegetation Clearing	Sanctioned Camping Linear Corridors	Sanctioned Camping Other Disturbances Comment	Sanctioned Camping Porta Potties	Sanctioned Camping Wash - rooms	Sanctioned Camping Outhouses	Sanctioned Camping Boat Ramp	Sanctioned Camping Other Facilities	Sanctioned Camping Number of Facilities Category
59	No Delivery	Possible erosion from land clearing activities, very minor	No	No		5571-74	Low		Yes	Yes	Quad path leading to cabin	No	No	Yes	No	1 firepit	
60	Evident and Direct	boat lanch, access road	Yes	Yes	Sump on road	5659-5677	Low	8 outhouses	Yes	Yes		No	Yes	Yes	No	septic	> 5
61			No	No					No	No		No	No	No	No		
62			No	No					No	No		No	No	No	No		
63			No	No					No	No		No	No	No	No		
64			No	No					No	No		No	No	No	No		
65			No	No					No	No		No	No	No	No		
66			No	No					No	No		No	No	No	No		
68																	
69																	

Point Number	Sanctioned Camping Facilities Distance Category	Sanctioned Camping Facilities Comment	Un - sanctioned Camping Sites Number	Un - sanctioned Tenting	Un - sanctioned Campers	Other Types of Un - sanctioned Camping	Un - sanctioned # Firepit	Un - sanctioned Comments	Un - sanctioned Disturbance Category	Un - sanctioned Disturbance Extent	Un - sanctioned Disturbance Comment	Un - sanctioned Proximity	Un - sanctioned Proximity Comment	Un - sanctioned Garbage Present	Un - sanctioned Erosion Present	Un - sanctioned Erosion Category
59	< 20 metres	No impact	0	No	No		0		< 10 square metres	0		Above		No	No	
60	> 20 metres	Appear well maintained and well kept	0	No	No		0			0				No	No	
61			0	No	No		0			0				No	No	
62			0	No	No		0			0				No	No	
63			0	No	No		0			0				No	No	
64			0	No	No		0			0				No	No	
65			0	No	No		0			0				No	No	
66			0	No	No		0			0				No	No	
68			0				0			0						
69			0				0			0						

Point Number	Un - sanctioned Sediment Delivery	Un - sanctioned Erosion Comment	Un - sanctioned Barriers Present	Un - sanctioend Barriers Functioning	Un - sancationed Barriers Comment	Un - sanctioned Qualitative Severity	Un - sanctioned Linear Corridors	Un - sanctioned Vegetation Clearing	Un - sanctioned Sediment Delivery	Un - sanctioned Other Disturbances Comment	Un - sanctioned Comments	Un - sacntioned Photos
59			No	No			No	Yes	No			
60			No	No			No	No	No			
61			No	No			No	No	No			
62			No	No			No	No	No			
63			No	No			No	No	No			
64			No	No			No	No	No			
65			No	No			No	No	No			
66			No	No			No	No	No			
68												
69												

Point Number	Cattle Presence	Cow Fecal Density Category	Cattle Fecal Density	Cattle Proximity	Cattle Erosion	Cattle Erosion Category	Cattle Sediment Delivery	Cattle Vegetation Disturbance	Cattle Aggregation	Cattle Stream Length Impacted Category	Cattle Actual Stream Length Impacted	Cattle Guards Present	Cattle Exclusion Fencing Present	Quality Cattle Severity	Cattle Photo Numbers	Cattle Comments	Motorized Recreation Present
70	Yes	6 - 10	8	Below	Yes	Moderate Erosion	Evident and Direct	Yes	Yes	> 10 metres	200	No	No	High	5124-32	Cattle wallowing in low areas adjacent to creek, lots of vegetation disturbance	No
71	Yes	Greater than 10	12	Below	Yes	Moderate Erosion	Evident and Direct	Yes	Yes	>10 metres	300	Yes	Yes	High	4800-05	Cattle guard on rd to south, fencing along creek	No
72	Yes	1-5	2	Above	No	No Erosion Evident	No delivery	No	No		0	No	No	Low	8859-61	Cattle using road to access steep canyon and ultimately creek	Yes
73	No		0		No			No	No		0	No	No				Yes
74	Yes	1-5	5	Below	Yes	Negligeable	Evident and Direct	Yes	Yes	> 10 metres	50	No	No	Moderate	8929-30	Cattle congregating at stream crossing and following ephemeral creek to Vernon Creek	No
75	Yes	6-10	7	Above	Yes	Negligeable	Indirect andfiltered	Yes	Yes	No Impact	0	No	No	Moderate	8988-91	High density fecal counts, Cattle congregating at 4x4 track	Yes

Point Number	Non Motorized Recreation Present	Sanctioned Camping Present	Un - sanctioned Camping Present	ATV Vehicles Present	Vehicle Access	Motor Boat Access	Snow - mobile Access	Other Motorized Vehicle Presence	Motoized Vehicle Comments	Motorized Type	Motorized Other Type	Motorized Vehicle Disturbance Category	Motorized Vehicle Acutal	Motorized Vehicle Disturbance Comment	Motorized Vehicle Proximity	Motorized Vehicle Proximity Comment	Motorized Vehicle Garbage Present
70	No	No	No										0				
71	No	No	No										0				
72	No	No	Yes	Yes	Yes	No	Yes		Nonfunctional barrier via dugout trenches, vehicles getting across	Off Road/Trail		< 10 square metres	0	Blocked road unsuccessful	Above	On the plateau above Vernon Creek Canyon	Yes
73	No	No	No	Yes	Yes	No	Yes		Road has been blocked with dug out trenches	Off Road/Trail		< 10 square metres	0	Barrier functioning thus far	Above	On the plateau above Vernon Creek Canyon	No
74	No	No	No	No	No	No	No						0		<Null>		<Null>
75	No	No	No	Yes	Yes	No	Yes		Site of intense off road activity	Off Road/Trail		> 50 sqaure metres	3000	Vehicle tracks through standing water	Above	800 metres from Vernon Creek	Yes

Point Number	Motorized Vehicle Erosion	Motorized Vehicle Erosion Catetory	Motorized Vehicle Sediment Delivery	Motorized Vehicle Erosion Comment	Motorized Vehicle Barriers Present	Motorized Vehicle Barriers Functioning	Motorized Vehicle Barriers Comment	Motorized Vehicle Photo Numbers	Motorized Vehicle Qualitative Severity	Motorized Vehicle Comment	Non-Motorized Hiking Present	Non Motorized Biking Present	Non Motorized Skiing Present	Non Motorized Fishing Present	Other Non Motorized Activities Present	Non Motorized Comment	Non Motorized Type
70																	
71																	
72	No	No Erosion Evident			Yes	No	Recommend 3 deeper trenchs in combination with boulders	8859-61	High	need to prevent access in this area	No	No	No	No			
73	No	No Erosion Evident			Yes	Yes	Dug out trench, appears to be blocking access	8888-8890	Low		No	No	No	No			
74	<Null>				<Null>	<Null>			<Null>		No	No	No	No			
75	Yes	Minor Erosion	Indirect andfiltered		Yes	No	Watershed sign is not deterring activities	8988-91	Moderate	Extensive activity	No	No	No	No			

Point Number	Non Motorized Other Types	Non Motorized Other Comments	Non Motorized Disturbance Catetgory	Non Motorized Disturbance Actual	Non Motorized Disturbance Comment	Non Motorized Proximity	Non Motorized Proximity Comment	Non-motorized Garbage Present	Non Motorized Erosion	Non Motorized Erosion Category	Non Motorized Sediment Delivery	Non Motorized Erosion Comment	Non Motorized Barriers Present	Non Motorized Barriers Functioning	Non Motorized Barrier Comment	Non Motorized Photo Numbers
70				0												
71				0												
72				0				No	No				No	No		
73				0				No	No				No	No		
74				0				No	No				No	No		
75				0				No	No				No	No		

Point Number	Non Motorized Qualitative Severity	Non Motorized Comments	Sanctioned Camping # of Sites	Sanctioned Camp - ground	Sanctioned Resort	Sanctioned Cabins	Other Sanctioned Activities	Sanctioned Camping Comments	Sanctioned Camping Disturbance Category	Sanctioned Camping Acutal Disturbance	Sanctioned Camping Disturbance Comment	Sanctioned Camping Proximity	Sanctioned Camping Proximity Comment	Sanctioned Camping Gargbage Present	Sanctioned Camping Erosion Present	Santioned Camping Erosion Category
70			0							0						
71			0							0						
72			0	No	No	No				0				No	No	
73			0	No	No	No				0				No	No	
74			0	No	No	No				0				No	No	
75			0	No	No	No				0				No	No	

Point Number	Sanctioned Camping Sediment Delivery	Sanctioned Camping Erosion Comment	Sanctioned Camping Barriers Present	Sanctioned Camping Barriers Functioning	Sanctioned Camping Barriers Comment	Sanctioned Camping Photos	Sanctioned Camping Qualitative Severity	Sanctioned Camping Comment	Sanctioned Camping Vegetation Clearing	Sanctioned Camping Linear Corridors	Sanctioned Camping Other Disturbances Comment	Sanctioned Camping Porta Potties	Sanctioned Camping Wash - rooms	Sanctioned Camping Outhouses	Sanctioned Camping Boat Ramp	Sanctioned Camping Other Facilities	Sanctioned Camping Number of Facilities Category
70																	
71																	
72			No	No					No	No		No	No	No	No		
73			No	No					No	No		No	No	No	No		
74			No	No					No	No		No	No	No	No		
75			No	No					No	No		No	No	No	No		

Point Number	Sanctioned Camping Facilities Distance Category	Sanctioned Camping Facilities Comment	Un - sanctioned Camping Sites Number	Un - sanctioned Tenting	Un - sanctioned Campers	Other Types of Un - sanctioned Camping	Un - sanctioned # Firepit	Un - sanctioned Comments	Un - sanctioned Disturbance Category	Un - sanctioned Disturbance Extent	Un - sanctioned Disturbance Comment	Un - sanctioned Proximity	Un - sanctioned Proximity Comment	Un - sanctioned Garbage Present	Un - sanctioned Erosion Present	Un - sanctioned Erosion Category
70			0				0			0						
71			0				0			0						
72			1	Yes	Yes	firepit in dugout trench	1	Likely camped overnight when attempting to gain access		0	Disturbance limited to existing road		On plateau above Vernon Creek canyon	Yes	No	
73			0	No	No		0			0				No	No	
74			0	No	No		0			0				No	No	
75			0	No	No		0			0				No	No	

Point Number	Un - sanctioned Sediment Delivery	Un - sanctioned Erosion Comment	Un - sanctioned Barriers Present	Un - sanctioend Barriers Functioning	Un - sancationed Barriers Comment	Un - sanctioned Qualitative Severity	Un - sanctioned Linear Corridors	Un - sanctioned Vegetation Clearing	Un - sanctioned Sediment Delivery	Un - sanctioned Other Disturbances Comment	Un - sanctioned Comments	Un - sacntioned Photos
70												
71												
72			No	No	Access barrier only	Low	No	No				8859
73			No	No			No	No				
74			No	No			No	No				
75			No	No			No	No				

Point Number	Cattle Presence	Cow Fecal Density Category	Cattle Fecal Density	Cattle Proximity	Cattle Erosion	Cattle Erosion Category	Cattle Sediment Delivery	Cattle Vegetation Disturbance	Cattle Aggregation	Cattle Stream Length Impacted Category	Cattle Actual Stream Length Impacted	Cattle Guards Present	Cattle Exclusion Fencing Present	Quality Cattle Severity	Cattle Photo Numbers	Cattle Comments	Motorized Recreation Present
76	Yes	6-10	7	Above	No			Yes	Yes	No Impact	0	No	No	Low	9148	Nonfunctional off channel watering site	No
77	Yes	1-5	1	Below	Yes	Negligeable	Evident and Direct	Yes	Yes	> 10 metres	100	No	No	High	9149-9158	Cattle activity within the first 400 m of the intake	No
78	Yes	1-5	1	Below	Yes	Negligeable	Evident and Direct	Yes	No	> 10 metres	0	No	No	Moderate	4811-4821	Cattle using riparian pasture, cattle path from road with some associated erosion	
79	Yes	6-10	0	Below	Yes	Minor	Evident and Direct	Yes	Yes	> 10 metres	0	No	No	High		Off channel watering, but cattle still accessing creek and using it as a crossing at this location	

Point Number	Non Motorized Recreation Present	Sanctioned Camping Present	Un - sanctioned Camping Present	ATV Vehicles Present	Vehicle Access	Motor Boat Access	Snow - mobile Access	Other Motorized Vehicle Presence	Motoized Vehicle Comments	Motorized Type	Motorized Other Type	Motorized Vehicle Disturbance Category	Motorized Vehicle Acutal	Motorized Vehicle Disturbance Comment	Motorized Vehicle Proximity	Motorized Vehicle Proximity Comment	Motorized Vehicle Garbage Present
76	No	No	No	No	No	No	No						0				No
77	No	No	No	No	No	No	No						0				No
78													0				
79													0				

Point Number	Motorized Vehicle Erosion	Motorized Vehicle Erosion Catetory	Motorized Vehicle Sediment Delivery	Motorized Vehicle Erosion Comment	Motorized Vehicle Barriers Present	Motorized Vehicle Barriers Functioning	Motorized Vehicle Barriers Comment	Motorized Vehicle Photo Numbers	Motorized Vehicle Qualitative Severity	Motorized Vehicle Comment	Non-Motorized Hiking Present	Non Motorized Biking Present	Non Motorized Skiing Present	Non Motorized Fishing Present	Other Non Motorized Activities Present	Non Motorized Comment	Non Motorized Type
76	No				No	No					No	No	No	No			
77	No				No	No					No	No	No	No			
78																	
79																	

Point Number	Non Motorized Other Types	Non Motorized Other Comments	Non Motorized Disturbance Catetgory	Non Motorized Disturbance Actual	Non Motorized Disturbance Comment	Non Motorized Proximity	Non Motorized Proximity Comment	Non-motorized Garbage Present	Non Motorized Erosion	Non Motorized Erosion Category	Non Motorized Sediment Delivery	Non Motorized Erosion Comment	Non Motorized Barriers Present	Non Motorized Barriers Functioning	Non Motorized Barrier Comment	Non Motorized Photo Numbers
76				0				No	No				No	No		
77				0				No	No				No	No		
78				0												
79				0												

Point Number	Non Motorized Qualitative Severity	Non Motorized Comments	Sanctioned Camping # of Sites	Sanctioned Camp - ground	Sanctioned Resort	Sanctioned Cabins	Other Sanctioned Activities	Sanctioned Camping Comments	Sanctioned Camping Disturbance Category	Sanctioned Camping Acutal Disturbance	Sanctioned Camping Disturbance Comment	Sanctioned Camping Proximity	Sanctioned Camping Proximity Comment	Sanctioned Camping Gargbage Present	Sanctioned Camping Erosion Present	Santioned Camping Erosion Category
76			0	No	No	No				0				No	No	
77			0	No	No	No				0				No	No	
78			0							0						
79			0							0						

Point Number	Sanctioned Camping Sediment Delivery	Sanctioned Camping Erosion Comment	Sanctioned Camping Barriers Present	Sanctioned Camping Barriers Functioning	Sanctioned Camping Barriers Comment	Sanctioned Camping Photos	Sanctioned Camping Qualitative Severity	Sanctioned Camping Comment	Sanctioned Camping Vegetation Clearing	Sanctioned Camping Linear Corridors	Sanctioned Camping Other Disturbances Comment	Sanctioned Camping Porta Potties	Sanctioned Camping Wash - rooms	Sanctioned Camping Outhouses	Sanctioned Camping Boat Ramp	Sanctioned Camping Other Facilities	Sanctioned Camping Number of Facilities Category
76			No	No					No	No		No	No	No	No		
77			No	No					No	No		No	No	No	No		
78																	
79																	

Point Number	Sanctioned Camping Facilities Distance Category	Sanctioned Camping Facilities Comment	Un - sanctioned Camping Sites Number	Un - sanctioned Tenting	Un - sanctioned Campers	Other Types of Un - sanctioned Camping	Un - sanctioned # Firepit	Un - sanctioned Comments	Un - sanctioned Disturbance Category	Un - sanctioned Disturbance Extent	Un - sanctioned Disturbance Comment	Un - sanctioned Proximity	Un - sanctioned Proximity Comment	Un - sanctioned Garbage Present	Un - sanctioned Erosion Present	Un - sanctioned Erosion Category
76			0	No	No		0			0				No	No	
77			0	No	No		0			0				No	No	
78			0				0			0						
79			0				0			0						

Point Number	Un - sanctioned Sediment Delivery	Un - sanctioned Erosion Comment	Un - sanctioned Barriers Present	Un - sanctioend Barriers Functioning	Un - sancationed Barriers Comment	Un - sanctioned Qualitative Severity	Un - sanctioned Linear Corridors	Un - sanctioned Vegetation Clearing	Un - sanctioned Sediment Delivery	Un - sanctioned Other Disturbances Comment	Un - sanctioned Comments	Un - sacntioned Photos
76			No	No			No	No				
77			No	No			No	No				
78												
79												

APPENDIX D

FIELD SURVEY PHOTOS OF INTEREST


Photo 1: Steep coupled slope approximately 1.8 km above the Vernon Creek intake.


Photo 2: Example of intentional dumping from accessible slopes.


Photo 3: Erosion associated with a cattle path that leads to Vernon Creek.


Photo 4: Rehabilitated landslide (on Vernon Creek) which has been trampled by cattle.

Photo 5: Garbage left at the trail head of the High Rim Trail.

Photo 6: Moderate erosion associated with the boat launch at the Beaver Lake Lodge.


Photo 7: Example of ATV use below the high water level of a source reservoir.


Photo 8: Erosion associated with a stream crossing.

Photo 9: Beaver Lake Recreation Site

Photo 10: Evidence of ATV use below the high water level between Crooked and Swalwell Lakes.

Photo 11: Excessive garbage was encountered at the Crooked Lake dam unsanctioned camp site.

Photo 12: Unsanctioned pit toilet at the crooked Lake dam site.


Photo 13: Evidence of vegetation burning below the high water level of the reservoir.


Photo 14: Cleared vegetation from lease lot piled below the high water level of reservoir for future burn.

Photo 15: A groyne associated with a lease lot.

Photo 16: Example of a lease lot moorage which is greater than 24 m^2 and ATV use below the high water level of the reservoir.

Photo 17: Example of substrate enhancement via importation of fines below the high water level of the reservoir.

Photo 18: Example of a lease lot retaining wall likely constructed to prevent erosion.

Photo 19: Educational signage within the Vernon Creek watershed.

Photo 20: Example of a damaged culvert.


Photo 21: Example of an off channel cattle water tank.


Photo 22: Portion of Damer Lake which is isolated and has a propensity for algae.

Photo 23: Entrance gate and signage at the Oyama Creek intake.


Photo 24: Cattle fencing immediately adjacent to Oyama Creek.

Photo 25: Example of a constructed barrier (using boulders) to block ATV use.

Photo 26: Shell casings at the “lookout” in the Oyama Creek watershed.

Photo 27: Well used cattle path to Oyama Creek.

Photo 28: Cattle feces below the high water level of Oyama Creek.


Photo 29: Boat launch at the Oyama Lake Recreation Site.


Photo 30: Ephemeral Creek, fire retardant and burned landscape due to the approximately 2 km fire in the Oyama Creek watershed on June 11th, 2009.

Photo 31: Access road which was built to fight the fire and must be deactivated to prevent vehicle access to lease lots.

Photo 32: The well maintained trail which provides walking access to lease lots on Oyama Lake.


Photo 33: Example of a lease lot on Oyama Lake.

Photo 34: Example of signage which discourages camping in unsanctioned locations on Oyama Lake.

Photo 35: Example of forest harvesting adjacent to a reservoir.

Photo 36: Illustrates dieing trees likely affected by mountain pine beetle.

Photo 37: The Oyama Lake Wilderness Fishing Resort

Photo 38: Outhouse facilities at the Oyama Lake Wilderness Fishing Resort.

Appendix E. Stream Crossings in the Vernon Creek Watershed.

Stream Crossing Number	Crossing Type	Road Use	Crossing Comment	Sediment Delivery Score	Sediment Delivery Interpretation	Ecoscape Grouping	Liklihood	Consequence	Risk	Recommendation
2	Corregated Pipe	Active Mainline	fill erosion	0.64	Moderate	High	Likely	Minor	High	Regularly monitor and implement erosion control measures. A gravel apron applied to both sides of the stream crossing would be useful to reduce sediment from cattle.
3	Corregated Pipe	Active Mainline	fill erosion at outlet, cattle crossing	0.53	Low to Moderate	High	Likely	Minor	High	This is an ephemeral stream, therefore it should be monitored during extreme weather and high flow periods and improvements made accordingly.
5	Corregated Pipe	Active Mainline	stream crossing	0.43	Low to Moderate	High	Likely	Minor	High	This is an ephemeral stream, therefore it should be monitored during extreme weather and high flow periods and improvements made accordingly.
6	Corregated Pipe	Low Activity	outer plounge, scour	0.20	Slight	High	Likely	Minor	High	Monitor cattle and erosion at this crossing, and make improvements where possible.
11	Corregated Pipe	Active Mainline	intermitant flow, c/b bed	0.18	Very Minor	High	Likely	Minor	High	This is an ephemeral stream, therefore it should be monitored during extreme weather and high flow periods and improvements made accordingly.
1	Bridge	Active Mainline	bridge, actively contributing sediment from road	0.88	Moderate to High	Moderate	Possible	Minor	Moderate	Implement erosion control measures to reduce sediment from road (upstream side of bridge).
4	Corregated Pipe	Low Activity	intermitant, cobble bed, may have washed down road	0.40	Low to Moderate	High	Possible	Minor	Moderate	Monitor during high flow periods and implement erosion control measures where possible.
7	Corregated Pipe	Low Activity	trample and widening	0.35	Slight	Moderate	Possible	Minor	Moderate	Regularly monitor and implement erosion control measures. A gravel apron should be applied to reduce the effects of trampling by cattle.
10	Corregated Pipe	Moderate Activity	intermitant flow, c/b bed	0.18	Very Minor	Moderate	Possible	Minor	Moderate	Monitor during high flow periods and implement erosion control measures where possible.
12	Non-designed ford	Moderate Activity	spillway u/s, ATV crossing, steepsided	0.40	Low to Moderate	Moderate	Possible	Minor	Moderate	Regularly monitor for erosion from motorized vehicles. Look at ways of preventing motorized access.
13	Corregated Pipe	Moderate Activity	at lake open access	0.40	Low to Moderate	Moderate	Possible	Minor	Moderate	Monitor to determine usage of motorized vehicles, and restrict access where possible.
17	Corregated Pipe	Low Activity	stream crossing within resort	0.30	Slight	Moderate	Possible	Minor	Moderate	Implement erosion control measures to reduce sediment from road.
8	Corregated Pipe	Low Activity	flow leaves ditch, freshet, crosses rd and goes subsurface	0.27	Slight	Moderate	Unlikely	Minor	Low	none
9	Corregated Pipe	Low Activity	strm runs parrallel to rd, 2 pipes cross road	0.27	Slight	Moderate	Unlikely	Minor	Low	none
14	No Structure	De-activated semi	Stream crossing a minimal use road, low risk, cattle	0.30	Slight	Low	Rare	Minor	Low	none
15	Corregated Pipe	Low Activity	Stream crossing on low activity road	0.35	Slight	Low	Rare	Minor	Low	none

Appendix E. Stream Crossings in the Vernon Creek Watershed.

Stream Crossing Number	Crossing Type	Road Use	Crossing Comment	Sediment Delivery Score	Sediment Delivery Interpretation	Ecoscape Grouping	Liklihood	Consequence	Risk	Recommendation
16	Corregated Pipe	Low Activity	Culvert crushed in center of pipe, needs replaced	0.30	Slight	Low	Rare	Minor	Low	Repair or replace culvert
18	Clear Span Bridge	Active Mainline	cobble moss bed	0.23	Slight	Moderate	Unlikely	Minor	Low	none
19	Corregated Pipe	Moderate Activity	cattle damage up/downstream	0.23	Slight	Low	Rare	Minor	Low	none
20	Corregated Pipe	Active Mainline	wet area above channelized by cattle	0.23	Slight	Low	Rare	Minor	Low	none
21	Corregated Pipe	Active Mainline	fill erosion at culvert	0.26	Slight	Low	Rare	Minor	Low	none
22	Corregated Pipe	Active Branch Line	cattle in stream, erosion over fill	0.18	Very Minor	Low	Rare	Minor	Low	none
23	Corregated Pipe	Low Activity	washes over road	0.14	Very Minor	Low	Rare	Minor	Low	none
24	Encroached Bridge	Active Mainline	degraded channel, cobble bed	0.12	Very Minor	Low	Rare	Minor	Low	none
25	Corregated Pipe	Active Mainline	disturbed by trampling	0.18	Very Minor	Low	Rare	Minor	Low	none
26	Encroached Bridge	Moderate Activity	armoured	0.00	No Problems	Low	Rare	Minor	Low	none
27	Encroached Bridge	Low Activity	bridge deck failed	0.00	No Problems	Low	Rare	Minor	Low	none

Appendix E. Drainage Culverts along Beaver Lake Main in the Vernon Creek Watershed.

Drainage Culvert Number	Crossing Type	Road Use	Crossing Comment	Sediment Delivery Score	Sediment Delivery Interpretation	Ecocape Grouping	Liklihood	Consequence	Risk	Recommendation
100	Corregated Pipe	Active Mainline	Significant water movement along rear ditch, defined outflow channel 30 m from top of bank	0.40	Low to Moderate	High	Likely	Minor	High	Clean out top end of culvert
101	Corregated Pipe	Active Mainline	Poorly defined channel all the way to creek, approx 100 m	0.40	Low to Moderate	High	Likely	Minor	High	Culvert functioning, but should monitor during high flow periods
116	Corregated Pipe	Active Mainline	Two culverts, one is old and nonfunctional, defined channel to 30 m from top of bank, cattle	0.15	Very Minor	Low	Possible	Minor	Moderate	Clean out upper end of culvert

Appendix E. Drainage Culverts along Beaver Lake Main in the Vernon Creek Watershed.

Drainage Culvert Number	Crossing Type	Road Use	Crossing Comment	Sediment Delivery Score	Sediment Delivery Interpretation	Ecocape Grouping	Liklihood	Consequence	Risk	Recommendation
102	Corregated Pipe	Active Mainline	culvert only	0.30	Slight	Moderate	Rare	Minor	Low	Fix end of culvert
104	Corregated Pipe	Active Mainline	Culvert parallel with road	0.30	Slight	Moderate	Rare	Minor	Low	Replace culvert, putting water on road
105	Corregated Pipe	Active Mainline	Functioning	0.35	Slight	Moderate	Rare	Minor	Low	Upper end needs cleaned out
106	Corregated Pipe	Active Mainline	Functioning	0.30	Slight	Moderate	Rare	Minor	Low	none
107	Corregated Pipe	Active Mainline	Functioning	0.35	Slight	Moderate	Unlikely	Minor	Low	none
108	Corregated Pipe	Active Mainline	Functioning	0.30	Slight	Moderate	Unlikely	Minor	Low	none
109	Corregated Pipe	Active Mainline	Sediment needs cleaned out of top end	0.30	Slight	Moderate	Unlikely	Minor	Low	clean
110	Corregated Pipe	Active Mainline	Top end of culvert damaged	0.30	Slight	Moderate	Unlikely	Minor	Low	Replace or repair
111	Corregated Pipe	Active Mainline	Defined channel stops 30 m from road	0.35	Slight	Moderate	Unlikely	Minor	Low	Clean out upper end of culvert
112	Corregated Pipe	Active Mainline	Cattle walllowing at culvert	0.30	Slight	Moderate	Unlikely	Minor	Low	Clean
113	Corregated Pipe	Active Mainline	Culvert	0.30	Slight	Moderate	Rare	Minor	Low	none
114	Corregated Pipe	Active Mainline	Culvert only, functioning	0.30	Slight	Moderate	Rare	Minor	Low	None
115	Corregated Pipe	Active Mainline	Culvert only, functional, cattle aggregation at out flow of culvert	0.20	Slight	Moderate	Rare	Minor	Low	None
117	Corregated Pipe	Active Mainline	Culvert only - functioning	0.00	No Problems	Low	Rare	Minor	Low	None

Appendix F - Oyama Creek Watershed: Road Risk Analysis

Road	Responsible Party	Basin	Comments	Length (m)	Hazard	Resource at Stake	Probability of Hazard Occurance	Effect on Resource at Stake	Risk
OR2 (lower)	Non-status	Oyama residual	Deactivation insufficient or failing as a result of ATV and range use. Drainage uncontrolled above steep coupled slope.	2025.219	Road erosion, landslide, debris flow or flood on mainstem	Water quality, District intake infrastructure	H	H	VH
LOR1	Private	Oyama residual	Uncontrolled drainage onto steep coupled slopes, multiple landslides into Oyama Creek, increasing likelihood of debris flood or flood related damage.	43.942	Landslides, increased sediment load on mainstem channel, road erosion.	Public safety on fan, private land, private road infrastructure	H	H	VH
N 7023.01 (OYAMA LAKE)	BCTS	Oyama residual	Long downhill approach, surface erosion, sediment input to Oyama Creek. Structure is sufficient.	592.947	Surface erosion, sediment input mainstem channel.	Water quality	H	M	H
N 7023.07 (OYAMA-LODGE)	BCTS	Oyama residual	Erosion on steep grades close to stream, sediment input to main Oyama Creek tributary. Road too close to stream, should be relocated.	775.047	Road erosion, sediment input to streams	Water quality, road infrastructure	H	M	H
OR3 (trails)	Non-status	Oyama residual	Deactivation failing or insufficient, diversions above steep coupled slopes, fill in draws.	1275.004	Landslide, road erosion	Water quality	M	H	H
OR2 (upper)	Non-status	Oyama residual	Deactivation failing, limited runoff but drainage becoming uncontrolled above steep coupled slope	1907.589	Road erosion, landslide, possible debris flow or debris flood on mainstem	Water quality, District intake infrastructure	M	H	H
OR1	Private	Oyama residual	Light pullback done with waterbars, insufficient to achieve low risk situation, fill in draws, limited runoff but moving water.	203.116	Landslide in mainstem	Water quality, District intake infrastructure	M	H	H
Intake 1	Private	Oyama residual	Road and crossing built on floodplain, potential to divert flows with avulsion resulting in road erosion.	151.866	Road erosion, increased sediment load on mainstem channel.	Public safety on fan, private land, private road infrastructure	M	H	H
KE1	Tolko	Oyama Lake	Uncontrolled drainage, ditch scour, poor connection to water.	407.422	Drainage concentration	Road infrastructure	M	M	M
KING EDWARD MAIN	Tolko	Oyama Lake	Downhill approach to fish stream crossing, surface erosion, sediment input to channel.	195.130	Surface erosion, sediment input to fish stream	Fish and fish habitat	M	M	M

Appendix F - Oyama Creek Watershed: Road Risk Analysis

Road	Responsible Party	Basin	Comments	Length (m)	Hazard	Resource at Stake	Probability of Hazard Occurance	Effect on Resource at Stake	Risk
LL1043-01	Tolko	Oyama Lake	Surface erosion on downhill approach to FSR and fish stream.	240.136	Road erosion, sediment input to fish bearing waters.	Fish and fish habitat, road infrastructure.	M	M	M
N 7023.01 (OYAMA LAKE)	BCTS	Oyama residual	Running surface erosion input to ephemeral channels.	1389.910	Road erosion, sediment input to streams	Water quality	H	L	M
N 7023.08 (OYAMA-LODGE - BR 0.2)	BCTS	Oyama residual	Floodplain crossing, culvert undersized and failing. Erosion of road surface with input to main tributary.	54.003	Road erosion, seidment input to Oyama tributary.	Water quality, road infrastructure.	H	M	M
N 7023.01 (OYAMA LAKE)	BCTS	Oyama residual	Undersize or inappropriate stucture on S3 floodplain crossing. Expect failure with flow over road and erosion.	56.205	Road erosion, seidment input to Oyama tributary.	Water quality, road infrastructure	H	L	M
N 7023.01 (OYAMA LAKE)	BCTS	North Oyama	Surface erosion with sediment input to North Oyama Creek	504.132	Surface erosion, sediment input to fish bearing channel.	Fish and fish habitat	H	M	M
NO2	Non-status	North Oyama	Road built on tributary, surface eroding, sediment input to fish bearing waters	476.940	Road erosion, sediment input to fish stream	Fish and fish habitat	H	L	M
NO1	Non-status	North Oyama	Surface erosion on steeper grades, sediment input to fish bearing waters	235.474	Road erosoin, sediment input to fish stream	Fish and fish habitat	H	L	M
OR4	Non-status	Oyama residual	Deactivation insufficient or failing, diversions and conentration down to FSR, sediment input to tributary	646.253	Road erosion, sediment input to streams	Water quality	H	L	M
OR5	Non-status	Oyama residual	S4 on road, erosion of running surface, sediment input to tributary.	102.062	Road erosion, sediment input to streams	Water quality	H	L	M
Towgood Road	Non-status	Oyama residual	Uncontrolled drainage down to crossing, surface erosion, sediment input to N. Oyama Creek. Structure on N. Oyama Creek is sufficient.	566.218	Road erosion, sediment input to streams	Water quality	H	L	M
Goat Trail	Non-status	Oyama Lake	Uncontrolled drainage on or above steep terrain, washout or landslide likely.	706.115	Road washout, landslide	Road infrastructure and downslope forest resources	M	M	M

Appendix F - Oyama Creek Watershed: Road Risk Analysis

Road	Responsible Party	Basin	Comments	Length (m)	Hazard	Resource at Stake	Probability of Hazard Occurance	Effect on Resource at Stake	Risk
	Tolko	Oyama Lake		49.002					L
A11-1	Tolko	Oyama Lake		368.466					L
KING EDWARD MAIN	Tolko	Oyama Lake		428.200					L
A11-1	Tolko	Oyama Lake		383.250					L
KING EDWARD MAIN	Tolko	Oyama Lake		395.195					L
KING EDWARD MAIN	Tolko	Oyama Lake		570.474					L
QUEEN	Tolko	Oyama Lake		35.401					L
QUEEN	Tolko	Oyama Lake		823.167					L
A10-2	Tolko	Oyama Lake		209.405					L
LL1005-05	Tolko	Oyama Lake		17.360					L
LL1005-05	Tolko	Oyama Lake		135.977					L
A10-1	Tolko	Oyama Lake		279.009					L
A10-3	Tolko	Oyama Lake		285.143					L
KING EDWARD MAIN	Tolko	Oyama Lake		328.559					L
QUEEN	Tolko	Oyama Lake		287.644					L
LL1005-06	Tolko	Oyama Lake		185.067					L
QUEEN	Tolko	Oyama Lake		62.183					L
LL1005-01	Tolko	Oyama Lake		286.365					L
LL1004-01	Tolko	Oyama Lake		164.617					L
LL1004-01	Tolko	Oyama Lake		73.037					L
LL1004-01	Tolko	Oyama Lake		101.898					L
	Tolko	Oyama Lake		105.560					L
LL1004-01	Tolko	Oyama Lake		185.269					L
LL1004-04	Tolko	Oyama Lake		140.189					L
LL1005-02	Tolko	Oyama Lake		206.431					L
LL1004-02	Tolko	Oyama Lake		223.340					L
LL1005-02	Tolko	Oyama Lake		109.635					L
QUEEN	Tolko	Oyama Lake		309.813					L
A10-1	Tolko	Oyama Lake		564.863					L

Appendix F - Oyama Creek Watershed: Road Risk Analysis

Road	Responsible Party	Basin	Comments	Length (m)	Hazard	Resource at Stake	Probability of Hazard Occurance	Effect on Resource at Stake	Risk
LL1005-03	Tolko	Oyama Lake		152.701					L
LL1004-04	Tolko	Oyama Lake		178.596					L
	Tolko	Oyama Lake		95.491					L
	Tolko	Oyama Lake		743.932					L
LL1004-03	Tolko	Oyama Lake		216.561					L
LL1005-03	Tolko	Oyama Lake		160.890					L
	Tolko	Oyama Lake		62.039					L
LL1004-02	Tolko	Oyama Lake		223.786					L
A10-4	Tolko	Oyama Lake		176.441					L
A10-1	Tolko	Oyama Lake		178.516					L
QUEEN	Tolko	Oyama Lake		250.521					L
KING EDWARD MAIN	Tolko	Oyama Lake		617.642					L
LL1032-01	Tolko	Oyama Lake		64.460					L
QUEEN	Tolko	Oyama Lake		549.627					L
	Tolko	Oyama Lake		79.350					L
	Tolko	Oyama Lake		207.151					L
	Tolko	Oyama Lake		111.505					L
	Tolko	Oyama Lake		221.601					L
STREAK	Tolko	Oyama Lake		2941.001					L
STREAK	Tolko	Oyama Lake		79.489					L
LL1032-01	Tolko	Oyama Lake		377.387					L
	Tolko	Oyama Lake		75.483					L
KING EDWARD MAIN	Tolko	Oyama Lake		660.187					L
LL1055-02	Tolko	Oyama Lake		148.411					L
	Tolko	Oyama Lake		59.448					L
LL1032-05	Tolko	Oyama Lake		368.037					L
LL1055-01	Tolko	Oyama Lake		455.952					L
LL1032-01	Tolko	Oyama Lake		103.377					L
LL1033-05A	Tolko	Oyama Lake		242.859					L
LL1033-01	Tolko	Oyama Lake		32.057					L
LL1033-05	Tolko	Oyama Lake		364.111					L
LL1055-02	Tolko	Oyama Lake		1029.665					L

Appendix F - Oyama Creek Watershed: Road Risk Analysis

Road	Responsible Party	Basin	Comments	Length (m)	Hazard	Resource at Stake	Probability of Hazard Occurance	Effect on Resource at Stake	Risk
KING EDWARD MAIN	Tolko	Oyama Lake		669.779					L
LL1033-06	Tolko	Oyama Lake		251.400					L
LL1033-01	Tolko	Oyama Lake		142.458					L
	Tolko	Oyama Lake		468.763					L
	Tolko	Oyama Lake		172.720					L
LL1006-01	Tolko	Oyama Lake		339.317					L
LL1033-01	Tolko	Oyama Lake		126.629					L
LL1033-01	Tolko	Oyama Lake		832.340					L
	Tolko	Oyama Lake		225.359					L
	Tolko	Oyama Lake		149.460					L
LL1033-01	Tolko	Oyama Lake		385.483					L
LL1033-02	Tolko	Oyama Lake		141.214					L
KING EDWARD MAIN	Tolko	Oyama Lake		842.906					L
	Tolko	Oyama Lake		182.094					L
	Tolko	Oyama Lake		148.075					L
	Tolko	Oyama Lake		122.516					L
	Tolko	Oyama Lake		69.246					L
LL1033-03	Tolko	Oyama Lake		300.825					L
LL1033-02	Tolko	Oyama Lake		431.821					L
	Tolko	Oyama Lake		171.486					L
	Tolko	Oyama Lake		149.390					L
	Tolko	Oyama Lake		214.886					L
	Tolko	Oyama Lake		456.831					L
	Tolko	Oyama Lake		77.322					L
LL1033-08	Tolko	Oyama Lake		110.739					L
	Tolko	Oyama Lake		136.915					L
	Tolko	Oyama Lake		216.540					L
	Tolko	Oyama Lake		288.396					L
	Tolko	Oyama Lake		389.815					L
KING EDWARD MAIN	Tolko	Oyama Lake		2680.653					L
LL1031-02	Tolko	Oyama Lake		29.052					L

Appendix F - Oyama Creek Watershed: Road Risk Analysis

Road	Responsible Party	Basin	Comments	Length (m)	Hazard	Resource at Stake	Probability of Hazard Occurance	Effect on Resource at Stake	Risk
LL1031-02	Tolko	Oyama Lake		25.245					L
	Tolko	Oyama Lake		41.535					L
A10-1	Tolko	Oyama Lake		1.792					L
A10-1	Tolko	Oyama Lake		374.419					L
	Tolko	Oyama Lake		273.055					L
LL1001-01	Tolko	Oyama Lake		67.292					L
LL1001-01	Tolko	Oyama Lake		43.806					L
	Tolko	Oyama Lake		58.571					L
LL1001-01	Tolko	Oyama Lake		130.168					L
LL1001-01	Tolko	Oyama Lake		260.319					L
	Tolko	Oyama Lake		273.706					L
LL1047-01	Tolko	Oyama Lake		220.150					L
	Tolko	Oyama Lake		160.444					L
LL1047-03	Tolko	Oyama Lake		267.213					L
LL1047-02	Tolko	Oyama Lake		393.065					L
LL1047-02	Tolko	Oyama Lake		165.264					L
KING EDWARD MAIN	Tolko	Oyama Lake		298.872					L
	Tolko	Oyama Lake		146.635					L
	Tolko	Oyama Lake		23.496					L
LL1043-02	Tolko	Oyama Lake		317.576					L
	Tolko	Oyama Lake		107.110					L
	Tolko	Oyama Lake		335.768					L
	Tolko	Oyama Lake		283.672					L
	Tolko	Oyama Lake		103.999					L
	Tolko	Oyama Lake		73.119					L
	Tolko	Oyama Lake		412.229					L
	Tolko	Oyama Lake		114.159					L
	Tolko	Oyama Lake		601.339					L
	Tolko	Oyama Lake		130.715					L
	Tolko	Oyama Lake		183.634					L
	Tolko	Oyama Lake		188.287					L
	Tolko	Oyama Lake		281.642					L
	Tolko	Oyama Lake		107.361					L
	Tolko	Oyama Lake		293.602					L
	Tolko	Oyama Lake		370.554					L

Appendix F - Oyama Creek Watershed: Road Risk Analysis

Road	Responsible Party	Basin	Comments	Length (m)	Hazard	Resource at Stake	Probability of Hazard Occurance	Effect on Resource at Stake	Risk
	Tolko	Oyama Lake		475.371					L
	Tolko	Oyama Lake		241.833					L
	Tolko	Oyama Lake		341.612					L
	Tolko	Oyama Lake		252.465					L
	Tolko	Oyama Lake		238.266					L
	Tolko	Oyama Lake		637.312					L
	Tolko	Oyama Lake		27.170					L
	Tolko	Oyama Lake		1862.563					L
A10-1	Tolko	Oyama Lake		45.814					L
	Tolko	Oyama residual		255.462					L
	Tolko	Oyama Lake	SECTION MAPPED INCORRECTLY IN FTA	63.268					L
KING EDWARD MAIN	Tolko	Oyama Lake		286.102					L
LL1043-01	Tolko	Oyama Lake		60.198					L
LL1043-01	Tolko	Oyama Lake		414.671					L
KING EDWARD MAIN	Tolko	Oyama Lake		710.300					L
KING EDWARD MAIN	Tolko	Oyama Lake		232.721					L
N 7023.07 (OYAMA-LODGE)	BCTS	Oyama Lake		2.139					L
N 7023.14 (DRIPPINGS)	BCTS	North Oyama		846.214					L
N 7023.13 (E. DAMER - SPUR 1202)	BCTS	North Oyama		586.081					L
N 7023.12 (EAST DAMER)	BCTS	North Oyama		2858.018					L
N 7023.11 (DAMER 6)	BCTS	North Oyama		667.024					L

Appendix F - Oyama Creek Watershed: Road Risk Analysis

Road	Responsible Party	Basin	Comments	Length (m)	Hazard	Resource at Stake	Probability of Hazard Occurance	Effect on Resource at Stake	Risk
N 7023.06 (GOOD GRAVY)	BCTS	North Oyama		872.933					L
N 7023.01 (OYAMA LAKE)	BCTS	North Oyama		3699.754					L
N 7023.13 (E. DAMER - SPUR 1202)	BCTS	Oyama residual		436.673					L
N 7023.12 (EAST DAMER)	BCTS	Oyama residual		543.957					L
N 7023.10 (OYAMA-LODGE - BR 1.5)	BCTS	Oyama residual		407.127					L
N 7023.09 (OYAMA-LODGE - BR 1.3)	BCTS	Oyama residual		599.355					L
N 7023.08 (OYAMA-LODGE - BR 0.2)	BCTS	Oyama residual		93.183					L
N 7023.07 (OYAMA-LODGE)	BCTS	Oyama residual		367.448					L
N 7023.01 (OYAMA LAKE)	BCTS	Oyama residual		870.461					L
ZN RP 79610 - K5MM / R16363-03	BCTS	Oyama residual		119.749					L
ZN RP 79610 - K5MM / R16363-01	BCTS	Oyama residual		406.454					L

Appendix F - Oyama Creek Watershed: Road Risk Analysis

Road	Responsible Party	Basin	Comments	Length (m)	Hazard	Resource at Stake	Probability of Hazard Occurance	Effect on Resource at Stake	Risk
N 7023.01 (OYAMA LAKE)	BCTS	Oyama residual		357.928					L
N 7023.01 (OYAMA LAKE)	BCTS	Oyama residual		535.051					L
N 7023.08 (OYAMA-LODGE - BR 0.2)	BCTS	Oyama residual		755.983					L
N 7023.01 (OYAMA LAKE)	BCTS	Oyama residual		402.761					L
N 7023.07 (OYAMA-LODGE)	BCTS	Oyama residual		540.948					L
N 7023.01 (OYAMA LAKE)	BCTS	North Oyama		2490.783					L
	Non-status	Oyama Lake		232.375					L
	Non-status	Oyama Lake		117.343					L
	Non-status	Oyama Lake		316.257					L
	Non-status	Oyama Lake		130.860					L
	Non-status	Oyama Lake		45.054					L
	Non-status	Oyama Lake		250.588					L
	Non-status	Oyama Lake		763.524					L
	Non-status	Oyama Lake		136.352					L
	Non-status	Oyama Lake		279.992					L
	Non-status	Oyama Lake		193.123					L
	Non-status	Oyama Lake		277.813					L
	Non-status	Oyama Lake		102.425					L
	Non-status	Oyama Lake		23.898					L
	Non-status	Oyama Lake		150.378					L
	Non-status	Oyama Lake		612.414					L
	Non-status	Oyama Lake		158.205					L
	Non-status	Oyama Lake		103.324					L
	Non-status	Oyama Lake		113.352					L

Appendix F - Oyama Creek Watershed: Road Risk Analysis

Road	Responsible Party	Basin	Comments	Length (m)	Hazard	Resource at Stake	Probability of Hazard Occurance	Effect on Resource at Stake	Risk
	Non-status	Oyama Lake		1299.549					L
	Non-status	Oyama Lake		205.276					L
	Non-status	Oyama Lake		150.181					L
	Non-status	Oyama Lake		540.815					L
	Non-status	Oyama Lake		22.986					L
	Non-status	Oyama Lake		221.984					L
	Non-status	Oyama Lake		615.960					L
	Non-status	Oyama Lake		783.277					L
	Non-status	Oyama Lake		229.882					L
	Non-status	Oyama Lake		45.467					L
	Non-status	Oyama Lake		365.558					L
	Non-status	Oyama Lake		308.147					L
	Non-status	Oyama Lake		313.760					L
	Non-status	Oyama Lake		295.048					L
	Non-status	Oyama Lake		189.584					L
	Non-status	Oyama Lake		176.462					L
	Non-status	Oyama Lake		96.669					L
	Non-status	Oyama Lake		270.820					L
	Non-status	Oyama Lake		216.960					L
	Non-status	Oyama Lake		467.523					L
	Non-status	Oyama Lake		67.865					L
	Non-status	Oyama Lake		192.083					L
	Non-status	Oyama Lake		375.301					L
	Non-status	Oyama Lake		395.832					L
	Non-status	Oyama Lake		213.036					L
	Non-status	Oyama Lake		165.146					L
	Non-status	Oyama Lake		567.590					L
	Non-status	Oyama Lake		44.809					L
	Non-status	Oyama Lake		116.269					L
	Non-status	Oyama Lake		121.444					L
	Non-status	Oyama Lake		162.950					L
	Non-status	Oyama Lake		171.678					L
	Non-status	Oyama Lake		261.839					L
	Non-status	Oyama Lake		159.848					L
	Non-status	Oyama Lake		745.292					L
	Non-status	Oyama Lake		147.467					L
	Non-status	Oyama Lake		19.698					L

Appendix F - Oyama Creek Watershed: Road Risk Analysis

Road	Responsible Party	Basin	Comments	Length (m)	Hazard	Resource at Stake	Probability of Hazard Occurance	Effect on Resource at Stake	Risk
	Non-status	Oyama Lake		28.348					L
	Non-status	Oyama Lake		317.040					L
	Non-status	Oyama Lake		26.153					L
	Non-status	Oyama Lake		14.000					L
	Non-status	Oyama Lake		290.492					L
	Non-status	Oyama Lake		581.831					L
	Non-status	Oyama Lake		10.817					L
	Non-status	Oyama Lake		6.000					L
	Non-status	Oyama Lake		7.000					L
	Non-status	Oyama Lake		209.968					L
	Non-status	Oyama Lake		25.055					L
	Non-status	Oyama Lake		151.662					L
	Non-status	Oyama Lake		58.572					L
	Non-status	Oyama Lake		72.484					L
	Non-status	Oyama Lake		79.970					L
	Non-status	Oyama Lake		349.884					L
	Non-status	Oyama Lake		87.529					L
	Non-status	Oyama Lake		165.289					L
	Non-status	Oyama Lake		146.678					L
	Non-status	Oyama Lake		66.228					L
	Non-status	Oyama Lake		149.020					L
	Non-status	Oyama Lake		216.428					L
	Non-status	Oyama Lake		46.896					L
	Non-status	Oyama Lake		273.137					L
	Non-status	Oyama Lake		79.920					L
	Non-status	Oyama Lake		196.905					L
	Non-status	Oyama Lake		320.049					L
	Non-status	Oyama Lake		133.276					L
	Non-status	Oyama Lake		160.757					L
	Non-status	Oyama Lake		8.246					L
	Non-status	Oyama Lake		221.159					L
	Non-status	Oyama Lake		175.498					L
	Non-status	Oyama Lake		48.128					L
	Non-status	Oyama Lake		41.248					L
	Non-status	Oyama Lake		30.104					L
	Non-status	Oyama Lake		58.389					L
	Non-status	Oyama Lake		473.661					L

Appendix F - Oyama Creek Watershed: Road Risk Analysis

Road	Responsible Party	Basin	Comments	Length (m)	Hazard	Resource at Stake	Probability of Hazard Occurance	Effect on Resource at Stake	Risk
	Non-status	Oyama Lake		143.716					L
	Non-status	Oyama Lake		287.437					L
	Non-status	Oyama Lake		189.630					L
	Non-status	Oyama Lake		371.315					L
	Non-status	Oyama Lake		487.400					L
	Non-status	Oyama Lake		71.947					L
	Non-status	Oyama Lake		128.395					L
	Non-status	Oyama Lake		145.063					L
	Non-status	Oyama Lake		89.610					L
	Non-status	Oyama Lake		43.847					L
	Non-status	Oyama Lake		224.007					L
	Non-status	Oyama Lake		54.698					L
	Non-status	Oyama Lake		46.186					L
	Non-status	Oyama Lake		181.089					L
	Non-status	Oyama Lake		263.929					L
	Non-status	Oyama Lake		271.324					L
	Non-status	Oyama Lake		143.897					L
	Non-status	North Oyama		871.697					L
	Non-status	North Oyama		259.854					L
	Non-status	North Oyama		968.486					L
	Non-status	North Oyama		699.209					L
	Non-status	North Oyama		205.078					L
	Non-status	North Oyama		217.890					L
	Non-status	North Oyama		415.231					L
	Non-status	North Oyama		316.889					L
	Non-status	North Oyama		571.890					L
	Non-status	North Oyama		501.168					L
	Non-status	North Oyama		77.414					L
	Non-status	North Oyama		877.704					L
	Non-status	North Oyama		1442.373					L
	Non-status	North Oyama		75.902					L
	Non-status	North Oyama		249.211					L
	Non-status	North Oyama		11.996					L
	Non-status	North Oyama		25.936					L
	Non-status	North Oyama		826.073					L
	Non-status	North Oyama		393.009					L
	Non-status	North Oyama		224.418					L

Appendix F - Oyama Creek Watershed: Road Risk Analysis

Road	Responsible Party	Basin	Comments	Length (m)	Hazard	Resource at Stake	Probability of Hazard Occurance	Effect on Resource at Stake	Risk
	Non-status	North Oyama		104.266					L
	Non-status	North Oyama		245.415					L
	Non-status	North Oyama		148.447					L
	Non-status	North Oyama		125.910					L
	Non-status	North Oyama		120.065					L
	Non-status	North Oyama		217.203					L
	Non-status	North Oyama		190.509					L
	Non-status	North Oyama		47.109					L
	Non-status	North Oyama		216.898					L
	Non-status	North Oyama		85.846					L
	Non-status	North Oyama		78.436					L
	Non-status	North Oyama		30.173					L
	Non-status	North Oyama		304.423					L
	Non-status	North Oyama		37.678					L
	Non-status	North Oyama		17.071					L
	Non-status	North Oyama		284.267					L
	Non-status	North Oyama		47.419					L
	Non-status	North Oyama		235.176					L
	Non-status	Oyama residual		373.506					L
	Non-status	Oyama residual		595.815					L
	Non-status	Oyama residual		90.398					L
	Non-status	Oyama residual		385.812					L
	Non-status	Oyama residual		365.597					L
	Non-status	Oyama residual		94.212					L
	Non-status	Oyama residual		314.667					L
	Non-status	Oyama residual		820.422					L
	Non-status	Oyama residual		608.800					L
	Non-status	Oyama residual		859.343					L
	Non-status	Oyama residual		194.937					L
	Non-status	Oyama residual		219.661					L
	Non-status	Oyama residual		223.802					L
	Non-status	Oyama residual		309.094					L
	Non-status	Oyama residual		551.022					L
	Non-status	Oyama residual		416.954					L
	Non-status	Oyama residual		14.737					L
	Non-status	Oyama residual		306.609					L
	Non-status	Oyama residual		642.867					L

Appendix F - Oyama Creek Watershed: Road Risk Analysis

Road	Responsible Party	Basin	Comments	Length (m)	Hazard	Resource at Stake	Probability of Hazard Occurance	Effect on Resource at Stake	Risk
	Non-status	Oyama residual		793.854					L
	Non-status	Oyama residual		704.032					L
	Non-status	Oyama residual		457.558					L
	Non-status	Oyama residual		147.988					L
	Non-status	Oyama residual		83.887					L
	Non-status	Oyama residual		68.175					L
	Non-status	Oyama residual		148.458					L
	Non-status	Oyama residual		221.474					L
	Non-status	Oyama residual		212.356					L
	Non-status	Oyama residual		183.833					L
	Non-status	Oyama residual		1124.573					L
	Non-status	Oyama residual		545.588					L
	Non-status	Oyama residual		245.253					L
	Non-status	Oyama residual		225.323					L
	Non-status	Oyama residual		533.189					L
	Non-status	Oyama residual		268.720					L
	Non-status	Oyama residual		89.263					L
	Non-status	Oyama residual		114.601					L
	Non-status	Oyama residual		84.536					L
	Non-status	Oyama residual		139.297					L
	Non-status	Oyama residual		59.106					L
	Non-status	Oyama residual		243.795					L
	Non-status	Oyama residual		43.384					L
	Non-status	Oyama residual		150.569					L
	Non-status	Oyama residual		525.388					L
	Non-status	Oyama residual		45.152					L
	Non-status	Oyama residual		274.984					L
	Non-status	Oyama residual		25.220					L
	Non-status	Oyama residual		152.632					L
	Non-status	Oyama residual		149.252					L
	Non-status	Oyama residual		98.416					L
	Non-status	Oyama residual		1.000					L
	Non-status	Oyama residual		155.180					L
	Non-status	Oyama residual		306.685					L
	Non-status	Oyama residual		273.401					L
	Non-status	Oyama residual		216.631					L
	Non-status	Oyama residual		86.823					L

Appendix F - Oyama Creek Watershed: Road Risk Analysis

Road	Responsible Party	Basin	Comments	Length (m)	Hazard	Resource at Stake	Probability of Hazard Occurance	Effect on Resource at Stake	Risk
	Non-status	Oyama residual		408.756					L
	Non-status	Oyama residual		122.976					L
	Non-status	Oyama residual		205.521					L
	Non-status	Oyama residual		106.979					L
	Non-status	Oyama residual		425.216					L
	Non-status	Oyama residual		48.175					L
	Non-status	Oyama residual		307.379					L
	Non-status	North Oyama		314.795					L
	Non-status	North Oyama		404.633					L
	Non-status	Oyama Lake		148.466					L
	Private	Oyama residual		29.186					L
	Private	Oyama residual		862.764					L
	Private	Lower Oyama residual		37.725					L
	Private	Lower Oyama residual		31.833					L

Appendix G. Road Risk Assessment (Vernon Creek Watershed).

Road ID	Road	Responsible Party	Length (m)	Ecoscape Ranking	Likelihood	Consequence	Risk
135	DEE LAKE MAIN	Tolko	2.126	High	Likely	Minor	High
157	317-2-8	Tolko	2.108	High	Likely	Minor	High
465		Tolko	94.544	High	Likely	Minor	High
471		Tolko	20.713	High	Likely	Minor	High
473		Tolko	318.155	High	Likely	Minor	High
474	LL1008-01	Tolko	173.069	High	Likely	Minor	High
496	LL1009-01	Tolko	49.523	High	Likely	Minor	High
508	LL1009-01	Tolko	158.188	High	Likely	Minor	High
510	LL1009-01	Tolko	201.978	High	Likely	Minor	High
526		Tolko	529.078	High	Likely	Minor	High
648	317-2-8	Tolko	2.233	High	Likely	Minor	High
429	DEE LAKE MAIN	Ministry of Transportation	68.967	High	Likely	Minor	High
450	DEE LAKE MAIN	Ministry of Transportation	33.899	High	Likely	Minor	High
451	DEE LAKE MAIN	Ministry of Transportation	454.317	High	Likely	Minor	High
452	DEE LAKE MAIN	Ministry of Transportation	42.921	High	Likely	Minor	High
487	BEAVER LAKE	Ministry of Transportation	2443.386	High	Likely	Minor	High
503	BEAVER LAKE	Ministry of Transportation	1127.889	High	Likely	Minor	High
512	BEAVER LAKE	Ministry of Transportation	698.280	High	Likely	Minor	High
579	DEE LAKE MAIN	Ministry of Transportation	88.457	High	Likely	Minor	High
594	DEE LAKE MAIN	Ministry of Transportation	35.396	High	Likely	Minor	High
53		Non-status Roads	2.355	High	Likely	Minor	High
73		Non-status Roads	2.299	High	Likely	Minor	High
388		Non-status Roads	45.951	High	Likely	Minor	High
442		Non-status Roads	70.162	High	Likely	Minor	High
468		Non-status Roads	130.951	High	Likely	Minor	High
476		Non-status Roads	173.133	High	Likely	Minor	High
480		Non-status Roads	1341.271	High	Likely	Minor	High
489		Non-status Roads	303.114	High	Likely	Minor	High
502		Non-status Roads	450.850	High	Likely	Minor	High
515		Non-status Roads	241.785	High	Likely	Minor	High
517		Non-status Roads	49.947	High	Likely	Minor	High
521		Non-status Roads	171.381	High	Likely	Minor	High
522		Non-status Roads	485.595	High	Likely	Minor	High
532		Non-status Roads	196.128	High	Likely	Minor	High
575		Non-status Roads	65.810	High	Likely	Minor	High

Appendix G. Road Risk Assessment (Vernon Creek Watershed).

Road ID	Road	Responsible Party	Length (m)	Ecoscape Ranking	Likelihood	Consequence	Risk
583		Non-status Roads	10.210	High	Likely	Minor	High
669		Non-status Roads	235.935	High	Likely	Minor	High
670		Non-status Roads	557.092	High	Likely	Minor	High
671		Non-status Roads	1050.187	High	Likely	Minor	High
673		Non-status Roads	352.700	High	Likely	Minor	High
136	DEE LAKE MAIN	Tolko	156.115	Moderate	Possible	Minor	Moderate
57		Tolko	2.383	Moderate	Possible	Minor	Moderate
124	LL1060-05	Tolko	6.960	Moderate	Possible	Minor	Moderate
156	317-2-8	Tolko	30.786	Moderate	Possible	Minor	Moderate
158	317-2-8	Tolko	32.330	Moderate	Possible	Minor	Moderate
445		Tolko	126.089	Moderate	Possible	Minor	Moderate
464		Tolko	583.702	Moderate	Possible	Minor	Moderate
466		Tolko	323.018	Moderate	Possible	Minor	Moderate
472		Tolko	118.491	Moderate	Possible	Minor	Moderate
495	LL1009-01	Tolko	90.558	Moderate	Possible	Minor	Moderate
509	LL1009-01	Tolko	423.145	Moderate	Possible	Minor	Moderate
525		Tolko	205.750	Moderate	Possible	Minor	Moderate
542	LL1010-01	Tolko	239.889	Moderate	Possible	Minor	Moderate
547		Tolko	149.423	Moderate	Possible	Minor	Moderate
549	LL1010-01	Tolko	423.247	Moderate	Possible	Minor	Moderate
554		Tolko	159.631	Moderate	Possible	Minor	Moderate
584	LL1114-02	Tolko	29.658	Moderate	Possible	Minor	Moderate
649	317-2-8	Tolko	71.440	Moderate	Possible	Minor	Moderate
428	DEE LAKE MAIN	Ministry of Transportation	122.119	Moderate	Possible	Minor	Moderate
430	DEE LAKE MAIN	Ministry of Transportation	76.451	Moderate	Possible	Minor	Moderate
447	BEAVER LAKE	Ministry of Transportation	83.590	Moderate	Possible	Minor	Moderate
449	DEE LAKE MAIN	Ministry of Transportation	59.320	Moderate	Possible	Minor	Moderate
453	DEE LAKE MAIN	Ministry of Transportation	103.832	Moderate	Possible	Minor	Moderate
486	BEAVER LAKE	Ministry of Transportation	219.719	Moderate	Possible	Minor	Moderate
488	BEAVER LAKE	Ministry of Transportation	338.557	Moderate	Possible	Minor	Moderate
504	BEAVER LAKE	Ministry of Transportation	266.468	Moderate	Possible	Minor	Moderate
513	BEAVER LAKE	District of Lake Country	225.732	Moderate	Possible	Minor	Moderate
580	DEE LAKE MAIN	Ministry of Transportation	100.801	Moderate	Possible	Minor	Moderate
593	DEE LAKE MAIN	Ministry of Transportation	64.277	Moderate	Possible	Minor	Moderate
602	DEE LAKE MAIN	Ministry of Transportation	30.395	Moderate	Possible	Minor	Moderate

Appendix G. Road Risk Assessment (Vernon Creek Watershed).

Road ID	Road	Responsible Party	Length (m)	Ecoscape Ranking	Likelihood	Consequence	Risk
54		Non-status Roads	80.696	Moderate	Possible	Minor	Moderate
55		Non-status Roads	35.590	Moderate	Possible	Minor	Moderate
61		Non-status Roads	6.481	Moderate	Possible	Minor	Moderate
63		Non-status Roads	182.901	Moderate	Possible	Minor	Moderate
74		Non-status Roads	30.954	Moderate	Possible	Minor	Moderate
75		Non-status Roads	44.215	Moderate	Possible	Minor	Moderate
87		Non-status Roads	101.505	Moderate	Possible	Minor	Moderate
130		Non-status Roads	2.206	Moderate	Possible	Minor	Moderate
145		Non-status Roads	43.159	Moderate	Possible	Minor	Moderate
386		Non-status Roads	46.980	Moderate	Possible	Minor	Moderate
387		Non-status Roads	244.960	Moderate	Possible	Minor	Moderate
432		Non-status Roads	199.588	Moderate	Possible	Minor	Moderate
434		Non-status Roads	97.683	Moderate	Possible	Minor	Moderate
441		Non-status Roads	363.713	Moderate	Possible	Minor	Moderate
443		Non-status Roads	261.890	Moderate	Possible	Minor	Moderate
460		Non-status Roads	149.648	Moderate	Possible	Minor	Moderate
469		Non-status Roads	167.908	Moderate	Possible	Minor	Moderate
477		Non-status Roads	191.586	Moderate	Possible	Minor	Moderate
479		Non-status Roads	87.656	Moderate	Possible	Minor	Moderate
481		Non-status Roads	142.282	Moderate	Possible	Minor	Moderate
490		Non-status Roads	465.295	Moderate	Possible	Minor	Moderate
516		Non-status Roads	7.212	Moderate	Possible	Minor	Moderate
530		Non-status Roads	46.496	Moderate	Possible	Minor	Moderate
531		Non-status Roads	20.740	Moderate	Possible	Minor	Moderate
535		Non-status Roads	312.869	Moderate	Possible	Minor	Moderate
537		Non-status Roads	325.975	Moderate	Possible	Minor	Moderate
539		Non-status Roads	49.128	Moderate	Possible	Minor	Moderate
544		Non-status Roads	161.844	Moderate	Possible	Minor	Moderate
545		Non-status Roads	112.817	Moderate	Possible	Minor	Moderate
570		Non-status Roads	110.508	Moderate	Possible	Minor	Moderate
574		Non-status Roads	29.933	Moderate	Possible	Minor	Moderate
576		Non-status Roads	182.037	Moderate	Possible	Minor	Moderate
582		Non-status Roads	197.242	Moderate	Possible	Minor	Moderate
652		Non-status Roads	2.284	Moderate	Possible	Minor	Moderate
667		Non-status Roads	326.001	Moderate	Possible	Minor	Moderate

Appendix G. Road Risk Assessment (Vernon Creek Watershed).

Road ID	Road	Responsible Party	Length (m)	Ecoscape Ranking	Likelihood	Consequence	Risk
672		Non-status Roads	436.815	Moderate	Possible	Minor	Moderate
674		Non-status Roads	202.625	Moderate	Possible	Minor	Moderate
132	DEE LAKE MAIN	Tolko	621.551	Low	Rare	Minor	Low
137	DEE LAKE MAIN	Tolko	535.245	Low	Rare	Minor	Low
138	DEE LAKE MAIN	Tolko	692.495	Low	Rare	Minor	Low
140	DEE LAKE MAIN	Tolko	125.258	Low	Rare	Minor	Low
147	DEE LAKE MAIN	Tolko	550.369	Low	Rare	Minor	Low
1	A10-4	Tolko	65.396	Low	Rare	Minor	Low
2	LL1032-01	Tolko	257.196	Low	Rare	Minor	Low
3	LL1033-01	Tolko	92.140	Low	Rare	Minor	Low
4	LL1033-05	Tolko	38.296	Low	Rare	Minor	Low
5	LL1033-06	Tolko	64.615	Low	Rare	Minor	Low
6	LL1033-01	Tolko	82.121	Low	Rare	Minor	Low
7	LL1032-02	Tolko	346.388	Low	Rare	Minor	Low
8	LL1032-02	Tolko	59.722	Low	Rare	Minor	Low
9	LL1032-04	Tolko	69.870	Low	Rare	Minor	Low
10	LL1033-01	Tolko	18.845	Low	Rare	Minor	Low
11	LL1032-02	Tolko	322.236	Low	Rare	Minor	Low
12	LL1033-01	Tolko	274.593	Low	Rare	Minor	Low
13	LL1032-03	Tolko	325.152	Low	Rare	Minor	Low
14	LL1033-07	Tolko	241.083	Low	Rare	Minor	Low
15	LL1033-07A	Tolko	274.181	Low	Rare	Minor	Low
16	LL1033-02	Tolko	85.757	Low	Rare	Minor	Low
18	LL1033-01	Tolko	786.286	Low	Rare	Minor	Low
19	LL1033-02	Tolko	272.558	Low	Rare	Minor	Low
20	LL1033-01	Tolko	195.156	Low	Rare	Minor	Low
24	LL1033-01	Tolko	123.815	Low	Rare	Minor	Low
26	LL1059-04	Tolko	52.220	Low	Rare	Minor	Low
28	LL1033-08	Tolko	275.034	Low	Rare	Minor	Low
29	LL1033-08	Tolko	254.598	Low	Rare	Minor	Low
31	LL1059-03	Tolko	161.046	Low	Rare	Minor	Low
32	LL1058-03	Tolko	47.671	Low	Rare	Minor	Low
33	LL1059-01	Tolko	319.094	Low	Rare	Minor	Low
34	LL1059-01	Tolko	199.392	Low	Rare	Minor	Low
35	LL1058-02	Tolko	135.888	Low	Rare	Minor	Low

Appendix G. Road Risk Assessment (Vernon Creek Watershed).

Road ID	Road	Responsible Party	Length (m)	Ecoscape Ranking	Likelihood	Consequence	Risk
36	LL1058-01	Tolko	280.752	Low	Rare	Minor	Low
37	LL1059-02	Tolko	44.736	Low	Rare	Minor	Low
38	LL1059-01	Tolko	204.801	Low	Rare	Minor	Low
39	LL1059-03	Tolko	397.001	Low	Rare	Minor	Low
40	LL1058-01	Tolko	1261.436	Low	Rare	Minor	Low
41		Tolko	247.778	Low	Rare	Minor	Low
43	A13-1	Tolko	36.105	Low	Rare	Minor	Low
48		Tolko	197.983	Low	Rare	Minor	Low
49		Tolko	650.649	Low	Rare	Minor	Low
52	LL1000-01	Tolko	144.671	Low	Rare	Minor	Low
58		Tolko	459.044	Low	Rare	Minor	Low
60		Tolko	1014.683	Low	Rare	Minor	Low
64		Tolko	234.754	Low	Rare	Minor	Low
65		Tolko	146.569	Low	Rare	Minor	Low
66		Tolko	354.196	Low	Rare	Minor	Low
67		Tolko	38.486	Low	Rare	Minor	Low
68	A6-1	Tolko	113.938	Low	Rare	Minor	Low
69	A7-1	Tolko	548.957	Low	Rare	Minor	Low
71	A7-1	Tolko	288.060	Low	Rare	Minor	Low
72	A6-1	Tolko	215.818	Low	Rare	Minor	Low
79	LL1001-03	Tolko	75.847	Low	Rare	Minor	Low
82	LL1001-03	Tolko	67.399	Low	Rare	Minor	Low
83	LL1001-04	Tolko	152.192	Low	Rare	Minor	Low
84	LL1001-02	Tolko	186.418	Low	Rare	Minor	Low
85	LL1001-04	Tolko	86.896	Low	Rare	Minor	Low
86		Tolko	532.747	Low	Rare	Minor	Low
91		Tolko	264.125	Low	Rare	Minor	Low
92		Tolko	234.019	Low	Rare	Minor	Low
93		Tolko	617.349	Low	Rare	Minor	Low
95		Tolko	452.759	Low	Rare	Minor	Low
96	LL1035-01	Tolko	231.579	Low	Rare	Minor	Low
97	LL1035-01	Tolko	225.564	Low	Rare	Minor	Low
98		Tolko	314.755	Low	Rare	Minor	Low
99	LL1032-01	Tolko	70.205	Low	Rare	Minor	Low
100		Tolko	19.437	Low	Rare	Minor	Low

Appendix G. Road Risk Assessment (Vernon Creek Watershed).

Road ID	Road	Responsible Party	Length (m)	Ecoscape Ranking	Likelihood	Consequence	Risk
101		Tolko	736.291	Low	Rare	Minor	Low
102		Tolko	73.192	Low	Rare	Minor	Low
103	LL1035-02	Tolko	474.667	Low	Rare	Minor	Low
105		Tolko	162.031	Low	Rare	Minor	Low
106		Tolko	64.541	Low	Rare	Minor	Low
107	LL1035-03	Tolko	444.598	Low	Rare	Minor	Low
111		Tolko	629.366	Low	Rare	Minor	Low
113		Tolko	105.898	Low	Rare	Minor	Low
114		Tolko	425.469	Low	Rare	Minor	Low
115	LL1060-02	Tolko	53.995	Low	Rare	Minor	Low
116	LL1060-01	Tolko	129.312	Low	Rare	Minor	Low
117	LL1060-03	Tolko	221.119	Low	Rare	Minor	Low
118		Tolko	277.026	Low	Rare	Minor	Low
119	LL1060-01	Tolko	66.124	Low	Rare	Minor	Low
120	LL1060-04	Tolko	164.538	Low	Rare	Minor	Low
122	LL1060-01	Tolko	191.279	Low	Rare	Minor	Low
123		Tolko	130.482	Low	Rare	Minor	Low
125	LL1060-05	Tolko	64.195	Low	Rare	Minor	Low
129	LL1060-01	Tolko	595.983	Low	Rare	Minor	Low
159	317-2-8	Tolko	299.327	Low	Rare	Minor	Low
163		Tolko	204.034	Low	Rare	Minor	Low
165		Tolko	87.224	Low	Rare	Minor	Low
166	317-2-1A	Tolko	154.150	Low	Rare	Minor	Low
167	317-2-8	Tolko	221.176	Low	Rare	Minor	Low
169	317-2-7	Tolko	155.468	Low	Rare	Minor	Low
170	317-2-1A	Tolko	227.513	Low	Rare	Minor	Low
173	LL1065-07	Tolko	25.945	Low	Rare	Minor	Low
174	LL1065-06	Tolko	88.668	Low	Rare	Minor	Low
175	LL1065-06	Tolko	33.462	Low	Rare	Minor	Low
176	317-2-8	Tolko	207.730	Low	Rare	Minor	Low
177	317-2-7	Tolko	202.460	Low	Rare	Minor	Low
178	317-2-6	Tolko	267.992	Low	Rare	Minor	Low
179	317-2-1A	Tolko	255.894	Low	Rare	Minor	Low
180		Tolko	153.509	Low	Rare	Minor	Low
181		Tolko	3.818	Low	Rare	Minor	Low

Appendix G. Road Risk Assessment (Vernon Creek Watershed).

Road ID	Road	Responsible Party	Length (m)	Ecoscape Ranking	Likelihood	Consequence	Risk
182	317-2-8	Tolko	370.561	Low	Rare	Minor	Low
183	317-2-1A	Tolko	315.359	Low	Rare	Minor	Low
184	317-2-1B	Tolko	63.280	Low	Rare	Minor	Low
186	317-2-3	Tolko	167.178	Low	Rare	Minor	Low
187	317-2-8	Tolko	212.966	Low	Rare	Minor	Low
188	317-2-2	Tolko	192.805	Low	Rare	Minor	Low
189	317-2-4	Tolko	380.128	Low	Rare	Minor	Low
190	LL1065-01	Tolko	99.306	Low	Rare	Minor	Low
191	LL1066-01	Tolko	33.449	Low	Rare	Minor	Low
192	317-2-1B	Tolko	300.919	Low	Rare	Minor	Low
193		Tolko	121.905	Low	Rare	Minor	Low
194	317-2-4	Tolko	244.419	Low	Rare	Minor	Low
195	LL1066-01	Tolko	173.888	Low	Rare	Minor	Low
196	317-2-1B	Tolko	55.438	Low	Rare	Minor	Low
197	LL1066-01	Tolko	267.016	Low	Rare	Minor	Low
198		Tolko	60.869	Low	Rare	Minor	Low
199	LL1065-01	Tolko	351.209	Low	Rare	Minor	Low
200		Tolko	599.118	Low	Rare	Minor	Low
201	LL1066-03	Tolko	194.935	Low	Rare	Minor	Low
202		Tolko	223.923	Low	Rare	Minor	Low
203	LL1065-02	Tolko	380.135	Low	Rare	Minor	Low
204	317-2-1B	Tolko	322.069	Low	Rare	Minor	Low
205	LL1066-03	Tolko	143.986	Low	Rare	Minor	Low
206	LL1065-03	Tolko	315.201	Low	Rare	Minor	Low
207	317-2-5	Tolko	382.676	Low	Rare	Minor	Low
208		Tolko	262.303	Low	Rare	Minor	Low
209	317-3-1	Tolko	443.914	Low	Rare	Minor	Low
210	317-3-2	Tolko	110.859	Low	Rare	Minor	Low
211		Tolko	228.600	Low	Rare	Minor	Low
212	LL1065-02	Tolko	495.226	Low	Rare	Minor	Low
213	LL1064-03	Tolko	720.560	Low	Rare	Minor	Low
214		Tolko	483.469	Low	Rare	Minor	Low
215		Tolko	160.455	Low	Rare	Minor	Low
216	LL1070-01	Tolko	563.213	Low	Rare	Minor	Low
217	LL1068-05	Tolko	301.951	Low	Rare	Minor	Low

Appendix G. Road Risk Assessment (Vernon Creek Watershed).

Road ID	Road	Responsible Party	Length (m)	Ecoscape Ranking	Likelihood	Consequence	Risk
218	315-8-1	Tolko	113.337	Low	Rare	Minor	Low
219		Tolko	83.421	Low	Rare	Minor	Low
220	LL1070-02	Tolko	637.770	Low	Rare	Minor	Low
221	315-1-5	Tolko	104.504	Low	Rare	Minor	Low
223	LL1068-05	Tolko	384.904	Low	Rare	Minor	Low
226	LL1068-02	Tolko	266.362	Low	Rare	Minor	Low
228	315-4-1	Tolko	366.666	Low	Rare	Minor	Low
229	315-4-3	Tolko	345.883	Low	Rare	Minor	Low
230	315-4-2	Tolko	433.055	Low	Rare	Minor	Low
231	315-4-1	Tolko	127.979	Low	Rare	Minor	Low
232	315-4-1	Tolko	231.658	Low	Rare	Minor	Low
233	LL1068-02	Tolko	450.154	Low	Rare	Minor	Low
234		Tolko	511.591	Low	Rare	Minor	Low
235	LL1070-01	Tolko	358.123	Low	Rare	Minor	Low
236	LL1068-06	Tolko	231.702	Low	Rare	Minor	Low
237	315-4-1	Tolko	556.169	Low	Rare	Minor	Low
238	315-6-1	Tolko	489.892	Low	Rare	Minor	Low
239	315-9-1	Tolko	369.641	Low	Rare	Minor	Low
241	LL1070-01	Tolko	56.256	Low	Rare	Minor	Low
242	LL1068-03	Tolko	320.297	Low	Rare	Minor	Low
243	LL1070-03	Tolko	688.483	Low	Rare	Minor	Low
245	317-1-6	Tolko	130.852	Low	Rare	Minor	Low
246	315-8-1	Tolko	698.074	Low	Rare	Minor	Low
248	315-9-1	Tolko	468.626	Low	Rare	Minor	Low
250	LL1070-04	Tolko	159.254	Low	Rare	Minor	Low
251	317-1-6	Tolko	87.167	Low	Rare	Minor	Low
252	317-1-4	Tolko	116.247	Low	Rare	Minor	Low
253	317-3-4	Tolko	91.790	Low	Rare	Minor	Low
254	315-9-3	Tolko	100.392	Low	Rare	Minor	Low
255	315-9-2	Tolko	474.076	Low	Rare	Minor	Low
256	315-1-3	Tolko	335.811	Low	Rare	Minor	Low
257	LL1068-03	Tolko	494.112	Low	Rare	Minor	Low
258	LL1068-02	Tolko	447.042	Low	Rare	Minor	Low
259	LL1067-01	Tolko	108.659	Low	Rare	Minor	Low
262	LL1046-02	Tolko	61.876	Low	Rare	Minor	Low

Appendix G. Road Risk Assessment (Vernon Creek Watershed).

Road ID	Road	Responsible Party	Length (m)	Ecoscape Ranking	Likelihood	Consequence	Risk
263	LL1067-01	Tolko	541.881	Low	Rare	Minor	Low
264	LL1067-01	Tolko	348.308	Low	Rare	Minor	Low
266	LL1067-02	Tolko	110.489	Low	Rare	Minor	Low
267	315-9-3	Tolko	235.190	Low	Rare	Minor	Low
268	LL1068-07	Tolko	317.899	Low	Rare	Minor	Low
269	LL1068-02	Tolko	216.842	Low	Rare	Minor	Low
271	317-1-5	Tolko	43.992	Low	Rare	Minor	Low
272	LL1068-04	Tolko	214.399	Low	Rare	Minor	Low
273	317-1-6	Tolko	436.874	Low	Rare	Minor	Low
274	LL1067-03	Tolko	219.740	Low	Rare	Minor	Low
275	LL1067-04	Tolko	286.181	Low	Rare	Minor	Low
276	315-5-1	Tolko	881.255	Low	Rare	Minor	Low
277	317-1-3	Tolko	322.193	Low	Rare	Minor	Low
278	LL1067-03	Tolko	214.755	Low	Rare	Minor	Low
279	315-5-1	Tolko	61.894	Low	Rare	Minor	Low
280	LL1046-02	Tolko	330.251	Low	Rare	Minor	Low
281	LL1046-03	Tolko	171.665	Low	Rare	Minor	Low
282	LL1068-01	Tolko	361.304	Low	Rare	Minor	Low
283	LL1068-02	Tolko	160.621	Low	Rare	Minor	Low
285	LL1046-02	Tolko	440.630	Low	Rare	Minor	Low
287	317-1-6	Tolko	265.735	Low	Rare	Minor	Low
288	317-1-1	Tolko	495.229	Low	Rare	Minor	Low
289	317-1-2	Tolko	300.660	Low	Rare	Minor	Low
290	317-1-5	Tolko	159.975	Low	Rare	Minor	Low
291	LL1046-03	Tolko	167.252	Low	Rare	Minor	Low
293	LL1046-03	Tolko	294.618	Low	Rare	Minor	Low
294	315-9-3	Tolko	248.402	Low	Rare	Minor	Low
295	LL1045-05	Tolko	92.809	Low	Rare	Minor	Low
296	LL1046-03	Tolko	173.769	Low	Rare	Minor	Low
297		Tolko	228.685	Low	Rare	Minor	Low
298	LL1068-01	Tolko	428.889	Low	Rare	Minor	Low
299	315-9-4	Tolko	227.243	Low	Rare	Minor	Low
300	315-7-1	Tolko	443.233	Low	Rare	Minor	Low
301	315-9-4	Tolko	21.060	Low	Rare	Minor	Low
303	317-1-5	Tolko	158.415	Low	Rare	Minor	Low

Appendix G. Road Risk Assessment (Vernon Creek Watershed).

Road ID	Road	Responsible Party	Length (m)	Ecoscape Ranking	Likelihood	Consequence	Risk
304	315-7-2	Tolko	248.302	Low	Rare	Minor	Low
305	KING EDWARD MAIN	Tolko	59.098	Low	Rare	Minor	Low
307	315-9-4	Tolko	218.563	Low	Rare	Minor	Low
308	315-3-1	Tolko	157.769	Low	Rare	Minor	Low
309	LL1046-04	Tolko	117.401	Low	Rare	Minor	Low
310	LL1046-01	Tolko	50.134	Low	Rare	Minor	Low
311	315-9-5	Tolko	278.477	Low	Rare	Minor	Low
312	315-3-2	Tolko	304.748	Low	Rare	Minor	Low
313	LL1046-01	Tolko	105.740	Low	Rare	Minor	Low
316	LL1046-01	Tolko	111.507	Low	Rare	Minor	Low
317	LL1046-01	Tolko	63.357	Low	Rare	Minor	Low
318		Tolko	230.600	Low	Rare	Minor	Low
319	LL1046-01	Tolko	152.843	Low	Rare	Minor	Low
320	315-9-6	Tolko	117.023	Low	Rare	Minor	Low
323	KING EDWARD MAIN	Tolko	210.659	Low	Rare	Minor	Low
324	LL1122-06	Tolko	145.699	Low	Rare	Minor	Low
325	315-5-2	Tolko	481.004	Low	Rare	Minor	Low
326	LL1045-02	Tolko	89.965	Low	Rare	Minor	Low
327	LL1045-03	Tolko	125.370	Low	Rare	Minor	Low
328	LL1045-02	Tolko	197.823	Low	Rare	Minor	Low
329		Tolko	414.137	Low	Rare	Minor	Low
331	315-9-6	Tolko	195.643	Low	Rare	Minor	Low
332	LL1116-02	Tolko	501.912	Low	Rare	Minor	Low
333	317-1-5	Tolko	396.622	Low	Rare	Minor	Low
334	317-1-5	Tolko	47.777	Low	Rare	Minor	Low
336	ECHO	Tolko	147.458	Low	Rare	Minor	Low
337	KING EDWARD MAIN	Tolko	170.744	Low	Rare	Minor	Low
338	ECHO	Tolko	17.929	Low	Rare	Minor	Low
339	ECHO	Tolko	23.674	Low	Rare	Minor	Low
340	ECHO	Tolko	9.934	Low	Rare	Minor	Low
341	ECHO	Tolko	647.872	Low	Rare	Minor	Low
342	LL1045-02	Tolko	186.928	Low	Rare	Minor	Low
343	ECHO	Tolko	40.095	Low	Rare	Minor	Low
344	ECHO	Tolko	178.947	Low	Rare	Minor	Low
347	317-1-1	Tolko	710.158	Low	Rare	Minor	Low

Appendix G. Road Risk Assessment (Vernon Creek Watershed).

Road ID	Road	Responsible Party	Length (m)	Ecoscape Ranking	Likelihood	Consequence	Risk
350	315-7-1	Tolko	497.203	Low	Rare	Minor	Low
352	ECHO	Tolko	128.662	Low	Rare	Minor	Low
353	LL1116-01	Tolko	175.545	Low	Rare	Minor	Low
354	LL1116-02	Tolko	457.594	Low	Rare	Minor	Low
356	ECHO	Tolko	668.711	Low	Rare	Minor	Low
357		Tolko	435.899	Low	Rare	Minor	Low
360	LL1122-01	Tolko	200.561	Low	Rare	Minor	Low
361	LL1116-03	Tolko	327.245	Low	Rare	Minor	Low
362	LL1116-01	Tolko	188.084	Low	Rare	Minor	Low
363	LL1045-04	Tolko	269.442	Low	Rare	Minor	Low
364	LL1122-02	Tolko	243.296	Low	Rare	Minor	Low
365		Tolko	226.741	Low	Rare	Minor	Low
366	ECHO	Tolko	901.086	Low	Rare	Minor	Low
369	ECHO	Tolko	321.032	Low	Rare	Minor	Low
374	LL1041-03	Tolko	247.640	Low	Rare	Minor	Low
375	ECHO	Tolko	100.236	Low	Rare	Minor	Low
378	LL1122-03	Tolko	201.723	Low	Rare	Minor	Low
379	LL1122-04	Tolko	45.929	Low	Rare	Minor	Low
380	LL1045-01	Tolko	454.809	Low	Rare	Minor	Low
381	LL1049-04	Tolko	271.258	Low	Rare	Minor	Low
384	LL1049-03	Tolko	367.308	Low	Rare	Minor	Low
385	LL1045-01	Tolko	168.027	Low	Rare	Minor	Low
390	LL1122-03	Tolko	302.196	Low	Rare	Minor	Low
392	LL1116-04	Tolko	540.571	Low	Rare	Minor	Low
395	LL1041-02	Tolko	403.933	Low	Rare	Minor	Low
396	LL1040-05	Tolko	225.405	Low	Rare	Minor	Low
398	ECHO	Tolko	772.446	Low	Rare	Minor	Low
407	LL1041-02	Tolko	355.890	Low	Rare	Minor	Low
411	LL1049-01	Tolko	124.066	Low	Rare	Minor	Low
412	LL1049-01	Tolko	229.877	Low	Rare	Minor	Low
414	LL1040-03	Tolko	345.655	Low	Rare	Minor	Low
416	LL1049-02	Tolko	184.281	Low	Rare	Minor	Low
417	LL1040-02	Tolko	292.678	Low	Rare	Minor	Low
418	LL1040-01	Tolko	628.914	Low	Rare	Minor	Low
419	LL1040-01	Tolko	711.823	Low	Rare	Minor	Low

Appendix G. Road Risk Assessment (Vernon Creek Watershed).

Road ID	Road	Responsible Party	Length (m)	Ecoscape Ranking	Likelihood	Consequence	Risk
421	LL1041-01	Tolko	468.161	Low	Rare	Minor	Low
426	LL1121-01	Tolko	1183.777	Low	Rare	Minor	Low
436		Tolko	1457.784	Low	Rare	Minor	Low
437		Tolko	637.210	Low	Rare	Minor	Low
438		Tolko	42.258	Low	Rare	Minor	Low
439		Tolko	471.532	Low	Rare	Minor	Low
446		Tolko	281.568	Low	Rare	Minor	Low
455	ECHO	Tolko	40.556	Low	Rare	Minor	Low
456		Tolko	80.431	Low	Rare	Minor	Low
467		Tolko	162.199	Low	Rare	Minor	Low
497	LL1009-01	Tolko	164.207	Low	Rare	Minor	Low
506	LL1052-01	Tolko	725.939	Low	Rare	Minor	Low
511	LL1009-01	Tolko	145.849	Low	Rare	Minor	Low
519	LL1052-06	Tolko	338.719	Low	Rare	Minor	Low
520	LL1052-01	Tolko	352.271	Low	Rare	Minor	Low
523	LL1052-05	Tolko	343.375	Low	Rare	Minor	Low
527		Tolko	280.760	Low	Rare	Minor	Low
528		Tolko	171.276	Low	Rare	Minor	Low
529	LL1052-01	Tolko	239.360	Low	Rare	Minor	Low
543	LL1010-01	Tolko	232.760	Low	Rare	Minor	Low
550	LL1052-04	Tolko	756.025	Low	Rare	Minor	Low
553		Tolko	121.009	Low	Rare	Minor	Low
555		Tolko	427.083	Low	Rare	Minor	Low
556	LL1011-01	Tolko	54.465	Low	Rare	Minor	Low
562	317-2-8	Tolko	795.797	Low	Rare	Minor	Low
569		Tolko	78.749	Low	Rare	Minor	Low
578	LL1113-01	Tolko	683.580	Low	Rare	Minor	Low
585	LL1114-02	Tolko	115.165	Low	Rare	Minor	Low
586	LL1114-01	Tolko	839.902	Low	Rare	Minor	Low
587	LL1080-01	Tolko	142.618	Low	Rare	Minor	Low
588	LL1080-07	Tolko	120.043	Low	Rare	Minor	Low
589	LL1080-02	Tolko	337.304	Low	Rare	Minor	Low
590	LL1080-01	Tolko	99.182	Low	Rare	Minor	Low
591	LL1080-01	Tolko	80.542	Low	Rare	Minor	Low
592	LL1080-06	Tolko	61.359	Low	Rare	Minor	Low

Appendix G. Road Risk Assessment (Vernon Creek Watershed).

Road ID	Road	Responsible Party	Length (m)	Ecoscape Ranking	Likelihood	Consequence	Risk
598	317-3-5	Tolko	123.395	Low	Rare	Minor	Low
599	317-3-5	Tolko	94.999	Low	Rare	Minor	Low
601	317-3-4	Tolko	410.959	Low	Rare	Minor	Low
605	317-3-4	Tolko	25.939	Low	Rare	Minor	Low
607	LL1080-03	Tolko	717.689	Low	Rare	Minor	Low
608	LL1080-02	Tolko	1314.257	Low	Rare	Minor	Low
609	LL1080-03	Tolko	41.567	Low	Rare	Minor	Low
610	LL1080-04	Tolko	250.323	Low	Rare	Minor	Low
613	LL1080-02	Tolko	76.718	Low	Rare	Minor	Low
614	LL1080-04	Tolko	236.387	Low	Rare	Minor	Low
616		Tolko	392.901	Low	Rare	Minor	Low
617	LL1080-08	Tolko	257.502	Low	Rare	Minor	Low
618		Tolko	240.775	Low	Rare	Minor	Low
619	LL1080-09	Tolko	260.296	Low	Rare	Minor	Low
620		Tolko	172.271	Low	Rare	Minor	Low
621	LL1080-08	Tolko	200.843	Low	Rare	Minor	Low
622		Tolko	588.066	Low	Rare	Minor	Low
623		Tolko	23.374	Low	Rare	Minor	Low
624		Tolko	15.381	Low	Rare	Minor	Low
625		Tolko	133.401	Low	Rare	Minor	Low
626		Tolko	117.108	Low	Rare	Minor	Low
627		Tolko	117.623	Low	Rare	Minor	Low
628	LL1080-10	Tolko	195.402	Low	Rare	Minor	Low
629		Tolko	104.506	Low	Rare	Minor	Low
630	LL1080-08	Tolko	276.573	Low	Rare	Minor	Low
631	313-1-2B	Tolko	474.258	Low	Rare	Minor	Low
632		Tolko	1048.359	Low	Rare	Minor	Low
633	313-1-5	Tolko	366.987	Low	Rare	Minor	Low
634	313-1-2A	Tolko	29.640	Low	Rare	Minor	Low
635	313-1-2A	Tolko	265.634	Low	Rare	Minor	Low
636	313-1-3	Tolko	177.035	Low	Rare	Minor	Low
637	313-1-2A	Tolko	113.865	Low	Rare	Minor	Low
638	313-1-5	Tolko	410.646	Low	Rare	Minor	Low
639	313-1-3	Tolko	138.993	Low	Rare	Minor	Low
640	LL1039-03	Tolko	111.217	Low	Rare	Minor	Low

Appendix G. Road Risk Assessment (Vernon Creek Watershed).

Road ID	Road	Responsible Party	Length (m)	Ecoscape Ranking	Likelihood	Consequence	Risk
641		Tolko	48.837	Low	Rare	Minor	Low
642	LL1039-04	Tolko	330.882	Low	Rare	Minor	Low
643	LL1039-01	Tolko	172.297	Low	Rare	Minor	Low
644	LL1039-02	Tolko	34.316	Low	Rare	Minor	Low
645	LL1039-01	Tolko	180.643	Low	Rare	Minor	Low
646	LL1032-01	Tolko	602.074	Low	Rare	Minor	Low
650	317-2-8	Tolko	1128.650	Low	Rare	Minor	Low
654	317-2-8	Tolko	492.495	Low	Rare	Minor	Low
655	317-2-8	Tolko	395.090	Low	Rare	Minor	Low
658		Tolko	198.002	Low	Rare	Minor	Low
659		Tolko	507.058	Low	Rare	Minor	Low
662	317-3-2	Tolko	110.226	Low	Rare	Minor	Low
663	317-3-3	Tolko	1148.835	Low	Rare	Minor	Low
664		Tolko	96.316	Low	Rare	Minor	Low
142	DEE LAKE MAIN	Ministry of Transportation	89.152	Low	Rare	Minor	Low
150	DEE LAKE MAIN	Ministry of Transportation	209.481	Low	Rare	Minor	Low
153	DEE LAKE MAIN	Ministry of Transportation	91.048	Low	Rare	Minor	Low
314	DEE LAKE MAIN	Ministry of Transportation	257.724	Low	Rare	Minor	Low
321	DEE LAKE MAIN	Ministry of Transportation	1368.288	Low	Rare	Minor	Low
322	DEE LAKE MAIN	Ministry of Transportation	307.208	Low	Rare	Minor	Low
330	DEE LAKE MAIN	Ministry of Transportation	329.291	Low	Rare	Minor	Low
345	DEE LAKE MAIN	Ministry of Transportation	165.428	Low	Rare	Minor	Low
346	DEE LAKE MAIN	Ministry of Transportation	37.328	Low	Rare	Minor	Low
355	DEE LAKE MAIN	Ministry of Transportation	402.017	Low	Rare	Minor	Low
370	DEE LAKE MAIN	Ministry of Transportation	110.327	Low	Rare	Minor	Low
371	DEE LAKE MAIN	Ministry of Transportation	427.619	Low	Rare	Minor	Low
376	DEE LAKE MAIN	Ministry of Transportation	178.752	Low	Rare	Minor	Low
383	DEE LAKE MAIN	Ministry of Transportation	239.287	Low	Rare	Minor	Low
391	DEE LAKE MAIN	Ministry of Transportation	291.313	Low	Rare	Minor	Low
393	DEE LAKE MAIN	Ministry of Transportation	147.803	Low	Rare	Minor	Low
394	DEE LAKE MAIN	Ministry of Transportation	136.161	Low	Rare	Minor	Low
397	DEE LAKE MAIN	Ministry of Transportation	245.275	Low	Rare	Minor	Low
399	DEE LAKE MAIN	Ministry of Transportation	86.498	Low	Rare	Minor	Low
400	DEE LAKE MAIN	Ministry of Transportation	71.119	Low	Rare	Minor	Low
420	DEE LAKE MAIN	Ministry of Transportation	625.339	Low	Rare	Minor	Low

Appendix G. Road Risk Assessment (Vernon Creek Watershed).

Road ID	Road	Responsible Party	Length (m)	Ecoscape Ranking	Likelihood	Consequence	Risk
423	DEE LAKE MAIN	Ministry of Transportation	39.751	Low	Rare	Minor	Low
431	DEE LAKE MAIN	Ministry of Transportation	99.596	Low	Rare	Minor	Low
448	BEAVER LAKE	Ministry of Transportation	176.260	Low	Rare	Minor	Low
454	DEE LAKE MAIN	Ministry of Transportation	439.835	Low	Rare	Minor	Low
514	BEAVER LAKE	District of Lake Country	654.031	Low	Rare	Minor	Low
558	DEE LAKE MAIN	Ministry of Transportation	346.045	Low	Rare	Minor	Low
561	DEE LAKE MAIN	Ministry of Transportation	353.252	Low	Rare	Minor	Low
563	DEE LAKE MAIN	Ministry of Transportation	167.934	Low	Rare	Minor	Low
567	DEE LAKE MAIN	Ministry of Transportation	471.926	Low	Rare	Minor	Low
572	DEE LAKE MAIN	Ministry of Transportation	220.896	Low	Rare	Minor	Low
573	DEE LAKE MAIN	Ministry of Transportation	4.098	Low	Rare	Minor	Low
581	DEE LAKE MAIN	Ministry of Transportation	32.434	Low	Rare	Minor	Low
595	DEE LAKE MAIN	Ministry of Transportation	758.643	Low	Rare	Minor	Low
596	DEE LAKE MAIN	Ministry of Transportation	181.436	Low	Rare	Minor	Low
597	DEE LAKE MAIN	Ministry of Transportation	138.340	Low	Rare	Minor	Low
603	DEE LAKE MAIN	Ministry of Transportation	504.698	Low	Rare	Minor	Low
604	DEE LAKE MAIN	Ministry of Transportation	103.116	Low	Rare	Minor	Low
606	DEE LAKE MAIN	Ministry of Transportation	24.152	Low	Rare	Minor	Low
657	DEE LAKE MAIN	Ministry of Transportation	510.548	Low	Rare	Minor	Low
17		Non-status Roads	178.064	Low	Rare	Minor	Low
21		Non-status Roads	424.037	Low	Rare	Minor	Low
22		Non-status Roads	579.556	Low	Rare	Minor	Low
23		Non-status Roads	17.886	Low	Rare	Minor	Low
25		Non-status Roads	413.724	Low	Rare	Minor	Low
27		Non-status Roads	159.914	Low	Rare	Minor	Low
30		Non-status Roads	704.744	Low	Rare	Minor	Low
42		Non-status Roads	200.496	Low	Rare	Minor	Low
44		Non-status Roads	626.531	Low	Rare	Minor	Low
45		Non-status Roads	389.973	Low	Rare	Minor	Low
46		Non-status Roads	8.117	Low	Rare	Minor	Low
47		Non-status Roads	676.123	Low	Rare	Minor	Low
50		Non-status Roads	357.494	Low	Rare	Minor	Low
51		Non-status Roads	443.087	Low	Rare	Minor	Low
56		Non-status Roads	186.663	Low	Rare	Minor	Low
59		Non-status Roads	581.611	Low	Rare	Minor	Low

Appendix G. Road Risk Assessment (Vernon Creek Watershed).

Road ID	Road	Responsible Party	Length (m)	Ecoscape Ranking	Likelihood	Consequence	Risk
62		Non-status Roads	228.682	Low	Rare	Minor	Low
70		Non-status Roads	514.563	Low	Rare	Minor	Low
76		Non-status Roads	792.074	Low	Rare	Minor	Low
77		Non-status Roads	405.675	Low	Rare	Minor	Low
78		Non-status Roads	291.135	Low	Rare	Minor	Low
80		Non-status Roads	464.780	Low	Rare	Minor	Low
81		Non-status Roads	88.331	Low	Rare	Minor	Low
88		Non-status Roads	1024.665	Low	Rare	Minor	Low
89		Non-status Roads	415.650	Low	Rare	Minor	Low
90		Non-status Roads	574.815	Low	Rare	Minor	Low
94		Non-status Roads	130.344	Low	Rare	Minor	Low
104		Non-status Roads	1017.318	Low	Rare	Minor	Low
108		Non-status Roads	966.281	Low	Rare	Minor	Low
109		Non-status Roads	384.577	Low	Rare	Minor	Low
110		Non-status Roads	694.642	Low	Rare	Minor	Low
112		Non-status Roads	75.936	Low	Rare	Minor	Low
121		Non-status Roads	70.734	Low	Rare	Minor	Low
126		Non-status Roads	97.641	Low	Rare	Minor	Low
127		Non-status Roads	82.312	Low	Rare	Minor	Low
128		Non-status Roads	401.827	Low	Rare	Minor	Low
131		Non-status Roads	130.715	Low	Rare	Minor	Low
133		Non-status Roads	187.418	Low	Rare	Minor	Low
134		Non-status Roads	193.021	Low	Rare	Minor	Low
139		Non-status Roads	196.713	Low	Rare	Minor	Low
141		Non-status Roads	254.905	Low	Rare	Minor	Low
143		Non-status Roads	1346.091	Low	Rare	Minor	Low
144		Non-status Roads	180.953	Low	Rare	Minor	Low
146		Non-status Roads	62.194	Low	Rare	Minor	Low
148		Non-status Roads	1318.562	Low	Rare	Minor	Low
149		Non-status Roads	580.559	Low	Rare	Minor	Low
151		Non-status Roads	399.089	Low	Rare	Minor	Low
152		Non-status Roads	188.536	Low	Rare	Minor	Low
154		Non-status Roads	284.998	Low	Rare	Minor	Low
155		Non-status Roads	1444.605	Low	Rare	Minor	Low
160		Non-status Roads	314.756	Low	Rare	Minor	Low

Appendix G. Road Risk Assessment (Vernon Creek Watershed).

Road ID	Road	Responsible Party	Length (m)	Ecoscape Ranking	Likelihood	Consequence	Risk
161		Non-status Roads	96.488	Low	Rare	Minor	Low
162		Non-status Roads	158.896	Low	Rare	Minor	Low
164		Non-status Roads	382.125	Low	Rare	Minor	Low
168		Non-status Roads	375.075	Low	Rare	Minor	Low
171		Non-status Roads	321.720	Low	Rare	Minor	Low
172		Non-status Roads	91.651	Low	Rare	Minor	Low
185		Non-status Roads	659.938	Low	Rare	Minor	Low
222		Non-status Roads	333.751	Low	Rare	Minor	Low
224		Non-status Roads	100.146	Low	Rare	Minor	Low
225		Non-status Roads	430.096	Low	Rare	Minor	Low
227		Non-status Roads	164.350	Low	Rare	Minor	Low
240		Non-status Roads	139.264	Low	Rare	Minor	Low
244		Non-status Roads	0.248	Low	Rare	Minor	Low
247		Non-status Roads	542.456	Low	Rare	Minor	Low
249		Non-status Roads	459.943	Low	Rare	Minor	Low
260		Non-status Roads	687.020	Low	Rare	Minor	Low
261		Non-status Roads	43.611	Low	Rare	Minor	Low
265		Non-status Roads	205.944	Low	Rare	Minor	Low
270		Non-status Roads	866.453	Low	Rare	Minor	Low
284		Non-status Roads	227.463	Low	Rare	Minor	Low
286		Non-status Roads	489.748	Low	Rare	Minor	Low
292		Non-status Roads	320.346	Low	Rare	Minor	Low
302		Non-status Roads	199.616	Low	Rare	Minor	Low
306		Non-status Roads	524.849	Low	Rare	Minor	Low
315		Non-status Roads	234.960	Low	Rare	Minor	Low
335		Non-status Roads	262.908	Low	Rare	Minor	Low
348		Non-status Roads	478.075	Low	Rare	Minor	Low
349		Non-status Roads	124.796	Low	Rare	Minor	Low
351		Non-status Roads	153.904	Low	Rare	Minor	Low
358		Non-status Roads	106.026	Low	Rare	Minor	Low
359		Non-status Roads	82.619	Low	Rare	Minor	Low
367		Non-status Roads	245.845	Low	Rare	Minor	Low
368		Non-status Roads	852.203	Low	Rare	Minor	Low
372		Non-status Roads	8.353	Low	Rare	Minor	Low
373		Non-status Roads	328.272	Low	Rare	Minor	Low

Appendix G. Road Risk Assessment (Vernon Creek Watershed).

Road ID	Road	Responsible Party	Length (m)	Ecoscape Ranking	Likelihood	Consequence	Risk
377		Non-status Roads	666.234	Low	Rare	Minor	Low
382		Non-status Roads	200.848	Low	Rare	Minor	Low
389		Non-status Roads	503.415	Low	Rare	Minor	Low
401		Non-status Roads	476.041	Low	Rare	Minor	Low
402	LL1040-05	Non-status Roads	70.672	Low	Rare	Minor	Low
403		Non-status Roads	29.901	Low	Rare	Minor	Low
404		Non-status Roads	130.594	Low	Rare	Minor	Low
405		Non-status Roads	270.438	Low	Rare	Minor	Low
406		Non-status Roads	802.969	Low	Rare	Minor	Low
408		Non-status Roads	323.126	Low	Rare	Minor	Low
409		Non-status Roads	226.002	Low	Rare	Minor	Low
410		Non-status Roads	145.715	Low	Rare	Minor	Low
413		Non-status Roads	195.864	Low	Rare	Minor	Low
415	LL1040-04	Non-status Roads	98.767	Low	Rare	Minor	Low
422		Non-status Roads	98.827	Low	Rare	Minor	Low
424		Non-status Roads	489.447	Low	Rare	Minor	Low
425		Non-status Roads	1232.261	Low	Rare	Minor	Low
427		Non-status Roads	239.847	Low	Rare	Minor	Low
433		Non-status Roads	619.746	Low	Rare	Minor	Low
435		Non-status Roads	463.406	Low	Rare	Minor	Low
440		Non-status Roads	1183.254	Low	Rare	Minor	Low
444		Non-status Roads	205.586	Low	Rare	Minor	Low
457		Non-status Roads	536.702	Low	Rare	Minor	Low
458		Non-status Roads	641.600	Low	Rare	Minor	Low
459		Non-status Roads	1156.452	Low	Rare	Minor	Low
461		Non-status Roads	1178.247	Low	Rare	Minor	Low
462		Non-status Roads	234.038	Low	Rare	Minor	Low
463		Non-status Roads	87.657	Low	Rare	Minor	Low
470		Non-status Roads	968.411	Low	Rare	Minor	Low
475		Non-status Roads	611.693	Low	Rare	Minor	Low
478		Non-status Roads	2086.704	Low	Rare	Minor	Low
482		Non-status Roads	331.624	Low	Rare	Minor	Low
483		Non-status Roads	289.759	Low	Rare	Minor	Low
484		Non-status Roads	70.088	Low	Rare	Minor	Low
485		Non-status Roads	777.247	Low	Rare	Minor	Low

Appendix G. Road Risk Assessment (Vernon Creek Watershed).

Road ID	Road	Responsible Party	Length (m)	Ecoscape Ranking	Likelihood	Consequence	Risk
491		Non-status Roads	549.776	Low	Rare	Minor	Low
492		Non-status Roads	952.473	Low	Rare	Minor	Low
493		Non-status Roads	96.731	Low	Rare	Minor	Low
494		Non-status Roads	146.383	Low	Rare	Minor	Low
498		Non-status Roads	253.971	Low	Rare	Minor	Low
499		Non-status Roads	383.768	Low	Rare	Minor	Low
500		Non-status Roads	860.651	Low	Rare	Minor	Low
501		Non-status Roads	149.591	Low	Rare	Minor	Low
505		Non-status Roads	626.821	Low	Rare	Minor	Low
507		Non-status Roads	362.832	Low	Rare	Minor	Low
518		Non-status Roads	1586.722	Low	Rare	Minor	Low
524		Non-status Roads	494.852	Low	Rare	Minor	Low
533		Non-status Roads	258.265	Low	Rare	Minor	Low
534		Non-status Roads	155.643	Low	Rare	Minor	Low
536		Non-status Roads	809.286	Low	Rare	Minor	Low
538		Non-status Roads	233.577	Low	Rare	Minor	Low
540		Non-status Roads	360.099	Low	Rare	Minor	Low
541		Non-status Roads	699.948	Low	Rare	Minor	Low
546		Non-status Roads	86.797	Low	Rare	Minor	Low
548		Non-status Roads	203.635	Low	Rare	Minor	Low
551		Non-status Roads	556.458	Low	Rare	Minor	Low
552		Non-status Roads	635.584	Low	Rare	Minor	Low
557		Non-status Roads	176.356	Low	Rare	Minor	Low
559		Non-status Roads	151.132	Low	Rare	Minor	Low
560		Non-status Roads	216.367	Low	Rare	Minor	Low
564		Non-status Roads	74.393	Low	Rare	Minor	Low
565		Non-status Roads	148.539	Low	Rare	Minor	Low
566		Non-status Roads	107.430	Low	Rare	Minor	Low
568		Non-status Roads	381.721	Low	Rare	Minor	Low
571		Non-status Roads	19.080	Low	Rare	Minor	Low
577		Non-status Roads	35.154	Low	Rare	Minor	Low
600		Non-status Roads	97.441	Low	Rare	Minor	Low
611		Non-status Roads	215.158	Low	Rare	Minor	Low
612		Non-status Roads	224.285	Low	Rare	Minor	Low
615		Non-status Roads	224.165	Low	Rare	Minor	Low

Appendix G. Road Risk Assessment (Vernon Creek Watershed).

Road ID	Road	Responsible Party	Length (m)	Ecoscape Ranking	Likelihood	Consequence	Risk
647		Non-status Roads	285.216	Low	Rare	Minor	Low
651		Non-status Roads	1370.053	Low	Rare	Minor	Low
653		Non-status Roads	757.943	Low	Rare	Minor	Low
656		Non-status Roads	429.049	Low	Rare	Minor	Low
660		Non-status Roads	320.950	Low	Rare	Minor	Low
661		Non-status Roads	452.767	Low	Rare	Minor	Low
665	CP 2	Non-status Roads	111.919	Low	Rare	Minor	Low
666		Non-status Roads	53.490	Low	Rare	Minor	Low
668		Non-status Roads	387.986	Low	Rare	Minor	Low

SUMMARY OF STAKEHOLDER COMMENTS ON DRAFT VERSIONS OF THE OYAMA AND VERNON CREEK SOURCE WATER ASSESSMENT

Assembled By:

ECOSCAPE ENVIRONMENTAL CONSULTANTS LTD.
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June, 2010
Ecoscape File No: 09-367/415

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1.0 MINISTRY OF FOREST AND RANGE

1.1 Rob Dinwoodie, P.Ag.

February 12, 2010

Oyama Creek and Vernon Creek Source to Tap Assessment Report

RANGE COMMENTS ON RECOMMENDATIONS

General Cattle Recommendations:

1. **Our preferred method of dealing with cattle is to completely exclude them from the very high and high vulnerability zones between intakes and the outlet of storage reservoirs.**

   Comment: These areas no doubt pose the highest risk to impact to water quality, however it is not possible or practical to exclude livestock due to costs of fencing and improvements. The Best Management Practice applied to the areas where livestock are not excluded is using prescribed stubble heights on indicator forage species for livestock management. The practice is linked to the science based approach of proper functioning condition of riparian areas, where the healthy system provides both buffer and filtration to movement of deleterious substances and the capture, storage and release of water.

2. **The minimum distance in which cattle can safely congregate from source watercourses below the outflow of reservoir lakes is 30 m from the high water level (as defined by normal annual flows and flooding) or a 5 m offset from the top of the bank (the portion of land that is less than 30% slope for a minimum of 15 horizontal m), whichever is greater.**

   Comment: As per #1 the filtering of deleterious substances by a healthy functioning plant community is significant. The use of 30 meters from the outflow will be excluded from grazing by constructing fence or other improvement to prevent use. Collaboration with Lake Country to authorize improvements to dam sites will be required on these reservoir lakes. Off stream/reservoir watering will be considered as an additional tool to manage livestock in these areas.

3. Roads and unsanctioned quad paths facilitating cattle access to highly vulnerable areas should be decommissioned wherever possible.

   Comment: MFR Range is responsible for livestock trails that have been identified as range improvements. The deactivation of livestock trails is most often accomplished by fencing to prevent access. The deactivation of roads would be under the jurisdiction of the MFR engineering program (see additional comments).

4. A mapping initiative (GPS inventory) of fences and cattle guards should be undertaken to assess the effectiveness of existing structures and to gain a broader understanding of how and where cattle are gaining access to source streams, diversions and reservoirs.

   Comment: This is currently being undertaken with the construction of new and repair of existing infrastructure. This layer will reside with the forest district local database through the Geomatics program.

5. Natural barriers should also be inventoried and mapped.

   Comment: The mapping of natural barriers will be conducted by both retention planning by the forest licensees and as a project by MFR Range as we progress in the development of the GIS layers for the Range program. Realistically this will occur as a lower priority in the short term as range infrastructure is being constructed and rebuilt.

6. Proposed fencing should also be overlaid with proposed logging in the watershed in order to determine if logging activities will impede fence locations or disrupt the necessary natural barriers upon which strategic fencing relies.

Comment: This planning is presently occurring but needs to be more intentional as the existing range developments are critical to the success of the range plan in addressing water quality.

7. **Buffers of mature forest and road deactivation should be considered around important source watercourses in high vulnerability areas to help reduce cattle access.**

Comment: MFR Range is in the process of developing policy with respect to livestock access to reservoirs and creeks due to timber extraction by Small Scale Salvage program or major licensees.

8. **Cattle should be directed to strategically placed off channel watering or watering dugouts, as an alternative to source watercourses.**

Comment: Off site watering is currently being used on these ranges. During the field season of 2009 potential sites for off stream watering were identified and will be constructed in the 2010 grazing season. Addition sites will be assessed as need arises.

9. **The use of range riders is encouraged to monitor livestock movement patterns and activities.**

Comment: The use of riders is an important tool for management of livestock and the use of management tool employed by the range agreement holder is not dictated by legislation. Further exploration of this tool is necessary as well as funding mechanism, including JOP.

10. **A communication plan between relevant stakeholders needs to be implemented.**

Comment: The communication plan forms one of the four key components of the CWS – Range Plan that MFR is preparing for IHA. This plan identifies triggers and reporting and recording mechanisms for range activities in the watershed.

11. **The MFR has indicated they will require cattle ranchers to keep active logs of cattle locations and numbers.**

Comment: This is part of the communication plan, including recording and reporting of activities within the watershed.

12. **An adaptive management model should be implemented.**

Comment: The adaptive management approach has been implemented for a number of years with MFR Range and watersheds. Annual Range-Water planning meeting to address both planning needs within the watershed and implement these are integral to this approach. A monitoring plan will provide the data for adaptive management as it is used by stakeholders. The source to tap report has brought all stakeholders together in a better understanding of each other's risks to the watershed as well as how each resource use affects each other and water quality. The annual meetings will continue to occur with a broader audience including IHA and MOE water stewardship representation.

Recommendations for Range Use Plans

1. **Range Use Plans should include a map of highly sensitive riparian features.**

Comment: The vulnerability layer will form a key component of the Range Use Plan maps and as previously mentioned will be used as key areas for monitoring to occur to provide indicator or trigger information for the management of livestock within and without these zones. The maps will also provide information on pastures, range improvements and range boundary which both assist in planning and management of range activities but other resource use as well.

2. **An extremely conservative stubble height approach should be undertaken.**

   Comment: MFR includes the prescribed stubble heights for forage species within the Range Use Plan. These stubble heights reflect both water quality objectives as well as the health of the plant community. Field days will occur with ranchers and resource users to ensure a full understanding of activities within the watershed to assist in management of integrated resource use.

3. **The Range Use Plan should identify who is responsible for key components including monitoring and maintenance of infrastructure and these responsibilities must be explicitly stated.**

   Comment: The maintenance of range improvements is the responsibility of the range agreement holder by requirement in Forest and Practices Act regulation. The maintenance agreements (who does what portion between shared range) will be a part of the Range Use Plan. The Compliance and Enforcement part of range improvement maintenance is clearly spelled out in FRPA legislation.

4. **Grazing schedules should be determined on the basis of riparian sensitivity rather than forage capacity of uplands.**

   Comment: The application of stubble heights as a management indicator provides the Range Agreement holder the information needed to ensure the use of the forage does not impede the ability of the riparian area to function to preserve the integrity of water quality. Scheduling of livestock within a pasture does not take priority over stubble height criteria. Contingencies will form part of the Range Use Plan and will be developed over the 2010 grazing season to provide range agreement holders with practical alternatives to graze their livestock.

5. **Range Use Plans must address the locations of natural barriers that they require successful management.**

   Comment: The Range Use Plans will address values at risk and improvements.

6. **Use standardized monitoring forms.**

   Comment: Monitoring forms will be developed by MFR Range to gather information on livestock activities within the watershed. These forms will form the basis for the annual report that will be required by the MFR each year.

Cattle Recommendations Specific to Oyama Creek Watershed

Bullet #1 - As previously discussed regarding distances and vulnerability zones.

Bullet #2 - As previously discussed the meadow area complex of North Fork creek will be used by livestock while applying stubble height criteria that will be monitored for purposes of management. The adaptive management approach will be used if this method of grazing does not provide the protection to water quality. It should be noted that funding is limited and that an alternative fund should be provided by an agency like the OBWB in response to extraordinary measures required within a watershed.

Cattle Recommendations Specific to Vernon Creek Watershed

Bullet #1 - The cooperative approach will be used in this situation due to private land concerns and limited funding. Key areas that need to be addressed are the outflow of Swalwell Lake and associated meadow, and within approximately 1 km. up from the intake. Strategic fencing is planned through JOP funding and a partnership requiring commitment by private land holder, Lake Country Irrigation District, MFR Range and Coldstream Ranch.

Bullet #2 - . Cattle trails can be dealt with through the range program, however generally this will require fencing as the mechanism to prevent livestock use.

Bullet #3 - This approach to mitigating livestock impact to the watershed may be effective but will require funding which is not currently accounted for. A collaborative approach to funding through an agency like OBWB may be the most effective way of completing these type of improvements.

1.2 Kimm Magill-Hofmann, R.P.F.

January 15, 2009

Comments on the Oyama and Vernon Creeks Watershed Assessment –

Pg 28: Wildfires – there is no mention of the fuel reduction project for the fire location of June 11th. There was limited spread of the fire due to the reduction in fuel and access for wildland fire fighters was increased as a result of the treatment.

1. Pg 33: "…the affects of the infestation (MPB) are still felt in the watershed in the form of severe recreational access to reservoirs and creeks from historic road development." With funding and a plan, access can be managed.

2. Table 1-12 Intrinsic Hazard Identification Table

    a. Wildfire: There is no mention under "preventative measures" of the fuel modification treatments conducted on both Oyama and Beaver Lakes to reduce the intensity of fire and increase access for wildland fire fighters.

    b. MPB: What does "Age of stands determination" mean? Preventative measures could include selective harvesting and/or rapid reforestation.

3. Pg 46: The author is referring to "forestry recreation sites". These sites are controlled by MTSA, not MFR.

4. Pg. 50: It is identified roads within the Oyama Creek watershed "could" result in increased potential for large scale events (landslides) and increased contaminants. There is no mention likelihood or risk.

5. Pg 53: The author has stated MPB harvesting will ultimately result in less vegetation. There will be less timber right after harvesting, however, there will be lots of vegetation and in the long term, there will again be a mature stand of trees.

6. Pg 54: Incorrect statement maximum allowable harvest area for SSSP is 1 ha. This is maximum clearcut size. Maximum harvest is volume based, 2,000 m3 or 5,000 m3).

7. Pg 56: Incorrect statement the SSSP operations have been directed to riparian management areas. There is no direction from MFR on where to harvest. Also, it has been indicated the major licensees do not harvest within riparian management areas. This is not true, they do not harvest in riparian reserve zones (unless extenuating circumstances).

8. Table 6-8:

    a. 2-4: Roads deactivated where possible. New roads are deactivated where appropriate. Old roads (non-status) are deactivated when funds are available.

    b. 2-5: “no logging of stream side management areas” inconsistent wording. Should read “riparian management areas”. This is also incorrect as stated above, there is harvesting in RMAs, but not in RMZs. Tolko has made commitments in their FSP for assessments in a watershed.

9. Pg 73: Industry (forestry, mining and cattle) are governed by legislation. The report uses worst case scenarios without consideration for likelihood of a worst case scenario. Private land and recreational use are not legislated to the same level and could be considered a higher risk.

10. Pg 83: roads are not “under permit” to the MFR. Roads are not under permit to the MFR. If the road is not permitted to a licensee, it is the responsibility of the MFR. You could speak with the engineering staff for more information or clarity.

11. Pg 84 SWOT Analysis.

    a. Listed as a weakness: “Poor compliance monitoring of best management practices and a transition to industry self regulation.” Tolko and BCTS are both members of a Sustainable Forest Management Plan (SFM) and were successfully audited by a third party in June of 2006 to CSA Standards. Tolko has maintained their registration since their certification. For more information http://www.tolko.com/sustainability/sfm/regional/okanagan.php

    b. Pg 84 SWOT analysis. Listed as a threat: SSSP activities will create access for cattle and recreational users. This COULD happen, but processes are in place to try to prevent it.

    c. Enhanced salvage activities MAY result in moderate to high peak flow hazards. This is influenced by weather patterns as well as harvesting schedules, replanting, etc.

    d. A missing "strength" is the communication between the water purveyor and the major licensees prior to harvest activities.

12. Pg 86 Recommendation #6. Government agencies must take a leadership role. From the MOU: "The Ministry of Environment will responsible for source water quality standards, monitoring, compliance and enforcement, and resource ministries will be responsible for protecting drinking water sources under their legislated mandates." It sounds to me like MOE is the leader.
13. Pg 87
    a. Recommendation #10. Forested buffers. Harvesting of forest buffers MAY lead to increased access. Opportunities are presented during the referral stage for licensees and the water purveyor to address concerns and attempt to mitigate impacts.
    b. Recommendation #11. MFR Compliance and Enforcement staff are also empowered to enforce compliance with mudbogging regulations.
14. Pg 95
    a. The road built to access the Oyama Creek fire was rehabilitated and inspected in November of 2009. The landing still needs to be grass seeded.
    b. The Minstry of Forests and Range is NOT responsible for camping, trails or other recreational activities in areas outside of forest service recreation sites.
15. Page 113 and 114: Forestry and MPB Recommendations, I see a number of issues with this section. I recommend further discussion. I think a lot of what is recommended is happening. There are several implications such as harvesting must be carried out with extreme caution and disturbance must be minimized. Are the current standards set out in legislation for soil disturbance not adequate?

1.3 Katherine Ladyman, R.P.F.

January 12, 2010

I've given your report a quick skim (focussing on the forestry sections), and have some feedback for you, mostly related to SSS. I know some of this stuff is fairly confusing, so hopefully my comments will help you out a bit

General clarification: SSSP

- The SSSP is a district (MFR) program that issues Forestry Licences to Cut (FLTCs) for small volumes (up to 2000m3) of dead or damaged timber. The applicant is responsible for finding an area and having an application prepared by a professional forester. The RPF is responsible for ensuring that all potential impacts to other resources and stakeholders are considered, and that the plan is consistent with legislation, policies, and guidance. The SSSP then reviews the application and makes a recommendation to the district manager to either issue a licence or not. We, the SSSP, are not directly doing any harvesting, which is how your report makes it sound. I have suggested some wording changes on specific pages below.

General clarification: RMA vs LMA

- Without having actually looked closely at any of Tolko's recent cutting permits, I would say that it is probably not actually true to say that either Tolko or BCTS are NOT harvesting within RMAs- as far as I know, they are doing some harvesting within RMAs on <u>streams</u> within CWS, as are SSS licensees.

- This next part is confusing, since all of the majors/BCTS have somewhat different FSP commitments, but I think this is close enough (you will probably get feedback from them as well). The difference between majors and SSS is that, through FSP commitments, majors are staying out of the **210m LMA of L1-B class A** lakes. Their FSPs <u>do</u> allow them to do some harvesting within LMAs of class b through e lakes, but on the Aberdeen Plateau, they have chosen to put most of the LMAs within their long-term retention areas, so they haven't been harvesting much in LMAs in these CWSs (Tolko and BCTS could tell you the definite answer). Some SSS harvesting <u>is</u> occurring in these areas, where it is consistent with district policy (the LMA Guidance document that you talked to Rich about), the LRMP, and the best practices found in the Lakeshore Mgmt Zone Guidebook.

- LMAs are not legally established currently, but were identified under the FPC on all lakes >5 ha. The LMA includes a 10m reserve plus a 200m management zone. See the FPC Lakeshore Mgmt Zone Guidebook for details:

http://www.for.gov.bc.ca/tasb/LEGSREGS/FPC/FPCGUIDE/kamlake/kam-toc.htm

Some Page-specific Comments:

P. 52 "logging by the SSSP" should be "logging done by Small Scale Salvage tenure holders"

p. 54 should be "In addition to the major forest licensees, minor tenures holders with forestry licences to cut (FLTCs) issued by the MFR Small Scale Salvage Program (SSSP) also operate in both watersheds, but do not have defined operating boundaries. The objective of the SSSP is to harvest small patches or scattered dead timber not normally...." "Ecoscape understands that the <u>licensees</u> who take part in the SSSP are typically..."

P. 56 “Large scale licensees do not harvest….” should say “Major licensees are generally not harvesting within Lakeshore Management Areas (LMAs),… (they do harvest within RMAs of streams fairly often, and could harvest within LMAs of lakes other than class a)
And.. “…prior to harvest by the SSSP” should be something like… “Prior to the issuance of a licence under the SSSP, a professional forester must prepare a professional site plan for the proposed works which considers the impacts of the proposed harvesting on other resource values. Information for this plan is collected by on-site assessments and referrals to potentially impacted stakeholders (such as DLC and range tenure holders). A broader FSP is not required.”

p. 57
We also have additional RMA requirements established through the LRMP- these are incorporated within FSPs and we expected other licensees who don’t have FSPs to follow them as well. Also, while wider RRZs and RMZs may not be “officially” established, I would say that all licensees are establishing actual block boundaries and RMAs in the logical location, taking into account topography, windthrow hazard etc- not just following minimum requirements.

P.58
It would be more accurate to say that “a SSS tenure holder is working on a proposal for harvesting within the LMA on the southeastern side of Oyama Lake. In addition to any windthrow issues, this proposal *could* increase access to the lakeshore by recreationalists and cattle.” (When the applicant’s RPF has prepared a final proposal, it will be reviewed by the LRMP monitoring committee for their opinion before the District Manager makes any decision on approval, and of course there are the normal stakeholder referrals as well. And, I use the wording “could increase access”, because the applicant is well aware that we would not approve a plan that is going to significantly increase access to the lake, so their plan will have to minimize that impact).

That’s all I’ve got for now. Kimm is going to review the document as well, and she may have some comments.

Thanks,

Katherine Ladyman, RPF
Small Scale Salvage Coordinator
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http://www.for.gov.bc.ca/dos/Programs/Small_Scale_Salvage/sss_index.htm

1.4 Ray Crampton, R.P.F.

February 17, 2010

Hi Mary Ann

Please find the Okanagan Shuswap Forest District (DOS) response to those recommendations related to roads and engineering, pages 110 through 113 of the EcoScape report.

Road users who hold forest roads under permits issued by the Ministry of Forests and Range (MFR) are responsible for maintenance.

These roads are inspected by DOS Compliance and Enforcement staff in accordance to a risk model (high risk = higher inspection frequency).

Designated Forest Service Roads (FSRs) not under permit are inspected and maintained by the Okanagan Shuswap Forest District (DOS) Engineering Program.

As with permitted roads, FSRs are risk rated and inspected accordingly.

High risk roads in close proximity to source watercourses are inspected at a higher frequency.

DOS staff work with the Forest Investment Account (FIA) program leads and along with industry, identify and prioritize annual projects.

DOS staff are currently in discussions with these agencies regarding opportunities to identify and rectify high risk issues in areas such as the Oyama and Vernon Creek watersheds.

Sedimentation issues associated with roads not under permit or roads designated as wilderness roads would be addressed under such a proposal.

Hope this helps.

Thanks.

Ray Crampton RPF
Operations Manager

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2.0 INTERIOR HEALTH

2.1 Byrn Lord – February 15, 2010

February 15, 2010

Attention: Jack Allingham & Patti Hansen
District of Lake Country
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V4V 2M1

IH Review of: *Draft* Oyama and Vernon Creek Watershed Assessment Report
Overall, the report provides a valuable compendium of information regarding the Oyama & Vernon Creek Assessment areas. The thorough identification of hazards establishes a platform for District of Lake Country and other stakeholders in the watershed to move forward with actions to better protect drinking water. In particular, the evidence based approach to identifying sensitive areas is arguably the most important contribution the District of Lake Country can make in support of integrated watershed management.

Recommendations
The value of any source protection plan can ultimately be evaluated based on the changes it effects on the ground. As important as the science and technical elements, is the utility of the plan to direct action by the water supplier and other stakeholders for improving drinking water safety. On page 89, the authors state the intent of module eight is to prioritize recommendations for action based on risk, but this does not come across in the report. Relative to the framework set out in the *Comprehensive Drinking Water Source to Tap Assessment Guideline*, an explicit link between identified hazards in Module 2, corresponding risks established in Module 7 and the recommended risk management actions identified in Module 8 is a necessary objective.

Further, the primary concepts outlined in Module 8 of the guideline suggest that effective risk management actions 1. identify what/where the most critical problems are, 2. direct resources most immediately to actions with the highest potential for improvement, 3. protect unimpaired

areas from degradation, 4. identify areas where there is a need to coordinate multiple remedial/
protective priorities, 5. follow SMART principles to develop risk management actions that are specific, measurable, achievable, realistic & time-bound.
In order to arrive at a risk-based response plan with clear objectives, deliverables, and benchmarks, the risk characterization (Module 7) & subsequent prioritization of specific risk management actions (Module 8) will require revision in order meet the deliverables set out in the *Comprehensive DW Source to Tap Assessment Guideline*. Following the framework outlined within these modules, the water supplier should be able to initiate an effective response
with risk management actions that are specific, risk based, prioritized, measurable, realistic & time-bound.
The following provides elaboration on the above recommendations as they pertain to each module, as well as additional specific comments:

Module 2 - *Hazard Identification*

- Figure 2-4 shows 117 stream crossings and drainage culverts for the Vernon Cr Watershed, while Appendix E shows a ***Drainage Culvert/Stream Crossing Assessment*** for these sites.
- Appendix F shows a ***Road Risk Analysis*** for sedimentation in the Oyama Watershed with the first 2 pages prioritizing road sections based on VH, H & M risk.

Where is the ***Road Risk Analysis for the Vernon Cr Watershed*** & the ***Drainage Culvert/Stream Crossing Assessment for the Oyama Cr Watershed***? Are there not sections of road in the Vernon Watershed that are contributing to sedimentation into source water irrespective of stream crossings and culverts? Similarly, are there not stream crossings & drainage culverts in the Oyama watershed that are contributing to sedimentation into source water irrespective of the identified road sections. Differences in these 2 methodologies could result in missing road sections in the Vernon WS & stream crossings/road culverts in the Oyama
WS that are contributing to sedimentation and impacting water quality.
Appendix C – lists a number of assessment sites in both the Oyama and Vernon Watersheds together, but what and where is the assessment of risk (Module 7) and prioritization for remediation efforts (Module 8). Likewise, these sites should be identified as to their major hazard or contaminant of concern: ie. sedimentation (ie. from land clearing, road drainage directed into creek, cattle), biological/fecal (outhouse, unapproved septic system, cattle), etc.
P50 - Mike Milne's work – Oyama Creek Watershed - The specific analysis, identified hazards, and key concerns should be identified in this section (Module 2). The risk assessment, etc can then be discussed in Module 7 and prioritized recommendations included in Module 8..

Module 7 – *Characterization of Risk*

For each of the major hazards that were identified in Module 2, including information within data
sets (figures & tables), there should be an assessment of risk and associated discussion in Module 7. From reading module 7, the reader should be able to identify what hazards are considered as posing the greatest risk to water quality impacts. This risk characterization should then be used to prioritize the risk management actions presented in Module 8. It

appears that some of the risk characterization discussion and recommendations for improvement occurred in modules 1 & 2, however, this did not allow the reader to determine what were the greatest threats to source water in the Oyama & Vernon Creek Watersheds.

Module 8 – *Recommended Actions to Improve Drinking Water Protection*
Again, it is an expectation that the water supplier should be able to initiate an effective response
with risk management actions that are specific, risk based, prioritized, measurable, realistic & time-bound. To assist in this process, it may also be beneficial to organize risk management actions in Module 8 based on:
1.) Prioritized r*ecommendations that relate to* ***specific identified hazards*** (ie. road sections/culverts/ crossings contributing to sedimentation, cattle access/grazing areas contributing to sedimentation/fecal inputs, existing land clearing sites - both forestry and "land
ownership" that are contributing to sedimentation, outhouses/sewerage systems contributing to
biological inputs, landslide areas contributing to sedimentation, recreation sites contributing to
sedimentation/biological inputs, shallow area at Damer reservoir contributing to algae, etc).
2.) Prioritized recommendations that relate to ***protecting unimpaired areas from degradation***
(ie. recommendations for logging %ECA - present and future, protection of forest buffers surrounding lakes, protective measures in lakeshore management/riparian areas, incorporation
of Source Assessment information into OCP, etc).

Specific Comments

p.i, para.1 – It is stated that a/the primary focus of this report is the exploration of filtration deferral. The report goes on to indicate turbidity levels are <1NTU only 33% of the time and that disinfection by-products (see THM values on p.22) and their precursors (TOC >10mg/L) do not meet generally recognized water quality standards. If the report is intended to provide information in support of filtration planning these issues should be discussed. For example, they may wish to explore likely sources of TOC in the watershed (e.g. based on information discussed on p.16, Sect. 3.7). Moreover, the primary aim of the Source Assessment is not for filtration deferral, but ***"to identify hazards and vulnerabilities that may threaten the safety and sustainability of the water supply and to recommend risk management actions to address them".***

p.ii "Highlights from the recommendations…" These highlights should also reflect risk management actions for recommendations relating to the major/specific identified hazards/contaminant sources.

The report purpose includes implications for quantity, including the stated need to retain ability to increase storage. However, I don't see any significant analyses of patterns in use or discussion/recommendations regarding demand side management. Fig. 1-3, p.7 and information on p.11 indicate seasonally linked demand patterns; further, the DoLC's states that 80% of the water is used for irrigation (p.33, para.3). Some comments on demand versus supply side management is needed (e.g. on p.34 and/or p.114) as raising reservoir levels is likely to have a significant impact on the natural ecosystem function of the watershed. As the lead for water resource management MOE Water Stewardship should have an opportunity to provide input-guidance on this issue.

p.6 – Literature suggest most outbreaks in North American water systems are associated with extreme weather events. There should be some discussion of the patterns in water quality associated with rain storms, etc. If this data is not available, it should be noted as an information gap.

p.7, last para. – water flows through several lakes and wetland complexes before reaching the intake. TOC levels reported on p.18-19 appear to be from the intake. It may be beneficial to DoLC to understand where the TOC is coming from (see previous comments re: p.i, para.1). Can the information provided on p.22, last para. support this discussion?

p.10, para.1 – typo in second line, "… on step slopes …"

p.10, para. 2 – Time of travel (TOT) is estimated from the reservoir dam to the intake. Some estimate of travel times upstream in the lakes and wetlands (e.g. p.12, para. 4) should also be provided. The model explained on p.15-16 seems a reasonable means of defining sensitivity for terrestrial activities. However, it is not clear how/if this model can account for variability in risk in surface waters located on the plateau. As discussed elsewhere in the report (e.g. p.20, para.4 & 5) it is reasonable to assume activities occurring on the lake surface closer to the outlet pose a higher potential risk than those further away. If the information available is inadequate to account for this variation it should be documented as an information gap.

p.20, para.2 – "… the effect of pathogenic ingestion is a chronic *acute* gastrointestinal …"

p.20, para. 1 – A statement regarding the likely sources of turbidity would be helpful here (e.g. see comment for p.i, para.1). Elsewhere it was suggested primary source is deposition from creek channel?

p.21, last para. – I believe the trend in TOC noted here is similar to that noted in the Duteau Creek Assessment for Grizzly Swamps. May wish to cross reference (indicator of regional as apposed to local trend?).

p.29, para. 3 – Can a comment regarding monitoring for cyanotoxins, cyanobacteria or the precursor conditions be added? If data doesn't exist should identify as information gap.

p.33, para. 2 – Can there be some discussion/comment added here regarding the known concerns with road and harvesting practices versus uncertain (and perhaps unavoidable) hydrologic impacts?

p.37, 4.3.1 – With activity in a source water area comes risk to water quality … this is something that needs to be recognized. Statements seem to suggest it is poor practices that result in impacts (e.g. increased nutrients, sediments) but should be acknowledged that some level of impact is unavoidable. Judgement of activity (e.g. good vs. poor practice) should be made in context of assessing risk and effectiveness of mitigation. In general I think this section could be reworked to reflect a more balanced assessment of the issue (including potential positives of having private land-owners).

p.44, para.4 – Please confirm the process of which lease lot sales was suspended pending review of water quality assessment. I understood it was based on assessment of quantity and supply management.

p.44-45 – Can a comment be added regarding the specific hazards to better support the recommendations for management? With presence of activity in the source areas comes risk; however that can be said for all users in the watershed. The potential advantages and disadvantages of having private ownership in the upland watershed should be presented, including what could be done to better address the current situation with private ownership and implications for stewardship (e.g. observe-recordreport based enforcement strategies).

p.45 4.3.2 Wind Generation – What is the contaminant of concern (sedimentation from land clearing, roads, etc), assessment of risk (module 7) & where is the recommendation in Module 8 to address the concern

p.47 – Recreation activities in and about surface waters is identified as a primary concern. Being able to further differentiate shorelines and surface areas based on risk would provide an opportunity to better focus DoLC effort to improve management.

p.49, para. 2 - A non-status road above the intake…. & para. 4 – The forestry access road to the recreational site….. What is the assessment of risk and the specific prioritized recommendations in Module 8 to address these concerns.

p.74, para.1 – hazards of a cumulative nature could be considered as being distinct from the hazard zone approach to evaluating risk. Could nutrients and other persistent pollutants be addressed here?

p.77-80 – I can appreciate that a range of consequences exist based on the magnitude (e.g. dose) of contaminants. However, trying to account for the full range of possible scenarios impacts on the effectiveness of the report to focus DoLC efforts. In environmental risk management defining a reasonable worst case scenario is typically considered an acceptable means of guiding prioritizing action. For example, the probability of a 50gal drum of pesticide being spilled directly into the creek below the dam is unlikely based on the observations recorded in this report. In general the likelihood of a targeted (aka terrorist) attack on the system should generally be considered a low probability based on the available information. Although it may be of value to point out the possibility of such occurrences, the purposes of this report would be better served by establishing (and sticking with) and estimated risk based on a probable scenario. Effort should be made to not avoid lumping high consequence-low probability (e.g. terrorism) with lower-consequence-high probability (e.g. impact from an ATV breaching a stream) hazards.

p.88, Sect.5 – It is not clear in the report what methods or criteria were applied in creating the SWOT. This is a management tool intended to assist in implementation (i.e. by identifying strengths to address threats and opportunities to address weaknesses). It is not clear how the elements in the SWOT are linked to the preceding chapters (i.e. the issues and vernacular don't seem to match). Some supporting description of the methods employed in creating the SWOT and how if was applied to support the subsequent recommendations is needed.

p.89, Sect.6 – it is indicated that the purpose of this section is to rank recommendations based on priority. However, it is not apparent how the recommendations provided are linked to the risks identified in Module 7 and/or the SWOT. The purpose of Module 7 is to prioritize actions in support of a response plan for operators to improve source protection. Source protection plans for water sources (whether they be upland, lakes, or groundwater) invariably generate a long list of recommendations for improvement, and this report is not different. The DoLC (as with other stakeholders in the watershed) will have a finite amount of resources with which to pursue implementing these recommendations. Experience suggests that any meaningful source protection initiative will need to be supported by evidence of risk (i.e. to human health and/or the water supply system function).

p.89, para.2 – Typo, "… necessarily address intended to address …"

p.90, Point 7 – The statement that threats from vandalism/terrorism have been seriously underestimated is not well supported in the evidence provided. This should be supported by information in the risk assessment component of the report and/or an external reference.

p.97, Point 3 – Related to comments regarding p.44-45 provided above, a balanced discussion of potential positives and negatives associated with presence of residences on the reservoir is needed to support this recommendation.

p.101, para.5 – A good example of the value in prioritization discussed in the comment for p.89, Sect.6 above. This recommendation likely has implications for access and boater safety. The relative importance (and thus resources the DoLC should apply) to pursue implementing this recommendation should be clearly established.

If you have any questions, please contact me weekdays at 250.308-9288.

Sincerely,
Bryn Lord
Water Quality Specialist
Interior Health-Okanagan Service Area

cc: EcoScape Consultants Ltd.
Ivor Norlin, Source Protection Officer, Interior Health
Mike Adams, Team Leader, Interior Health

2.2 Byrn Lord – April 19, 2010

April 19, 2010

Attention: Jack Allingham & Patti Hansen
District of Lake Country
10150 Bottom Wood Lake Rd
Lake Country, BC
V4V 2M1

IH Review of *Draft* 2 - Oyama and Vernon Creek Watershed Assessment Report
We would like to recognize the District of Lake Country's efforts in working towards satisfying Condition 1 on both the Winfield Okanagan Centre Water System and the Wood Lake Water System Operating Permits. From our review of draft 2, it appears that Ecoscape Environmental Consultants has attempted to address many of the points outlined in our February 15th letter. We would also anticipate that Section 6.0 (Module 8) of the document will effectively serve as the next steps and foundation for the District's "response" portion of the Source Protection Plan.
In order to finalize our review of this document, we request that District staff indicate whether input collected from stakeholders has been adequately incorporated. I have also noted a few points below, as outlined in our February 15th letter, which have not yet been addresses - please also indicate whether you feel these comments should be included:

Understanding Source Water Characteristics

p.6 – Literature suggest most outbreaks in North American water systems are associated with extreme weather events. There should be some discussion of the patterns in water quality associated with rain storms, etc. If this data is not available, it should be noted as an information gap and possibly as a further recommendation.

p.29, para. 3 – Can a comment regarding monitoring for cyanotoxins, cyanobacteria or the precursor conditions be added? Presently there is no data available on whether cyanobacteria and cyanotoxins are a concern. Consequently, if data doesn't exist this

should be identified as an information gap with a recommendation for monitoring.
Sedimentation - Roads and Stream Crossings:

Oyama Creek Watershed – Appendix F clearly identifies road sections contributing to sediment inputs into Oyama creek with an assignment of risk and a somewhat prescriptive recommendation provided in the associated paragraph on page 134. With this approach, the DLC can clearly identify a priority list of sites/road sections that require a specific and measurable sediment mitigation strategy.
Alternatively, in the Vernon Creek Watershed - Appendix E & G - Stream crossing and road risk assessments are presented with a consequence rating as minor for all of them, a likelihood rating as likely, possible, unlikely or rare and an assignment of risk as high, moderate and low, respectively. From these tables and associated recommendations, the assessment of risk to water quality is not really clear. Specifically, are these sites contributing directly to sediment input into source waters and to what extent? If so, corresponding recommendations to mitigate sediment inputs at moderate and high risk sites should be prescriptive beyond the suggested strategy outlined within the appendix tables and on p.134 - “Regularly monitor and implement erosion control measures where possible”. Sites contributing to a moderate or high risk of sediment input into source water should have a specific & measurable risk mitigation strategy.

Also, p109 - The priority table 8-3 for addressing sediment point sources are all located at the reservoir lakes, apart from one cattle trail (contaminant #25). Although roads and stream crossings are discussed in later recommendations, are there some priority roads, stream crossings or culverts that should be immediately addressed as posing a high risk for point source sediment inputs?
Land Ownership

An assessment of risk from existing sewerage systems at reservoir lakes was not included in this report (location, type/pit privy, etc). Based on a lack of their inventory and assessment of risk (ie. type and location), it is unknown as to whether existing sewerage systems are a possible concern to water quality. There should also be corresponding recommendation(s) provided in Module 8. Improperly sited and constructed sewerage systems/privies can contribute to pathogen and nutrient inputs and consequently, may also contribute to algae proliferation.

Also, it is unclear whether there are areas on the foreshore of reservoir lakes that have been cleared, may be contributing to sedimentation/loss of ecosystem function and should be revegetated.

Cattle

Recommendation should be made towards the application of Provincially Recognized Best Management Practices for ranging cattle in community watersheds.

Supplement the recommendation on p.118 with utilization of other monitoring parameters in

addition to stubble height, such as, condition of the ground surface, condition of the channel/stream bank, presence of livestock dung, etc to ensure proper ecosystem function.
If you have any questions, please contact me weekdays at 250.308-9288.

Sincerely,
Bryn Lord
Water Quality Specialist
Interior Health-Okanagan Service Area
cc: Ivor Norlin, Source Protection Officer, Interior Health
Mike Adams, Team Leader, Interior Health

3.0 MINISTRY OF ENVIRONMENT

3.1 Solvej Patschke – February, 2010

MOE Comments- Oyama and Vernon Cr Watershed Assessment
February 2010

- Would prefer to have the two assessments written up separately. In some sections, it is not clear which watershed is being discussed and some topics were generalized over both watersheds when it may be more applicable to only 1 watershed. E.g. Oyama Lake does not have road access and has less riparian impacts. Also, different hydrology assessments were done in Oyama vs. Vernon Creek (and are not comparable).

- Pg iii: MOE should be recognized under Acknowledgements for the loan of the orthophotos.

- Pg 5, 3.4. Delete the community watershed criteria. The criteria have changed since 1996 (and are too detailed to include here)

- Pg 6-7. Describe the entire watershed in one section (rather than trying to describe as 'residual, lake basin and north basin'). The source area characterization should include the biophysical characterization (vegetation/ biogeoclimatic zones/ terrain, stability, lakes, soils, elevation etc).

- Why have the basins been divided up into hydrologic zones? Is this to differentiate 'buffered' from 'non-buffered' sections of the watershed? If so, then report on pg 15.

- Pg 8- first paragraph- should be in Mod 2 (ie land use & potential contaminants).

- Pg 12. How is the Eldorado Reservoir consider a 'key step in mitigation' if the storage capacity will last for only 12 hrs? (pg 14 "This reservoir provides a modest level of flexibility if service is interrupted at the intake").

- Pg 13- describe landslides in more detail – either in characterization if natural or in Mod 2 if anthropogenic (i.e. initiated from poor drainage off a road). Provide an assessment of the level of risk and whether the landslides are still an issue (i.e. is the landslide contributing sediment to the creek). If they are an issue, assess risk in Mod 7 and provide specific recommendations in Mod 8.

- Pg 16- need to clarify that the 'Vulnerability' criteria is for 'water quality' and not 'water quantity'. I.e. much of the upper watershed (in the snow sensitive zone) is rated as 'low'. However, harvesting in the SSZ may cause changes in hydrology/ peak flow hazard.

- Pg 16. Table 1-4. Buffering. Suggest using terms "Buffered" and "Unbuffered" rather than Residual area and Upper Sub-basins.

- Pg 16. Table 1-4. In Assumptions: "the lower sub-basins have a greater sensitivity". Suggest rewording to : 'The unbuffered areas have a greater sensitivity.'

- Pg 18. If discussing Oyama Creek first in text, be consistent (i.e. Table 1-6 before Table 1-5).

- Pg 25. "Milne & Associates documented three landslides upstream of the intake". Provide an assessment of the landslides. Are they an issue? Are they generating sediment? Assess risk in Mod 7. Do they need rehabilitation work? Provide recommendations in Module 8.

- Pg 26- Vernon creek landslides. See comments above. Need to assess the landslides, not just 'document' them. If rehabilitation work was undertaken, assess how effective the work was. Is there still an issue?

- Pg 26. If there are terrain stability issues, a professional geoscientist/ hydrologist/engineer should assess. (Not SHIM mapping).

- Pg 26. Field results of potential contaminants/ hazards should be recorded in Module 2 (and risk assessed in mod 7 & recommendations in Mod 8).

- Pg 28. "it was noted that fire retardant remained at the site". Field results of potential contaminants/ hazards should be recorded in Module 2 (and risk assessed in mod 7 & recommendations in Mod 8). Also Pg 29 (Algae blooms).

- Pg 31-32. "Based on the limited understanding of the effects of salvage harvesting as opposed to no harvest (e.g. assumption that grey stands would have a similar hydrologic effect as clearcuts), DEL (2008 a&b) concluded that the proposed salvage harvest and plant scenario, although considerable in the short term, would have a significant benefit to the long-term hydrology since the recovery would be greater and would occur more quickly". Not all hydrology professionals agree with this statement (as reflected in the Figures 2-7).

By including it in this section, it appears that this is accepted information. Best to not include at all.

- Table 1-11. Don't include (see reason above). Why is Clarke Creek table?
- Pg 33. "There is also works underway by the Ministry of Environment to more comprehensively determine the composition of forest cover…". Not really. As part of a contract for MOE, stand structure data for ECA modelling was collected in 245 random plots in 30 pine-leading stands in the hydrologically sensitive snow zone in 7 Okanagan watersheds. This work has been completed. (also referenced in Table 1-12 pg 35).
- Pg 33-34. Detailed information on modeling/ methodology of delineation of the high water level of lakes is not relevant to the source assessment (and shouldn't be included here).
- Pg 37. Land ownership is not a contaminant. Land uses or human activities and other potential contaminant sources that could affect source water quality should be identified in Module 2.
- Pg 37-38: "Ecoscape has documented numerous examples of this during foreshore mapping exercises along many of the moderate to large lakes around the province including Shuswap, Okanagan, Moyie, Monroe, Mara, Mable, Wood and Kalamalka." Not relevant (don't include). What contaminants were found in Oyama and Vernon Creek watersheds?
- Pg 38. "Existing zoning allows many different uses that can impact water quality, including marinas". Were any marinas found to be a contaminant source? Be specific.
- Pg 38. "Relevant Legislation." Legislation is not a contaminant. Would be more appropriate to include in Module 7 which evaluates the effectiveness of source protection barriers. (i.e. legislation can be used as a source water barrier)
- Pg 40. "…possible non conforming septic system." Why is it possibly non conforming?
- Pg 42-43. Specific contaminants should be recorded in a contaminant source inventory table. Too vague to have issues for both watersheds listed together. Pg 44. "The differences were stark, with little to no foreshore modification within the Oyama lease lots". Yet pg 43 "Numerous different point sources of sediment from cabin paths and access roads to the reservoirs were observed". Identify the land use activity, possible contaminant and the location. Then in Mod 7- determine the risk and Mod 8 make specific recommendations.
- Pg 44. The sale of lease lots is not a contaminant. It is a political issue. It should not be discussed in Mod 2- Contaminant source inventory.

- Pg 45. What is the issue with wind generation? What is the contaminant?
- Pg 47: "description of the site:" Rather than just 'describing' what was observed. Assess the site and determine what are the possible contaminants of concern.
- Pg 48. Off-road vehicle regulations are not a contaminant. Would be more appropriate to include in Module 7 which evaluates the effectiveness of source protection barriers.
- Pg 48. "It is highly probable that hydrocarbons are the most prevalent chemical that would occur as a result of recreational activities". Yet next paragraph states "It is also evident that potential contaminants, such as sediment and pathogen loading are resulting from this recreational use." Which is the greatest concern?
- Pg 48. Vernon Cr "The road occurs directly adjacent to historic landslides on steep coupled slopes". This should be included in 4.3.4. (not recreation impacts).
- Pg 49. What is the water quality/ quantity issue associated with shotgun shells?
- Pg 49. "A non-status road above the water intake remains and has been kept open in order to drive cattle up into the watershed." Include in 4.3.4 road risk (not recreation impacts). Assess risk in Mod 7 & recommendations in Mod 8.
- Pg. 49: "Mr Milne indicated that the water bars are not sufficient to protect source waters because there is still potential for the overland storm flows from the road resulting in mass wasting events…" Provide recommendations in Mod 8.
- Pg 49. "The forestry access road to the recreational site on Damer Lake is contributing a substantial volume of sediment directly into the reservoir." This should be included in 4.3.4. (not recreation impacts). Assess risk Mod 7. Provide recommendations in Mod 8.
- Pg 49. "The main effect of roads on source water quality is the potential re-routing of surface flows via ditch lines which can result in direct release of sediment and other contaminants to source watercourses." That is just one possible effect. Re-routing of surface flows can also result in mass wasting events- which would have a much higher consequence.
- Pg 50. Oyama Creek Watershed. Specific road issues should be included in Module 2 (see notes above about comments on roads from pg 49). (and risks assessed in Mod 7).
- Pg 50. "These roadways could result in numerous different potential contaminants….." What kind of contaminants? Be specific.
- Pg 51. "Documented problems include cattle intrusions at most sites, partially blocked culverts, damaged culverts and overall maintenance issues." Include a summary of the

sites with high SCQI ratings in a table in the body of text (and a comment on why they have a high SCQI rating). (also assess risk in Mod 7 and provide specific recommendations in Mod 8).

- Pg 51 “Only a single stream crossing (#62) received a score of 0.8”. In Appendix E, 9 sites have a “high” SCQI category. Provide summary table in body of text that identifies the ‘high’ sites with a comment on what the issues are at the site (and rank them in order of priority).

- Pg 51. Numbering on Figure 2-4 does not match numbering in Appendix E. No #62 in Appendix E. Numbering goes from 1-27, then 100-117.

- Pg 51. ‘SCQI ratings ranged from 0 to 0.8.’ Which column is this in Appendix E? Road Score, Ditch Score & Combine Score go over 0.8.

Appendix E. Vernon Creek Watershed: Drainage and Stream Crossing Assessment

Crossing ID	RRGD Photos	RRRD Erosion	RRRD Sediment Delivery	RRRD Erosion Mitigation Present	RRRD Erosion Mitigation Functioning	RRRD Erosion Mitigation Type	RRRD Comments	RRRD Photos	Road Score	Ditch Score	Combine Score	Watershed Location	SQCI Category
1	5170	Moderate Erosion	Evident and Direct	No	No			5175	1.43	2.09	0.88	Above	High
2		No Erosion Evident	No delivery	No	No		drains away		0.70	0.57	0.64	Below	High
3		No Erosion Evident	No delivery	No	No		drains away		0.80	0.80	0.53	Below	High
4		No Erosion Evident	No delivery	Yes	Yes	vegetation			0.80	0.00	0.40	Below	High
5		No Erosion Evident	No delivery	No	No				0.60	0.70	0.43	Below	High

- Pg 51. “The most significant result of the drainage culvert assessment was the determination that three of the believed to be drainage culverts were actually facilitating flows of ephemeral creeks.” I don’t agree that this is the most significant result. Ephemeral creeks are not mapped at 1:20,000. Ephemeral creeks are identified in the field at the time of road layout and appropriate drainage is installed (as was done). It is not necessary or practical to map every ephemeral creek on a 1:20,000 map. Instead, which road segments are delivering large amounts of sediment? (i.e. 9 sites had ‘high’ SCQI ratings).

- Pg 52: “Skid trails and roads from these early harvest periods remain but typically have a low impact even though they were seldom deactivated”. What about the road above Oyama intake that was identified by M. Milne as VH risk?

- Pg 52. Ephemeral streams will not necessarily have riparian reserves- even if mapped in a provincial database.

- Pg 55. 4 harvest scenarios. What is the difference between 3) proposed only (Tolko’s retention plan) and 4) proposed + CC (Tolko’s proposed clearcuts and all of the remaining susceptible pine)? I.e. does the retention plan include salvage harvesting?

- Pg 56 Table 2-3. Is this table from Tolko or M. Milne? Reference source.
- Pg 56. "The unsalvaged scenario .... ECAs are still within the moderate peak flow hazard level". Current ECAs are also in the moderate peak flow hazard. (as they are already above 25% ECA).
- Pg 60. Table 2-6. What is the current ECA and the ECA with proposed harvesting (in SSZ)? Not clear.
- Pg 64. Summarize key areas of concern where cattle severity was rated as high (and prioritize) and include summary table in body of text. Reference raw field data in Appendix.
- Pg 66 "Certain portions of this trail have extensive erosion concerns (the worst documented in the watershed)". Included in the section on roads (4.3.4). Assess risk mod 7. Recommendations should be included (and ranked) in Mod 8.
- Pg 66 "cattle movement across the landslide is compromising rehabilitation efforts and resulting in direct sediment and fecal input to Vernon Creek". Assess the risk in Mod 7. Create recommendations in Mod 8.
- Pg 67. "In recent months, the MoFR has completed a more comprehensive investigation...." MFR has also spent considerable effort repairing the cattle fencing, installing nose holes etc.
- Pg 67. "Two locations of high cattle density and source contaminants..." What are the site numbers? Create specific recommendations (Mod 8).
- Pg 68. "Ecoscape recommends that additional measures are undertaken to block the old road". Include in Mod 8.
- Pg 68. "At this particular site, it would be beneficial if the fence could be moved away from the creek to the top of ridge". Create specific recommendation (Mod 8).
- P 68. *E.Coli* levels of 13 to 25 are *slightly higher* than the guideline of 10 CFU/100 ml (not 'far exceeded')
- Pg 69. 'Summary of Proposed works by MoFR' is not a contaminant. Would be more appropriate to include in Module 7 which evaluates the effectiveness of source protection barriers. (Works being undertaken by MFR are source protection barriers).
- Pg 72. 4.5 Hazard and Contaminant Summary. Specific examples should be included in table (i.e. issues with old roads/ landslides/ cattle fencing near intake, fire retardant etc).
- Pg 72. 4.5 Hazard and Contaminant Summary. Land ownership is not a contaminant.

- Pg 72. 4.5 Hazard and Contaminant Summary. No issues were raised in the text with Wind Generation & previously disturbed areas were to be used. Not consistent with 4.5 summary.
- Pg 72. 4.5 Hazard and Contaminant Summary. FRPA is based on professional reliance. It is not prescriptive and does not "ensure no negative impacts on the quantity or quality of source water".
- Pg 73. "Ecoscape argues that it DLC's lack of authority to control activities within the watershed that prevents an effective protection barrier at the source". In multi-use watersheds, working with partners/ stakeholders and other agencies that have authority under their legislation is key to effective source protection.
- Pg 73. Table 7-1. The Eldorado Reservoir is not an alternate water source – the water still comes from Vernon Creek.
- Mod 7- Also discuss specific hazards that were identified – ie landslides, cattle fence too close to the creek near the intake, roads that need to be deactivated etc. and determine the risk for each hazard identified.
- Pg 74. "This approach is useful, but does not provide water managers with sufficient information…." If specific hazards are identified- i.e. landslide 200m u/s of the intake, then the 'likelihood' will take into account the location within the watershed (and will be reflected in the risk).
- Pg 74. "Ecoscape used a GIS analysis to identify four different vulnerability zones …" These vulnerability zones relate more to water quality (than water quantity). Potential impacts from MPB salvage harvesting are more likely to have an effect on water quantity. Harvesting in the snow sensitive zone (which has a low vulnerability rating) will have more of an influence on potential changes in the peak flow hazard than harvesting below the reservoirs (Ecoscape high vulnerability zone, but is not in the snow sensitive zone).
- Pg 75. "In the case where an identified hazard can act as two different hazard types (e.g. biological and physical), the hazard is referred to as a combination." What if the hazard is a different combination? Be specific- don't combine.
- Pg 76. Not sure that table 7-5 makes sense. "The risk of a hazard…" Risk= Likelihood * Consequence. Just because an activity may occur within a certain area, does not necessarily control the likelihood that the activity may occur.
- Pg 76. Table 7-5. Where does harvesting in the SSZ fall within the table? Low?
- Pg 77. there is also provincial legislation that governs forestry, mining and ranching.

- Pg 78. Table 7-6. 1-2. Slope failures/ debris flows. Likelihood “unlikely”?? Contradicts previous sections of the assessment that have discussed issues from non status roads and describes previous landslides in both watersheds.
- Pg 78- Describe in text reasoning for how risk levels were determined.
- Pg 78. A landslide from a forestry road can be significant if it occurs in the high vulnerability zones
- Pg 78- what is the hazard “combination” for forestry? Sediment and ?
- Pg 80. Forestry in the SSZ (Ecoscape Low Vulnerability Zone)- could change the peak flow hazard – not addressed in Table 7-6c.
- Pg 80. 7-6d. How will MPB create a drinking water hazard – high risk?
- Pg 82. Include summary table of roads with VH and H risk in body of text and rank in order of priority. (instead of Table 7-7)
- Pg 82. “the very high risk rating was applied only to OR2(lower)…” In Appendix F, LOR1 also VH.
- Pg 83. 5.4.3. Vernon Watershed road risk should not be assessed with a GIS analysis. It needs to be assessed by a professional hydrologist, geoscientist, forester, or engineer. Table 7-8: untested methodology.
- Pg 84- Don’t include GIS software methodology in Mod 7
- Pg 88. SWOT. SIRDWT will not be responsible for distribution of the SWA.
- Pg 88. SWOT. SHIM and FIM mapping not needed. Assessments need to be conducted by PGeo, Hydrologist/ Forester/ Engineer.
- Pg 88. SWOT. “The continued mismanagement of grazing cattle…” this is a very confrontational statement.
- Pg 88. SWOT. Was 4X4 activity observed below the HWM? Isn’t there large woody debris on lake shore & limited access?
- Pg 89. Module 8: Too many general recommendations. Need specific recommendations from the hazards identified during field work (Mod 2).
- Pg 89. “Two main objectives… 2) Prioritize risk management actions”. Recommendations were not prioritized.

- Pg. 89. Recommended risk management actions should follow SMART principles. Specific. Measureable. Achievable. Realistic. Time-bound.
- Pg. 89. Recommendations should be specific to the watershed.
- Pg 90. #5. Forestry in SSZ (low vulnerability)- still an issue.
- Pg 92. #13. Delete. More detailed mapping is not a priority.
- Pg 92. #14- delete.
- Pg 93. #15. Delete.
- Pg 94. 6.3. #4. Damer Reservoir. Where was this identified in Mod 2?
- Pg 95. Terrain stability. #1. More detailed mapping is not what is needed. Instability concerns should have been assessed by a PGeo/Hydrologist/Engineer/Forester as part of this assessment. SHIM mapping is not the correct assessment.
- Pg 99. Rec #1. Be specific to Oyama & Vernon watersheds- not the whole Okanagan. Was mud-bogging observed in Oyama & Vernon watersheds?
- Pg 102. Too many general livestock recommendations. DLC is working closely with MFR and ranchers to improve the cattle range use in the watersheds.
- Pg 111. Roads. Include specific recommendations from Mike Milne & recommendations on how to address VH and H risk roads.
- Pg 112. #4. Delete.
- Pg 112. Forestry. "Deactivating roads is critical because continued access increases the risks of ongoing contamination". Forestry roads are deactivated to deal with water related issues (not human or cattle access).
- Pg 114. "A more detailed ECA anaylsis should be undertaken within the Vernon Creek Watershed". Is this to model ECA projections for unharvested vs CC salvage scenarios?
- Appendix C: specify which watershed the points are in. Summarize key sites (high hazard/ risk) in the body of the text with comments on what the key issues are. Rank / prioritize issues.
- Appendix D: include photos of all high and very high sites, not just representative ones (and reference site numbers in photo captions).

- Appendix E: summarize key sites in body of text with a comment on why they are an issue (and rank in order of priority when generating recommendations in Mod 8).
- Figures: need a much larger map (i.e. 36 inches wide) with detail of sites (does not need to have orthophoto in background) so that the reader can tell where specific sites/ roads/ issues are located.

3.2 Solvej Patschke – April, 2010

MOE Comments- Oyama and Vernon Cr Watershed Assessment
April 2010

- Figures 1-6 a and 1-6 b 'Vulnerability' maps. Need to clarify that the vulnerability zones only apply to water quality (and not quantity).
- Appendix D- need to include all photos from high and very high sites, not just representative ones (and reference site numbers in photo captions)
- Pg 51 "In our opinion, questionable human behaviour and irresponsible use acts as the greatest risk to water quality." Not consistent with Table 7-6a (slope failure/ debris flows- very high, wildfire –very high, vs. human access and recreation – high).
- Numbering in Figure 2-4 does not match numbering in Appendix E. No #49, 37 etc in Appendix E.
- Table 2-6, include the year for the ECA
- Table 2-8 a & b. Describe 'possible contaminants of concern' – ie manure (pathogens), road salt, sediment, gasoline, oils etc. See Page 9, Table 2-2, Module 2 of S2T Assessment Guideline. "Physical, biological, chemical" is too vague.
- Pg 52 "Potential Effects of Roads and Stream Crossings on Water Quality". Slope failures off roads are a significant risk to water quality.
- Include landslides in Vernon Cr watershed in Appendix E? Where are they documented otherwise?
- Not sure I agree with all the risk levels in Tables 7-7 a & b. Lot coming out as 'high' risk. For example, #9 and 20 and "access and recreation" 'high risk'.
- Table 7-7a. #24. LMZs. And 7-7b #23. Likely * Moderate = high (not very high).
- Table 7-7b. Likelihood for cattle access (#24)- is probably reduced from 'almost certain' with range improvements made in 2009 and 2010.

- Vernon Watershed road risk should not be assessed with a GIS analysis. It needs to be assessed by a professional hydrologist, geoscientist, forester or engineer. Table 7-9 Vernon Cr: untested methodology.
- Too many general recommendations. 38 pages of recommendations is not realistic- especially with many of them with a timeline of “within a 1 year” or “immediately”.
- Move Tables 8-5 a & b before the general recommendations.

4.0 MINISTRY OF TOURISM CULTURE AND THE ARTS

January 29, 2010
Oyama and Vernon Creek Watershed Assessment

4.3.3 Human Access and Recreation

Point 1)-Page 45 In the report it states “In most cases access is a result of the general public seeking out Recreational opportunities”. This statement is misleading and refers to recreation as the cause for access into the wilderness areas when actuality Industrial activities are the major contributor for access which creates the access for humans to explore recreational opportunities.

Point 2)-Page 47 MOTCA removed all of the recreational attributes for Crooked Lake which is now unmanaged at the request of DLC.

Abandoned vehicle dumping, illegal drug activities, excessive garbage at the High Rim trail head, are not due to recreational impacts but of illegal dumping and activities of crime.

Point 3)-Page 48 the statement “the following are specific instances of recreational impacts identified within each watershed.”

Point 4)-Page 95 Access and Recreation first paragraph is in correct. FYI All designated trails and recreation sites are managed by Recreation Sites and Trails Branch of the Ministry of Tourism, Culture and the Arts. Camping sites are not Forest Service Recreation sites.

Point 5)-Page 95-Number 1 “further impacts of existing Recreational licensees are becoming readily apparent (eg motorized recreation concerns within the Lambly, Powers and Bald Creek watersheds).....First-MOTCA does not issue Recreational Licensees, MOTCA issues tenures but the recreational attributes created belong to the Crown. Secondly what are the impacts the author(s) are identifying and do they have scientific data to back up their claims?

Point 6)-Page 96-Number 2- “states -A detailed access management plan which prioritizes areas for access (motorized and non-motorized)”. This was accomplished through the LRPM.

Point 7)-Page 97- Number 6 -reference made to the expansion of McCulloch Reservoir….poor trail and road construction practices because access to the lake was not incorporated into the development plan……….MOTCA did not build new trails an existing road was re-built. The existing trails are un-sanctioned and were not built by MOTCA. It should be noted Recreation is the responsibility of individuals on Crown Land.

JJ Jeff Jacobi HDF the best letters to have

Ministry of Tourism,Culture and the Arts

Mail to: Jeff.Jacobi@gov.bc.ca

250-260-4640

5.0 FORESTRY LICENSEES

5.1 Harold Waters

During this assessment we encountered several ephemeral streams that are not included in the provincial database, and hence would not be protected from harvest activities.

Comment: Not true because when we layout cutblocks and roads we map all water features via GPS during our on the ground field work. These water features show up on our cutblock and road Site Plan (SP) maps and are addressed in the SP documents. The bigger issue of adding a stream to the TRIM base map is more complicated and needs a government process to capture and incorporate these new water features. We generally don't GPS them beyond the road or block so they are just segments suspended in space on a map.

Increased access to watercourses in high vulnerability zones, or across natural barriers intended to control cattle movement, can be detrimental.

Comment: I have never seen a map from the MOFR that depicts areas being relied upon as "natural barriers intended to control cattle movement." In most cases the cows just haven't found their way to the water until we remove enough timber that they discover easy access to it. Each time we refer new cutblocks and roads we ask the range tenure holders to identify natural range barriers that they are relying on and to let us know if our proposed timber harvesting or road construction will remove or render ineffective a natural range barrier to grazing. Unfortunately we very rarely receive any information back so it's left up to us to figure it out.

Although the licensees make use of existing status and non-status roads, they do not hold themselves accountable for upgrades during their industrial traffic use or do not consider it their responsibility to decommission after use.

Comment: Actually any SSS in Tolko's operating area requires the SSS operator to obtain a road use agreement with us for the use of any road we hold the permit on or are responsible for maintenance. Generally there are two options: the SSS operator pays us a fee and we look after all maintenance and any required deactivation; or they pay only an admin fee and they look after any maintenance and deactivation necessary. Either way it gets done.

Recovery rates are similar for the four different scenarios, with a slight advantage given to the Proposed + CC salvage scenario, however this scenario also carries the highest short term ECA response.

Comment: And not to mention it most likely blows the retention areas by harvesting some of them that are based on pine in sensitive areas. See my comments below.

Unfortunately, the model that tries to account for the role of dead standing pine and non-pine overstory and understory on ECA over time was not conducted for the Vernon Creek watershed. Therefore, it is not possible to compare the proposed salvage with other management scenarios. Nevertheless, Tolko has the majority of planned blocks in both watersheds so it is likely that the planned activities are based on a similar rationale.

Comment: Note that although Dobson did not account for understory he did model some basic assumptions for mature mixed species stands to net down the impacts of the MPB in these stands based on percent pine and crown closure.

Over the long term, additional harvest activities will further expose the watersheds for subsequent access by cattle, wildlife and recreational users. After the proposed harvest has been implemented, more than 54 and 63 % of the Vernon and Oyama Creek watersheds, respectively, will be accessible by road. Although many of the roads will have undergone deactivation or rehabilitation, access is not always entirely prevented.

Comment: Note that we have options on how to construct and administer roads. We can either create Temporary roads that will then receive some form of rehabilitation or create Permanent roads that will have some form of deactivation. The choice to build a temporary or permanent road depends on a number of factors such as the likelihood that we can grow trees or grass on any road surface when we have deactivated or rehabilitated it. The choice is further complicated by the rules for Temporary Access Structures (part of the Net Area to be Reforested within a cutblock) verses Permanent Access Structures (PAS verses TAS) as per the FPPR sections 35 and 36. Levels of deactivation or rehabilitation are centred around achieving the practice requirements of the FPPR for roads and the results or strategies of the FSP which in turn has adopted sections 35 and 36 of the FPPR as our result and strategy for soils. Suffice to say it's complicated and sometimes the road will be totally gone with no indication that it ever was there and in other situations and circumstances the road will mostly still be there following rehab or deactivation.

Ecoscape understands that a proposal of this nature must outline mitigative measures to minimize the impact of access, and that it will be reviewed by the LRMP monitoring committee for their opinion, as well as referred to relevant stakeholders. Nevertheless, the importance of mitigative measures that are successful in preventing subsequent access cannot be overstated.

Comment: The LRMP monitoring committee stopped meeting as of last year due to budget cutbacks and a new ILMB model for land use planning tables. So this point is not relevant anymore.

Forest harvesting should only occur within the 200 m Lakeshore Management Zone (LMZ) of reservoirs (Swalwell, Crooked, Oyama & Damer) when the risk of wildfire out weighs the potential access issues and water quality impacts. If harvesting is to occur within LMZs, it must be carried out with extreme caution and disturbance must be minimized. Care should be taken to mask trail locations and debris should be used to create barriers for cattle.

Comments: As I mentioned in the meeting Tolko does not harvest within the LMZ of class A lakes. Damer lake is in BCTS's operating area and is a class B lake so not sure what BCTS has for plans here if anything. The other three lakes our within our operating area and are class A lakes so we will not be harvesting there.

Retain and protect mature riparian vegetation in fan and floodplain areas of S1 – S4 streams. Ecoscape understands that both major licensees and SSSP tenure holders operate within riparian management areas (RMAs) therefore it is essential that riparian buffers are maintained to reduce any effects on water quality.

Comment: Just to be clear our FSP has result and strategies that outline how much retention will be placed in the RMZ of streams, wetlands and lakes by riparian classification and windthrow hazard. On some small streams (S4) with high windthrow potential we may retain little mature timber due to the additional issues resulting from wind thrown trees in and around the stream channel. All larger streams have a reserve zone as well as a management zone so retention of mature trees in these areas is guaranteed.

Forest licensees should work with the grazing licensees and the MoFR officers to limit cattle access to water courses and reservoirs when natural barriers may be removed during salvage harvesting. The importance of maintaining these features cannot be overstated, especially over the short term while cattle exclusion is dependent on short segments of fence tied into natural features.

Comment: See my comments above on lack of participation from Range Tenure Holders in this regard.

There should be no further salvage above the snowline in the North Oyama Basin until the ECA returns to the low range (likely about 20 – 25 years from now). This includes no operations by SSS tenure holders.

Comment: Although this is BCTS's operating area we question why the ECA's would have to return to a Low range and not an intermediate range. What is the rational for this recommendation? What happens if there is more forest health that needs to be addressed?

Tolko should critically evaluate the stands proposed for salvage and only log those stands which make the most sense from a MPB perspective. The proposed scenario has slightly higher ECAs than the WTP 80% + Pl, which targets greater than 80% pine and retains 10% wildlife-tree patches, suggesting that there may be opportunities for additional retention of stands that are less than 80% pine.

Comment: This is the problem with aspatial modeling verses spatial based analysis and planning. While the aspatial results might suggest a better approach - if you looked at where the 80% Pl plus WTP's would be spatially located you would see that it targets some of the highly vulnerable areas our retention plan based proposed scenario seeks to avoid. Furthermore by not harvesting areas with between 50 to 80 percent Pl you are missing not only a current short term economic opportunity but locking in lower harvest volumes from these stands in the future when the pine is dead and the watershed has recovered these stands will provide much lower volume as up to 79% of the volume could be dead. Not to mention depending on the non Pine and understory these unsalvaged (<80%Pl) stands may take much longer to hydrologically recover than a clearcut with reserves plantation. What makes the "most sense from a MPB perspective" is to create a retention plan that targets retention of stands regardless of percent pine in areas that most need to be buffered from forest operations and to target forest operations (addressing forest health issues) on areas of lower landscape sensitivity (taking into account all the landscape issues to develop the salvage plan and not just focusing on a single variable such as percent pine). Tolko is disappointed that this recommendation does not give more credit to the spatial planning done through Tolko's retention plan (ask Michael Milne to comment on our placement of harvest verses retention areas) and does not recommend following it instead of an aspatial modeled result that might look better on paper but on the ground would produce inferior results.

No future, non forest health related, forestry development should be implemented until the peak flow hazard has recovered from moderate to low levels. We believe this recommendation is reasonable for a community watershed, especially given the resources at stake.

Comment: That's the purpose of our retention plan.

A more detailed ECA analysis should be undertaken within the Vernon Creek watershed. This analysis could help to understand the incremental effect of planned salvage over a unsalvage approach.

Comment: As I pointed out in the meeting just because Dobson didn't use the Huggard approach to modeling ECA and recovery doesn't mean his method doesn't produce "detailed results." As mentioned above Dobson did model for mature non pine however he used guidance from the latest Code Watershed Assessment Guidebook regarding crown closure to model for mature non pine effects on ECA's. Tolko considers Dobson's report for this watershed to be a professional report and sees no need to redo it or update it based on the Huggard model – we therefore disagree with this recommendation.

Tolko should critically evaluate the stands proposed for salvage in the Vernon Creek watershed and only log those stands which make the most sense from a MPB perspective. Although the detailed ECA analysis has yet to be undertaken, Tolko could proactively evaluate their proposed development plan to ensure that stands with less than 80% pine are retained.

Comment: Same response as the one above for Oyama Creek.

5.2 Brian Bedard

The industry is largely self-regulated and addresses these objectives via individual Forest Stewardship Plans (FSP).

Comment: The Licensees FSP also devotes a section to Community Watersheds where the Results and Strategies are designed to prevent the cumulative hydrological effects of primary forest activities within the community watershed

Currently, the Oyama Creek watershed is experiencing the early stages of MPB attack and we have yet to know the extent of mortality.

Comment: Actually both Oyama and Vernon watersheds have been experiencing moderate levels of MPB attack for a number of years now.

Forest harvesting should only occur within the 200 m Lakeshore Management Zone (LMZ) of reservoirs (Swalwell, Crooked, Oyama & Damer) when the risk of wildfire out weighs the potential access issues and water quality impacts.

Comment: How is this risk comparison measured. I agree with the intent of the statement, but will probably need some parameters to determine if risk of wildfire outweighs potential access issues and water quality impacts.

In order to reduce the risk of wildfire and subsequent harvesting, LMZs should be replanted with a mixture of spruce and deciduous species.

Comment: Would be better to state that area should be planted with a mixture of deciduous plus coniferous species that are suited to the zone and elevation. Avoid monoculture silviculture activities.

There should be no further salvage above the snowline in the North Oyama Basin until the ECA returns to the low range (likely about 20 – 25 years from now).

Comment: I have to question the validity of arbitrarily excluding salvage from these sites. Each area needs to be assessed on its own merit. If logging makes sense to reduce disease, MPB infestation or wildfire incidence, then it should proceed.

6.0 OKANAGAN COTTAGE OWNERS ASSOCIATION

February 3, 2010

Attention: Mary Ann Olson-Russello
Ecoscape Environmental Consultants

Re: Oyama and Vernon Creek Watershed Assessments

Dear Mary Ann,

The following comments and questions and possible recommendations are provided to you from the OCOA. These comments are in two categories. One relates directly to the report and the other are water quality factors that were not incorporated in the report. The page numbers may not be consistent with the final draft report, therefore the Sections are noted as well.

As an association, the OCOA is extremely concerned by the tone of your report as it relates to cabin owners and its' assumptions that all cabin owners a culpable for the actions of a few. Your reference to terminating our leases is not called for and beyond the scope of a watershed risk assessment. As well, your assessment of qualitative risk analysis of land ownership seems skewed given current and long-term use patterns. Included in this is your assumption that water purveyors will have less flexibility to raise the reservoirs with cabins around these. Our mapping and yours would indicate that there is sufficient setback of cabins from the lakes thereby not reducing flexibility.

We hope that you incorporate some of our comments in your revised report.

Environmentally yours,

Lloyd Manchester
President
Okanagan Cottage Owners Association

Report Comments:

Page 2. Introduction: You state that in "the 1970's the systems were updated, and evolved to become a major domestic water supply."

Comment: It should be noted that over 80 percent of the water coming from these upland lakes is used for irrigation. Currently, Lake country is using the Hiram Walker pipe to pull water from Okanagan Lake to service their domestic population in times of high turbidity. Given the ability to draw from Okanagan Lake, this means that it is most likely that these lakes now supply less than 15% of their water supply to the domestic population.

Page 21. TTHM's The report states that, "High levels of total organic material will result in formation of total trihalomethanes when water is chlorinated" and TTHM's are consistently over 0.1000 mg/l and the graph suggest there is an increasing trend"

Discussion: TTHM's are an extremely carcinogenic compound (per. comm. Steve Pope, IHA) Current research and restrictive Federal Health guidelines support this statement.
Recommendation: Given this and the above statement regarding the increase in TTHM's, the District of Lake country should notify water users of the system of this fact so they can make the choice to drink or not drink the water.

Page 22. Evaluation of Raw Water Sampling Program:

This section talks about the need to increase sampling and determine "whether total organic carbon is consistently a concern at the DLC intake"

Discussion: Currently there are several thousand cubic meters of raw logs floating in the lake and moving down the lake after breakup in mid May. These logs have been in the lakes for years and are a result of original flooding. Some of these logs are deposited on the shoreline and increase the risk of shoreline deterioration as a result of wave action. In some cases where they build up, they prevent access. Many cabin owners remove these logs from the foreshore area and burn them in the winter.

These logs have been releasing tannins into the lakes for decades, which is why the colour of the water is brown. Tannins may also affect other water quality parameters. Decomposition of these logs must also contribute to the total carbon in the water as well.

Recommendation: There needs to be a determination of risk associated with these logs being in the lakes and their effect on water quality as it relates to the release of carbon and tannins. There also needs to be a calculation of deposition from deterioration which would involve calculating the total mass/temperature coefficient/time and total water mass in order to ascertain the effects on water quality.

This risk to water quality is not incorporated in your report and should be.

Page 33. Drought Management and Climate Change:

Discussion: This section talks about inundation zones (areas that will be flooded should the dams at Oyama, Crooked and Beaver Lakes be raised as per the water application by DLC.) It also relates to the recommendation section of the report Page 97 recommendation 3, "Additional development….privatizing the shoreline reduces flexibility with regard to long term source water management decisions. E.g. could not boost the capacity of the reservoir by increasing the dam height due to the loss of private lands."

The OCOA did a similar mapping exercise to determine the extent of flooding in relation to where the cabins were. Our mapping shows that with the exception of possibly two cabins, all other cabins on all the lakes in question are well back from the foreshore and would not be affected by the increasing the heights of the dams. This would mean that the argument that it would cost millions of dollars to expropriate or buy out these lots is not valid. These maps have been provided to Ecoscape.

Recommendation: That the impacts of raising these dams be considered as a high risk to the environment, water quality and the fact that red and blue listed species will be lost. Regardless of whether and Environmental Impact Assessment process is conducted a statement as to the impacts of raising the dams to water quality and the disruption of the water supply system is warranted.

Discussion: The following relates directly to your recommendation on P.97 of your report, Recommendation 3…"Additional development of private properties and expansion/sale of Crown leases…….is not recommended." The rationale provided for this recommendation, in part, is based on "reduced flexibility. …e.g.: could not boost the capacity of the reservoir by increasing the dam height, due to the loss of private lands)."

Recommendation: As stated above, our mapping exercise, which is similar to Ecoscape's, shows that the cabins (lease lots) would not be affected by the increase and therefore does not reduce flexibility of the water purveyor to raise the height of dams. The recommendation should be changed to reflect this.

4.3.1 Land Ownership: Potential Impacts on Water Quality

Discussion: This section speaks to possible impacts to water Quality from land use activities of cabin owners. The OCOA resents the implication of a "monkey see, monkey do" approach as it relates to cutting down trees on the foreshore. It is important to note, that this reference relates to a couple of cabins that had trees removed in front of their cabins. This should be noted in the report and not assume that this activity is being done by all cabin owners. These cabin owners had a professional forester retained to do a hazard tree assessment and it was determined that these trees be removed. Mitigation measures were implemented on one lot with the immediate replanting of up to 50 trees and planting will occur on the other lot this spring.

As well, all cabin owners have been informed of the RAR regulation which requires an assessment by a qualified professional for any works in the RAR zone. It is important to note that the majority of cabins are located outside of the RAR zone.

Relating land use of cabin owners to Livestock presence is unacceptable. Cabin owners fence off their properties and remove cattle from the riparian area and leaseholds when they are seen. Cabin owners have no control over the movement of cattle. Cattle access the foreshore from many areas including the Fish hatchery, forest recreation sites and numerous other access roads to the lakes.

Another concern with these potential impacts is how they are utilized in your Qualitative Risk Assessment as it relates to your vulnerability zones. It is hard to fathom how our risk (of residence), as it relates to land ownership or lease ownership is the same as forestry in most categories. This does not make sense given the cumulative impacts over time associated with clear cutting over 50% the community watersheds (soil erosion, contaminants from landings, road networks etc). There will be a further discussion of this in our assessment of your Qualitative Risk Assessment Section.

Recommendation: Cabin owners will continue to work with the Ministry of Forests, MOTSA and the cattle ranchers to put up fencing that will stop cattle from accessing the Lake. It is important to note that the OCOA has agreed to maintain the fencing around the lakes where cabins are.

Identified Source Water Concerns originating form Private/Crown Lease Lots P.41

Discussion: P.44 We have provided you with the letter from the former Minister Stan Hagen, clarifying the rationale for the moratorium. We have also provided you with the ILMB Results and Considerations document.

Recommendation: Change the report to reflect the Minister's comments and as part of the history include the ILMB process that occurred. As well, the Minister's letter clarifies who would pay for hydrological studies.

Sewerage Comments P.40-42:

Discussion: All of your comments in your report refer to resorts and cabins not conforming to existing subdivision guidelines as it relates to sewerage (Oland 2007 engineering reports are sited).

It is important to note that the resorts and the cabin owners do not have to conform with subdivision guidelines as referenced in the report. The resorts and cabins are considered existing lots if they were transferred to freehold, not subdivision lots. This issue was debated during the three year consultation process initated by ILMB and clarified that resorts and cabins would considered existing if transferred.

Oland's reports were based on this subdivision requirement premise which does not reflect current regulatory requirements. For example, the Dee Lake Lodge septic system which was referred to in the report as non-conforming to subdivision guidelines does not apply. In personal communication with Steve Pope, Inspector for IHA he informed me that, the Dee Lake system conformed to IHA guidelines, that it was well set back, good soils, high and dry, good capacity and that it was a community system which differs from subdivision sewage guidelines that require that you have a 2 acre parcel to place a septic system before you can subdivide.

The report addresses sewerage disposal with respect to lease lots and quotes the Oland report in that the lease lots are not of sufficient size to accommodate a system based on the subdivision sewerage guidelines. Again, the current lease lots are considered existing lots and are not incorporated into the realm of having to conform to a subdivision bylaw regarding sewerage requirement.

Recommendation: That all levels of government consider that there are innovative septic systems that can be utilized in sensitive environments, and that they should be investigated to determine whether they are more beneficial to the environment than a community system or an outhouse. A good reason to pursue this recommendation is that leases are not likely to be extinguished as requested by the Okanagan Basin Water Board, and B.C. Water Supply Association, therefore viable and sustainable alternatives should be explored and implemented per the current regulatory process. We also recommend that instead of just relying on published reports from one professional, that you speak directly with Steve Pope of IHA to confirm their validity with respect to the current regulatory regime and their relationship to resorts and to pit privy's which are a legal form of disposal. It should also be noted that the Lakeshore Environmental report on Page 18 refers to the legally permitted septic system on Dee Lake.

The above discussion should warrant the re-wording on P.52 under the bullet Sewerage…."In our review of information collected to date, it is clear that many of the lots are of insufficient size to accommodate sewerage systems of appropriate size following standard subdivision guidelines of the Interior Health Authority" We encourage you to speak directly with IHA to confirm or not confirm your suppositions as they relate to sewerage.

6.2 General Recommendations Applicable to Both Watersheds P. 89

Recommendation #3: All watershed stakeholders need to acknowledge the cost of managing a watershed

Cabin and Resort owners pay taxes to the RDOC. Perhaps a recommendation that these taxes go towards education is warranted in that the RDOC provides very few services to cabin or resort owners.

Recommendation: It should be noted at the last meeting that the RDOC has funding and is conducting a community wildfire plan:

Land Ownership: Page 93 Recommendation #4:

Discussion: It should be noted that the majority of lease lots are well set back and are not in the Riparian Zone. Violations of the RAR zone a covered under the regulations, therefore, this does not pertain to lease agreements. On leasehold properties, the lessee is required to have permission from ILMB or the Ministry of Forest to remove any trees from their leasehold. Provisions are in the lease for violating this clause.

Recommendation: That this recommendation #4 is somewhat harsh with respect to the termination of leases, and should be removed. It should be clearly identified that if activities contrary to the RAR act occur then it is that legislation that deals with it, and is separate from the lease. If it is activities that occur on a leasehold property, then it is ILMB and Ministry of Forests that permit them.

Recommendation #4

Discussion: Your comment that "degradation of sources water will continue little by little (i.e., death by a 1000 cuts)". Again this comment is extremely negative and it would be more appropriate to the Forestry section. Your comment is also not based on any scientific evidence or the Lakeshore Environmental report that concluded, "It appears, based on published reports, that other activities in the watershed have a much greater chance of impacting water quality in the watersheds. On-site inspections of all lease properties has shown that the properties are presently having little or no discernable impact on water quality in the reservoir lakes." The 2004 report also stated, "The majority of these properties have good riparian buffers which are a major factor in protecting lake general environmental quality."

It is also curious that you refer to published information you reviewed, but only refer to the Lakeshore report as being opposed by the Okanagan Basin Water Board and the Water Supply Association. Good science and review should warrant consideration of this report given all lease lots were evaluated.

Access and Recreation P.101 Recommendation #5 "The Ministry of Environment should designate all reservoirs as "electric motor only" due to the potential of hydrocarbon contamination originating from motor use."

Discussion: It should be noted that it is not in the Ministry of Environment's jurisdiction to declare a lake 'motorized only'. This jurisdiction is with the Department of Fisheries and Oceans and involves an extensive consultation process led by the competent jurisdiction (i.e.RDOC). Further more, this issue has to be looked at in the context of safety. Should a storm come up on Beaver Lake, an electric motor is not sufficient to maintain headway.

Recommendation: More appropriate, would be to look at the size of each lake and the possible recommendation that only 4 stroke engines be allowed on larger size lakes.

Forestry:

Discussion: Although many recommendations in this section make sense, a recommendation to maintain more stand structure by selective logging was not considered. Stand retention and under story replanting is not discussed within the aspect of hydrological recovery in selectively cut stands.

The aspect of potential cumulative impacts was not discussed at all and in conversation with Ecoscape considered outside the scope of the project. This is hard to believe in that there will be continual sedimentation release to the environment with every rain. This will continue throughout the years and should be considered whether the cumulative impacts can be measured or not.

Qualitative Risk Analysis:

Discussion: This risk analysis assumes that "The risk levels outlined above assume common, every day occurrences." Regardless of whether the lease lots are sold there is very little likelihood that all the cabins would be year round residences. As well, it does not appear that the buffering capacity (set back of the cabins from the Lake) has been taken into consideration given that the major concern sited in the report is leaking septic systems and outhouses and the potential for the contaminant to reach the intake. It should be clarified that there are very few septic systems at the lakes, possibly four at most and that all cabins have an outhouse.

Reference to pesticides and landscaping are common in your hazard and contaminant summary and your risk characterization tables. The majority of cabins, with the exception of a few cabins, do not have any form of landscaping and the presence of lawns is almost non-existent. The use of pesticides is highly unlikely in a cabin setting and any risk should be considered as extremely low.

The majority of risk characterization tables show the same level risk associated with Forestry in most cases as the same as land use by cabin owners. This does not make any sense given the extent of clear cut logging and the daily and cumulative impacts of run off of sedimentation and contaminants from landings (not discussed in the report)

General Comments:

Discussion: It appears evident based on previous water quality data that one of the main sources of concern is from the outlet to the intake. The report documents this fact quite well.

Recommendation: That DLC look to have a pipe installed from the outlet to the intake ensuring that turbidity and colour concerns resulting from travel down the watershed become a non-issue.

Discussion:

It is not recognized in the report, that the OCOA has an active education program in the watersheds as well as a signage program.

7.0 OCEOLA FISH AND GAME CLUB

Dear Ms Olson-Russello,

The Oceola Fish and Game club has spent countless hours pouring through this document. It should be noted that these hours have all been volunteer hours. We've been less than impressed by many of the comments that seem to vilify backcountry users as unknowledgeable, uncaring, and destroyers of the environment. It would appear that backcountry users have been targeted in this report as being bad for water quality, yet other users of the backcountry, including the District of Lake Country itself, appear beyond reproach.

We were disappointed that the report did not address the serious threat to riparian and littoral zones that will result from the DLC's plans to raise the water storage levels of the Oyama, Swalwell, and Crooked Lake systems. Raising the Oyama Lake storage level by the planned 2 meters will completely flood out the large wetlands area between Oyama and Streak Lakes, effectively rendering that large natural water filter useless. Biologists from Ducks Unlimited that toured the area with me in 2008 assured me that there was little to no chance of mitigating, compensatory new wetlands being created because of the surrounding terrain. DFO has set guidelines for "no net loss" of riparian areas, yet that is not considered in this report. Many species of wildlife and fish are heavily dependent on the riparian and littoral ecosystems that will be destroyed, yet there has been no mention of this in the report, nor has the effect on water quality from the loss of natural filtration been mentioned.

We are also very concerned about the report's recommendations which severely restrict access to our club members. We believe that there is more than sufficient legislation in place now to protect sensitive areas from damage, and that education of backcountry users should be the goal, rather than a knee-jerk "lockout" of users. It's likely that those who are wont to do environmental damage will show no respect for access restrictions, thus rendering said restrictions useless. The law-abiding, conscientious users are those who will be kept from these areas, and these are users who pose insignificant threats to the environment. Essentially, conscientious users who act as the "eyes and ears" of enforcement agencies such as the Conservation Officer Service will be denied access, and this could very well lead to an increase in problem behaviour when the destructive perpetrators know that there is little chance that they will be seen doing damage. The aging demographic of outdoors people require sufficient access opportunities, especially motorized access.

Backcountry camping is very important to our club members, and we believe that the vast majority of campers are responsible, caring people with a deep respect for the environment. Again, we believe that education and enforcement of existing legislation is far preferable to outright bans and "sanctioned" camping that has little to no "outdoors appeal."

We're of the opinion that this report is a "cart before the horse" approach to watershed management, as there is as of yet no water use plan in place for the DLC (no integrated watershed management plan). Here we have a report that is trying to measure impacts of recreational users on water quality, yet we have no idea what quantity of water is currently demanded, nor what quantity will be demanded in the future, by water system consumers. You have to measure it to manage it – you haven't measured it, but you're trying to tell us how to manage it!

Despite the report's statement that we have been consulted, the Oceola Fish and Game Club does not endorse or support the report as it is currently drafted. We believe that piecemeal and ad hoc application of this report's recommendations could negatively affect our members' traditional uses of the watershed areas.

Thank you for the opportunity to provide comment on the report, and we look forward to seeing our concerns incorporated into the final draft.

Yours in conservation,

Patrick Whittingham, CGA, DBA
Vice President
Oceola Fish and Game Club

Rick Simpson, BA
Fisheries Chair
Oceola Fish and Game Club

8.0 DEE LAKE WILDERNESS RESORT

Comments to Watershed Assessment Report (Draft)

Ecoscape Consultants have put considerable effort in the presentation of a commendable Draft. It does however, not indicate precise and direct recommendations for threat mitigation or in the prospects to carry forward the recommendations to reality upon completion of the report.

- A key issue appears to be the raising of the dams and subsequent water level. Do these plans call for clearing of the enlarged basin or simply to flood the existing forest buffers and land with the resultant increase in sedimentation and organic matter? Have the effect of higher levels been analyzed to identify the effected properties and related concerns? What are the recommendations to deal with these effects?

- The Report has identified the intakes on Oyama Creek and Vernon Creek as being at high risk due to sedimentation from landslides as well as increased bacteria due to the open water runs from the dams. Perhaps a recommendation would be to move the intake points up to the dams. This would minimize the potential impact from bacteria, landslides, and spring runoff from the current locations.

- The report identifies concerns with ATV traffic. ATV's are designed with a very low footprint for minimal impact. Human or Cattle traffic over the same terrain would have a substantially greater impact. Perhaps designated trails with bridges at crossings would mitigate the possibilities. An aging population will have a resultant increase in there use.

- The report indicates considerable concern with sedimentation and organic matter entering the water supply. It appears to be unknown as to the current level of sediment and organics in the lakes. Without this information it is difficult to monitor any increase as there does not exist a base line for comparison.

- The Boat launch at Beaver Lake has been in place since the 1920's and therefore would seem to be an ideal location to inspect for long term detrimental effects. In terms of prospective, how does sedimentation from a boat launch compare to any of the creeks during spring runoff?

- Page 39 Wilderness Resorts and related concerns:

  Ice fishing: Current regulations prohibit ice fishing on the Dee Lake Chain. Perhaps this should be extended to all lakes in the watershed.
  Concentration: While the report expresses concern over the concentration of human activity it also express sever concern over unsanctioned camping and usage in undesignated areas.
  Boat Launches: These are not in the perception of a normal boat launch. The number of launches where a trailer enters the water is of a minority where at a conventional site they are the norm. A more precise definition would be a lake access. Simple design guidelines would minimize runoff into the water.
  Marina's: None of the Resorts have what may be concerned the conventional definition. While Marina's are perceived as fuelling stations for water craft and in some cases aircraft, these capabilities are not evident at the Resorts and over water fuelling does not occur. The resorts are sources for watercraft rentals and in many cases are used by the public in lieu of transporting and launching their own craft.
- Page 41 Pit Toilets and Sewer Systems

At Dee Lake our main pit toilets are constructed on concrete tanks which are pumped out by septic truck. The Report indicates that the systems are under permit from IHA but the Dee Lake System does not meet current requirements for a “subdivision”. As Dee Lake is not a subdivision I am unclear as to the relevance of this statement. This needs to be clarified with the consultant and its application to all existing systems.

- Page 43 Docks:

Several areas of the Report indicate concern over Docks and their construction and anchorage. The Report indicates lack of conformity with “Best Practises” but there is no Appendix including the definition of “Best Practises”.

- Page 44-45 Control Agencies

The report expresses concern over the number and variance of multiple control agencies such as Integrated Land Management, Regional District of Central Okanagan, and District of Lake Country. If the properties in question were converted to “freehold” ILMB would be eliminated and control would be from RDCO to which DLC has direct input and is part of.

- Page 97-5 Electric Motors

The Report indicates a strong support for electric motors as a viable alternative. While this may be true of some of the smaller lakes it is not currently possible on the larger lakes and has its own detriments. The currently available electric motors are not designed as primary propulsion units and will not withstand the rigors of even one season. On the larger lakes they require multiple batteries to last even one day. While outboards have the potential release of hydrocarbons, these are containable and easily recovered in the case of boat upset. Batteries are essentially not recoverable in the case of an upset. This statement needs clarification as to the viability on the larger lakes.

- Pages 87 and 102-7

The Report places considerable emphasis on forest buffers as a deterrent to cattle and recreation activities. These buffers have been recognized for many years but it is unfortunate that their maintenance has been neglected. They are now composed of over mature timber and pine beetle kill which is resulting in timber falling into and beside the lakes with the resulting increase in organics entering the water supply.(See attached photos) Their ability to deter cattle is questionable as in evidence by the dead cow in the channel between Crooked and Deer Lake. This channel has a major density of natural barrier but was to no avail. (See attached photo)

- Hydrocarbons:

The Report indicates outlines in numerous areas the possible negative effects of hydrocarbons. Are hydrocarbons measurable and have they been measured in the watershed? If they are measurable can they be monitored to show specific trends? The report fails to address the airborne hydrocarbon contaminant from aircraft.

- Dee Lake Improvements:

  At Dee Lake as with all resorts we have a primary concern for the watershed. To this end we started in 1998 with a massive clean up of the site. This included the removal of over 200 pickup loads of garbage, 40 truckloads of scrap including abandoned automobiles and the removal of any detectable debris including over 20 bulk steel drums with unknown contents from the lake. We have established an approved Sewer System. All new construction has a self imposed set back of 100 feet from the high water mark. It is our belief that the concentration factor is outweighed by the benefits of a controlled environment. We have one dock and a few floats to service 50 accommodation units, one sewer system, contained pit toilets and constant monitoring of our guests.

- Leasehold Vs. Freehold:

  Leasehold tenures have the disadvantages of poor tenure security, (length and lack of title registration do not allow for financing options and require direct cash input) inability to create improvement district, (cannot arrange for power line to eliminate fuel storage and use of better treatment facilities) multiple jurisdictions of government and negative cash flow from required removal of danger and over mature timber, (have to pay all costs to remove and full stumpage rates)
  Freehold tenure would allow for financing to enable long term improvements to infrastructure, allow for establishment of an improvement district to enable a power line (eliminate storage of diesel fuel and enable better treatment systems as well as providing a viable alternative to heating with wood burning appliances) simplify relations with government, create profit from timber harvesting to be used for replanting and restoration.

- Recommendations:

  -Support funding for extensive control of cattle and eliminate their direct access to lakes and streams.
  -Support the conversion of leasehold to freehold.
  -Support the establishment of a stakeholder driven committee for input to RDCO for recommendations on by-laws and zoning and prioritization of threat mitigation.

-Support lobby to government to close all lakes to ice fishing and limiting of outboard motor horsepower as well as use of electric motors on the smaller lakes.
-Support lobby to government to have the forest service sites given to RDCO for use as controlled campgrounds.
-Support an RDCO governed linear park along Beaver Lake and Dee Lake Roads. RDCO parks would now control access.
-Support funding for extension of the diversion points to the dams.
-Support the establishment and maintenance of a recognized trail network both non and motorized.

- The Future:

  We cannot reverse time. We can, make the best of the cards we are dealt. The pressure from recreation will only increase and more people will be using this watershed. It is all but impossible to stop this expansion and there will always be the possibilities for negative impact. We can however, manage this impact by directing the recreation users away from sensitive areas and towards controlled areas. Working together, with the cooperation of all stakeholders, we can achieve the goal and protect this resource.

Thank you
Bruce Williams
Dee Lake Wilderness Resort

9.0 REGIONAL DISTRICT OF CENTRAL OKANAGAN

By the way – page 96 under Land Ownership makes reference to …"the RDCO issues development permit for erection of structures …" first paragraph – should have been building permit – since we do not have development permit areas identified in that area. Minor issue but thought you should know…

I was just going over the Water Source Protection Report and recommendations associated with RDCO and do not think that you have reference the CL8 – Conservation Lands zoning. The zoning map Figure 2 does not appear to show the zone – and the zone is particular to community water supply and completely surrounds the lakes in question – and does have a 30 m setback from the lakes. I don't believe this changes anything in the report except maybe Figure 2. Well – you may want 1 sentence in section 4.3.1 Land Ownership regarding Relevant Legislation? …

Sorry for just catching this now – but I didn't actually review the entire report – just the recommendations….

See attached – part is cut and paste below…

CONSERVATION LANDS CL8

Purpose: To manage lands and watercourses where protection and conservation of the natural environment is the principle objective and to permit passive recreational uses where appropriate.

5.3.1 **Permitted uses, buildings and structures:**
.1 Conservation area;
.2 Ecological reserve, flood hazard, groundwater protection, or community water supply area;
.3 Erosion or sediment control;
.4 Interpretive centre;
.5 Forest or wilderness oriented recreation and wilderness purposes including campsites where the use exists prior to March 17, 2008;
.6 Open space;
.7 Silviculture for purpose of forest health or fire hazard reduction;
.8 Water, fisheries and wildlife, biological diversity and culture heritage purposes.
.9 Accessory Building or Structures (see Section 3.17)

Column 1 Column 2
5.3.2 **Minimum** ***parcel area*** 1 hectare (2.5 acres)
5.3.3 **Minimum** ***setback from watercourse*** 30 m (98.4 ft.)
5.3.4 **Minimum** ***setbacks from parcel boundaries*** 4.5 m (14.8 ft.)
5.2.5 **Minimum** ***setbacks from A1 Zone*** 15.0 m (49.2 ft.)
5.2.6 **Maximum** ***parcel coverage*** 5% of the *parcel area*
5.2.7 **Maximum** ***building height:***
.1 *Principle buildings* 9.0 m (29.5 ft)

.2 *Accessory uses, buildings and structures*

(see Section 3.17) 5.0 m (16.4 ft.)

Margaret Bakelaar
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10.0 INDIVIDUALS

10.1 Patrick Whittingham

Hello Mary Ann, I am a stakeholder in the watersheds that were studied. I camp, fish, hunt, and use my parents' cabin on occasion in the watersheds. I have recently been forwarded a link to the Draft Assessment Report.

I have a question about the source of certain information in the report. You mention at the bottom of page 44 that if the sale of leased lots occurs, that the costs of raising water levels is more expensive and complicated. However, recent mappings by CTQ Consultants have shown that the proposed water level increase by the DLC for Oyama Lake would not infringe upon any of the land under lease, and similarly at Beaver Lake, the cabins that would be impacted by the DLC's proposed storage increase were agreed to be relocated by ILMB should the need arise. I would like to know, therefore, how you arrived at the conclusion that raising storage levels would become more complicated and expensive for DLC if leased lots were sold. I note that you reference a personal communication with Nelson Jatel of OBWB in the preceding paragraph. Is your conclusion on expense and complication also the result of personal communication with Mr Jatel?

Also, point number 3 on page 93 infers that the sale of leased lots will lead to increased development and occupation of said lands. On what empirical evidence do you base this assertion? Can you give me any examples wherein the conversion of a leased lot, such as those at Oyama Lake with no road access, services, and current zoning rules, to fee simple has resulted in increased occupation or degradation of the surrounding landscape, and is there considerable documented evidence of such occurrences to declare your conclusion as being the most likely result?

Thank you. I'm looking forward to your reply.

Patrick Whittingham, CGA
Controller
Winfield Home Systems
A Division of SRI Homes ULC
(250) 766-0588

10.2 Rick Simpson

Hi Mary Ann,

Re: Your Request - > Re: Oyama and Vernon Creek Watershed Meeting Follow-up

"We" will do as you request regarding the report...a detailed page-by-page review, critique and comment with page references, including typos and factual errors...for the OFGC BOD meeting Thursday, February 4, 2010....a report to you will be forthcoming after OFGC BOD review and approval of our feedback

Please note that "our" review is being done, as requested, pro-bono by club members who are lay-person volunteers.

Our preliminary estimate is that such a review will require a minimum of
75 - 100 hours of unpaid volunteer time by club members..an estimated in-kind contribution of $7,500 - $10,000.

We understand that your report is a "starting point" report and is estimated to cost $105,000 to March 24, 2010....funded by OBWB and DLC.

As mentioned verbally today...Our Major Concerns:
Implementation work plans, including specific resources required to implement each report recommendation and a budget for each recommendation...the anticipated partners required and their respective committed financial contributions for each recommendation... specific accountability and responsibility for the implementation of each recommendation....these remain major practical concerns to us lay-person
volunteers....ie: implementation on-the-ground, real-world action of report recommendations...

We have observed far too many similar consultant reports with practical recommendations, that consume huge amounts of volunteer good will, time, resources and money but go nowhere after these reports are submitted...and remain un-actioned...or are selectively and/or partially implemented depending on which way the political wind blows.

Eg: the 1974 13 volume report done on the Okanagan Valley water resources has many worthwhile recommendations...for instance those related to water licenses, which after 35 years still remain to be actioned. ie: no accountability.

I plan to begin my review starting where I left off on page 63 (I have 3 pages of notes (21 comments/concerns). I have also received some preliminary and worthwhile written and verbal comments from Lorne Davies and some from Patrick Whittingham, so far...I plan to spend most of Thursday, Friday and the weekend (perhaps 30 - 35 hours) completing my review and notes write-up on the text and on the attached graphics, etc.
I don't know how many hours Patrick and Lorne will spend on their review and write ups.

Thanks for your help.

Rick Simpson

10.3 Heather Larratt

Hi Mary Ann and Jason: I've scanned your report - looks great. I read Section 3.8.6 Algal Blooms and thought you might like to see the section of the attached report that discusses treatment of cyanobacteria; toxicity etc. Enjoy! HL

10.4 Lloyd Manchester

Hi Mary Ann,

From a cabin owners perspective, we are assessed as if we are freehold properties and we pay taxes on that amount whitch is not what we could sell our lots for. As well we pay 3 percent to the government based on the assessed land value. As a result, our taxes and lease fees continue to escalate making it very expense for cabin owners. We as cabin owners, who only use our cabins seasonally find this unaccaptable and would like to purchase our properties and avoid this expense. We will continue to be stewards in the watershed regardless of purchase. We are not that interested in having power like the resorts because of our usage. Another reason we want to purchase is so we can make improvements to our buildings making it a good investment.Hope this helps. As well, many cabin owners have created trusts to ensure that the cabin is passed down in the family. Hope this helps. Lloyd