11. ASSESSMENT OF TERRESTRIAL ECOLOGY EFFECTS

11.1 INTRODUCTION

Terrestrial ecology is included in the EIS because of its key role in the maintenance of wildlife habitat, nutrient cycling, productivity, biodiversity, and carbon sequestration. It is recognized that Aboriginal groups place value on all ecosystems and their interconnections and as such soils and all vegetated ecosystems that may be affected by the Project were included in the assessment. The terrestrial ecology chapter provides a description of soils, ecosystems and vegetation within a regional and local area surrounding the Project and assesses the effects of the Project on these components.

A full description and the associated methodology for the terrain and soils baseline studies and the ecosystems and vegetation studies are provided in the *Murray River Coal Project 2012 Terrain and Soils Baseline Report* (Appendix 10-A) and the *Murray River Coal Project 2010-2012 Terrestrial Ecosystem and Vegetation Baseline Report* (Appendix 11-B) and the *Murray River Coal Project Soils and Vegetation Tissue Metals, 2010 to 2012* (Appendix 11-C). Wetland ecosystems are assessed in Chapter 12.

11.2 REGULATORY AND POLICY FRAMEWORK

Provincial and federal acts, along with best management practices, guidelines and standards, direct resource development and conservation. Table 11.2-1 summarizes the legislation, regulations, and guidelines that may apply to activities that affect soils, terrestrial ecosystems or vegetation.

Table 11.2-1. Terrestrial Ecology Regulatory and Legislative Framework

Name	Year	Type	Level of Government	Description
Mines Act	1996	Act	Provincial	The *Mines Act* requires Terrestrial Ecosystem Mapping (TEM) of a local study area for all mining permit applications. For projects in either the Provincial or Federal environmental assessment process, the BC Ministry of Environment (MOE) requires Predictive Ecosystem Mapping (PEM) to be conducted over a regional study area, which is delineated by natural boundaries such as river drainages or other landscape features, and contains the LSA. Additionally, the BC MEM requires characterization of baseline metal concentrations in plant tissues. This information is used to assess changes over time and to guide reclamation planning (BC Ministry of Energy and Mines 1998).

(continued)

Table 11.2-1. Terrestrial Ecology Regulatory and Legislative Framework (continued)

Name	Year	Type	Level of Government	Description
Species at Risk Act (SARA)	2002	Act	Federal	The purpose of SARA (2002b) is to prevent species at risk from becoming extirpated or extinct and ensure the appropriate management of species to prevent them from becoming at risk. Certain species are also protected under SARA as part of wildlife habitat and in accordance with the Canadian Biodiversity Strategy (CBS). The CBS provides federal legislation that supports the conservation of particular species and populations to ensure continuance of biological diversity over time (Minister of Supply and Services Canada 1995).
Forest and Range Practices Act (FRPA)	2002	Act	Provincial	The *Forest and Range Practices Act* (FRPA; 2002a) governs all forestry activities including logging, road building, reforestation and riparian area management. FRPA requires that all forestry-related development be conducted in accordance with the rules and regulations identified in the Act to ensure the protection of environmental values. FRPA also manages ecosystems as wildlife habitat through the Identified Wildlife Management Strategy (IWMS).
Wildlife Act	1996	Act	Provincial	The provincial *Wildlife Act* (1996c) provides for conservation of specific ecosystems and ecosystem components as they provide habitat for species managed by the MOE.
Environmental Protection Act	1999	Act	Federal	The *Environmental Protection Act*'s (1999) purpose is to prevent pollution and protect the environment and human health by ensuring developments are ecologically, socially, and economically sustainable.
Environmental Management Act	2004	Act	Provincial	The *Environmental Management Act* (2004) prohibits the introduction of deleterious substances into the environment in any manner or quantity that may cause pollution to the environment as defined in the Act. The Contaminated Sites Regulation (BC Reg. 131/92) included in British Columbia's Environmental Management Act lists Soil Criteria for Toxicity to Soil Invertebrates and Plants. These provide numerical standards to define if a site is contaminated, to determine if the soils are suitable for salvage, to determine liability for site remediation, and to assess reclamation success.
Fish Protection Act	1997	Act	Provincial	The *Fish Protection Act* (1997) and associated amendments to the provincial *Water Act* (1996a) regulate provincial approvals of alterations and work in and around watercourses. The regulations focus on riparian retention, which may be involved in vegetation removal and introduction of harmful debris (clay, silt, sand, rock, or any material, natural or otherwise) into the waterways.

(continued)

Table 11.2-1. Terrestrial Ecology Regulatory and Legislative Framework (completed)

Name	Year	Type	Level of Government	Description
Fisheries Act	1985	Act	Federal	The *Fisheries Act* Section 35 (1985a) prohibits serious harm to fish and fish habitat that are part of or support commercial, recreational, or Aboriginal fisheries.
Weed Control Act	1996	Act	Provincial	The BC *Weed Control Act* (RSBC 1996) regulates the management of noxious plants in BC. The Act requires all land occupiers to avoid establishment and dispersal of noxious weeds as defined by the Act.
Dawson Creek Land & Resource Management Plan (LRMP)			Provincial	The Dawson Creek LRMP guides resource development and conservation for each of the region's Landscape Units (LUs). The LRMP was completed in 1999 as a strategic long-term planning framework for Crown land resource access, development and management (BC Ministry of Forests and Range 1999). Pertinent to the Project are Wolverine, Kinuseo, and Bearhole LUs, which are intermediate biodiversity emphasis option LUs that intersect the LSA.
BC Conservation Data Centre	2007		Provincial	The British Columbia Conservation Data Centre (CDC) (BC MOE 2007a) systematically collects and disseminates information on plants, animals, and ecosystems (ecological communities) at risk in British Columbia. This information provides a centralized and scientific source of information on the status, locations and level of protection of these organisms and ecosystems.
Canadian Environmental Protection Act	1999		National	The *Canadian Environmental Protection Act* (1999) regulates the release of toxic substances into the environment, which includes potential contamination of soil by mining activities (Section 9). The Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (2013) provide Canada-wide maximum limits of toxic substances (e.g., metals, hydrocarbons, pesticides, etc.) for the soil.
Invasive Plant Committee of the Peace River Regional District (IPCPRRD)	n/a		Regional	The Invasive Plant Committee of the Peace River Regional District has established guidelines for invasive plant prevention, eradication, containment, rehabilitation and control (Peace River Regional District 2014). The IPCPRRD categorizes invasive plants according to their level of invasiveness and management priority.
Metal Mining Effluent Regulations (MMER)	2012	Regulation	National	Sets out a list of substances defined as "deleterious" and prescribes thresholds and procedures whereby an owner or operator of a mine may deposit such substances.

11.3 REGIONAL OVERVIEW

The Project is located within the District of Tumbler Ridge in the Rocky Mountain Foothills in northeastern BC. It is situated within the Central Canadian Rocky Mountain Ecoregion, the Sub-boreal Interior Ecoprovince and the Hart Foothills Ecosection (Figure 11.3-1; Demarchi 2011). The Hart Foothills are situated along the east side of the Rocky Mountains and consist of rounded mountains and wide valleys generally lower than the Rocky Mountains to the north and south.

The major drainages originate in the Rocky Mountains, including Flatbed Creek, Bullmoose Creek, and Wolverine River. These rivers flow northeast and merge, near Tumbler Ridge, into the Murray River which continues north, emptying into the Pine River near East Pine Provincial Park. The Pine River then flows north and east, joining the Peace River near the Town of Taylor, BC.

South of Tumbler Ridge, the Murray River is large and meanders through an incised floodplain between the remnants of benches from older floodplains. Through time, the valley has undergone a process of flattening, as the river has continued to rework the sand and gravel bed materials. North of the confluence of the Murray River and the Wolverine River, a study of tree ring data from the present floodplain indicated that the oldest trees are 150 years old, suggesting that the river may have encompassed the entire floodplain over approximately the past 200 years (Thompson, Berwick, Pratt & Partners 1978).

While recent floods have shaped local ecosystems and terrain, there have been four major glaciations during the Quaternary period (about 2 million to 8.5 thousand years ago). These events produced the rounded summits and ridge crests and the undulating and rolling terrain at lower elevations. Morainal deposits blanket the sedimentary bedrock, except in areas where colluvial materials have collected on steeper slope or recent fluvial deposits have altered valley floors (Valentine et al. 1978).

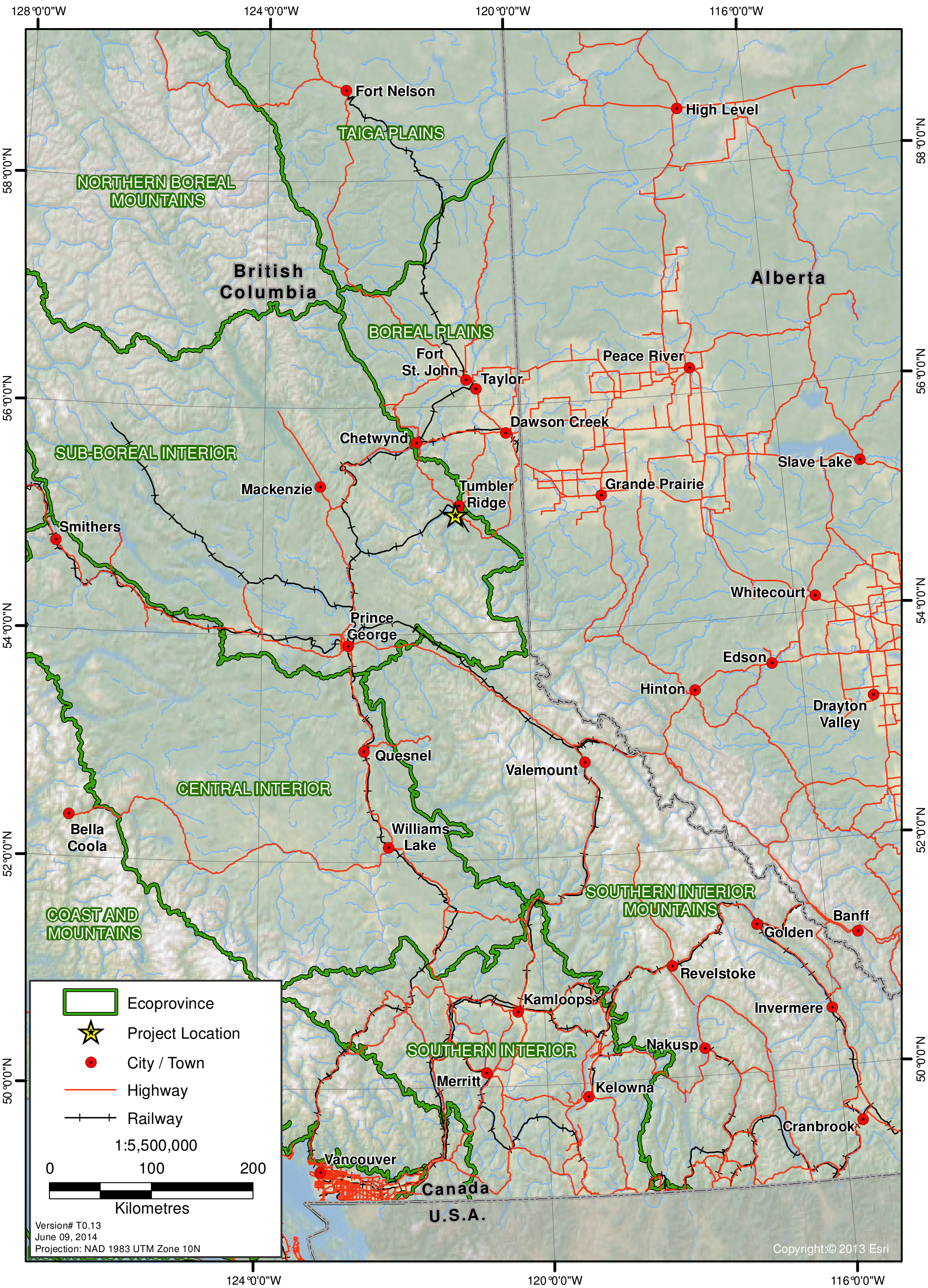
11.4 HISTORICAL ACTIVITIES

Several historic and current human activities are within close proximity to the proposed Project area. These include mining exploration and production, oil and gas, forestry, tourism/recreation, and hunting/trapping.

The Murray River Project's License area is located within the Peace River Coalfield, known for producing metallurgical grade (hard coking) coal. In the 1950s and 1960s, 15 significant coal deposits were discovered in this region. In response to rising coal prices in the mid-1970s, the Government of Canada examined the viability of accessing and transporting coal to the Pacific Coast for export. In 1981, the governments of BC and Canada, two Canadian mining companies and a consortium of Japanese steel mills signed an agreement to develop the mining industry in the area. As a result, the District of Tumbler Ridge was built as well as two coal mines (Quintette and Bullmoose), and Highways 52 and 29 connecting the municipality with Highway 97. A power line from the W.A.C. Bennett Dam and a rail line through the Rocky Mountains were also built to support economic development in the region. Quintette mine and the Bullmoose mine started production in 1982 and were closed in 2000 and 2003 respectively. Oil and natural gas exploration and development are also active in the region, with gas wells and gas pipelines near the Project.

Figure 11.3-1

General Location of the Proposed Project



The Quintette Coal Mine consisted of five open pits in three discrete areas: Sheriff (Wolverine and Mesa Pits), Frame (Shikano Pit), and Babcock (Windy and Window Pits). Mine permits for the Wolverine and Mesa Pits were issued in December 1982, and mining commenced in 1983 and continued until 1998 (Wolverine) and 2000 (Mesa). Raw coal was transported via an overland conveyor from the Mesa and Wolverine Pits to the Quintette plant site for processing. The conveyor was decommissioned in 2011. The coal processing plant is currently under care and maintenance, with a mine permit application to re-initiate mining currently under review.

The Bullmoose Coal Mine was the largest open pit coal mine at the time, producing about 3 million tons of metallurgical coal. The 1.7-million-tonne-per-year operation consisted of an open-pit mine, a plant facility in the Bullmoose Creek valley below the mine, and a separate rail loadout facility on the B.C. Rail branchline.

Previous exploration in the area included seismic lines and drilling for oil and gas wells. These drilling programs helped target areas for coal exploration and resulted in the development of natural gas wells near the proposed Murray River Coal Project.

The Tumbler Ridge Wind Energy Project, located 8 km west of Tumbler Ridge, has received an Environmental Assessment Certificate and General Area Licence of Occupation for the 47 megawatt project. While no construction date is scheduled and some uncertainty exists on whether the project will proceed, the proposed turbine locations occur above coal seams that are part of the Murray River Coal Project mine plan.

Canadian Forest Products Limited (Canfor) holds the rights to Tree Farm License (TFL) 48. The TFL consists of five supply blocks and has an area of 643,239 ha. Block 5 of the TFL overlaps a portion of the proposed Murray River Project. Canfor's mill is located in Chetwynd, which is the community most dependent on harvesting in the TFL (Benskin 2007). Mining related activity has had a minor impact on the timber harvesting land base (THLB), which is reflected in the 2007 annual allowable cut (AAC) calculations. An area of 2,236 ha was removed from the THLB related to mine sites, of which 479 ha were forested. At the time of the AAC calculation, 29 mine sites were proposed in the Peace Forest District. In his report, Deputy Chief Forester Henry Benskin stated that all mine sites were to be permanently excluded from the THLB as there were no examples of reclaimed mine sites in TFL 48 being restored to forested conditions (Benskin 2007).

In the LSA, Canfor has 13 licenses to cut. Two of these are proposed blocks for 2020, seven have been harvested but have not yet met free-to-grow obligations (the silvicultural obligation of reforesting the sites still reside with Canfor), and three licenses have been declared free-to-grow and have reverted to the crown. The remaining license is stagnant.

The District of Tumbler Ridge holds the rights to a new community forest license that overlaps the LSA. The community forest is 19,739 ha and has an AAC of 20,000 m^3.

Mining and other industrial users may have an impact on forest management as evinced by the August 2012 Forest Practices Board report that voiced concerns over the increase in non-forestry resource extraction taking place in the TFL and the ability of Canfor to manage the TFL without better cumulative effects management.

BC Hydro currently operates a 230 kV transmission line that intersects the LSA. This line supplies power to the community of Tumbler Ridge as well as other communities and commercial enterprises in the region.

Subsistence activities, such as trapping, hunting, and fishing are common land uses regionally. Three trapping tenures and four guide-outfitting tenures occur near the Project. Multiple recreation tenures, as well as temporary and permanent residences exist within the Project area. The nearest trapline cabin is 1.7 km from the Project on the west bank of Murray River; the nearest campground is 9.5 km north from the proposed Murray River Project (near Tumbler Ridge); the nearest hunt camp is 26 km west from the proposed Murray River Project; and the nearest residential area (Tumbler Ridge) is 12.4 km north from the proposed Murray River Project.

There are multiple previously recorded archaeological sites (pre-contact lithic scatters) within 5 km of the proposed Murray River Coal Project infrastructure.

The Project is located near two provincial parks and protected areas. Bearhole Lake Provincial Park and Protected Area is located approximately 17 km east of the Project, and Monkman Provincial Park is located approximately 27 km south of the Project.

This description is not exhaustive but does illustrate decades of recent human activity. Although effects to the terrestrial ecology have likely resulted from these projects, the magnitude and significance is largely unknown due to lack of information on ecosystems and vegetation in the region and across BC.

11.5 BASELINE STUDIES

Terrestrial ecology baseline studies were undertaken in 2010, 2011 and 2012 within a local and a regional area surrounding the Project. The goal of the baseline studies was to characterize the terrestrial ecology within the LSA to guide Project planning, management and environmental assessment. The following sections summarize the methodology and results of the baseline studies, which provide the basis for evaluating potential effects on soils, ecosystems and vegetation in accordance with the provincial Application Information Requirements (AIR). The specific objectives of the baseline studies included the following:

- map and characterize the terrain, surficial materials, and soils in proposed infrastructure areas to guide reclamation planning;
- map and characterize terrain, soils, and ecosystems within a local study area to provide local ecological context for the assessment;
- map and characterize ecosystems within a regional study area to provide regional ecological context and to support wildlife baseline studies;
- document plant and lichen species listed by the BC CDC, NatureServe, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), SARA, or otherwise considered rare or of conservation interest;
- document invasive plants species listed by the *Weed Control Act* (1998) or by the local invasive plant committee; and

- determine baseline metal concentrations in soils and vegetation.

11.5.1 Data Sources

A number of data sources were consulted to guide the terrestrial ecology baseline studies and environmental effects assessment. These sources included the following:

- Terrestrial Ecosystem Mapping (TEM) line work and descriptions (2008 and 2012);
- Terrain Resource Information Management (TRIM);
- BC CDC (for provincially blue- and red-listed plants and ecosystems);
- publically available data associated with relevant adjacent projects;
- stereo aerial photography interpretation using ArcGIS and Purview;
- relevant literature;
- data acquired via data sharing agreements;
- the Dawson Creek Land and Resource Management Plan (BC Ministry of Forests and Range 1999; BC ILMB 2000); and
- data made available from First Nations, local stakeholders, and the general public.

11.5.2 Methods

This section provides an overview of the terrestrial ecology baseline studies conducted for the Project. Included is a summary of the methods and results for terrain mapping, predictive ecosystem mapping, TEM, soil mapping, field data collection, rare plant and lichen surveys, soils and plant metal collections, and quality assurance and control procedures.

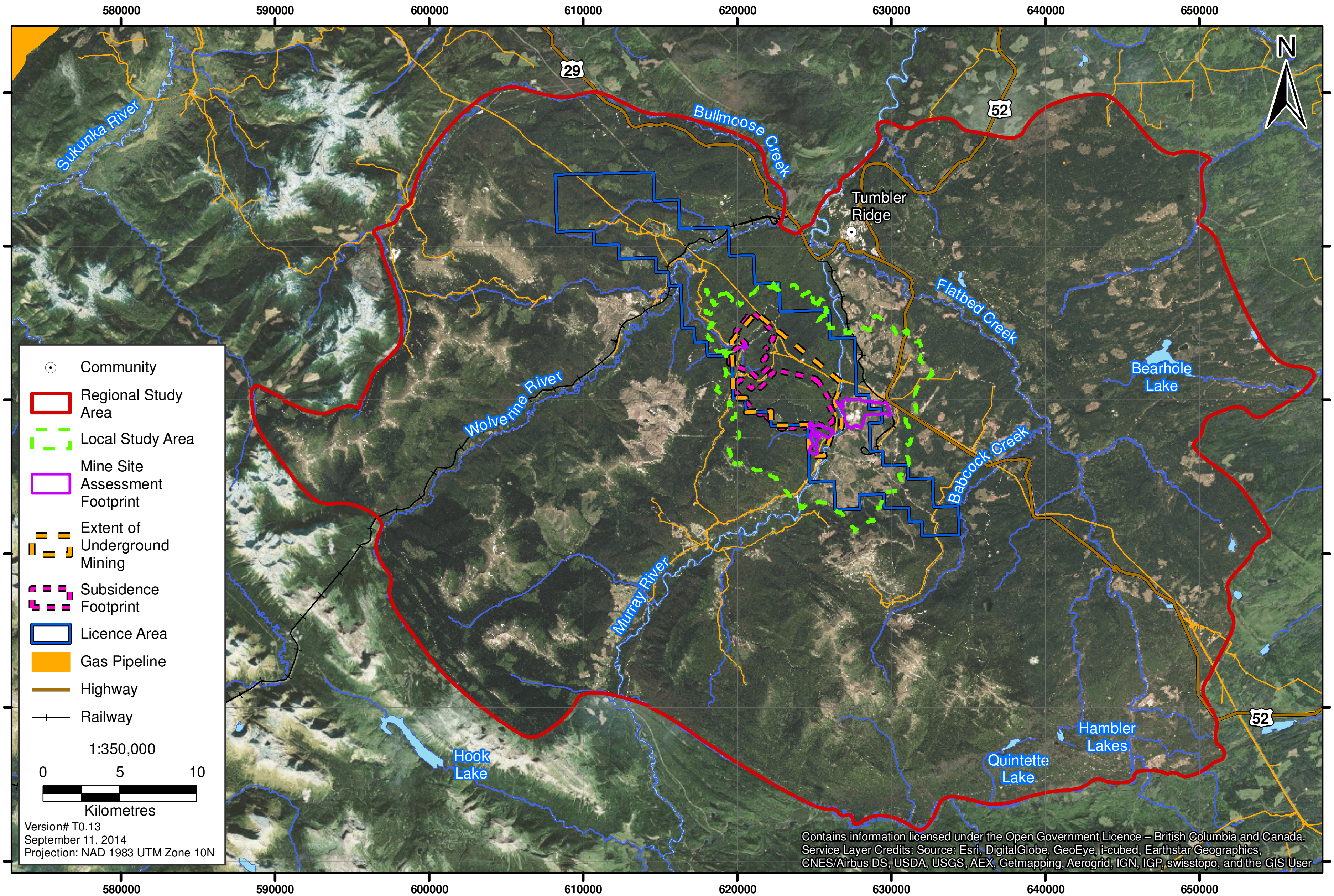
Full descriptions of the terrain and soils baseline studies and the ecosystems and vegetation studies are provided in Appendix 11-A and Appendix 11-B. The terrain map is provided in Appendix 11-C and the soil map in Appendix 11-D.

11.5.2.1 Baseline Study Area

Terrestrial ecology was characterized for a Regional and a Local Study Area surrounding the Project (Figure 11.5-1). The Regional Study Area (RSA) is 227,615 ha in size and was delineated to encompass an area on which to base regional characterizations. It is intended to be ecologically relevant based on the home range of key wildlife species known to inhabit the region, which is used to evaluate the potential effects of the Project on wildlife and wildlife habitat (Chapter 13) valued components (VCs). Ecosystem mapping in the RSA provides a regional context for ecosystem distribution and available wildlife habitat.

The Local Study Area (LSA) was defined by a combination of topographical features and buffers surrounding proposed Project infrastructure. The LSA is 14,853 ha and was expanded from the LSA defined in *Murray River Coal Project: 2010 to 2012 Terrestrial Ecosystem and Vegetation Baseline Studies* (Appendix 11-B) to include the extent of underground mining associated with the Project.

Figure 11.5-1
Terrestrial Ecology Study Areas



11.5.2.2 Predictive Ecosystem Mapping

Predictive Ecosystem Mapping is an automated, computer-based method using available imagery, spatial data, other environmental variables (e.g., terrain maps, slope and aspect models), and ecological knowledge to predict the distribution of ecosystems across large areas (i.e., regional scale).

The Murray River PEM was completed within the RSA using a raster-based approach. The raster cell size was 20 m, with each cell representing 400 m^2 on the ground. The Murray River PEM was developed using the programs and procedures developed by LandMapper Environmental Solutions Inc. (LMES). The procedures are termed the LMES Direct-to-Site-Series (DSS) method and are based on two primary assumptions. The first assumption is that topography is one of the primary controlling factors behind the local flow and accumulation of water, energy, and matter in landscapes (MacMillan 2003). The flow and accumulation of water shapes the development and properties of soils and site-level environmental conditions. The second assumption is that, where subtle differences among classes are important, human-imposed classification systems are superior to those based on statistical analyses and ordination (MacMillan 2003). These assumptions, and consequently the LMES DSS procedures, parallel the logic and decision making processes outlined in the regional Field Guide produced by the BC Ministry of Forests (BC MOF; Banner et al. 1993).

The input layers incorporated into the Murray River PEM represent the classification logic presented in the landscape profile diagrams, edatopic grids (relative soil moisture and nutrient regimes), site series flowcharts, and environment tables of the respective regional field guides (DeLong, Tanner, and Jull 1994; DeLong 2004; DeLong et al. 2010).

The input components, input data quality, and the process of assessment and refinement, are described within Appendix 11-B. The PEM was assessed and refined throughout its development using field survey data, satellite imagery, aerial photographs, and TEM information.

11.5.2.3 Terrain Mapping

Terrain mapping is the identification of permanent terrain units based on surficial material, geomorphology, and landform. Initial mapping involved polygon delineation and the assignment of general attributes to individual polygons. Terrain polygons were delineated based upon observable characteristics such as surficial material, texture, surface expression, and geomorphic processes (Appendix 11-A). Detailed attributes such as texture, parent material, surficial expression, and geomorphic process were assigned using the field data collected from ground plots. Attributes were described using the Terrain System Classification for British Columbia (Howes and Kenk 1997).

11.5.2.4 Terrestrial Ecosystem Mapping

Terrestrial Ecosystem Mapping is the manual delineation of ecosystem boundaries and attributes to predict the distribution of ecosystems on a local scale.

The Murray River TEM was completed using PurVIEW software within ArcMap 9.3. PurVIEW enables users to view stereo pairs of digital air photos in 3D at variable scales. A DEM created from the provincial TRIM data was used to provide a control on the vertical plane (z-axis) to enable on-screen digitizing of polygons that are photogrammetricly accurate. Ecosystem polygons were cut from the larger terrain polygons when necessary to ensure identical common boundaries. The dataset was then cleaned to ensure no gaps, slivers or overlaps between polygons exist. The associated database was then populated as per the provincial standards (RIC 1998).

Mapping was based upon colour aerial photography (year: 2005; scale: 1:30,000) and was guided by respective provincial standards for terrain and ecosystem mapping (Howes and Kenk 1997; RIC 1998, 2000). Field survey data were collected to refine mapping, and to provide quality control of mapping classification (Appendix 11-B).

11.5.2.5 Soil Mapping

Soil map units (SMUs) are the basic unit used to describe the soil within a mapping polygon and the range of soil resources in the LSA. SMU characteristics are interpreted for their relative suitability for management applications such as root zone materials in reclamation. Soil mapping is largely an interpretive exercise based upon field data, terrain attributes, and local climate.

Project-specific soil maps were developed using information from the terrain, vegetation, wetland field data and mapping, as well as from the digital elevation models. The relationship between soil moisture regime and soil development (related to soil order classification) was derived from the TEM mapping and verified by field data.

Individual SMUs were created using a combination of attributes, including soil climate, parent material (terrain surficial material), drainage (as derived from soil moisture regime, or SMR), and probable soil development to the Canadian System of Soil Classification (CSSC) order level of classification. Characterization of SMU soil properties including horizon type and depths, texture, coarse fragment content, and basic chemistry were derived from field data and described in the terrain and soil baseline report (Rescan 2012). SMU maps of the LSA were developed at a scale of 1:20,000 (Appendix 11-A). The soil maps for the proposed mine development area were completed at the scale of 1:5000 (Appendix 11-E).

11.5.2.6 Classification of Soil Ecological Value

A four class ratings system was developed to reflect the ecological value of soil. The rating is based on potential soil productivity (potential to sustainably generate biomass relative to natural productivity range within a respective BEC subzone) and its role in enhancement of vegetation diversity.

The rating was interpreted from soil development and parent material characteristics. For example, higher quality (higher rated) soils exhibit finer soil textures with relatively higher nutrient and moisture holding capacity, are better developed, are in stable environments, have relatively deeper effective root zones, and are not poorly drained. The ratings were adjusted according to specific terrain attributes, such as evidence of active geo-processes, or depth to bedrock that may impact land productivity potential.

The ratings also reflect soil function/value contribution to the overall maintenance, resilience or function of the ecosystem. For example, wetland soils including Mesisols (M or M.t) and peaty Gleysols (G.p) were rated as High (1.1) to reflect their special environmental value.

The ecological value ratings for soils are summarized in Table 11.5-1. The rating was applied to each soil polygon (n = 1664) mapped within the LSA.

Table 11.5-1. Summary of Ecological Value Ratings Assigned to Project Soils

Rating		Description of Typical Project Soils[1]
High	1, 1.1	Brunisolic and Luvisolic soils commonly developed on morainal 'M' parent materials. Luvisolic soils developed on colluvial and glaciofluvial parent materials. Wetland organic and peaty soils – rated high because of their special ecological function.
Moderate	2	Gleysolic soils on a variety of parent materials; or better drained Brunisols on less suitable parent materials such as colluvium 'C', fluvial 'F' and glacio-fluvial 'G' materials with typically high coarse fragment content.
Low	3	Regosolic soils; especially those in areas of active terrain processes (high energy flooding or mass movement) where soil development is retarded by frequent disturbance and/or biomass may be removed; shallow soils developed on and around bedrock outcrops.
Very Low	4	Non-soils, exposed bedrock and soils disturbed by anthropogenic activities/materials.

[1] *The rating was applied to each soil polygon mapped (n = 1664) within the LSA.*

11.5.2.7 Mapping Field Surveys

The primary goal of the field surveys was to characterize the ecosystems, soils, and vegetation present within the Mine Site Assessment Footprint and the Local Study Area. Fieldwork was completed in 2010, 2011, and 2012, using a combination of detailed sample plots (ground inspections) and visual plots (visual inspections). The field data were collected following the guidelines established in the Field Manual for Describing Terrestrial Ecosystems (BC MELP and BC MOF 1998). The soils were classified according to the Canadian System of Soil Classification (Soil Classification Working Group 1998). Detailed information on field methods for soils as well as ecosystems and vegetation can be found in Appendix 11-A and 11-B.

11.5.2.8 Characterization of Baseline Metals

Soil, lichen, and plant tissue samples were collected and analyzed as part of soils, terrestrial, and wetland baseline studies conducted for the Project. The metals analyses determines baseline metal levels in soils, lichens, and plants in the area of proposed infrastructure as well as control sites outside of the expected zone of influence of potential Project environmental effects. This data is used to evaluate any changes in metal levels due to the Project. The samples collected, sampling sites, and results of the metal analysis are provided in the Appendix 11-C.

Between the 2010 and 2013, soils and vegetation tissues were sampled throughout the LSA. Samples were submitted to ALS Environmental (ALS), Vancouver, BC, for laboratory analysis where the soil samples were analyzed for soil reaction (pH), total organic carbon content, and concentration of 31 metals according to standard procedures (Appendix 11-C). The interpretation of baseline data included comparing soil analytical results to the guidelines, provided for 19 of the metals by the Canadian Council of Ministers of the Environment (CCME 2013) and by the BC Contaminated Sites Regulation (BC Reg. 375/96).

The lichen and plant tissues were tested for concentrations of 31 elements (Appendix 11-C). This information was used to quantify background tissue metal concentrations within the LSA and at reference sites outside of the LSA. The list of samples collected, sampling sites, and results of the metal analysis are provided in the *Murray River Coal Project: Soil and Vegetation Tissue Metals 2010 to 2012* (Rescan 2013).

11.5.2.9 Acid Deposition and Soil Acidification

In order to calculate the acid deposition associated with the Project, the methodology outlined in *AQTAG06 Technical guidance on detailed modelling approach for an appropriate assessment for emissions to air* was used (Environment Agency 2006). The NOx and SOx associated with the Project were modelled using the CALPUFF model (Appendix 6-B). The dry deposition flux was then calculated by multiplying the ground level concentration from the model by the deposition velocity provided in Table 11.5-2 below. The dry deposition flux was then converted from units of mg m^{-2} s^{-1} (where mg refers to mg of the chemical species) to units of kg ha^{-1} $year^{-1}$ (where kg refers to kg of nitrogen or sulphur) using the conversion rates below. The unit of "equivalents" is often used for acidification purposes, rather than a unit of mass. It is termed "moles of charge" and is a measure of how acidifying the chemical species is. In order to convert the units of mass to equivalents, the conversion factors shown in Table 11.5-3 were applied.

Table 11.5-2. Conversion Factors used in Calculations of Rates of Acid Deposition

Chemical Compound	Deposition Velocity ($m\ s^{-1}$)	Conversion Factor ($mg\ m^{-2}\ s^{-1}$ of Species X to $kg\ ha^{-1}\ year^{-1}$)	Conversion Factor ($kg\ ha^{-1}\ year^{-1}$ to $eq\ ha^{-1}\ year^{-1}$)
NO_2	0.003	96 (N)	71.4
SO_2	0.024	157.7 (S)	62.5

Table 11.5-3. Background Levels of Acid Deposition Recorded in the LSA

Chemical Compound	Background (eq/ha/y)
Nitrate	100.0
Sulphate	158.1

The median nitrate and sulphate deposition values, from the five dustfall monitoring sites measured during the 2011 air quality baseline program, were then applied to the modelled concentrations in order to calculate a total acid deposition value. The background values used in the assessment are shown in Table 11.5-3. Further details of the air quality baseline monitoring program can be found in Chapter 6, Effects Assessment Air Quality.

Coarse-textured soils that developed on parent materials derived from acid rocks like sandstone, gravel, granite, quatzine, and gneiss are categorized as highly sensitive to acid input, and a critical load of less than 250 eq/ha/year is applied to these soil types (WHO 2000). Coarse soils that developed on glacial till or parent materials derived from neutral rocks (e.g., shale) were deemed to be sensitive to acidification with a critical load of 250 to 500 eq/ha/year. Moderately coarse soils that developed on glacial till or parent materials derived from neutral rocks were classified as sensitive to acidification with a critical load of 500 to 1,000 eq/ha/year. Medium to moderately fine textured soils that developed on a variety of parent materials are classified as moderately sensitive with a critical loads ranging between 1000 to 1,500 eq/ha/year. Finely textured soils developed on parent materials derived from intermediate to basic rocks (gabbro, basalt, dolomite, or volcanic) are deemed not sensitive and able to withstand loading exceeding 1,500 eq/ha/year of acid input.

Due to narrower range of soil parent material conditions found in Alberta, only three of the four critical loads used in Europe were recommended for application in that province: 250 eq/ha/year for sensitive soils, 500 eq/ha/year for moderately sensitive soils, and 1,000 eq/ha/year for soils of low sensitivity (Target Loading Subgroup 1996). Organic soils were classified using an ecosystem-based approach proposed by L. W. Turchenek, Abboud, and Dowey (1998). According to this approach moderately rich fens as well as bogs occurring in the LSA were classified as wetlands moderately sensitive to acidification.

Based on a similar approach, soils within the LSA were classified into three sensitivity categories according to the chemical properties of their parent material, texture, and organic content. The critical loads recommended for Alberta (Target Loading Subgroup 1996; L. W. Turchenek, Abboud, and Dowey 1998) were used to assess the sensitivity of the LSA soils to acidification.

11.5.2.10 Ecosystems of Conservation Interest

Ecosystems of conservation interest represent rare, threatened, or at-risk component of regional and/or provincial biodiversity. In BC, ecosystems of conservation interest are tracked by the Conservation Data Centre. Rare, threatened, or at-risk ecosystems are listed as red (endangered, extirpated or threatened) or blue (of special concern) depending on the particular threat, population trend, or distribution restriction.

The candidate list of ecosystems was determined through an online search of the BC CDC database, which provides information on rare ecosystems, their known distribution and conservation rank. The resultant list and habitat information was used to inform field data collection, ecosystem mapping, and ultimately to determine the known and predicted type and distribution of red or blue listed ecosystems within the LSA and RSA.

11.5.2.11 Harvestable Plants

Plant and tree species of cultural importance were identified through a review of the Saulteau First Nations Knowledge and Use Study {The Firelight Group, 2014 #884} and the summary notes from a community scoping exercise (held April 16, 2013) undertaken by McLeod Lake Indian Band, Saulteau First Nations, West Moberly First Nations, and a third party consultant hired by the Aboriginal groups. Supplementary information was collected from the Murray River Coal Project: Ethnographic Overview and Traditional Knowledge and Use Desk-Based Research Report (Appendix 17-A), which provides an ethnographic overview and characterizes traditional uses of the local environment by Treaty 8 Nations and other Aboriginal groups near the Project. Ethnographic information from published sources has limitations and will not necessarily reflect the concerns of Aboriginal groups in the vicinity of the Project.

Information on the traditional use of plant resources in the terrestrial ecosystems RSA is derived from ethnographic information documented for each of the following:

- West Moberly First Nations (WMFN);
- Saulteau First Nations (SFN);
- McLeod Lake Indian Band (MLIB);
- Blueberry River First Nations (BRFN);
- Horse Lake First Nation (HLFN); and
- Kelly Lake Aboriginal groups, consisting of the Kelly Lake Cree Nation (KLCN) and the Kelly Lake Metis Settlement Society).

11.5.2.12 Rare Plants and Lichens

Rare plant and lichen surveys were conducted in 2012 to determine the presence of species that are red or blue listed and/or have a conservation-priority S-ranking (subnational, i.e., provincial) conservation ranking; protection under the *Species at Risk Act* (SARA), those ranked as threatened or endangered by COSEWIC or otherwise considered rare (Appendix 11-B).

Surveys were timed to optimize plant identification (e.g., during flowering and/or fruiting). All surveys were conducted by a qualified botanist using a controlled intuitive wander method. Survey efforts focused on sites where proposed infrastructure overlapped with likely rare plant habitat within the Mine Site Assessment Footprint. Presence/absence level surveys were also conducted in conjunction with the field mapping surveys.

11.5.3 Characterization of Terrestrial Ecosystems Baseline Condition within the RSA

The Murray River RSA overlaps nine provincial BEC units (Figure 11.5-2) including six forested units, two parkland units, and one alpine unit (Table 11.5-4). Forested units cover 207,108 ha (92%) of the RSA, and alpine and parkland units cover 20,470 ha (9%). The characteristics of each BEC unit, including descriptions of the regional climate and typical tree species composition (for the forested units) are provided in Appendix 11-B.

Upland soils developed predominantly on loamy morainal material (till), sandy glaciofluvial deposits, variable (but mostly sandy) colluvial material, and coarse to medium-textured fluvial sediments. Chemical characteristics of till usually reflect the chemistry of the rocks from which it originated. Depending on drainage conditions, Brunisols, Podzols, or Gleysols have formed on veneers (or blankets) of morainal till overlaying shale bedrock in the region (Natural Resources Canada 2009). Glaciofluvial and colluvial deposits tend to be permeable, due to their generally coarse texture, and typically give rise to well-drained Brunisols. Fluvial deposits can be also coarse; however, due to their typical location at the bottom of valleys, they are often imperfectly or poorly drained. Consequently, Gleysols frequently develop on fluvial parent materials. In poorly drained areas, vegetation is often dominated by peatlands. The accumulation of organic matter in these ecosystems exceeds decomposition, which leads to the development of organic soils. Where the soils are saturated for only part of the year, organic soils typically grade into mineral Gleysols with only a thin organic veneer on top.

Figure 11.5-2
BEC Units within the Terrestrial Ecology Regional Study Area

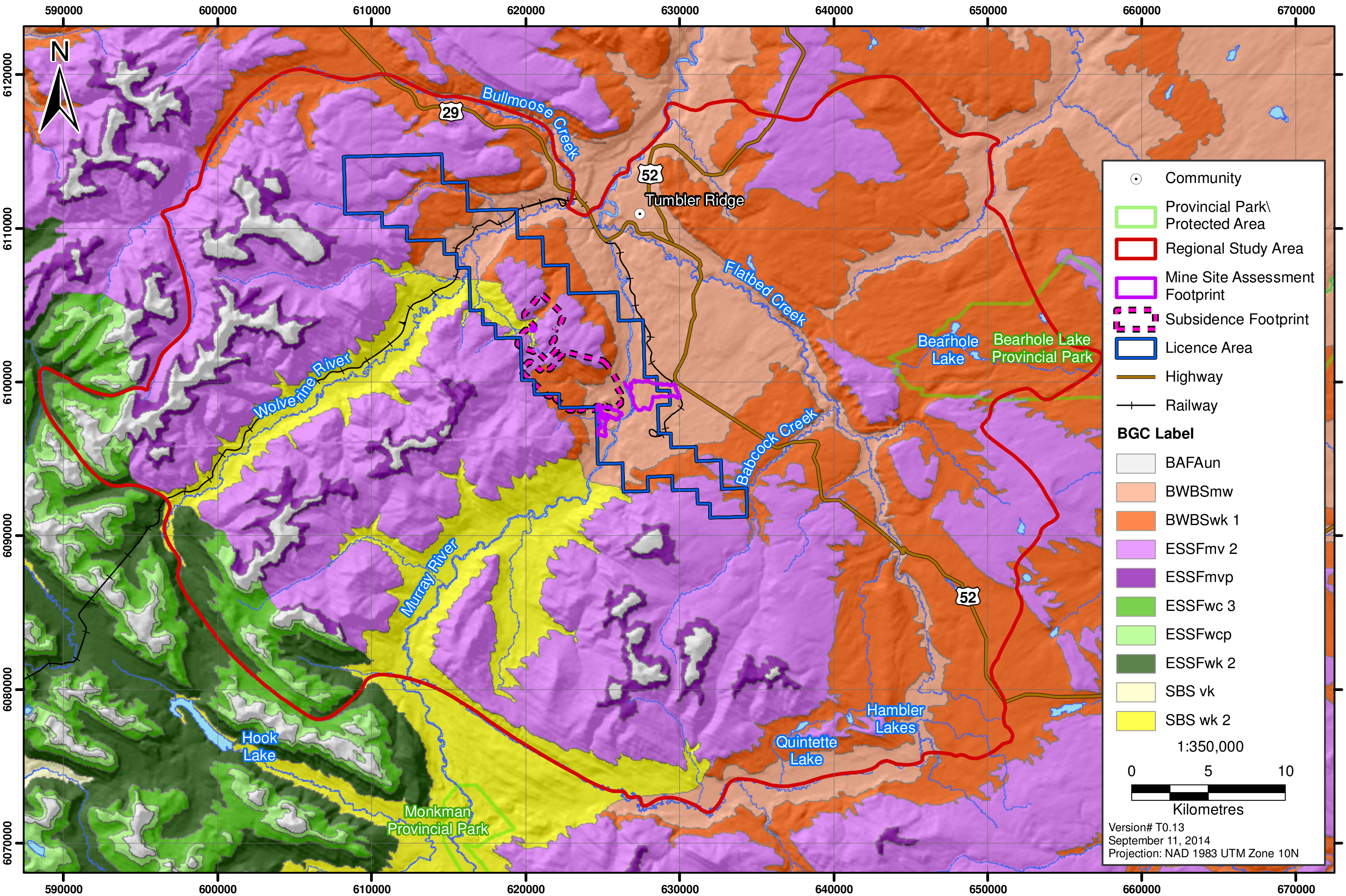


Table 11.5-4. Distribution of BEC units within the Murray River RSA

BEC Unit (Name)	% of RSA	Mapped Elevation	Geographic Range
Forested BEC Units			
ESSFmv2 (Bullmoose Moist Very Cold Engelmann Spruce – Subalpine Fir Variant)	37%	1,000 to 1,400 m	Mapped to the east of the Rocky Mountains, extending as far north as the Peace Arm of the Williston Reservoir (DeLong, Tanner, and Jull 1994).
BWBSwk1 (Murray Wet Cool Boreal White and Black Spruce Variant)	27%	850 to 1,200 m	Mapped along the foothills and on middle to lower slopes of the Rocky Mountains, from where the Rocky Mountains transect the Alberta border to just north of the Peace arm of Williston Lake (DeLong, Tanner, and Jull 1994).
BWBSmw (Moist Warm Boreal White and Black Spruce Subzone)	14%	750 to 1,050 m	Mapped east of the Rocky Mountains, near the Alberta border, at elevations between 750 to 1,050 m (DeLong, Tanner, and Jull 1994).
SBSwk2 (Finlay-Peace Wet Cool Sub-Boreal Spruce Variant)	10%	950 to 1,200 m	Mapped along the Williston Lake reservoir and other major drainages in the Rocky Mountains, from Narraway River in the south to the Peace Arm of Williston Lake, in the north.
ESSFwc3 (Cariboo Wet Cold Engelmann Spruce - Subalpine Fir Variant)	2%	1,300 to 1,500 m	Mapped in northeastern BC, south of the Peace River, within the Misinchinka, Hart and Park Ranges of the Rocky Mountains and the McGregor Plateau.
ESSFwk2 (Misinchinka Wet Cool Engelmann Spruce - Subalpine Fir Variant)	2%	950 to 1,300 m	Mapped to the west of the Rocky Mountain divide as far south as the Morkill River and as far north as the Ospika Arm of Williston Lake.
Parkland BEC Units			
ESSFmvp (Moist Very Cold Engelmann Spruce – Subalpine Fir Parkland)	5%	> 1,400 m	Mapped above the ESSFmv2 and below the BAFAun, where present.
ESSFwcp (Wet Cold Engelmann Spruce - Subalpine Fir Parkland)	<1%	> 1,500 m	Mapped above the ESSFwc3 and below the BAFAun, where present.
Alpine BEC Units			
BAFAun (Undifferentiated Boreal Altai Fescue Alpine)	3%	above ESSFmvp and ESSFwcp	Mapped along much of the lee side of the Coast Mountains and within the northern Rocky, Skeena, Omineca, and Cassiar Mountains (BC MFLNRO 2011).

A total of 113 ecosystems (unique combinations of BEC unit and site series) were mapped in the RSA, including the non-forested and undescribed '00' sites series (Section 4.1.2, Ecological Characteristics of Map Units within the Regional Study Area of Appendix 11-B. To simplify results of ecosystem mapping for reporting purposes, site series were grouped into broad General Ecosystem Types, according to relative moisture status and potential climax structural stage, such as herb, shrub or forest (Table 11.5-5). Forested ecosystems occur on greater than 80% of the RSA, and Mesic, Slightly Dry to Moist, and Moist Forests were the most common.

Table 11.5-5. Summary of Ecosystem Types Mapped within the RSA

BEC	EcoUnit	Structural Stage	GenEcoType	Area (ha)
BAFAun	BA	1	Barren	3,902.6
	FM	2	Moist to Wet Herb	322.7
	HE	2	Dry to Mesic Herb	2,102.0
	KR	3	Dry to Mesic Forest	490.0
	LA	0	Water	4.7
	WE	2	Wetland	0.3
BWBSmw	101	2	Mesic Forest	2,596.0
		3		2,074.7
		4		353.5
		5		419.5
		6		2,956.6
		7		3,626.4
	101$	2	Mesic Forest	97.7
		3		93.0
		4		3.1
		5		504.8
		6		939.0
		7		1,080.2
	102	2	Moderately Dry Forest	22.2
		3		25.8
		4		29.2
		5		25.5
		6		310.2
		7		359.2
	102$	2	Moderately Dry Forest	15.1
		3		11.5
		4		3.1
		5		24.1
		6		140.8
		7		111.1
	103	2	Moderately Dry Forest	275.9
		3		511.2
		4		67.6
		5		103.8
		6		887.7
		7		747.8

(continued)

Table 11.5-5. Summary of Ecosystem Types Mapped within the RSA (continued)

BEC	EcoUnit	Structural Stage	GenEcoType	Area (ha)
BWBSmw *(cont'd)*	103$	2	Moderately Dry Forest	28.4
		3		35.9
		4		0.4
		5		157.3
		6		372.2
		7		326.1
	103$/102$	2	Moderately Dry Forest	7.8
		3		5.9
		4		0.6
		5		16.7
		6		107.8
		7		64.4
	103/102	2	Moderately Dry Forest	146.0
		3		112.0
		4		16.5
		5		17.7
		6		310.9
		7		258.8
	104	2	Slightly Dry to Moist Forest	76.1
		2		188.5
		3		248.4
		4		36.5
		5		25.3
		6		458.5
		7		511.3
	104$	2	Slightly Dry to Moist Forest	9.0
		3		3.0
		4		0.6
		5		38.4
		6		111.0
		7		98.9
	110	2	Moist Forest	61.3
		3		72.7
		4		22.5
		5		16.3
		6		161.6
		7		196.3

(continued)

Table 11.5-5. Summary of Ecosystem Types Mapped within the RSA (continued)

BEC	EcoUnit	Structural Stage	GenEcoType	Area (ha)
BWBSmw *(cont'd)*	110$	2	Moist Forest	3.8
		3		5.5
		4		0.1
		5		25.1
		6		47.1
		7		56.4
	111	2	Moist Forest	307.7
		3		418.8
		4		71.8
		5		76.7
		6		751.1
		7		1,039.2
	111$	2	Moist Forest	5.9
		3		9.2
		4		0.1
		5		26.8
		6		82.0
		7		73.6
	111$/112	2	Moist Forest/Mid Bench Floodplain	30.1
		3		20.9
		4		3.8
		5		56.4
		6		244.0
		7		235.2
	BA	1	Barren	2,437.8
	LA	0	Water	65.3
	MA	2	Wetland	331.4
	RI	0	Water	855.8
	SA	2	Wetland	116.9
		3		623.1
	WA	0	Water	30.9
	WB	2	Wetland	1.9
		3		181.9
		4		8.7
		5		10.3
		6		189.9
		7		353.5

(continued)

Table 11.5-5. Summary of Ecosystem Types Mapped within the RSA (continued)

BEC	EcoUnit	Structural Stage	GenEcoType	Area (ha)
BWBSmw *(cont'd)*	WE	2	Wetland	99.5
		3		377.8
	WF	2	Wetland	44.2
	WH	2	Wetland	0.4
BWBSwk1	101	2	Mesic Forest	1,576.4
		3		4,264.8
		4		105.3
		5		1,331.8
		6		8,182.8
		7		6,540.9
	101$	2	Mesic Forest	154.6
		3		143.1
		4		1,554.0
		5		1,288.0
		6		1,749.6
		7		985.8
	102	2	Moderately Dry Forest	226.5
		3		394.5
		4		17.5
		5		87.5
		6		1,046.1
		7		785.2
	102$	2	Moderately Dry Forest	19.9
		3		13.4
		4		191.4
		5		82.0
		6		191.9
		7		65.5
	103	2	Moderately Dry Forest	0.6
		3		147.4
		4		0.9
		5		37.5
		6		92.0
		7		85.1
	103$	2	Moderately Dry Forest	2.4
		3		0.1
		4		9.4

(continued)

Table 11.5-5. Summary of Ecosystem Types Mapped within the RSA (continued)

BEC	EcoUnit	Structural Stage	GenEcoType	Area (ha)
BWBSwk1 *(cont'd)*	103$ *(cont'd)*	5	Moderately Dry Forest	50.4
		6		41.3
		7		25.6
	104	2	Slightly Dry to Moist Forest	961.3
		3		1,631.6
		4		75.9
		5		425.6
		6		4,875.7
		7		4,410.3
	104$	2	Slightly Dry to Moist Forest	72.3
		3		56.9
		4		986.8
		5		344.9
		6		860.8
		7		332.7
	110$	2	Moist Forest	27.0
		3		27.8
		4		207.5
		5		198.6
		6		434.8
		7		230.2
	110/111	2	Moist Forest	453.6
		3		961.0
		4		22.6
		5		250.4
		6		2,081.6
		7		1,776.8
	BA	1	Barren	1,363.1
	LA	0	Water	494.0
	MA	2	Wetland	233.7
	RI	0	Water	76.1
	SA	2	Wetland	64.4
		3		1,149.0
	WA	0	Water	16.2
	WB	3	Wetland	258.2
		6		0.0

(continued)

Table 11.5-5. Summary of Ecosystem Types Mapped within the RSA (continued)

BEC	EcoUnit	Structural Stage	GenEcoType	Area (ha)
BWBSwk1 *(cont'd)*	WE	2	Wetland	201.2
		3		843.6
	WS	2	Wetland	5.1
		3		331.1
		4		137.7
		5		85.4
		6		1,227.0
		7		1,203.5
ESSFmv2	01	2	Mesic Forest	2,955.6
		3		12,373.5
		4		159.3
		5		7,164.4
		6		14,600.0
		7		1,491.4
	01/03/04	2	Slightly Dry to Moist Forest	677.7
		3		1,497.2
		4		23.3
		5		1,973.1
		6		6,640.0
		7		253.5
	02	2	Moderately Dry Forest	439.5
		3		1,126.0
		4		7.1
		5		688.1
		6		1,509.5
		7		97.9
	03	2	Slightly Dry to Moist Forest	283.6
		3		789.5
		4		111.2
		5		706.8
		6		4,710.0
		7		38.3
	04	2	Mesic Forest	112.0
		3		508.8
		4		31.1
		5		297.8

(continued)

Table 11.5-5. Summary of Ecosystem Types Mapped within the RSA (continued)

BEC	EcoUnit	Structural Stage	GenEcoType	Area (ha)
ESSFmv2 *(cont'd)*	04 *(cont'd)*	6	Mesic Forest	1,282.2
		7		26.3
	05	2	Moist Forest	832.6
		3		3,322.3
		4		69.5
		5		1,674.4
		6		7,435.0
		7		353.7
	06	2	Wet Forest	196.8
		3		864.9
		4		21.6
		5		365.0
		6		1,685.1
		7		131.8
	BA	1	Barren	4,381.6
	LA	0	Water	71.5
	MA	2	Wetland	68.4
	RI	0	Water	11.2
	SA	2	Wetland	24.5
		3		286.4
	WB	1	Wetland	13.6
		2		32.1
		3		85.9
		4		12.3
		5		33.4
		6		364.9
		7		0.1
	WE	2	Wetland	48.0
		3		139.4
	WH	2	Wetland	0.1
	WS	3	Wetland	1.3
ESSFmvp	BA	1	Barren	2,545.5
	BC	2	Dry to Mesic Forest	11.1
		3		317.6
		3		2,903.4
		4		1.0
		5		362.3

(continued)

Table 11.5-5. Summary of Ecosystem Types Mapped within the RSA (continued)

BEC	EcoUnit	Structural Stage	GenEcoType	Area (ha)
ESSFmvp *(cont'd)*	BC *(cont'd)*	6	Dry to Mesic Forest	1,476.8
		7		408.4
	BV	2	Wet Forest	0.8
		3		753.4
		3		79.5
		4		0.0
		5		74.7
		6		287.2
		7		53.5
	FM	2	Moist to Wet Herb	378.1
	HE	2	Dry to Mesic Herb	2,311.9
	LA	0	Water	7.6
	MA	2	Wetland	3.9
	SA	2	Wetland	0.1
		3		0.4
	WA	0	Water	12.0
	WE	2	Wetland	4.7
		3		1.0
ESSFwc3	01	2	Mesic Forest	57.6
		3		478.4
		5		3.0
		6		1,180.7
		7		281.7
	02	2	Moderately Dry Forest	0.1
		3		85.1
		5		1.2
		6		312.1
		7		75.0
	03	2	Moist Forest	72.4
		3		417.1
		6		344.5
	BA	1	Barren	108.6
	LA	0	Water	1.5
	WE	2	Wetland	0.4
		3		32.5
ESSFwcp	BA	1	Barren	258.0

(continued)

Table 11.5-5. Summary of Ecosystem Types Mapped within the RSA (continued)

BEC	EcoUnit	Structural Stage	GenEcoType	Area (ha)
ESSFwcp *(cont'd)*	BC	3	Dry to Mesic Forest	32.1
		3		495.8
		5		2.4
		6		288.2
		7		124.3
	BV	3	Wet Forest	92.0
		3		0.4
		5		0.2
		6		23.3
		7		18.1
	FM	2	Moist to Wet Herb	74.4
	HE	2	Dry to Mesic Herb	239.7
	LA	0	Water	1.2
	WE	2	Wetland	0.8
		3		0.9
ESSFwk2	01/03	2	Mesic Forest	148.4
		3		252.1
		5		18.6
		6		833.2
		7		799.6
	02	2	Moderately Dry Forest	3.9
		3		8.6
		5		0.3
		6		34.0
		7		27.6
	04	2	Moist Forest	53.7
		3		74.3
		5		5.3
		6		189.4
		7		155.0
	05	2	Moist Forest	110.2
		3		118.6
		5		7.5
		6		188.9
		7		138.8
	06	2	Wet Forest	13.0
		3		59.1

(continued)

Table 11.5-5. Summary of Ecosystem Types Mapped within the RSA (continued)

BEC	EcoUnit	Structural Stage	GenEcoType	Area (ha)
ESSFwk2 *(cont'd)*	06 *(cont'd)*	5	Wet Forest	3.2
		6		98.7
		7		96.4
	BA	1	Barren	144.4
	LA	0	Water	0.1
	WE	2	Wetland	4.6
		3		3.2
SBSwk2	01	2	Mesic Forest	1,331.8
		3		1,283.6
		4		121.6
		5		1,831.3
		6		2,783.3
		7		170.4
	02	2	Moderately Dry Forest	85.6
		3		92.7
		4		7.9
		5		112.8
		6		145.8
		7		13.7
	03	2	Moderately Dry Forest	801.5
		3		932.3
		4		100.8
		5		1,298.8
		6		2,060.4
		7		133.4
	04	2	Slightly Dry to Moist Forest	129.2
		3		210.7
		4		18.2
		5		240.1
		6		610.7
		7		13.1
	05	2	Moist Forest	727.3
		3		814.4
		4		59.1
		5		821.8
		6		1,516.9
		7		101.7

(continued)

Table 11.5-5. Summary of Ecosystem Types Mapped within the RSA (completed)

BEC	EcoUnit	Structural Stage	GenEcoType	Area (ha)
SBSwk2	06	2	Wetland	6.0
		3		0.1
		4		4.5
		5		41.8
		6		103.9
		7		2.0
	07	2	Wetland	2.5
		4		8.7
		5		44.3
		6		62.6
		7		2.0
	BA	1	Barren	1,852.5
	LA	0	Water	43.8
	MA	2	Wetland	31.0
	RI	0	Water	473.1
	SA	2	Wetland	23.3
		3		96.2
	WA	0	Water	14.5
	WE	2	Wetland	70.0
		3		161.8
	WH	2	Wetland	92.4
	WS	3	Wetland	276.5

Note:
Structural stages: 1 = sparse/bryoid; 2 = herb; 3 = shrub; 4 = pole/sapling; 5 = young forest; 6 = mature forest; 7 = old forest

Forested ecosystems (structural stages 4 through 7) occur on nearly 60% of the RSA, dominated largely by mature forests (structural stage 6), which comprise 35% of the RSA. Shrub- and herb-dominated ecosystems (structural stages 2 and 3, respectively) comprise 31% of the RSA, and sparsely vegetated/bryoid-dominated ecosystems (structural stage 1); comprise nearly 8% of the RSA. The remainder (approximately 2%) of the RSA is covered by non-vegetated ecosystems.

11.5.4 Characterization of Terrestrial Ecosystems Baseline Condition within the LSA

The following sections characterize the baseline conditions for soils, ecosystems and vegetation within the LSA.

11.5.4.1 Local Surficial Materials and Soils

Due to considerable mining activity locally, a relatively large proportion of the terrain in the LSA has been modified by people. Anthropogenic materials, typically associated with mining activity or gravel extraction, have a wide range of physical properties (e.g., terrain morphology, structure, and texture). Many areas have compacted surficial layers. Typical surficial material texture varies between silt loams and clay loams, and coarse fragment content varies between 0 and 75%. Coarse fragments usually consist of gravels and cobbles that are rounded (e.g., near gravel pits) or angular (e.g., near waste rock disposal sites). Rapid mass movement and the evidence of localized erosion were occasionally recorded on steeper slopes. Anthropogenic materials (SMU-A) cover almost 12% of the LSA (Table 11.5-6).

Table 11.5-6. Proportional Distribution of Soil Parent Materials in the Local Study Area

Parent Materials / Terrain Types	Area (ha)	Proportion of LSA
Anthropogenic	1,747	11.8
Colluvial	2,096	14.1
Fluvial	985	6.6
Glaciofluvial	1,180	7.9
Morainal	8,177	55.1
Organic	416	2.8
Open Water	203	1.4
Bedrock	47	0.3
Total	**14,853**	**100.0**

Note:
One organic and one fluvial soil unit were grouped together with Organic veneers due to similarity of their soil properties.

Surficial materials found in the LSA were classified into eight groups listed in Table 11.5-7. When predominant soil parent material, site moisture regime, and soil order were considered, 67 soil types were identified in the LSA. Soils characterized by similar properties were grouped into 15 mapping units.

Colluvial Surficial Materials

About 14% of the LSA has been mapped as colluvial terrain. Colluvial materials are the products of mass-wasting, typically occurring on moderate to steep slopes. They are generally poorly sorted and contain a wide range of particle sizes. Colluvial soils were subdivided into two soil mapping units: the SMU-C1, and the SMU-C2, which respectively cover about 90% and 10% of the colluvial deposits in the LSA.

The SMU-C1 represents non-stratified, non-compacted colluvial veneers covering morainal or glaciofluvial materials deposited on moderate to steep slopes and in higher elevations. Coarse fragments consist mainly of sub-angular to angular gravels (1 to 60%) and up to 20% cobbles. The combination of high slope gradients and moderately fine soil textures (e.g., clay loams) results in high erodibility of these materials. The SMU-C1 soils frequently display evidence of significant water erosion (i.e., gullies) and slow or rapid mass movement. Most soils (over 90%) were classified as Brunisols (of which about 5% are lithic), with pockets of Brunisolic Gray Luvisols, Orthic Humo-ferric Podzols, and Regosols.

Table 11.5-7. Proportional Distribution of Soil Mapping Units and their Ecological Value Rating in the Local Study Area

Parent Materials	Soil Mapping Units	Area (ha)	Proportion of LSA (%)	Proportion of SMU (%)	Soil Ecological Value Rating
Anthropogenic		**1,747**	**11.76%**		
	SMU-A	*1,747*	*11.76%*	*100%*	
	An_n	1,747	11.76%	100%	4
Colluvial		**2,096**	**14.11%**		
	SMU-C1	*1,906*	*12.83%*	*100%*	
	C2_B	244	1.65%	12.8%	2
	C2_R	1	0.01%	0.1%	3
	C3_B	344	2.32%	18.1%	2
	C3_B.lit	61	0.41%	3.2%	3
	C4_B	1,167	7.86%	61.3%	2
	C4_B.lit	2	0.02%	0.1%	3
	C4_BR.GL	57	0.38%	3.0%	2
	C4_O.HFP	4	0.02%	0.2%	2
	C4_R	24	0.16%	1.3%	3
	SMU-C2	*191*	*1.28%*	*100%*	
	C5_B.g	167	1.12%	87.4%	2
	C5_BR.GL.g	21	0.14%	11.0%	2
	C6_G	3	0.02%	1.7%	2
Fluvial		**985**	**6.63%**		
	SMU-F1	*479*	*3.22%*	*100%*	
	F2_B	2	0.02%	0.5%	2
	F2_CU.R	5	0.03%	1.0%	3
	F3_B	25	0.17%	5.2%	2
	F3_CU.R	182	1.22%	38.0%	3
	F4_B	110	0.74%	22.9%	2
	F4_CU.R	90	0.61%	18.8%	3
	F4_GLCU. R.	65	0.44%	13.6%	3
	SMU-F2	*506*	*3.41%*	*100%*	
	F5_B.g	80	0.54%	15.8%	2
	F5_G	7	0.05%	1.4%	2
	F5_GLCU. R.	8	0.06%	1.6%	3
	F5_n	2	0.01%	0.4%	4
	F5_R.g	9	0.06%	1.7%	3
	F6_G	94	0.63%	18.5%	2
	F6_G.p	138	0.93%	27.3%	1.1
	F6_G.r	13	0.09%	2.5%	3
	F6_GLCU. R.	155	1.04%	30.6%	3

(continued)

Table 11.5-7. Proportional Distribution of Soil Mapping Units and their Ecological Value Rating in the Local Study Area (continued)

Parent Materials	Soil Mapping Units	Area (ha)	Proportion of LSA (%)	Proportion of SMU (%)	Soil Ecological Value Rating
Glaciofluvial		**1,180**	**7.95%**		
	SMU-FG1	*473*	*3.19%*	*100%*	
	FG2_B	146	0.98%	30.8%	2
	FG2_BR.GL	6	0.04%	1.2%	1
	FG3_B	73	0.49%	15.5%	2
	FG3_BR.GL	44	0.29%	9.2%	1
	FG4_B	205	1.38%	43.3%	2
	SMU-FG2	*652*	*4.39%*	*100%*	
	FG|M3_B	51	0.34%	7.8%	2
	FG|M3_BR.GL	104	0.70%	15.9%	1
	FG|M4_B	449	3.03%	68.9%	2
	FG|M4_BR.GL	48	0.32%	7.3%	1
	SMU-FG3	*55*	*0.37%*	*100%*	
	FG5_B.g	3	0.02%	5.5%	2
	FG5_BR.GL.g	35	0.23%	63.8%	1
	FG6_G	2	0.01%	2.8%	2
	FG|M5_B.g	11	0.07%	19.7%	2
	FG|M5_BR.GL.g	2	0.01%	4.1%	1
	FG|M6_G	2	0.01%	4.1%	2
Morainal		**8,177**	**55.05%**		
	SMU-M1	*2,999*	*20.19%*	*100%*	
	M2_B	86	0.58%	2.9%	1
	M2_CU.R	5	0.03%	0.2%	3
	M3_B	208	1.40%	6.9%	1
	M3_B.lit	54	0.36%	1.8%	3
	M4_B	2,149	14.47%	71.7%	1
	M4_B.lit	497	3.35%	16.6%	3
	SMU-M2	*3,449*	*23.22%*	*100%*	
	M2_BR.GL	70	0.47%	2.0%	1
	M3_BR.GL	358	2.41%	10.4%	1
	M4_BR.GL	3,021	20.34%	87.6%	1
	SMU-M3	*1,729*	*11.64%*	*100%*	
	M5_B.g	395	2.66%	22.8%	1
	M5_BR.GL.g	1,034	6.96%	59.8%	1
	M6_G	300	2.02%	17.3%	2

(continued)

Table 11.5-7. Proportional Distribution of Soil Mapping Units and their Ecological Value Rating in the Local Study Area (completed)

Parent Materials	Soil Mapping Units	Area (ha)	Proportion of LSA (%)	Proportion of SMU (%)	Soil Ecological Value Rating
Organic		**416**	**2.80%**		
	SMU-O1	*195*	*1.31%*	*100%*	
	O7_M	179	1.20%	91.7%	1.1
	O7_M.t	16	0.11%	8.3%	1.1
	SMU-O2	*221*	*1.49%*	*100%*	
	O|M5_B.g	64	0.43%	29.0%	1.1
	O|M6_G.p	102	0.69%	46.3%	1.1
	O5_G.p	13	0.09%	6.1%	1.1
	F7_G.p	41	0.28%	18.6%	1.1
Bedrock		**47**	**0.32%**		
	SMU-R	*47*	*0.32%*	*100%*	
	R0_n	8	0.05%	17.3%	4
	R2_B.lit	23	0.15%	48.6%	4
	R3_B.lit	3	0.02%	6.9%	4
	R3_R.lit	13	0.09%	27.3%	4
Open Water		**203**	**1.37%**		
	OW	*203*	*1.37%*	*100%*	
	OW99_n	203	1.37%	100%	not rated
Grand Total		**14,853**	**100.00%**		

The SMU-C2 represents moister soils (subhygric and hygric) found in ravines and on terrace slopes at lower elevations. Most soils were classified as gleyed Brunisols with pockets of gleyed Brunisolic Gray Luvisols and Gleysols.

<u>Fluvial Surficial Materials</u>

Fluvial deposits dominate the relatively flat areas located at the bottom of the Murray River valley (about 7% of the LSA). The textures are often sandy or loamy. In the areas where streams are generally slow or on level floodplains at the bottom of the valley, fluvial materials contain a significant fraction of silt and clay. Fluvial deposits are generally well-sorted and display stratification with a high proportion of rounded gravels and cobbles. Fluvial soils were divided into two mapping units: xeric to mesic SMU-F1 and subhygric to hygric SMU-F2.

SMU-F1 consists of coarse, rapidly to moderately well drained materials typically deposited on terraces and fluvial fans. The typical soils include Cumulic Regosols and Brunisols. SMU-F2 consists of moderately well to poorly drained and often finer deposits. They are typically found in the flood plains and fluvial fans of the Murray River and its tributaries. Characteristic soils include gleyed Cumulic Regosols, Gleysols, often covered by thin peaty veneers, and gleyed Brunisols.

Glaciofluvial Surficial Materials

Comprising 8% of the LSA, glaciofluvial materials have been deposited as blankets or veneers on both sides of the Murray River valley. They mainly consist of sandy and silty materials with a considerable component of rounded or sub-rounded coarse fragments. These well-sorted, often stratified, coarse materials have been subdivided into two groups consisting of blankets and veneers and a relatively small third group consisting of wetter (subhygric and hygric) glaciofluvial deposits of variable thickness.

SMU-FG1 consists of mesic or drier Glaciofluvial blankets. These sediments are found mostly on the west side of Murray River, in slightly higher elevations and on steeper slopes than SMU-FG2. The soils are typically well-drained. Evidence of slow mass movement and occasionally gullying has been recorded in these units. The typical soils include coarse, well-drained Eluviated Eutric Brunisols, with pockets of Brunisolic Gray Luvisols.

SMU-FG2 represents mesic or submesic glaciofluvial veneers deposited over gentle morainal slopes. These units are typically found on the eastern side of Murray River. They are characterized by relatively high coarse fragment content (average 48%). The soils of this unit are shallower compared to SMU-FG1, and their profiles typically feature a clear boundary between the coarser surficial horizons and the finer, more compacted, morainal horizons. The typical soils include coarse, well- to moderately well-drained Eluviated Eutric Brunisols and Brunisolic Gray Luvisols.

SMU-FG3 consists of soils that developed in lower slope seepage zones under subhygric and hygric conditions. Typical soils include gleyed Brunisolic Gray Luvisols, gleyed Brunisols, and pockets of Gleysols.

Morainal Surficial Materials

Morainal till generally consists of well-compacted, non-stratified material composed of a mixture of sand, silt, and clay. It contains a heterogeneous mixture of sub-rounded to angular coarse fragments of different sizes. More than half of the surficial materials (55%) found in the LSA are morainal tills. Morainal deposits are typically found on gentle to moderate slopes on both sides of the Murray River valley. Three soil units have been differentiated within this group: SMU-M1, SMU-M2, and SMU-M3.

SMU-M1 represents morainal mantles typically covering steeper sections of middle and upper slopes. Soils contain a considerable proportion of angular coarse fragments. Soil textures vary widely (sandy to clayey), but most typically include clay loams and silty clay loams. While slow mass movement has been occasionally recorded, this soil unit typically does not display evidence of significant erosion. The typical soils are mesic and include well-drained, eluviated Brunisols, of which almost 20% (often found at higher elevations on moderately gentle slopes) are shallow (lithic).

SMU-M2 units are found on gentler slopes. Typical soils have a silty clay or clay loam texture and are slightly deeper and are better developed than those found in SMU-M1. They contain moderate amounts of sub-angular to angular gravels and cobbles. SMU-M2 soils are classified as Brunisolic Gray Luvisols.

SMU-M3 units have typical characteristics of morainal soils, but are found on gentle slopes often associated with seepage. The typical soils include imperfectly to poorly drained gleyed Brunisolic Gray Luvisols, gleyed Brunisols and Humic Gleysols. No evidence of significant erosion was recorded in this soil unit.

Organic Surficial Materials

Organic materials are not common, occurring in less than 3% of the LSA, typically in the wet lowlands and in areas of intense seepage. Most form as a result of accumulation of very slowly decomposing vegetation on the surface of wet mineral deposits. These materials do not display evidence of significant erosion.

The organic soil mapping unit SMU-O1 represents blankets and more than 40 cm thick veneers of poorly or moderately decomposed peat that typically develop in lower slopes or toe positions. Generally the SMU-O1 is associated with bog and some fen ecosystems. The typical soils are deep and include very poorly drained Typic, Humic, or Terric Mesisols.

SMU-O2 is associated with wet forests or marshes distributed in small pockets throughout the LSA. Most are subhygric to hygric sites characterized by thin organic veneers over fine mineral deposits, but some hydric fluvial deposits are included into this unit due to similarity of soils. Typical soils include poorly drained peaty Gleysols but about one-third are gleyed Brunisols.

Bedrock

Bedrock-dominated terrain is 0.3% of the LSA and occurs as rocky outcrops and cliffs along the mountain ridge located on the eastern side of the river valley. Most SMU-R soils were classified as poorly developed, shallow (lithic) Brunisols. About one-fifth of that unit was classified as non-soils. Most bedrock areas found on the western side of the valley were altered by past mining activity and were classified as anthropogenic material.

11.5.4.2 Baseline Metal Characterization

Soil samples collected from the LSA were analyzed for soil reaction (pH), total organic carbon, and metal concentration. The well-drained soils in the LSA generally become less acidic with depth as a result of transfer of humic acids from organic layer into the surficial layers of mineral profile and ensuing eluviation of base cations to deeper horizons. The predominance of conifers in the forest canopy and generally cold climatic conditions slow down the organic matter turnover and are the most likely reason for the low organic carbon content of some of the mineral soils occurring within the LSA.

Soils within the LSA were classified into three acidification sensitivity categories according to the chemical properties of their parent material, texture, and organic content. The critical loads recommended for Alberta (Target Loading Subgroup 1996; L. W. Turchenek, Abboud, and Dowey 1998) were used to quantify the sensitivity of the LSA soils to acidification. Table 11.5-8 shows the total areas of each of the sensitivity classes.

Table 11.5-8. Classification of Soil Sensitivity to Acid Deposition in the LSA

Soil Sensitivity Class	Area (ha)	% of LSA
Low sensitivity (critical load 1,000 eq/ha/y)	7,511.7	51%
Moderately sensitive (critical load 500 eq/ha/y)	4,383.5	30%
Sensitive (critical load 250 eq/ha/y)	1,006.7	7%
Not rated (Anthropogenic)	1,747.2	12%
Not rated (Open Water)	203.5	1%
Total	**14,852.5**	**100%**

Metal concentrations of soil samples in the LSA varied substantially between sampling locations, which is not unusual, especially when soils develop on a number of different surficial materials. The concentrations of metals in the mineral soil have been compared to the BC Contaminated Sites Regulation Soil Criteria (375/96 2011) and to the Canadian Soil Quality Guidelines for Protection of Environmental and Human Health (CCME 2012). Elevated levels of arsenic, barium, cadmium, molybdenum, selenium, and tin, have been recorded in soil samples collected at 14 locations within the LSA (Table 11.5-9). Metal concentrations typically increased with soil depth, however, at sites where CCMA and/or BC CSR guidelines were exceeded, the highest concentrations were typically found in surficial horizons. Detailed information regarding metal concentrations recorded in the LSA soils is provided in Appendices 11-A and 11-C.

Table 11.5-9. Sampling Sites within the LSA where Soil Metal Concentrations Exceeded Regulatory Guidelines

Metal	Percent of Inspected Sites	Number of Sites	Inspection Point IDs	Guidelines Exceeded
Arsenic	2.7	2	NW-1, 413	CCME-A, CCME-I
Barium	9.5	7	NW-1, NW-3, W-2, 23, 34, 39, 54	CSR-L and I, CCME-A and I
Cadmium	10.8	8	NW-2, W-2, 16, 23, 45, 54, 88, 328	CCME-A
Molybdenum	1.4	1	54	CSR-L, CCME-A
Selenium	6.8	5	NW-1, 40, 45, 54, 328	CCME-A
Tin	1.4	1	88	CSR-L, CCME-A
Zinc	1.4	1	23	CSR-L, CCME-A

Notes:
CCME-A = CCME Canadian Soil Quality Guidelines for Protection for Environmental and Human Health, Agricultural Limits
CCME-I = CCME Canadian Soil Quality Guidelines for Protection for Environmental and Human Health, Industrial Limits
CSR-L = Contaminated Site Regulation (BC Reg. 375/96), Livestock Criteria
CSR-I = Contaminated Site Regulation (BC Reg. 375/96), Industrial Criteria

Elevated concentrations of arsenic, nickel and selenium exceeding the Soil Quality Guidelines for the Protection of Environment and Human Health (CCME 2012) were found in soil samples collected in the ravines and in the seepage areas along the embankments of the Quintette tailing storage area located directly east of the proposed Coarse Coal Rejects area. Concentrations of metals such as barium, cadmium, cobalt, lead, mercury, selenium, and zinc found in the soil samples collected in the ravine and seepage areas were significantly ($p < 0.05$) higher comparing to those found in the samples collected outside of the ravines.

A general trend of higher metal levels was observed in vegetation sampled in the north-western section of the LSA. A similar trend was also observed in soils (Appendix 11-A). A relatively high correlation between the concentrations of some metals found in soil and lichen tissue suggests that metals may be distributed in some areas either by air (e.g., in form of dust) or by runoff.

Vegetation tissues sampled included lichens, shrub leaves, berries, and wetland sedges. In the lichens and leaf tissues, besides the main macronutrients, aluminium and iron concentrations were typically high. In wetland vegetation, the elements calcium and magnesium attained the highest concentrations. Concentrations of certain metals in vegetation tissues were routinely below detection limits (e.g., antimony, beryllium, bismuth, lithium, selenium, silver, thallium, tin, and uranium).

11.5.4.3 Ecosystem Baseline within the Local Study Area

The ecosystems that have developed on this landscape within the LSA have done so in response to varied and complex interactions between geology, glacial history, climate, as well human interactions. To a great extent, the Murray River has dictated the development of ecologies along the valley floor, with wetlands and floodplains displaying structures related to flood extent an interval. Mid valley ecosystems are expressed as forests in various stages of maturity and complexity, with the ecological characteristics influenced greatly by soil moisture, soil nutrients, fire, insects and disease, and forest harvesting. As a result, a mosaic of stand ages and structures is easily discernable across the landscape.

Valleys in the LSA are similar to those in the RSA. They are generally wide and often deeply incised by rivers and streams (e.g., the Murray River, Wolverine River and Flatbed Creek). Floodplain forests dominate the banks of larger rivers and streams in the LSA. A variety of ecosystems occupy the hilly landscapes, including moderately dry forests, moist forests, and slightly dry to moist forests (Table 11.5-10). Only a small proportion of the LSA consists of irregularly shaped, steeper landscapes such as ridges and hummocks, which also contain many of the drier ecosystem types (barren and moderately dry forest). In contrast, most of the dry ecosystem (barren, dry to mesic forest, dry to mesic herb and dry to mesic shrub) within the RSA occur at higher elevation within the alpine and subalpine areas (BAFA and ESSFwvp).

Table 11.5-10. Summary of Ecosystem Types and Structural Stages Mapped within the LSA

BEC	Ecosystem Unit	Structural Stage	Name	General Ecosystem Type	LSA (ha)
BWBSmw	101	1	Sw – Trailing raspberry – Step moss	Mesic Forest	5
		2a			30
		2b			18
		3a			448
		3b			122
		4			73
		5			533
		6			611
		7			7

(continued)

Table 11.5-10. Summary of Ecosystem Types and Structural Stages Mapped within the LSA (continued)

BEC	Ecosystem Unit	Structural Stage	Name	General Ecosystem Type	LSA (ha)
BWBSmw *(cont'd)*	101$	3a	At – Rose – Creamy peavine	Mesic Forest	7
		3b			22
		4			94
		5			110
		6			44
	102	3a	Pl – Kinnikinnick – Lingonberry	Moderately Dry Forest	8
		3b			19
		4			43
		5			127
	102$	5	At – Soopolallie – Kinnikinnick	Moderately Dry Forest	7
	103	2a	SwPl – Soopolallie – Fuzzy-spiked wildrye	Moderately Dry Forest	32
		3a			222
		3b			27
		4			158
		5			279
		6			101
	103$	3b	At – Rose – Fuzzy-spiked wildrye	Moderately Dry Forest	9
		4			48
		5			20
		6			34
	104	3a	Sb – Labrador tea – Step moss	Slightly Dry to Moist Forest	90
		3b			12
		4			138
		5			140
		6			489
		7			18
	104$	4	At – Labrador tea – Lingonberry	Slightly Dry to Moist Forest	7
		5			13
		6			25
	110	3a	Sw – Oak fern – Sarsaparilla	Moist Forest	45
		3b			10
		4			7
		5			123
		6			238
		7			46

(continued)

Table 11.5-10. Summary of Ecosystem Types and Structural Stages Mapped within the LSA (continued)

BEC	Ecosystem Unit	Structural Stage	Name	General Ecosystem Type	LSA (ha)
BWBSmw *(cont'd)*	110$	4	At – Highbush-cranberry – Oak fern	Moist Forest	11
	111	2a	Sw – Currant – Horsetail	Moist Forest	3
		2b			18
		3a			16
		3b			6
		4			9
		5			98
		6			173
		7			32
	111$	3b	Acb – Dogwood – Highbush-cranberry	Moist Forest	2
		5			4
		6			6
	112	3a	AcbSw – Mountain alder – Dogwood	Mid Bench Floodplain	4
		3b			8
		4			0
		5			8
		6			83
		7			46
	CL	-	Cliff	Barren	1
	ES	-	Exposed Soil	Barren	84
	Fl05	3a	Drummond's willow - Bluejoint	Low Bench Floodplain	4
		3b			12
	GP	-	Gravel Pit	Anthropogenically Modified	25
	LA	-	Lake	Water	3
	MI	-	Mine	Anthropogenically Modified	98
	MZ	-	Rubbly Mine Spoils	Anthropogenically Modified	164
	OW	-	Shallow Open Water	Water	29
	PD	-	Pond	Water	44
	RI	-	River	Water	129
	RN	-	Railway Surface	Anthropogenically Modified	13

(continued)

Table 11.5-10. Summary of Ecosystem Types and Structural Stages Mapped within the LSA (continued)

BEC	Ecosystem Unit	Structural Stage	Name	General Ecosystem Type	LSA (ha)
BWBSmw *(cont'd)*	RY	2a 3a 3b	Reclaimed Mine	Anthropogenically Modified	273 30 9
	RZ	- 2 2b 3a	Road Surface	Anthropogenically Modified	399 1 2 2
	TZ	- 3a 4	Mine Tailings	Anthropogenically Modified	282 5 1
	UR	-	Urban/ Suburban	Anthropogenically Modified	111
	Wb	3b 4	Wetland - bog	Wetland Bog	1 3
	Wb04	4	Western hemlock – Cloudberry – Peat-moss	Wetland Bog	10
	Wb06	3a 3b 4 5	Tamarack – Water sedge – Fen moss	Wetland Bog	0 10 125 10
	Wb08	4	Black spruce – Soft-leaved sedge – Peat-moss	Wetland Bog	12
	Wb09	3b 4 5	Black spruce – Common horsetail – Peat-moss	Wetland Bog	0 2 5
	Wf	2b	Wetland - fen	Wetland Fen	3
	Wf04	3a 3b	Barclay's willow – Water sedge – Glow moss	Wetland Fen	7 1
	Wm	2b	Wetland - marsh	Wetland Marsh	4
	Wm01	2b	Beaked sedge – Water sedge	Wetland Marsh	40
	Ws	2b 3 3b 4	Wetland - swamp	Wetland Swamp	1 1 20 4

(continued)

Table 11.5-10. Summary of Ecosystem Types and Structural Stages Mapped within the LSA (continued)

BEC	Ecosystem Unit	Structural Stage	Name	General Ecosystem Type	LSA (ha)
BWBSmw *(cont'd)*	Ws *(cont'd)*	5	Wetland - swamp	Wetland Swamp	1
		6			8
	Ws04	4	Drummond's willow – Beaked sedge	Wetland Swamp	3
	Ws07	3a	Spruce – Common horsetail – Leafy moss	Wetland Swamp	1
		3b			4
		6			11
BWBSwk1	101	2a	SwBl – Huckleberry – Feathermoss	Mesic Forest	5
		3a			292
		3b			66
		4			69
		5			377
		6			897
	101$	4	At – Birch-leaved spirea – Huckleberry	Mesic Forest	36
		5			180
		6			60
	102	3a	Pl – Lingonberry – Reindeer lichen	Moderately Dry Forest	9
		3b			4
		4			5
		5			117
		6			4
	102$	3b	At – Kinnikinnick – Fuzzy-spiked wildrye	Moderately Dry Forest	3
		4			13
	103	3a	SwPl – Soopollalie – Showy aster	Moderately Dry Forest	9
		3b			1
		4			9
		5			144
		6			116
	103$	3b	At – Rose – Fuzzy-spiked wildrye	Moderately Dry Forest	15
		4			50
		5			99
		6			12
	104	2a	Sb – Huckleberry – Lingonberry	Slightly Dry to Moist Forest	1
		3a			48
		3b			48

(continued)

Table 11.5-10. Summary of Ecosystem Types and Structural Stages Mapped within the LSA (continued)

BEC	Ecosystem Unit	Structural Stage	Name	General Ecosystem Type	LSA (ha)
BWBSwk1 *(cont'd)*	104 *(cont'd)*	4 5 6	Sb – Huckleberry – Lingonberry	Slightly Dry to Moist Forest	51 110 82
	104$	5	At – Labrador tea – Lingonberry	Slightly Dry to Moist Forest	16
	110	- 2a 3a 3b 5 6	Sw – Currant – Horsetail	Moist Forest	3 3 61 48 47 628
	110$	3b 5 6	AcbAt – Cow-parsnip	Moist Forest	1 20 15
	110$.2	6	At – Highbush-cranberry – Oak fern	Moist Forest	10
	111	3a 3b 5 6	Sb – Horsetail – Step moss	Moist Forest	1 3 12 24
	ES	- 1	Exposed Soil	Exposed Soil	4 8
	FM	2 2a	Forb Meadow	Dry to Mesic Herb	2 3
	GB	1	Gravel Bar	Anthropogenically Modified	0
	MZ	-	Rubbly Mine Spoils	Anthropogenically Modified	6
	OW	-	Shallow Open Water	Water	4
	PD	-	Pond	Water	13
	RI	-	River	Water	7
	RO	1	Rock Outcrop	Rock Outcrop	0
	RY	2a 3b	Reclaimed Mine	Anthropogenically Modified	75 4
	RZ	-	Road Surface	Anthropogenically Modified	158

(continued)

Table 11.5-10. Summary of Ecosystem Types and Structural Stages Mapped within the LSA (continued)

BEC	Ecosystem Unit	Structural Stage	Name	General Ecosystem Type	LSA (ha)
BWBSwk1 *(cont'd)*	UR	-	Urban/ Suburban	Anthropogenically Modified	0
	Wb05	3b	Black spruce – Water sedge – Peat-moss	Wetland Bog	0
	Wf03	2b	Water sedge – Peat-moss	Wetland Fen	0
	Wf04	3a	Barclay's willow – Water sedge – Glow moss	Wetland Fen	0
	Wm	2b	Wetland - marsh	Wetland Marsh	4
	Ws	-	Wetland - swamp	Wetland Swamp	2
		3b			20
		4			1
		6			7
	Ws07	3a	Spruce – Common horsetail – Leafy moss	Wetland Swamp	1
		3b			3
		5			5
		6			1
ESSFmv2	BT	3a	BlSb - Labrador tea	Slightly Dry to Moist Forest	5
		4			24
		5			184
		6			188
	CL	-	Cliff	Barren	3
	ES	-	Exposed Soil	Exposed Soil	6
		1			5
	FD	3a	Bl – Devil's club - Rhododendron	Moist Forest	3
		3b			17
		5			51
		6			241
	FH	3a	Bl - Alder - Horsetail (Ws08 - Bl - Sitka valerian - Common horsetail)	Wet Forest	24
		3b			15
		5			43
		6			166
	FL	3a	Bl - Lingonberry	Moderately Dry Forest	4
		3b			19
		4			34

(continued)

Table 11.5-10. Summary of Ecosystem Types and Structural Stages Mapped within the LSA (continued)

BEC	Ecosystem Unit	Structural Stage	Name	General Ecosystem Type	LSA (ha)
ESSFmv2 *(cont'd)*	FL *(cont'd)*	5	Bl - Lingonberry	Moderately Dry Forest	127
		6			49
	FM	2a	Forb Meadow	Dry to Mesic Herb	7
	FO	3a	Bl - Oak fern - Knight's plume	Mesic Forest	40
		3b			9
		4			3
		5			32
		6			228
	FR	3a	Bl - Rhododendron - Feathermoss	Mesic Forest	128
		3b			25
		4			51
		5			422
		6			1,036
	GP	2b	Gravel Pit	Anthropogenically Modified	0
	OW	-	Shallow Open Water	Water	1
	PD	-	Pond	Water	5
	RI	-	River	Water	2
	RO	1	Rock Outcrop	Rock Outcrop	3
	RZ	-	Road Surface	Anthropogenically Modified	99
	TA	-	Talus	Barren	8
	UR	-	Urban/ Suburban	Anthropogenically Modified	4
	Wb06	3b	Tamarack – Water sedge – Fen moss	Wetland Bog	12
		4			1
		5			6
	Wf	2b	Wetland - fen	Wetland Fen	5
	Wf04	3b	Barclay's willow – Water sedge – Glow moss	Wetland Fen	3
	Wf06	3b	Slender sedge – Buckbean	Wetland Fen	1
	Wm	3a	Wetland - marsh	Wetland Marsh	1
	Wm01	2b	Beaked sedge – Water sedge	Wetland Marsh	1

(continued)

Table 11.5-10. Summary of Ecosystem Types and Structural Stages Mapped within the LSA (completed)

BEC	Ecosystem Unit	Structural Stage	Name	General Ecosystem Type	LSA (ha)
ESSFmv2 *(cont'd)*	Ws	3a 3b 5 6	Wetland - swamp	Wetland Swamp	0 24 0 1
	Ws04	3b	Drummond's willow – Beaked sedge	Wetland Swamp	2
	Ws07	5 6	Spruce – Common horsetail – Leafy moss	Wetland Swamp	2 3
SBSwk2	Fm02	6 7	Cottonwood – Spruce – Red-osier dogwood	Mid Bench Floodplain	7 2
	GP	-	Gravel Pit	Anthropogenically Modified	4
	LH	3b 4 5	Pl - Huckleberry - Cladina	Moderately Dry Forest	7 2 14
	MI	-	Mine	Anthropogenically Modified	5
	RZ	-	Road Surface	Anthropogenically Modified	6
	SC	4 5	Sxw - Huckleberry - Highbush-cranberry	Moderately Dry Forest	2 23
	SD	5 6	Sxw - Devil's club	Moist Forest	3 21
	SH	5	Sxw - Horsetail (Ws07 - Common horsetail - Leafy moss)	Wetland Swamp	1
	SO	5 6	Sxw - Oak fern	Mesic Forest	2 30
Total					**14,853**

Forested ecosystems comprise greater than 80% of the LSA, dominated by Mesic, Slightly Dry to Moist, and Moist Forests. Forested ecosystems (structural stages 4 through 7) collectively account for nearly 70% of the LSA, dominated largely by mature forests (structural stage 6), which comprise 38% of the LSA. Shrub- and herb-dominated ecosystems (structural stages 2 and 3, respectively) comprise 18% of the LSA, and sparsely vegetated/bryoid-dominated ecosystems (structural stage 1); comprise less than 1% of the LSA. The remainder (12%) of the LSA is covered by non-vegetated ecosystems.

11.5.4.4 Rare Ecosystems

Eight provincially blue listed ecological communities were identified within the LSA, covering 3,265 ha (Table 11.5-11 and Figure 11.5-3). In this assessment, ecosystems mapped in the TEM as ESSFmv2/06 (Subalpine fir - Alders - Horsetails; TEM code 'FH') are *excluded* from further assessment as blue-listed ecosystems, despite being described as analogous to the Ws08 ecosystem in the baseline (Rescan 2013). Described within Section 4.1.4.1 of the baseline, field plots established within wet forests in the LSA typically revealed forest stands dominated by open canopies of hybrid spruce and lodgepole pine, with neither subalpine fir nor an abundance of subalpine indicators. The shrub, herb and moss layers were typically dense, with mountain alder (*Alnus incana* ssp. *tenuifolia*), rhododendron (*Rhododendron* sp.), horsetail (*Equisetum* spp.), and oak fern (*Gymnocarpium dryopteris*) as common understory species.

Table 11.5-11. BC CDC Listed Ecosystems Mapped within the LSA

BC CDC Ecosystem	English Name	Structural Stage	BC List	Area within LSA (ha)
BWBSmw 112 *(Populus balsamifera - Picea glauca / Alnus incana - Cornus stolonifera)*	balsam poplar - white spruce / mountain alder - red-osier dogwood	5	Blue	8
		6		83
		7		46
Total (BWBSmw 112)				**137**
BWBSmw/110 *(Picea glauca / Gymnocarpium dryopteris - Aralia nudicaulis)*	white spruce / oak fern - wild sarsaparilla	5	Blue	123
		6		238
		7		46
Total (BWBSmw/110)				**407**
BWBSmw/111 *(Picea glauca / Ribes triste / Equisetum* spp.)	white spruce / red swamp currant / horsetails	5	Blue	98
		6		173
		7		32
Total (BWBSmw/111)				**304**
BWBSwk1/101 *(Picea glauca - Abies lasiocarpa / Vaccinium membranaceum / Pleurozium schreberi)*	white spruce - subalpine fir / black huckleberry / red-stemmed feathermoss	5	Blue	377
		6		897
Total (BWBSwk1/101)				**1,273**
BWBSwk1/103 *(Picea glauca – Pinus contorta / Shepherdia canadensis / Eurybia conspicua)*	white spruce - lodgepole pine / soopolallie / showy aster	5	Blue	144
		6		116
				260
Total (BWBSwk1/103)				**260**
BWBSwk1/110 *(Picea glauca / Ribes triste / Equisetum* spp.)	white spruce / red swamp currant / horsetails	5	Blue	47
		6		628
Total (BWBSwk1/110)				**675**

(continued)

Table 11.5-11. BC CDC Listed Ecosystems Mapped within the LSA (completed)

BC CDC Ecosystem	English Name	Structural Stage	BC List	Area within LSA (ha)
SBSwk2/02 (*Pinus contorta / Vaccinium membranaceum / Cladina* spp.)	lodgepole pine / black huckleberry / reindeer lichens	5		14
Total (SBSwk2/02)				**14**
ESSFmv2/06 (*Abies lasiocarpa / Alnus* spp. / *Equisetum* spp.)	subalpine fir / alders / horsetails	5	Blue	43
		6		166
Total (ESSFmv2/06)				**209**
Grand Total				**3,265**

During preparation of the Application for the Tumbler Ridge Wind Energy Project (Finavera Wind Energy Inc. 2011), the Project consultant engaged CDC staff (C. Cadrin, pers. comm) to discuss and clarify whether or not the mapped ESSFmv2/06 ecosystems represented blue-listed ecosystems. As their LSA overlaps the Murray River LSA, the assessment included data collected from within the Murray River LSA. The consensus was that spruce-dominated ecosystems, as described above, best reflect the Ws07 (Spruce – Common horsetail – Leafy moss) Swamp Site Association, a common ecosystem from low to subalpine elevations throughout the Northern Boreal Mountains and Central and Sub-Boreal Interior (MacKenzie and Moran 2004). Despite named as a swamp association, the Ws07 ecosystem is described by MacKenzie and Moran (2004) as including both wetland and non-wetland sites.

11.5.4.5 Rare Plants and Lichens

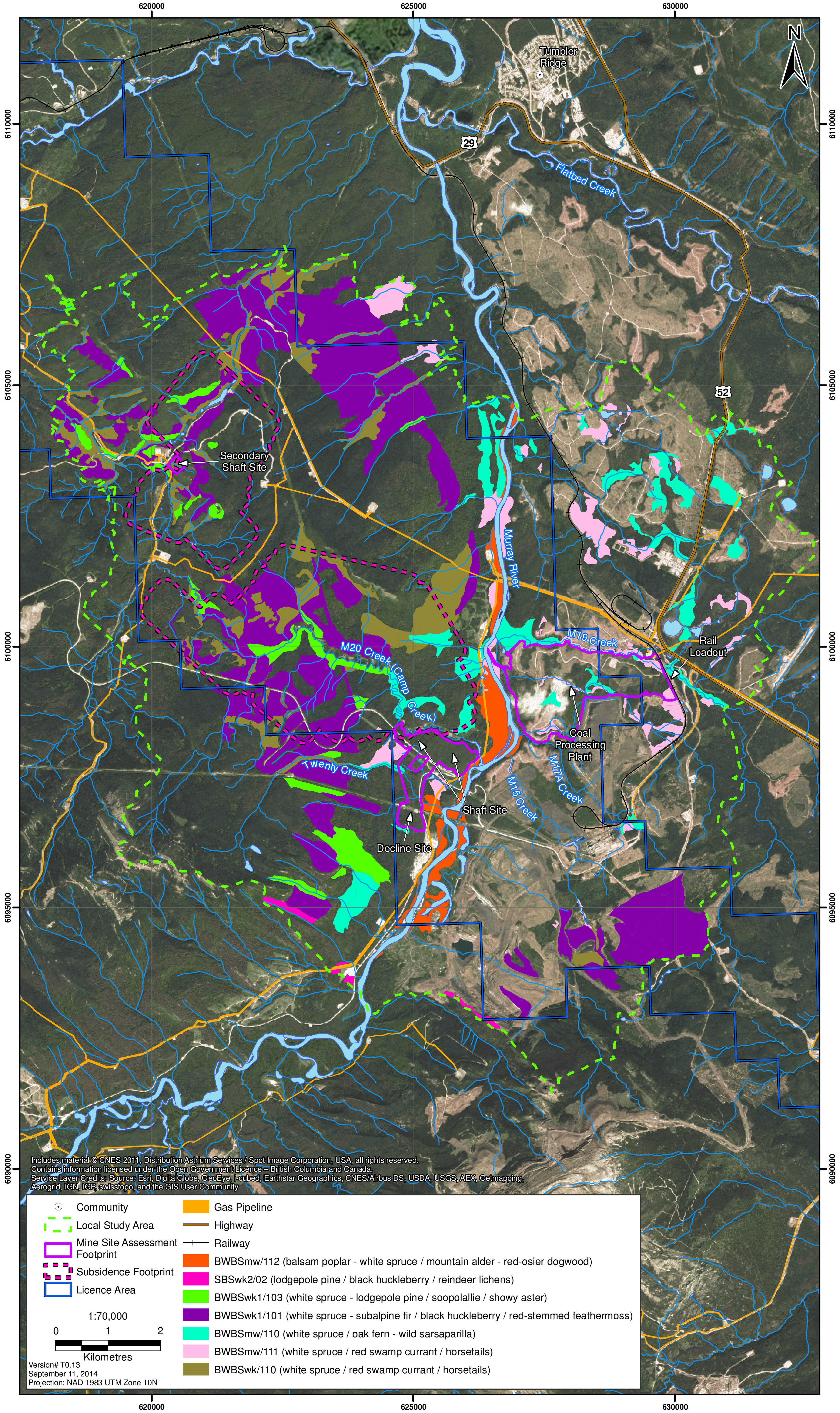
All plant and lichen species observed during the rare plant and lichen surveys were recorded within each field site, resulting in a total of 1,650 field identifications representing 510 species. Numerous plant and lichen specimens were gathered and field-curated and 162 field photos were taken. Rare plant or lichen species found include the lichens *Bryoria furcellata* (a new discovery for BC), *Cladonia coccifera* (red listed; S1: G5), *Collema tenax* var. *expansum* (globally rare), *Hypogymnia dichroma* (new to science), *Leptogium tenuissimum (*red listed; S2?; GNR*)* and *Usnea cavernosa (*blue listed; S2S3*)* the moss *Mielichhoferia elongata* (globally rare), the as well as the vascular plants *Cardamine parviflora* (blue listed; S2S3; G5), *Carex tenera* (blue listed; S2S3: G5TNR), and *Drymocallis arguta* (red listed; S1S3; G5T5) and *Botrychium crenulatum* (blue listed; S2S3; G3). The species accounts for the rare plants and lichens observed during field surveys as well as the rank status definitions are located in Appendix 11-D).

11.6 ESTABLISHING THE SCOPE OF THE EFFECTS ASSESSMENT FOR TERRESTRIAL ECOLOGY

This section of the effects assessment of terrestrial ecology includes a description of the scoping process used to identify potentially affected Valued Components (VCs), select assessment boundaries, and identify the potential effects of the Project that are likely to arise from the Project's interaction with VCs. Scoping is fundamental to focusing the Application for an Environmental Assessment Certificate / Environmental Impact Statement (Application/EIS) on those values where there is the greatest potential to cause significant adverse effects.

Figure 11-5.3

BC CDC Listed Ecosystems Mapped within the Local Study Area



The scoping process for the assessment of terrestrial ecosystems consisted of five steps, which are listed and described in the text below:

- *Step 1:* conducting a desk-based review of available scientific data, technical reports, and other Project examples to compile a list of potentially affected VCs in the vicinity of the Project;
- *Step 2:* carrying out detailed field baseline studies to fill information gaps and confirm presence/absence of VCs;
- *Step 3:* considering feedback from the EA Working Group on the proposed list of VCs included in the AIR and the EIS Guidelines;
- *Step 4:* defining assessment boundaries for terrestrial ecology VCs; and
- *Step 5:* identifying key potential effects on terrestrial ecology VCs.

The VC selection process is discussed in more detail in the following sections.

11.6.1 Selecting Valued Components

Valued components are components of the natural and human environment that are considered to be of scientific, ecological, economic, social, cultural, or heritage importance (BC EAO 2013b; CEAA 2013). To be included in the EA, there must be a perceived likelihood that the VC will be affected by the proposed Project. Valued components are scoped into the environmental assessment based on issues raised during consultation for the draft AIR and EIS Guidelines with Aboriginal communities, government agencies, the public, and stakeholders. Consideration of certain VCs may also be a legislated requirement, or known to be a concern because of previous project experience.

During the development of the dAIR, a VC-scoping exercise was conducted to explore potential Project interactions with candidate VCs, and to identify the key potential adverse effects associated with those interactions. A preliminary list of potential VCs was developed based on professional judgement, combined with knowledge of the Project, and experience from previous mining projects. The preliminary list of VCs in the dAIR was released for comment and feedback from the Working Group, and from the public. Feedback from that process and from additional comments received has been integrated into the EA. Selection also considered information from the BC CDC (MOF 1992), the BC MOE's Sensitive Ecosystem Inventory (BC MOE 2007b), the SARA (2002b) Public Registry (Government of Canada 2014), and the Dawson Creek Land and Resource Management Plan (BC ILMB 1999).

11.6.1.1 Summary of Valued Components Selected for Assessment

Terrestrial ecology has a key role in the maintenance of wildlife habitat, nutrient cycling, productivity, biodiversity, and carbon sequestration. Furthermore, it is recognized that Aboriginal groups place value on all ecosystems and their interconnections and as such all vegetated ecosystems that may interact with the Project are included in this assessment. Terrestrial ecosystems provide habitat for culturally important and harvestable plants, lichens and at-risk components of regional, provincial, federal, or global biodiversity.

For this assessment, Terrestrial Ecology was categorized into the following candidate VCs:

- ecologically valuable soil;
- alpine ecosystems;
- parkland ecosystems;
- forested ecosystems;
- rare ecosystems;
- harvestable plants; and
- rare plants and rare plant habitat.

Potential effects on Terrestrial Ecology VCs resulting from the Project, or similar industrial developments were identified by Aboriginal groups, government, community members, experts, and professionals in a variety of forums and reports including public/stakeholder comments, reviews of best management practices, scientific literature, and land use plans (Table 11.6-1). Rare ecosystems were defined as those listed by the BC CDC.

The alpine and parkland ecosystems were considered as candidate VCs but were not selected for the effects assessment. Both the alpine and parkland ecosystems are high altitude ecosystems which are highly sensitive to disturbance and provide habitat to important wildlife, plants, and lichen. Alpine and parkland ecosystems were not chosen as VCs for the effects assessment because they are not in close proximity to the Project and are unlikely to experience projects effects or interactions (Table 11.6-2).

11.6.2 Selecting Assessment Boundaries

Assessment boundaries define the maximum limit within which the effects assessment is conducted. They encompass the areas within which the Project is expected to interact with the VCs, and the times during which these interactions might occur. The assessment boundaries also reflect constraints that may be placed on the assessment of those interactions due to political, social, and economic realities (administrative boundaries), and limitations in predicting or measuring changes (technical boundaries). The definition of these assessment boundaries is an integral part of the assessment for Terrestrial Ecology, and encompasses possible direct, indirect, and induced effects of the Project on Terrestrial Ecology.

11.6.2.1 Spatial Boundaries

<u>Mine Site Assessment Footprint</u>

The potential effects of the Project on terrestrial ecology VCs were identified and evaluated within a Mine Site Assessment Footprint (the Assessment Footprint) and within the LSA (Figure 11.6-1). The Assessment Footprint is 495 ha and represents the spatial area within which development of infrastructure is expected to occur. Within the Assessment Footprint, all ecosystems are considered lost. Project caused effects outside this boundary are determined by the activity or type of infrastructure present.

Table 11.6-1. Terrestrial Ecosystem Valued Components Included in the Effects Assessment

Valued Components	Identified by* AG	G	P/S	Other	Rationale for Inclusion
Ecologically valuable soil		X		X	• Necessary to maintain ecological function of ecosystems; has direct influence on ecosystem development, wildlife habitat and reclamation objectives *Mines Act* (1996b).
Forested ecosystems	X	X	X	X	• Identified as an important management consideration in the Dawson Creek LRMP; • important for a variety of wildlife including grizzly bear and marten; • contribute to soil building processes; • provide biological processes, which are critical for efficient nutrient cycling productivity, and carbon storage; and • habitat for several plant species valued by Aboriginal groups (see Chapters 19 and 20).
BC CDC listed ecosystems	X	X		X	• Represent a rare, threatened, or at-risk component of regional and/or provincial biodiversity; and • preserving biodiversity is a common goal of many government and non-governmental organizations in BC (Biodiversity BC 2008) and is a specific management objective listed in the region's land and resource management plans (BC ILMB 2000; BC MFLNRO 2012). Best management practices and guidelines for land developments recommend that red- and blue-listed ecosystems be protected (BC MOE 2006).
Harvestable plants	X	X	X	X	• Valued by Aboriginal groups and local communities (see Chapters 19 and 20).
Rare plants and lichens and associated habitat		X	X	X	• Represent a rare, threatened, or at-risk component of regional and/or global biodiversity; • sensitive to disturbance; and • sensitive to changes in environment.

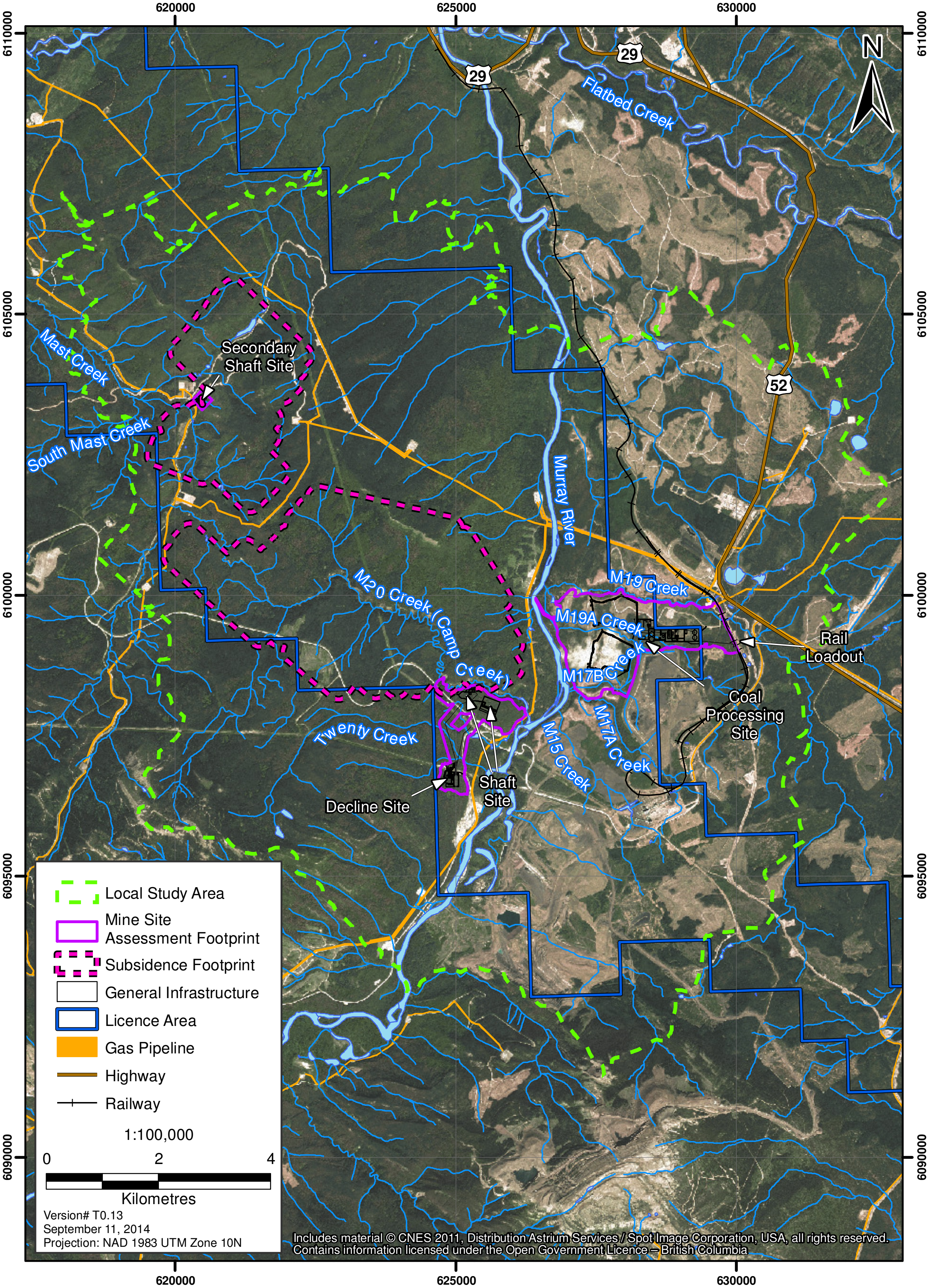
**AG = Aboriginal Group; G = Government; P/S = Public/Stakeholder; Other: could include an impact matrix scoping exercise undertaken to support the identification of VCs or some other method used to select VCs..*

Table 11.6-2. Valued Components Excluded from the Effects Assessment for Terrestrial Ecology

Valued Components	Identified by* AG	G	P/S	Other	Rationale for Exclusion
Parkland Ecosystems	X	X	X	X	Not mapped within LSA
Alpine Ecosystems	X	X	X	X	Not mapped within LSA

Figure 11.6-1

Terrestrial Ecology Effects Assessment Local Study Area



Local Study Area

The effects assessment LSA is 14,852 ha and was expanded from the LSA defined in *Murray River Coal Project: 2010 to 2012 Terrestrial Ecosystem and Vegetation Baseline Studies* (Appendix 11-B) to include the extent of subsurface development associated with the Project (Figure 11.6-1).

Subsidence Footprint

To assess potential effects related with subsidence caused by longwall mining, polygons delineating the longwall mining panels were created in GIS. The polygons were classified based on the number of panels to be mined vertically. The final polygon boundaries indicate the location of all longwall mining areas and the number of panels to be mined vertically in each area. A 200 m buffer was applied to the external panel footprint to identify the potential extent of subsidence or horizontal displacement on the grounds surface (X-traction Science and Technology 2014). The Subsidence Footprint will be used to indicate where the effects of subsidence on terrestrial ecosystems may be greatest.

Regional Study Area

The Regional Study Area (RSA) is 2,276 km^2 and is the same RSA used in the *Murray River Coal Project: 2010 to 2012 Terrestrial Ecosystem and Vegetation Baseline Studies* (Rescan 2013; Figure 11.5-1).

11.6.2.2 Temporal Boundaries

The potential effects of the Project on terrestrial ecology VCs were evaluated based on the temporal phases associated with Project activities. The temporal boundaries along with a brief description of activities considered for the effects assessment are summarized below and discussed in detail in the *Murray River Coal Project Description* (Chapter 3):

- **Construction:** 3 years;
- **Operation:** 25 year run-of-mine life;
- **Decommissioning and Reclamation:** 5 years;
- **Post Closure:** 30 years.

11.6.2.3 Administrative Boundaries

Administrative boundaries did not directly influence the assessment of terrestrial ecology.

11.6.2.4 Technical Boundaries

Technical boundaries did not directly influence the assessment of terrestrial ecology.

11.6.3 Identifying Potential Effects on Terrestrial Ecology Valued Components

Potential Project-related effects on terrestrial ecology VCs were identified through reviews of relevant literature (e.g., Project description, data made available from First Nations and local stakeholders or through ethnographic reports, scientific literature, data acquired via data sharing agreements, government documents, and publically available data associated with relevant adjacent projects) and professional judgement and experience.

Based on this review, potential effects associated with the Project are related to: loss or degradation/ alteration of soil quality and quantity, ecosystem function and extent, and loss and alteration of harvestable and/or rare plant and lichen species. Table 11.6-3 provides an impact-scoping matrix of Project components and activities that have a possible or likely interaction with the terrestrial ecology VCs.

Table 11.6-3. Ranking Potential Effects on Terrestrial Ecology

	Potential Effects on Terrestrial Ecology	
	Loss	Degradation or Alteration
Construction		
Underground Mine	M	M
Coal Processing Site	M	M
Shaft Site	M	M
Decline Site	M	M
Traffic and Transportation	M	M
Operation		
Underground Mine	H	H
Coal Processing Site	M	M
Shaft Site	M	M
Decline Site	M	M
Secondary Shaft Site	M	M
Utilities, Power, and Waste Handling	L	L
Heavy Machinery, Traffic and Transportation	L	M
Workforce and Administration	L	L
Decommissioning and Reclamation		
Infrastructure Removal and Site Reclamation	L	M
Heavy Machinery, Traffic, and Transportation	L	M
CCR	L	M
Underground Mine	L	M
Workforce and Administration	L	L
Post Closure		
Shaft Site	L	L
CCR	L	M
Underground Mine	L	L

L	*Negligible to minor adverse effect expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.*
M	*Potential moderate adverse effect requiring unique active management/monitoring/mitigation; warrants further consideration.*
H	*Key interaction resulting in potential significant major adverse effect or significant concern; warrants further consideration.*

11.6.3.1 Ecologically Valuable Soils

Soil Loss

Soil loss (i.e., direct removal of soils) can occur as a result of mine development activities, including mine facility construction, coal extraction and management of rock storage areas. Soil loss associated with surficial erosion, excavation (e.g., extraction of mineral materials from pits and quarries), or burial (e.g., covering of soil surface with overburden or rock) reduces the area of soil available to support vegetation growth, provide wildlife habitat, and provide other ecologically important functions, like nutrient, carbon, and water cycling.

Soil Degradation

Alteration of soil attributes such as the structure, pH, moisture, chemical composition and microbial activity can result in soil degradation. Soil degradation is the deterioration of the soil capacity to function and to sustain plant and animal productivity, enhance water and air quality, cycle nutrients, maintain biodiversity and productivity, and support human health and habitation. These changes can result from soil compaction, dust deposition, acidification, contamination, or modification of site drainage patterns.

Soil degradation can also result from removal of vegetation cover. Exposed soil surfaces are known to reduce infiltration, capture and channelize surface runoff, and modify subsurface flow paths (MacKenzie and Shaw 2000; Sayers, Hall, and Meadowcroft 2002), which affect soil moisture regime and other soil characteristics. Soil erosion associated with the construction and use of roads also decreases soil productivity in surrounding areas (Ohlson et al. 2003).

Soil Compaction

Soil compaction can occur as a result of heavy machinery compressing and consolidating the soil. Compaction changes the volume, porosity and bulk density of soils. These changes in turn limit water, nutrient, and air movement in the soil, which can lead to a decline in soil fertility and reduction in plant establishment and growth. Key ecological functions, such as site stability, productivity, nutrient cycling, carbon storage, water regulation, and wildlife habitat may be also affected depending on the severity of the compaction and the soil type affected.

Dust Deposition

Fugitive dust arises from the mechanical disturbance of granular material exposed to the air. The dust generated from these open sources is termed “fugitive” as it is not discharged to the atmosphere in a confined flow stream, such as a vent or a stack. Dust deposition estimates, based upon the CALPUFF model outputs, are provided for various dust sources, including un-paved roads, equipment activities, and coal preparation plant operation. Depending on the source and magnitude, deposition of dust can lead to increased soil contamination with metals, changes in soil salinity, or ecosystem eutrophication with nutrients.

Acidification

Soil acidification can occur as a result of industrial activities, (e.g., power generation, transportation, or any activity involving the use of diesel engines), which are associated with emission of compounds containing sulfur and nitrogen. Nitrogen oxides (NO_x) and sulfur dioxide (SO_2) emissions in Europe, North America, and most recently Asia have been associated with increased atmospheric acid deposition (Cowling 1982; Gorham 1992; Cowling and Nilsson 1995; Zhao et al. 2009). Atmospheric deposition appears to be one of the main factors affecting soil acidification in some regions (Reuss, Cosby, and Wright 1987; Galloway 1995). The transformation of nitric and sulphur oxides when they react with water molecules in the atmosphere produces acidic nitrates and sulphates. The deposition of these sulphates and nitrates in soils can cause leaching of base cations and lead to soil acidification, defined by the World Health Organization (WHO 2000) as a decrease in acid neutralizing capacity of the inorganic fraction of the soil. Soil acidification can lead to toxic conditions resulting from mobilization of metals stored in in the soil complex.

If the sulphide containing bedrock is exposed during mine construction or operation, it could result in acid generation and associated metal leaching. Presence of acid generating minerals in the coal reject storage piles may also become a source of soil acidification; however, this mode of acid dispersal is expected to have only localized effects on soils.

While the acidity of affected soil solution often increases, especially in coarse soils characterized by low buffering capacity, the most typical effects of acid deposition include a long-term net decline in soil exchangeable base cation concentrations leading to impoverishment of the nutrient status of the vegetation (Blaser et al. 1999; Watmough S.A. 2002; Fernandez et al. 2003).

Soil acidification increases ecosystem vulnerability to other stress factors such as frost, drought, pests, disease, and invasive species. Complex interactions between acidification and increased metal toxicity or nutrient imbalances caused by nitrogen addition have been suggested as a common cause of reduced ecosystem health (Heij and Schneider 1991; Greaver et al. 2012) and reduced species diversity (De Schrijver et al. 2011).

Contamination

Soil contamination can result from spills of transported cargo (e.g., chemicals, cement, or lime); drip spills of oil, fuels, or lubricants from trucks and machinery; atmospheric dust deposition; and metal leaching from exposed PAG rock. Spills may result from container leaks, lost cargo, and vehicle accidents. Deposition of dust associated with coal and rock handling/transportation, and vehicle traffic can lead to contamination of soils with metals. All the above listed potential pathways may adversely affect soil fertility and subsequently vegetation abundance, composition, nutritional value, and toxicity.

Subsidence

Subsidence is the depression of the ground surface resulting from the overburden collapse into an underground void, created by mining activity (R. A. Bauer et al. 1995).

The initial subsidence that occurs after mining, called active subsidence, accounts for 90 to 95% of all subsidence, and occurs rapidly within days to months after mining of panels is complete. Residual subsidence can continue over years after mining is completed as compaction of material in the gob (the mined seam) continues (Mehnert, Van Roosendaal, and Bauer 1992; L. Holla and Barclay 2000). However, residual subsidence changes are much smaller in magnitude (Bauer 2008).

The effects of longwall mining are not limited to directly above the mine panel but extend outward along the *angle of draw*. The *angle of draw* is a term used to describe where the limits of subsidence are expressed on the Surface Zone, and it may be 0.35 to 0.45 times the depth to the mined seam (R. Bauer 2008).

The heterogeneous nature of geological formations, topography, and other variables, can cause complex surface expressions of subsidence. Changes in surface topography can include: tilt, surficial cracking, horizontal as well as vertical changes in permeability, horizontal movement of rock strata, valley closure, and uplift of ground within subsided areas (upsidence).

Tilt occurs primarily along the edges of the areas of extraction and in areas where steep V-shaped valleys are incised, particularly within the angle of draw, which can cause increases in erosion and likelihood of slope failure or rockfall (Shea-Albin 1994).

Furthermore, because changes in terrain morphology may have considerable effects on hydrology of the affected areas, it is expected that the original edaphic and ecological characteristics (e.g., soil moisture, nutrient availability, redox conditions, species composition, diversity, percent cover) will change in some communities due to ground subsidence. The extent and degree of such ecosystem alteration are difficult to predict.

11.6.3.2 Forested Ecosystems

<u>Ecosystem Loss of Function or Extent</u>

Loss of ecosystem function and/or extent can occur as a result changes or loss of the ecological processes that support an ecosystem and its associated functions. For example, long-term changes to soil moisture regime may have an effect on the viability of some vegetation species. This may affect the quality and type of vegetation and wildlife habitat use.

<u>Edge Effects</u>

Changes to the abiotic environments at forest edges result in alteration of the structure, composition and function of the vegetation community. For example, road construction through a forested area will increase the abundance of shade-intolerant species that thrive on open sites, while the abundance and diversity of plant and lichen species dependant on forest interior conditions will decrease. The creation of edges in forests increases the abundance of shrubs and herbs and thus, provide habitat for species such as deer and moose (discussed in Chapter 13). These changes also provide favourable conditions for the establishment of invasive plant species (Murphy and Lovett-Doust 2004). Trees remaining in the transitional areas between the clearing and the forest are susceptible to disease, insect attacks and windfall depending on the magnitude of the change (Geiger 1965; Saunders et al. 1991; Chen et al. 1992 in BC MOF 1995). Typically, these effects occur within 200 m or less of the forest edge (BC MOF 1995).

<u>Windthrow</u>

Windthrow risk is greatest where wind speeds are high and/or rooting depth is restricted by factors such as wet or shallow soils. Although windthrow effects in BC have been documented to extend more than 100 m into forest stands (Burton 1991), most windthrow damage is expected within 10 to

20 m of forest edges (Stathers, Rollerson, and Mitchell 1994). The risk of windthrow is expected to be highest during the first few years after forest clearing. Windthrow can cause tree mortality which, in turn, may cause increased fire hazard and insect epidemics when downed trees are not salvaged (Stathers, Rollerson, and Mitchell 1994).

Fragmentation

Fragmentation alters ecological processes, including nutrient flows, energy transfers, interactions with pollinators, and genetic exchanges; each influences the development of ecosystem structure, composition, and function (Olivier Honnay et al. 2005; Society for Ecological Restoration 2013). Fragmentation has different effects on populations depending on the specific requirements of the species.

Alteration of Hydrology

Hydrological processes influence the geomorphic, biogeochemical, and ecological processes of ecosystems (Creed et al. 2011). Changes in hydrologic connectivity can alter sediment, water, and nutrient movement, which can alter successional pathways, ecological integrity, and ecological functions.

Dust Deposition

Fugitive dust can cause physical injuries to vegetation, including the alteration of photosynthetic receptors, respiration, and transpiration (Farmer 1993 in Trombulak and Frissell 2000). Dust can promote vegetation growth depending on the amount and frequency of dusting, the chemical properties of dust, and receptor plant species. Plant growth may be positively or negatively affected by a number of factors including dust-induced changes in soil pH and nutrient availability (Walker and Everett 1991; Farmer 1993; Auerbach, Walker, and Walker 1997), radiation absorption and leaf temperature (Eller 1977) and chemistry (McCune 1991; CEPA/FPAC Working Group 1998; Anthony 2001). Evergreen shrubs could experience greater cumulative dusting than deciduous shrubs as they retain leaves from year to year (Auerbach, Walker, and Walker 1997).

Introduction and/or Spread of Invasive Plants

Construction and development activities associated with the Project increase the potential of introducing invasive plants into local environments by creating favourable habitat through ground disturbance (Polster 2005). Features fundamental to the construction process, namely transportation corridors as well as the vehicles and machinery travelling along such corridors, provide access and dispersal mechanisms. Invasive plants are often found along road verges and within areas that have sustained some level of disturbance.

Invasive plant species can influence ecosystem diversity, structure, and function through invasion and hybridization. Invasive plants can alter the structure of a natural ecosystem and ultimately change the way in which the site is utilized by wildlife, insects, and micro-organisms. The effects of invasive species on native diversity have been well documented, are growing in magnitude, and are the second greatest threat to listed species after habitat loss (Wilcove et al. 1998; Enserink 1999). Changes to nutrient cycling, hydrology, erosion, and fire regimes may also occur (Canadian Food Inspection Agency 2008).

Subsidence

While general mechanisms and effects of subsidence are known, predicting specific effects of subsidence on specific terrestrial ecology VC extent or functions are challenging due to the complex interactions between subsidence, water flow, and geology in areas with variable topography and geology.

Tripathi, Singh and Singh (2008) examined the physio-chemical characteristics of vegetation following subsidence, and reported both positive and adverse impacts of subsidence on soil moisture, bulk density, water holding capacity, organic carbon content, as well as total N and total P. An increase in all these parameters was found in depression areas, while on slopes, the values were lower. The overlying vegetation in the subsidence zone may experience a reduction in growth due to the decrease of water availability in some areas (Sengupta 1993) or the water-logging of soils in newly formed depressions. Damage and/or tilting can occur to plants as well (Sengupta 1993), particularly noticeable in treed areas. Primary productivity and growth rates can also be affected by subsidence (Kundu and Ghose 1994).

11.6.3.3 Summary of Potential Effects on Terrestrial Ecology

The terrestrial ecology effects assessment will focus on the key effects of project activities which will result in loss and degradation/alteration of ecologically valuable soil, forested ecosystems, harvestable plants and rare plants. Assessment of alteration of ecosystems or ecosystem function includes consideration of soil erosion and compaction, loss of soil fertility, dust effects, acid deposition resulting in acidification of soils, edge effects, introduction and/or spread of invasive plant species, windthrow, fragmentation, and alteration of hydrological connectivity. These key effects will be analyzed in detail below. Effects of subsidence are also included in the assessment of terrestrial ecology, but are discussed independently from other potential effects.

11.7 EFFECTS ASSESSMENT AND MITIGATION FOR TERRESTRIAL ECOLOGY

The terrestrial ecology assessment identifies the potential effects on terrestrial ecology VCs taking into consideration the interconnections that occur across the landscape, information from key stakeholders, including Aboriginal and/or local communities, and the guiding principles outlined in the Dawson Creek Land and Resource Management Plan (BC ILMB 1999). The methodology and results of the assessment are described in the sections below.

11.7.1 Risk Model for Terrestrial Ecology Effects

The key potential Project-related effects on terrestrial ecology VCs was assessed through a risk model, which takes into consideration the magnitude, duration, frequency, geographic extent, reversibility, and resiliency of the terrestrial ecology VCs within an ecological context. A similar approach has been employed in various fields such as wildfire, flood, and ecological risk management (Sayers, Hall, and Meadowcroft 2002; Blackwell et al. 2004). The risk model identifies the probability (i.e., the likelihood that a Project effect will interact with a terrestrial ecology VC and the consequence or value of that VC (i.e., the relative importance of the ecosystem function Figure 11.7-1). The effects to rare plants were assessed separately from the risk model and are discussed in Section 11.7.3. Effects of subsidence are also included in the assessment of terrestrial ecology; however, these effects are considered separately from the risk model due to the uncertainty related to potential subsidence effects on the topographically and geographically complex landscape surrounding the Project.

The probability that a Project activity (e.g., surface clearing during mine Construction, road use during Operation,) will result in an effect on terrestrial ecology VCs was determined and rated according to information found in reviews of relevant literature, proposed Project activities, baseline information, and/or expert opinion.

Based on this review, seven potential effects were identified: high impact surface disturbance, dust effects, edge effects, introduction and/or spread of invasive plant species, windthrow, fragmentation, and alteration of hydrological connectivity. Each potential effect was assigned a magnitude rating based on empirical data or expert knowledge regarding the type, extent, and duration of the potential effect.

Each potential effect was assigned a magnitude rating based on empirical data or expert knowledge regarding the type, extent, and duration of the potential effect. For example, results of atmospheric modelling were used to estimate the potential of soil acidification resulting from nitrate and sulphate deposition. The assessment of the effects of dust deposition associated with road traffic was based on modeled dustfall rates along several transects perpendicular to roads located in areas away from the influence of any Project infrastructure. The dustfall rates along these transect were then assumed to be representative of the contribution of road traffic to dust deposition along the entire road outside of the atmospheric modelling domain. The results indicated that there was no statistically significant difference between the background levels of dust and acid deposition related to the Project beyond 100 m from the road. This information was later used to determine the probability ratings for the effect of dust on ecosystem function (Table 11.7-1). The contribution of an effect was expressed as the relative likelihood that this effect (i.e., fugitive dust) will influence ecosystem function. Figure 11.7-2 illustrates the probability rating of all potential effects within the LSA according to the current Project design, regardless of the consequence.

11.7.1.1 Determination of Consequence of an Effect

The consequence of a Project effect interacting with an ecosystem function or value was also determined through reviews of relevant literature, proposed Project activities, baseline information, and professional judgement. The consequence (i.e., relative importance) of all vegetated ecosystems were assessed and weighted in relation to the following attributes:

- ecologically valuable soil;
- forest productivity;
- carbon storage;
- habitat for select wildlife species;
- ecologically valuable habitat for fish species; and
- hydrological connectivity.

Figure 11.7-1

Probability and Consequence Components of the Terrestrial Ecology Risk Model

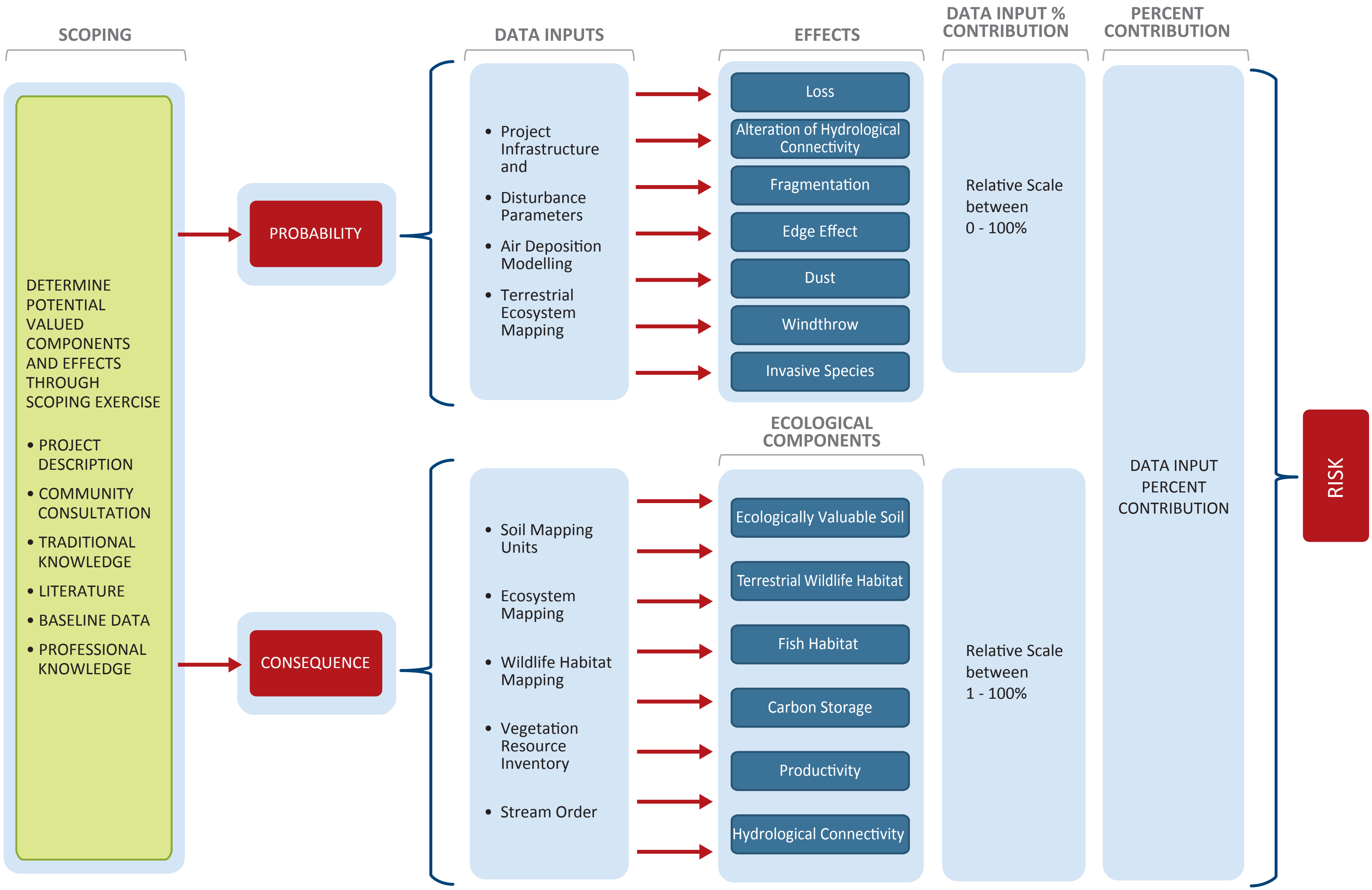


Figure 11.7-2
Probability Ratings for the Terrestrial Ecology Risk Model

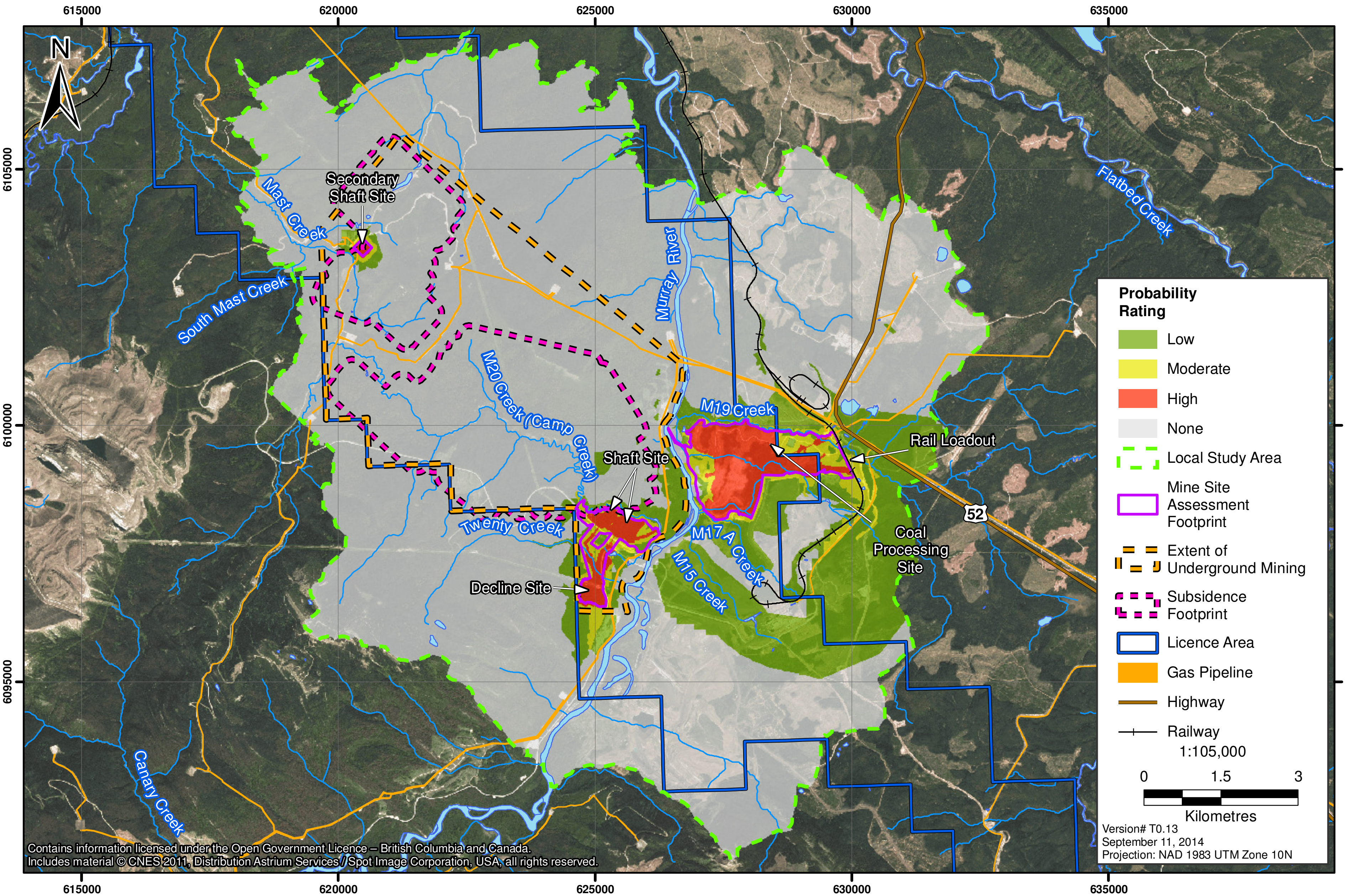


Table 11.7-1. Example of Probability Rating for Fugitive Dust Effects

Effects	Measured Criteria for Ecological Effects	Rating Weight for Effect	Overall Contribution of the Effect (%)
Dust	> 1.8 mg/dm²/day	10	20%
	1.7 - 1.8 mg/dm²/day	8	
	1.6 - 1.7 mg/dm²/day	2	
	<1.6 mg/dm²/day	0	
Acidification	*Acid Deposition Rate for Sensitive Soils:*		
	> 250 eq/ha/year	10	
	< 250 eq/ha/year	0	
	Acid Deposition Rate for Moderately Sensitive Soils:		
	> 500 eq/ha/year	10	
	< 500 eq/ha/year	0	

Note:
The critical loads of acid deposition recommended for application in northern Alberta (Target Loading Subgroup 1996) were used in the above table (see Section 11.6.2.1 for details).

The attributes listed above, although not exhaustive, represent characteristics that help to predict ecosystem functions and how an ecosystem is likely to respond to anthropogenic disturbances or other environmental stressors. The elements of each attribute were weighted based on a qualitative and quantitative assessment of their relative contribution to ecosystem functions. For example, the ecological value of soils was rated as high, moderate, low, and nil according to their relative degree of sustainable biomass productivity within their respective BEC subzones. This quality was interpreted from soil development and parent material characteristics – i.e., soils rated as high represent sites within stable environments that have deeper effective root zones, are well drained, and exhibit soil textures and organic matter content that allow for higher nutrient and moisture holding capacity (Table 11.7-2).

Attributes were further characterized through identification of a function/value contribution. The function/value contribution is the relative contribution of that attribute to the overall maintenance, resilience, or function of the ecosystem. For example, ecologically valuable soils are assigned a 40% relative contribution to the overall function of an ecosystem in this area. Figure 11.7-3 illustrates the consequence rating of the ecosystem functions within the LSA.

11.7.1.2 Determination of Risk of an Effect

The final output of the risk model is a spatial characterization of risk based on probability and consequence ratings for terrestrial ecology VCs. The final risk determination of this model is used to evaluate the type, distribution, likelihood and relative importance of each effect on a terrestrial ecology VC. The probability and consequence criteria for each attribute are summarized in Table 11.7-3 and Table 11.7-4. The results of this risk assessment are illustrated in Figure 11.7-4 and are discussed in detail in Sections 11.7.3.

Figure 11.7-3
Consequence Ratings for the Terrestrial Ecology Risk Model

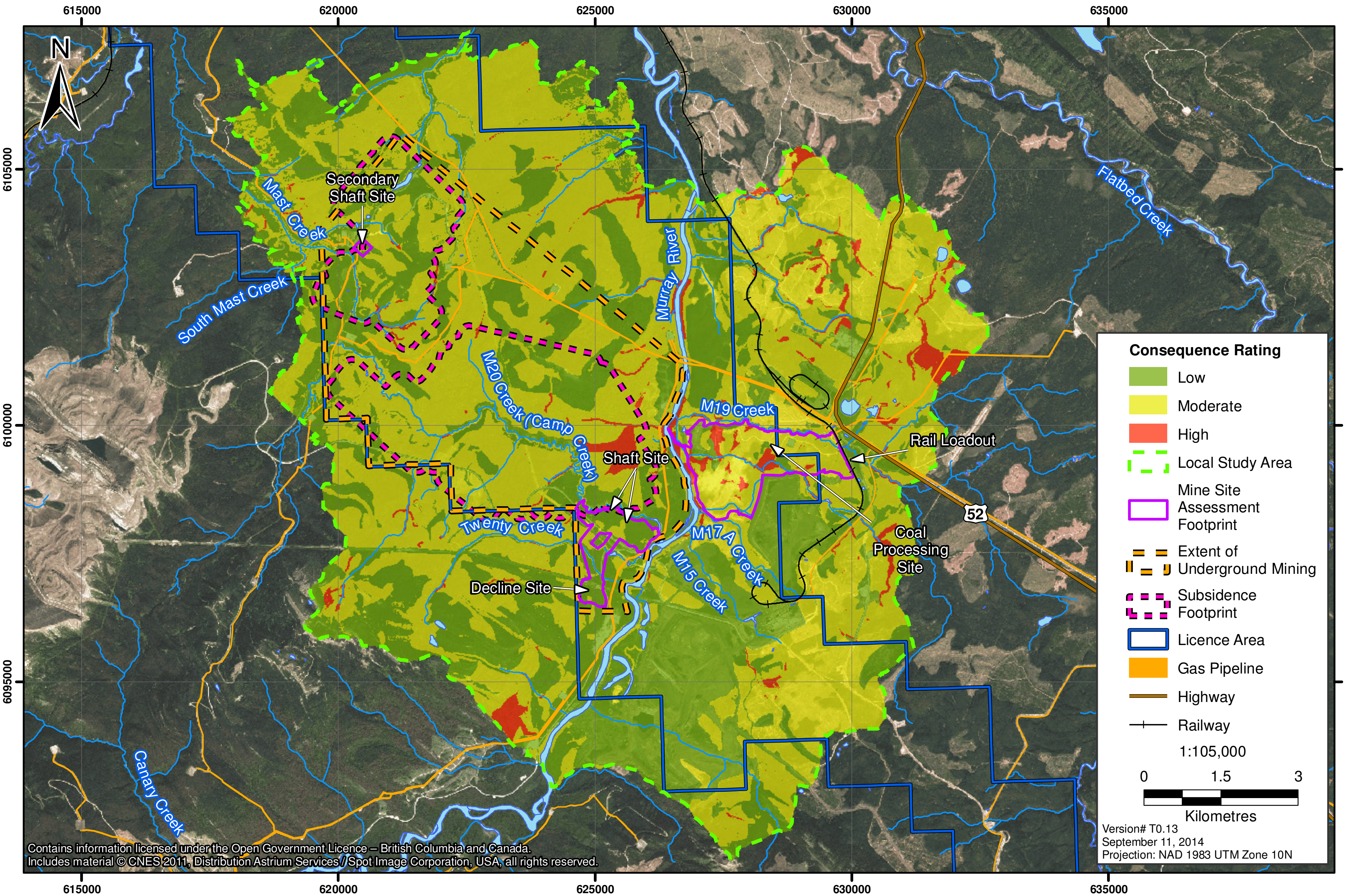


Figure 11.7-4
Risk Ratings for Terrestrial Ecology

ERM

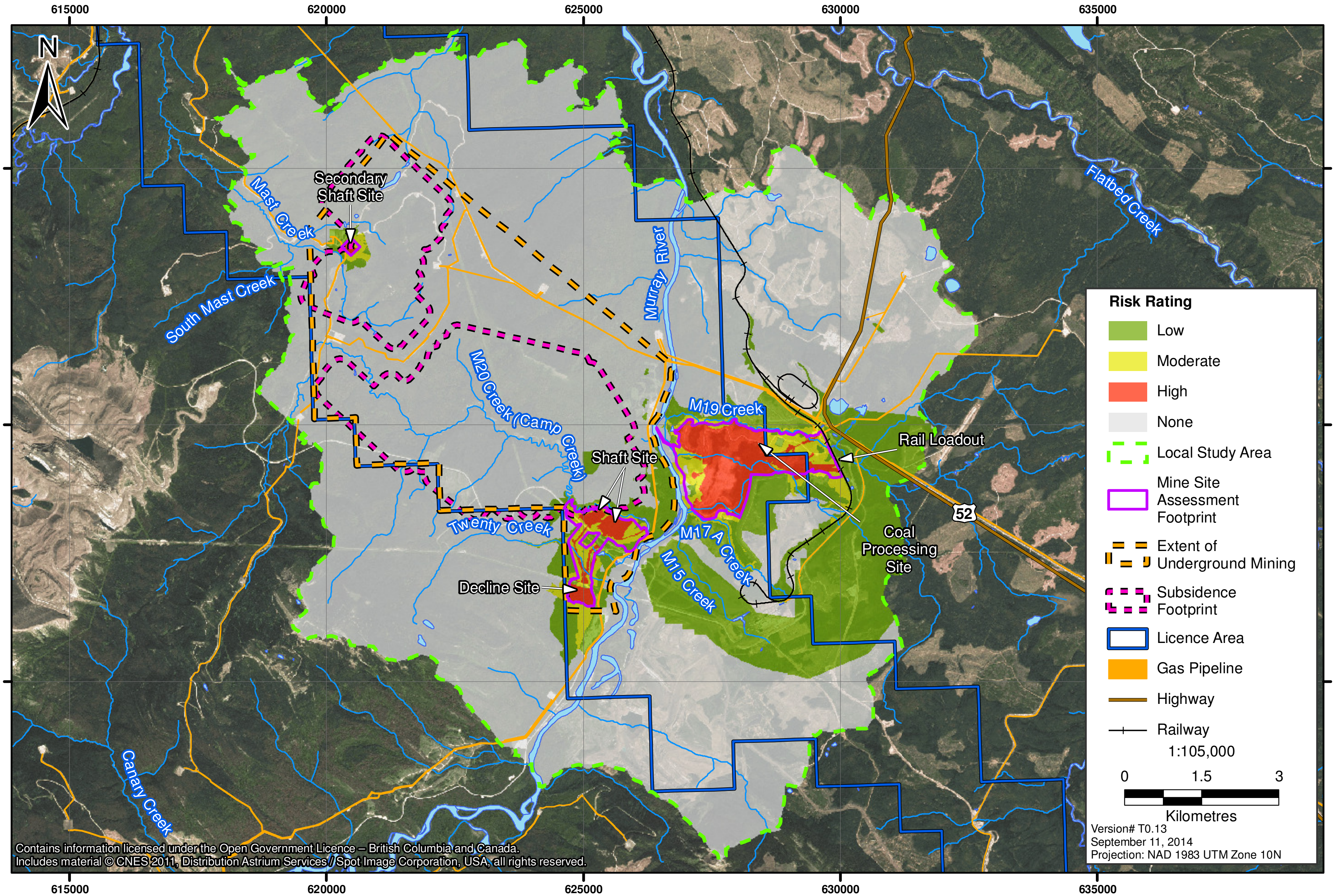


Table 11.7-2. Example of Consequence Rating for the Function of Ecologically Valuable Soils

Ecological Attribute	Description of Typical Project Soils	Attribute Contribution	Function/Value Contribution
Ecologically Valuable Soils	• Brunisolic, Podzolic, and Luvisolic soils commonly developed in morainal blankets. • Wetland organic and peaty soils – rated high because of their high organic matter content and nutrient holding capacity.	High (10)	40%
	• Gleysolic soils on a variety of parent materials; or better developed and better drained soils on less suitable parent materials (typically excessive coarse fragment content) such as colluvium 'C,' fluvial 'F,' and glacio-fluvial 'G' materials.	Moderate (7)	
	• Regosolic soils; especially those in areas of active terrain processes (high-energy flooding and avalanche activity) where soil development is interrupted by frequent disturbance and/or biomass may be removed; shallow soils developed in and around bedrock outcrops (weathered bedrock 'D' parent materials).	Low (3)	
	• Non-soils (exposed bedrock, water, glaciers – ice, permanent snow, soils disturbed by anthropogenic activities/materials).	Nil (1)	

11.7.2 Key Effects on Terrestrial Ecology Valued Components

Ecosystems are complex interactions of geomorphic, bio-geochemical, and ecological processes that result in unique soil types, species assemblages, and community structures and functions. The Project development is expected to result in loss or alteration of geomorphic, bio-geochemical, or ecological processes beyond the range of natural variation. The magnitude of loss or alteration is dependent on the type, extent, and duration of the effects, as well as on the resiliency of the affected ecosystem. The following sections summarize the Project related effects to Terrestrial Ecology VCs within the LSA.

11.7.2.1 Ecologically Valuable Soils

The Project is expected to result in the loss of 313 ha and the degradation of 182 ha of ecologically valuable soil. Approximately, 14,357 ha within the LSA will not be affected by Project activities (Table 11.7-5). The effects on ecologically valuable soils will vary throughout the life of the Project. Most of the direct effects on ecologically valuable soils will occur during Construction as a result of development activities associated with construction of infrastructure. Indirect effects to ecologically valuable soils will occur in each phase of the Project and will vary in terms of type, extent, duration, frequency and overall magnitude. The specific details of Project related effects on ecologically valuable soils are summarized below.

Table 11.7-3. Terrestrial Probability Ratings for Potential Project Effects

Data Resource for each Ecological Attribute	Effects	Measured Criteria for Ecological Effects		Rating Weight for Effect	Overall Contribution of the Effect (%)
Infrastructure	Removal of Ecosystem	Areas under Infrastructure		10	Presence automatically overrides values calculated using ecological attributes identified above at **100%** probability
Dust Modelling	Acidification	Acid Deposition Rate:			20
		For Sensitive	For Moderate Sensitivity		
		> 250 eq/ha/y	> 500 eq/ha/y	10	
		< 250 eq/ha/y	< 500 eq/ha/y	0	
	Dust	> 1.8 mg/dm2/day		10	
		1.7 - 1.8 mg/dm2/day		8	
		1.6 - 1.7 mg/dm2/day		2	
		< 1.6 mg/dm2/day		0	
Terrestrial Ecosystem Mapping	Edge Effects	TEM Polygon Adjacent to Project		10	20
		TEM Polygon not Adjacent Project		0	
	Invasive Species	TEM Polygon within 100 m of Linear Feature		10	20
		TEM Polygon Adjacent to Infrastructure		4	
		TEM Polygon not Adjacent to Infrastructure or within 100 m of a Linear Feature		0	
	Windthrow	Forested TEM Polygon within 20 m of Cleared Area		10	10
		Forested TEM Polygon within 20 - 70 m of Cleared Area		3	
		Forested TEM Polygon > 70 from Cleared Area		0	
	Fragmentation	Forested (i.e., Structural Stage 6 or 7) TEM Polygon Fragmented by Infrastructure		10	15
		Structural Stage 4 or 5 TEM Polygon Fragmented by Infrastructure		5	
		All Other Polygons		0	
	Hydrological Connectivity	Areas Within 50 m of Cleared Area		10	15
		Areas 50-100 m of Cleared Area		5	
		Areas > 100 m from Cleared Area		0	

Table 11.7-4. Consequence Ratings for Terrestrial Ecosystem Function

Data Resources for each Ecological Attribute	Ecological Attribute	Measured Criteria for Ecological Attributes	Rating Weight for Ecological Attribute	Overall Percent Contribution of the Ecological Attribute
Soil Mapping Units (Rescan 2013)	Ecologically Valuable Soil	Brunisolic, Podzolic, and Luvisolic Soils Wetland organic and Peaty Soils	10	40%
		Gleysolic Soils on a variety of parent materials; or better developed and better drained soils on less suitable parent materials (typically excessive coarse fragment content) such as colluvium 'C,' fluvial 'F,' and glacio-fluvial 'G' materials.	7	
		Regosolic soils; especially those in areas of active terrain processes (high-energy flooding and avalanche activity) where soil development is interrupted by frequent disturbance and/or biomass may be removed; lithic shallow soils developed in and around bedrock outcrops (weathered bedrock 'D' parent materials).	3	
		Non-soils (exposed bedrock, water, glaciers – ice, permanent snow, soils disturbed by anthropogenic activities/materials)	1	
Wildlife Habitat Suitability Mapping (Rescan 2012)	Terrrestrial Wildlife Habitat	Fisher Habitat (Birthing) - High	10	30%
		Fisher Habitat (Birthing) - Medium	7	
		Fisher Habitat (Birthing) - Low	3	
		Woodland Caribou-Quintette herd Habitat (Growing season) - High	10	
		Woodland Caribou-Quintette herd Habitat (Growing season) - Medium	7	
		Woodland Caribou-Quintette herd Habitat (Growing season) - Low	3	
		Woodland Caribou-Bearhole/Redwillow herd Habitat (Growing season) - High	10	
		Woodland Caribou-Bearhole/Redwillow herd Habitat (Growing season) - Medium	7	
		Woodland Caribou-Bearhole/Redwillow herd Habitat (Growing season) - Low	3	

(continued)

Table 11.7-4. Consequence Ratings for Terrestrial Ecosystem Function (continued)

Data Resources for each Ecological Attribute	Ecological Attribute	Measured Criteria for Ecological Attributes	Rating Weight for Ecological Attribute	Overall Percent Contribution of the Ecological Attribute
Wildlife Habitat Suitability Mapping (Rescan 2012) *(cont'd)*	Terrestrial Wildlife Habitat *(cont'd)*	Woodland Caribou-Quintette herd Habitat (Winter) - High	10	
		Woodland Caribou-Quintette herd Habitat (Winter) - Medium	7	
		Woodland Caribou-Quintette herd Habitat (Winter) - Low	3	
		Woodland Caribou-Bearhole/Redwillow herd Habitat (Winter) - High	10	
		Woodland Caribou-Bearhole/Redwillow herd Habitat (Winter) - Medium	7	
		Woodland Caribou-Bearhole/Redwillow herd Habitat (Winter) - Low	3	
		Moose Habitat (Winter)-High	10	
		Moose Habitat (Winter)-Medium	7	
		Moose Habitat (Winter)-Low	3	
		Grizzly Bear (Spring) - High	10	
		Grizzly Bear (Spring) - Medium	7	
		Grizzly Bear (Spring) - Low	3	
		Grizzly Bear (Summer) - High	10	
		Grizzly Bear (Summer) - Medium	7	
		Grizzly Bear (Summer) - Low	3	
		Grizzly Bear (Fall) - High	10	
		Grizzly Bear (Fall) - Medium	7	
		Grizzly Bear (Fall) - Low	3	
BC TRIM Slope gradient no greater than 22% Fish Surveys and Barriers	Fish-associated Habitat	Large Streams - Confirmed Fish Presence	10	
		Large Streams - Potential Fish Presence	7	
		Large Streams - No Fish Present	0	
		Small Streams - Confirmed Fish Presence	10	
		Small Streams - Potential Fish Presence	7	
		Small Streams - No Fish Present	0	

(continued)

Table 11.7-4. Consequence Ratings for Terrestrial Ecosystem Function (completed)

Data Resources for each Ecological Attribute	Ecological Attribute	Measured Criteria for Ecological Attributes	Rating Weight for Ecological Attribute	Overall Percent Contribution of the Ecological Attribute
Vegetation Resource Inventory Dataset to determine bark, foliage, branch and whole stem above ground biomass	Biochemistry (Carbon Storage and Productivity)	Null (non forested) Struct stage <=3	1	20%
		< 100 (young forest) Struct stage 4 & 5	3	
		100-275 (mature forest) Struct stage 6	6	
		> 275 (old forest) Struct stage 7	10	
Site Index/Biogeoclimatic Ecosystem Classification	Productivity	Null (non forested)	1	
		<13 (low)	3	
		13-18 (med)	6	
		>18 (high)	10	
BC Freshwater Atlas	Hydrological Connectivity	Stream Order 1-2 (20 m buffer)	5	10%
		Stream Order 3-4 (30 m buffer)	7	
		Stream Order 5-6 (50 m buffer)	8	
		Stream Order 7+ (100 m buffer)	10	
				100%

Table 11.7-5. Effects to Ecologically Valuable Soils within the LSA

Eco Rating	Parent Material	SMU Group	SMU	Degradation (ha)	Loss (ha)	No Effect (ha)
1	F	SMU-F2	F6_G.p	-	0	138
	F	SMU-O2	F7_G.p	1	-	40
	FG	SMU-FG1	FG2_BR.GL	-	-	6
	FG	SMU-FG1	FG3_BR.GL	-	12	33
	FG	SMU-FG3	FG5_BR.GL.g	-	2	33
	FG|M	SMU-FG2	FG|M3_BR.GL	14	3	36
	FG|M	SMU-FG2	FG|M4_BR.GL	29	19	-
	FG|M	SMU-FG3	FG|M5_BR.GL.g	2	0	-
	M	SMU-M1	M2_B	9	1	76
	M	SMU-M1	M2_BR.GL	-	-	70
	M	SMU-M1	M3_B	-	-	105
	M	SMU-M1	M3_BR.GL	14	42	417
	M	SMU-M1	M4_B	1	16	2,064
	M	SMU-M1	M4_BR.GL	1	14	2,949
	M	SMU-M2	M5_B.g	-	-	487
	M	SMU-M2	M5_BR.GL.g	1	2	939
	O	SMU-O1	O7_M	13	13	152
	O	SMU-O1	O7_M.t	-	-	16
	O	SMU-O2	O5_G.p	-	-	13
	O|M	SMU-O2	O|M5_B.g	-	9	44
	O|M	SMU-O2	O|M6_G.p	-	3	99
2	C	SMU-C1	C2_B	0	-	244
	C	SMU-C1	C3_B	1	2	344
	C	SMU-C1	C4_B	1	6	1,165
	C	SMU-C1	C4_BR.GL	-	-	53
	C	SMU-C1	C4_O.HFP	-	-	4
	C	SMU-C2	C5_B.g	3	1	163
	C	SMU-C2	C5_BR.GL.g	-	-	21
	C	SMU-C2	C6_G	-	-	3
	F	SMU-F1	F2_B	-	-	2
	F	SMU-F1	F3_B	4	1	7
	F	SMU-F1	F4_B	-	-	110
	F	SMU-F2	F5_B.g	6	3	71
	F	SMU-F2	F5_G	-	-	7
	F	SMU-F2	F6_G	1	5	88
	FG	SMU-FG1	FG2_B	12	25	109
	FG	SMU-FG1	FG3_B	-	-	31

(continued)

Table 11.7-5. Effects to Ecologically Valuable Soils within the LSA (completed)

Eco Rating	Parent Material	SMU Group	SMU	Degradation (ha)	Loss (ha)	No Effect (ha)
2 *(cont'd)*	FG	SMU-FG1	FG4_B	20	30	173
	FG	SMU-FG3	FG5_B.g	-	-	3
	FG	SMU-FG3	FG6_G	-	-	2
	FG|M	SMU-FG2	FG|M3_B	3	1	122
	FG|M	SMU-FG2	FG|M4_B	19	66	365
	FG|M	SMU-FG3	FG|M5_B.g	-	-	11
	FG|M	SMU-FG3	FG|M6_G	-	-	2
	M	SMU-M2	M6_G	11	4	284
3	C	SMU-C1	C2_R	-	-	1
	C	SMU-C1	C3_B.lit	2	1	39
	C	SMU-C1	C4_B.lit	-	-	2
	C	SMU-C1	C4_R	-	-	20
	F	SMU-F1	F2_CU.R	-	-	5
	F	SMU-F1	F3_CU.R	-	9	213
	F	SMU-F1	F4_CU.R	5	13	72
	F	SMU-F1	F4_GLCU. R.	-	-	65
	F	SMU-F2	F5_GLCU. R.	-	-	8
	F	SMU-F2	F5_R.g	-	-	9
	F	SMU-F2	F6_G.r	-	-	13
	F	SMU-F2	F6_GLCU. R.	0	0	155
	M	SMU-M1	M2_CU.R	-	-	5
	M	SMU-M1	M3_B.lit	-	-	49
	M	SMU-M1	M4_B.lit	-	5	614
4	A	SMU-A	An_n	8	5	1,734
	F	SMU-F2	F5_n	-	-	2
	OW	OpWater	OW99_n	-	2	202
	R	SMU-R	R0_n	-	-	8
	R	SMU-R	R2_B.lit	-	-	23
	R	SMU-R	R3_B.lit	-	-	5
	R	SMU-R	R3_R.lit	-	-	13
Total	**-**	**-**	**-**	**182**	**313**	**14,357**

Note:
Rating of ecological value of soil: 1 = the most valuable, 4 = the least valuable. Detailed information about the parent materials, soil management units (SMUs), and soil ecological value rating is provided in Section 11.6.4.

Soil Loss

Most of the direct effects to soils will occur during Construction within the Assessment Footprint. Construction activities such as clearing and grubbing, soil salvage, excavation, and installation of conveyors are expected to result in the soil loss through direct removal or burial under Project components. While a portion of the volume of the excavated soil will be salvaged and stored for reclamation, for the purposes of the effects assessment, the excavated material is still considered lost, as soil characteristics will be degraded during handling and storage.

The remaining exposed soil surfaces may have reduced capacity to absorb water, capture and channelize surface runoff, and to modify subsurface flow paths (MacKenzie and Shaw 2000; Sayers, Hall, and Meadowcroft 2002). Each of these potential effects can result in changes to the soil moisture regime and thus a number of related soil characteristics, affecting soil fertility. For this reason, for the purposes of the effects assessment, the soil within the Proposed Assessment Footprint is also considered lost.

Soil Degradation

Soil degradation is expected to occur in the vicinity of the proposed Decline Site, Shaft Site, Coal Processing Site, and Secondary Shaft Site as a result of compaction, erosion, contamination, acidification and hydrological changes associated with land subsidence. Project effects on a combination of other soil characteristics, such as soil structure, pH, moisture, chemical composition, microbial activity may also affect soil quality (i.e., its ability to provide ecological functions within the affected ecosystems).

Compaction

The greatest potential for soil compaction is also associated with Construction and Decommissioning and Reclamation activities because soil is most extensively moved and disturbed during these phases. These are also the times when earth moving machinery is the most likely to travel over the soil storage berms and in areas outside of the main transportation corridors. Soil compaction can also result from land subsidence.

Erosion

The greatest potential for soil erosion will occur during Construction and Decommissioning and Reclamation due to the amount of ground disturbance and exposed soil surfaces. On disturbed slopes, soil erosion and slope failure can occur during spring snow/ice melt and rainfall events. Even on relatively flat terrain, exposed finer soils may be susceptible to “splash erosion”, which can result in a loss of soil structure and crusting of the surface, thereby preventing root penetration and seedling development.

Contamination

The primary potential sources of metal contamination exposure, direct and indirect, for soils in the LSA, are (i) the coarse coal reject stockpile, and (ii) sedimentation ponds. Miscellaneous spills or accidents involving the release of fuel or chemicals are discussed separately as waste management and spill prevention issues (Chapter 22).

Coal reject materials produced during coal washing frequently generate acidic waste (Stewart and Daniels 1992). Since metals contained in oxidizing coal refuse can become mobile in an acidic environment, coal mine drainage often contains significant amounts of dissolved trace metals (Stewart et al. 2001), especially selenium (Donovan and Ziemkiewicz 2013). The analysis of drilling samples collected at the Project site suggest that the median (1.8 ppm) and maximum (5.9 ppm) concentrations of selenium in the coarse coal rejects will be similar to these recorded at the nearby Quintette, Trend, and Roman mines (Peace River Coal Inc. 2010; Teck Coal Limited 2012). Based on observations recorded at the existing CCR disposal area at the Quintette property (Teck Coal Limited 2012), conditions resulting in limited selenium leaching can be expected in the proposed CCR storage area.

Fugitive dust emission will occur during vehicle traffic along the Murray River Forest Service Road and along other local roads, but it is expected to be limited within the Mine Site Assessment Footprint where a substantial proportion of vehicle traffic and other dust-generating activities will occur underground (Figure 11.7-5). The detailed discussion of dust emission, distribution, and deposition patterns within the LSA and the assessment of dust effects on Air Quality are presented in Chapter 6.

Deposition of emitted dust is expected to be one of the pathways of potential soil contamination with metals. In the immediate vicinity of roads, direct deposition of dust on vegetation will likely decrease plant health.

Acidification

Industrial activities, such as power generation, transportation, or any activity involving the use of diesel engines, are expected to result in the emission of compounds containing sulfur and nitrogen, which indirectly affect sensitive soils and ecosystems throughout the life of the Project. Nitrogen oxides (NO_x) and sulfur dioxide (SO_2) emissions have been associated with increased atmospheric acid deposition which appears to be one of the factors affecting soil acidification (Reuss, Cosby, and Wright 1987; Galloway 1995).

Depending on the characteristics of soils (i.e., acid buffering capacity) and sensitivity of ecosystems, sustained aerial deposition of these compounds could result in acidification of soils and alteration of botanical composition in affected ecosystems. When acid deposition rates exceed the buffering capacity of the local soil, changes in soil chemical properties tend to modify the cycling of nutrients within the system, change the bioavailability of toxic chemicals, and affect the overall ability of the ecosystem to function. If soil acidification occurs, it is expected that the affected ecosystem will be more susceptible to stress factors such as frost, drought, pests, and intrusion of invasive species. Complex interactions between the listed stress factors and nutrient imbalances caused by acid addition have been suggested as a common cause of reduced ecosystem health (Heij and Schneider 1991; Greaver et al. 2012) and reduced species diversity (De Schrijver et al. 2011).

These effects may be detectable only through analytical methods or may exhibit clear visual symptoms (e.g., vegetation decline) within the affected area. The area of potential acidification within the LSA extends over approximately 1,007 ha (Table 11.7-6 and Appendix F), most of which results from high background (baseline) acid deposition levels in the LSA (exceeding the 250 eq/ha/year critical load). It is predicted that soil acidification directly attributable to the Project development will affect approximately 74 ha of sensitive soils. Figure 11.7-6 shows the spatial extent of the sensitive soils and the predicted levels of acid deposition within the LSA.

Figure 11.7-5

Spatial Extent of the Predicted Dust Deposition within the Local Study Area

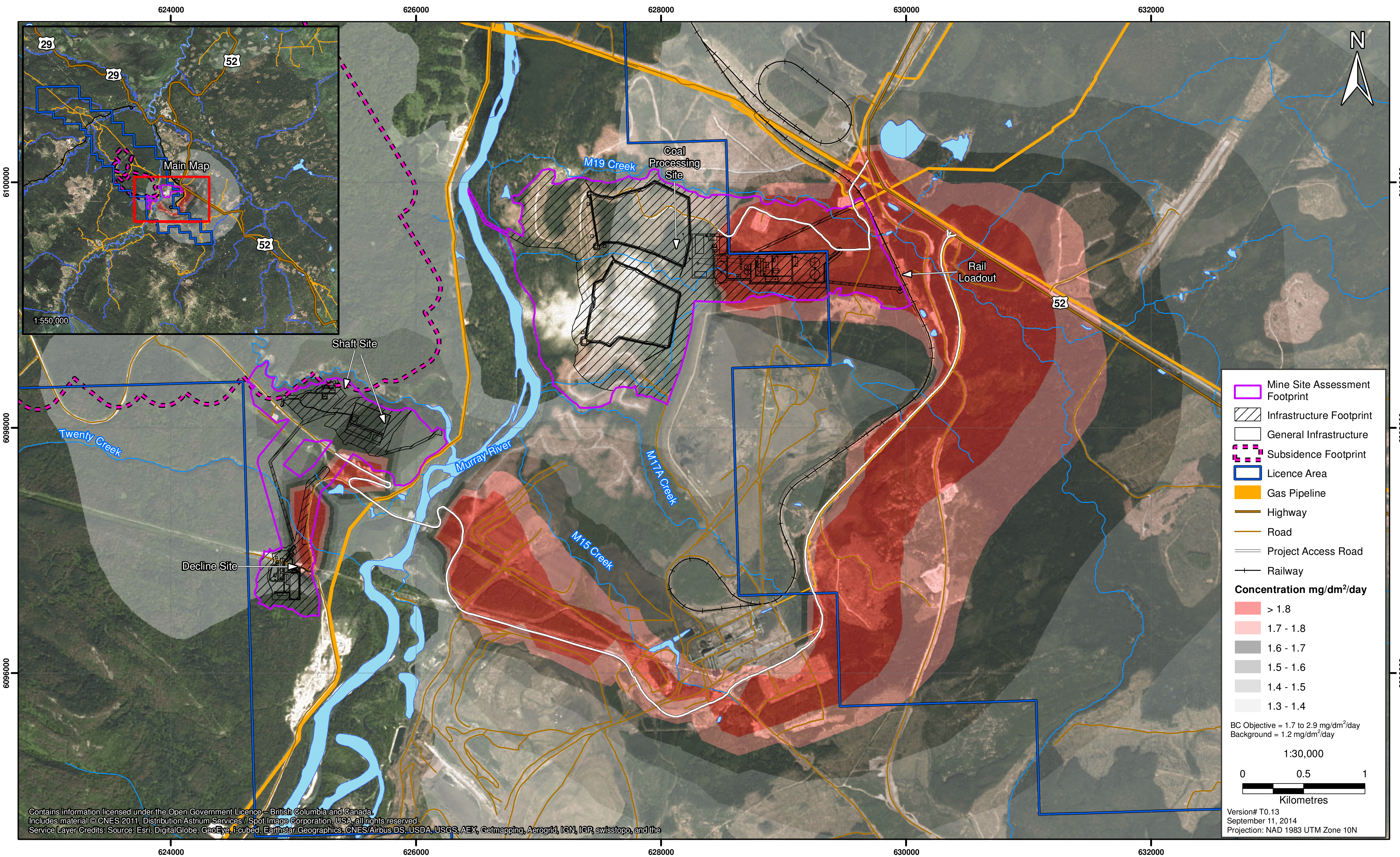


Figure 11.7-6

Spatial Extent of the Predicted Levels of Acid Deposition within the Local Study Area

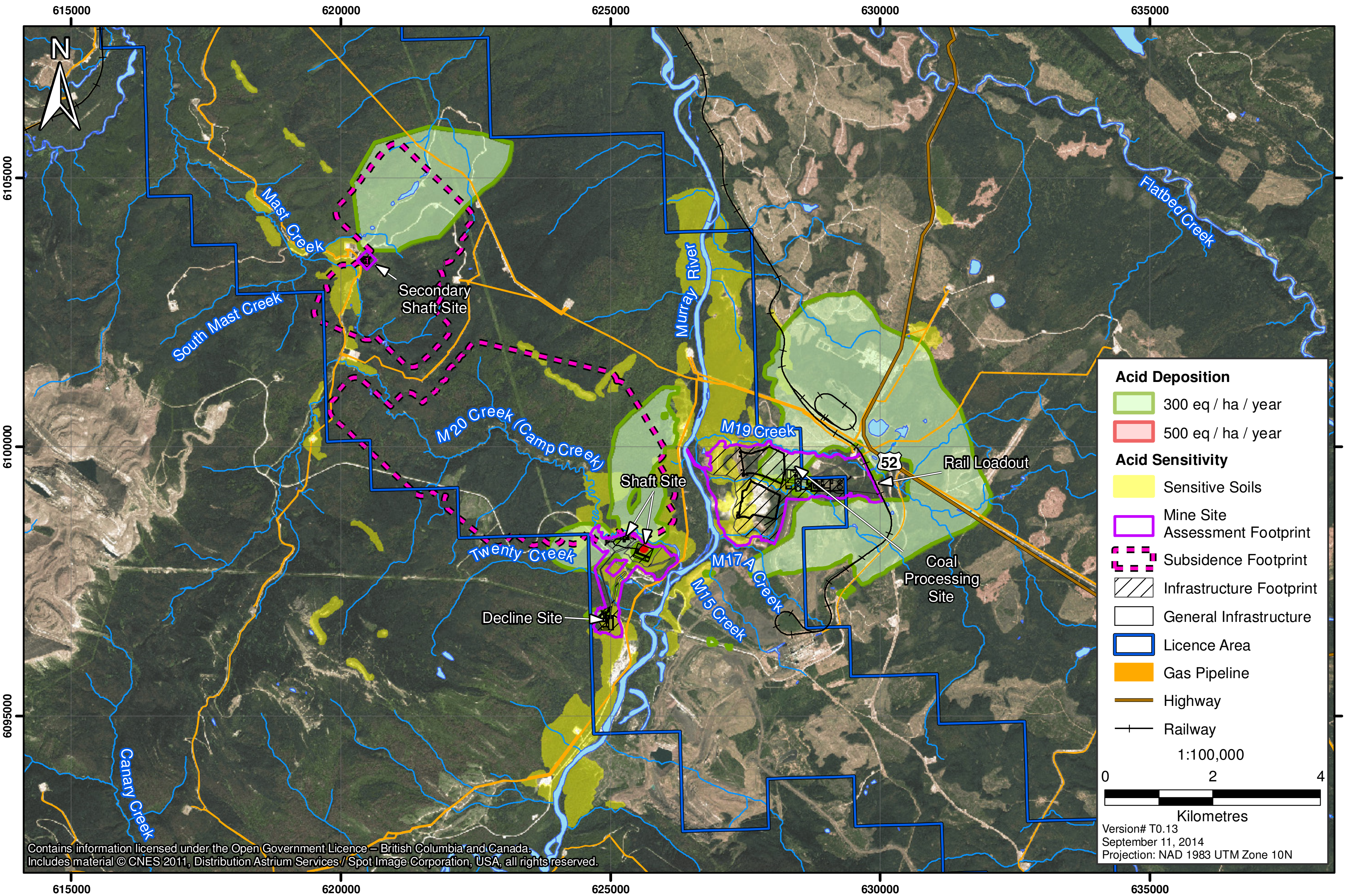


Table 11.7-6. Summary of Soil Acidification by Soil Types

Soil Type	Acid Deposition			
	< 250 eq/ha/y	250-499 eq/ha/y	500-700 eq/ha/y	Total
High Sensitivity (critical load 250-500 eq/ha/year)	0	1,006	0.47	**1,007**
Moderate Sensitivity (critical load 500 – 1,000 eq/ha/year)	0	4,383	0.04	**4,384**
Low Sensitivity (critical load > 1,000 eq/ha/year)	0	9,259	0	**9,259**
Not Classified (Anthropogenic or Open Water)	0	297	0	**297**
Total	**0**	**14,945**	**0.5**	**14,946**

Land Subsidence

Land subsidence associated with underground coal extraction may result in permanent changes in land morphology and alteration of existing hydrological patterns. Such changes may affect soil moisture regimes in the ecosystems affected by land subsidence and thus, influence their botanical composition, species diversity, productivity, and subsequently their quality as wildlife habitat. Potential soil erosion or solifluction events resulting from land subsidence may revert affected ecosystems to early seral stages. The area of subsidence was overlain on the soil mapping units to determine the level of risk to each ecologically valuable soil type. Assuming that subsidence will occur equally throughout the predicted subsidence area, subsidence represents a high risk to 75 ha, a medium risk to 1,508 ha and a low risk to 681 ha of ecologically valuable soils. Table 11.7-7 summarizes the overlap of predicted subsidence with ecologically valuable soils.

Table 11.7-7. Summary of Subsidence Overlap with Ecologically Valuable Soils

Eco Rating	Parent Material	SMU Group	SMU	High (ha)	Moderate(ha)	Low (ha)
1	F	SMU-F2	F6_G.p	-	4.7	23.9
	F	SMU-O2	F7_G.p	-	6.3	2.1
	FG	SMU-FG3	FG5_BR.GL.g	0.6	24.7	7.0
	M	SMU-M1	M2_B	-	16.1	0.4
	M	SMU-M1	M2_BR.GL	0.0	57.7	0.0
	M	SMU-M1	M3_B	1.0	27.3	0.3
	M	SMU-M1	M3_BR.GL	0.1	35.2	-
	M	SMU-M1	M4_B	16.3	423.4	7.1
	M	SMU-M1	M4_BR.GL	43.0	540.3	22.2
	M	SMU-M2	M5_B.g	9.7	138.6	-
	M	SMU-M2	M5_BR.GL.g	4.4	67.5	20.4
	O	SMU-O1	O7_M	-	0.2	7.9
	O	SMU-O2	O5_G.p	0.0	12.2	-
	O|M	SMU-O2	O|M6_G.p	-	1.0	-

(continued)

Table 11.7-7. Summary of Subsidence Overlap with Ecologically Valuable Soils (completed)

Eco Rating	Parent Material	SMU Group	SMU	High (ha)	Moderate(ha)	Low (ha)
2	C	SMU-C1	C2_B	-	1.1	52.7
	C	SMU-C1	C3_B	-	27.7	95.5
	C	SMU-C1	C4_B	-	27.2	170.8
	C	SMU-C1	C4_O.HFP	-	1.2	2.5
	C	SMU-C2	C5_B.g	-	21.2	23.3
	F	SMU-F1	F2_B	-	0.1	2.4
	F	SMU-F1	F4_B	-	2.5	3.0
	F	SMU-F2	F5_B.g	-	7.2	2.6
	FG	SMU-FG1	FG2_B	-	29.2	26.4
	FG	SMU-FG1	FG4_B	-	21.0	28.6
	FG	SMU-FG3	FG5_B.g	-	1.5	0.0
	FG|M	SMU-FG2	FG|M4_B	-	0.4	3.4
	M	SMU-M2	M6_G	-	12.8	19.5
3	C	SMU-C1	C2_R	-	-	1.2
	C	SMU-C1	C3_B.lit	-	-	21.3
	C	SMU-C1	C4_B.lit	-	-	0.5
	F	SMU-F1	F3_CU.R	-	-	1.1
	F	SMU-F2	F6_G.r	-	-	1.3
	M	SMU-M1	M2_CU.R	-	-	2.2
	M	SMU-M1	M3_B.lit	-	-	9.6
	M	SMU-M1	M4_B.lit	-	-	59.0
4	A	SMU-A	An_n	-	-	42.0
	OW	OpWater	OW99_n	-	-	8.5
	R	SMU-R	R2_B.lit	-	-	6.0
	R	SMU-R	R3_R.lit	-	-	6.6
Grand Total				**75.0**	**1,508.1**	**681.3**

In summary, it is expected that the area directly impacted by footprint development will result in the loss of 280 ha (2.4%) and degradation of 166 ha (1.4%) of ecologically valuable soils located in the LSA. Indirect effects to soils as a result of subsidence may result in degradation of an additional 2,105 ha (18.2% of valuable soils in the LSA). The level of soil degradation will vary depending on the severity of subsidence, soil compaction, erosion, contamination, acidification, and the soil type affected. Table 11.7-8 summarizes the predicted extent of the effects on the most valuable soils (Ecological Classes 1 and 2). Detailed information about the soil ecological value rating is provided in Section 11.6.4). Reclamation may reduce the area of lost soil and soil handling, stockpiling and redistribution will reduce soil quality.

Table 11.7-8. Summary of Effects on Ecologically Valuable Soils

Source of Effects	Loss (ha)	Degradation (ha)	No Effect (ha)	Total (ha)
Due to Footprint Development	280	166	-	-
Due to Subsidence	-	2105	-	-
Total Area Affected (ha)	**280**	**2,271**	**8,996**	**11,547**
Proportion of Total	2.4%	19.7%	77.9%	**100%**

11.7.2.2 Forested Ecosystems

Ecosystem Loss

According to the results of the risk model, Project activities represent a high risk to 356 ha, a medium risk to 428 ha, a low risk to 1, 708 and no risk to 9, 579 ha of forested ecosystems within the LSA (Table 11.7-9). The majority of the high risk is associated with the loss of mature forested ecosystem spatial extent and function as a result of physical vegetation clearing, soil salvage, and site preparation for the mine components (e.g., Processing Plant, Secondary Shaft Site) within BWBSmw BEC unit. Incremental losses are also expected during closure and reclamation due to slope stabilization and re-contouring, re-vegetation, and reclaimed area maintenance activities.

Ecosystem Alteration

The majority of the moderate to low risk to forested ecosystems is attributable to alteration of ecosystem function or extent. Alteration of ecosystem function and/or extent will occur at the local level and may extend to a landscape level as a result of soil erosion, compaction, loss of fertility, and dust deposition during each phase of the Project.

Edge effects (e.g., species isolation, increased species diversity, and favourable conditions for invasive plants), windthrow (i.e., trees uprooted or broken due to wind), and fragmentation (i.e., the breaking apart of habitat and its associated ecological processes) may occur throughout the life of the Project but mostly during the Construction phase within the Mine Site Assessment Footprint and at the Secondary Shaft Site. The introduction and/or spread of invasive plants could occur during any phase of the Project. The interruption or loss of hydrological connectivity during Construction and Operation is expected to occur at the local level.

Dust

Fugitive dust emissions will be limited within the Mine Site Assessment Footprint as a result of relatively low activity on surface. Some fugitive dust emissions will occur along the Murray River Forest Service Road and along local site roads (Figure 11.7-5). Areas cleared for infrastructure (i.e., laydown areas) will also be sources of dust.

Edge Effects

Edge effects are expected near infrastructure in areas where forest clearing leaves new edges, particularly surrounding portions of the Mine Site Assessment Footprint. Edge effects will vary depending on the size, shape, topography and orientation of the clearing and the adjacent ecosystems (Bannerman 1998).

Table 11.7-9. Risk to Forested Ecosystems within the LSA

BEC Unit	Site Series/ Map Code	Name	General Ecosystem Type	Structural Stage	High (ha)	Moderate (ha)	Low (ha)	None (ha)
BWBSmw	Fl05	Drummond's willow - Bluejoint	Low Bench Floodplain	3a	-	-	-	4
				3b	-	-	-	12
	101$	At – Rose – Creamy peavine	Mesic Forest	3a	-	-	-	7
				3b	20	2	-	-
				4	-	-	13	80
				5	-	-	45	65
				6	-	-	22	22
	102$	At – Soopolallie – Kinnikinnick	Moderately Dry Forest	5	-	-	7	-
	103$	At – Rose – Fuzzy-spiked wildrye	Moderately Dry Forest	3b	-	-	-	9
				4	-	-	5	43
				5	3	2	5	10
				6	-	-	14	19
	104$	At – Labrador tea – Lingonberry	Slightly Dry to Moist Forest	4	-	-	-	7
				5	-	2	12	-
				6	-	-	-	25
	110$	At – Highbush-cranberry – Oak fern	Moist Forest	4	-	-	11	-
	111$	Acb – Dogwood – Highbush-cranberry	Moist Forest	3b	-	-	-	2
				5	-	-	-	4
				6	2	4	-	-
	101	Sw – Trailing raspberry – Step moss	Mesic Forest	1	-	-	5	-
				2a	15	3	12	-
				2b	-	-	-	18
				3a	38	24	42	344
				3b	-	8	61	53
				4	2	9	27	34

(continued)

Table 11.7-9. Risk to Forested Ecosystems within the LSA (continued)

BEC Unit	Site Series/ Map Code	Name	General Ecosystem Type	Structural Stage	High (ha)	Moderate (ha)	Low (ha)	None (ha)
BWBSmw *(cont'd)*	101 *(cont'd)*	Sw – Trailing raspberry – Step moss *(cont'd)*	Mesic Forest *(cont'd)*	5	65	37	204	228
				6	51	28	182	350
				7	-	6	1	-
	102	Pl – Kinnikinnick – Lingonberry	Moderately Dry Forest	3a	-	-	-	8
				3b	-	8	11	-
				4	-	4	9	29
				5	25	34	42	26
	103	SwPl – Soopolallie – Fuzzy-spiked wildrye	Moderately Dry Forest	2a	31	1	-	-
				3a	-	59	31	131
				3b	-	3	16	8
				4	-	14	96	48
				5	34	23	143	79
				6	2	9	25	65
	104	Sb – Labrador tea – Step moss	Slightly Dry to Moist Forest	3a	-	-	19	71
				3b	-	1	11	1
				4	2	7	34	95
				5	7	9	43	81
				6	10	11	136	331
				7	-	-	-	18
	110	Sw – Oak fern – Sarsaparilla	Moist Forest	3a	-	1	-	44
				3b	-	-	6	4
				4		0	7	-
				5	2	8	67	46
				6	11	7	69	150
				7	-	35	10	1

(continued)

Table 11.7-9. **Risk to Forested Ecosystems within the LSA (continued)**

BEC Unit	Site Series/ Map Code	Name	General Ecosystem Type	Structural Stage	High (ha)	Moderate (ha)	Low (ha)	None (ha)
BWBSmw *(cont'd)*	111	Sw – Currant – Horsetail	Moist Forest	2a	-	-	-	3
				2b				18
				3a	-	-	1	15
				3b	-	1	-	4
				4	-	-		9
				5	5	23	29	40
				6	23	21	8	121
				7	-	-	25	8
	112	AcbSw – Mountain alder – Dogwood	Mid Bench Floodplain	3a	-	-	1	3
				3b	-	-	2	6
				4	-	-	-	-
				5	-	-	-	8
				6	-	-	8	75
				7	-	3	31	12
BWBSmw Total					**348**	**407**	**1,548**	**2,894**
BWBSwk1	101$	At – Birch-leaved spirea – Huckle-berry	Mesic Forest	4	-	-	3	33
				5	1	3	-	176
				6	-	-	-	60
	102$	At – Kinnikinnick – Fuzzy-spiked wildrye	Moderately Dry Forest	3b	-	-	1	3
				4	-	-	12	2
	103$	At – Rose – Fuzzy-spiked wildrye	Moderately Dry Forest	3b	-	-	1	14
				4	1	6	-	42
				5	1	4	1	94
				6	-	-	-	12
	104$	At – Labrador tea – Lingonberry	Slightly Dry to Moist Forest	5	-	-	-	16

(continued)

Table 11.7-9. Risk to Forested Ecosystems within the LSA (continued)

BEC Unit	Site Series/ Map Code	Name	General Ecosystem Type	Structural Stage	High (ha)	Moderate (ha)	Low (ha)	None (ha)
BWBSwk1 *(cont'd)*	110$	AcbAt – Cow-parsnip	Moist Forest	3b	-	-	-	1
				5	1	-	-	20
				6	-	-	-	15
	110$.2	At – Highbush-cranberry – Oak fern	Moist Forest	6	-	-	-	10
	101	SwBl – Huckleberry – Feathermoss	Mesic Forest	2a	-	-	-	5
				3a	-	-	12	280
				3b	-	-	-	66
				4	-	-	-	69
				5	-	2	3	372
				6	1	1	6	889
	102	Pl – Lingonberry – Reindeer lichen	Moderately Dry Forest	3a	-	-	-	9
				3b	-	-	1	3
				4	-	-	-	5
				5	-	-	-	117
				6	-	-	4	-
	103	SwPl – Soopollalie – Showy aster	Moderately Dry Forest	3a	-	-	-	9
				3b	-	-	-	1
				4	-	-	-	9
				5	1	2	5	136
				6	-	1	14	101
	104	Sb – Huckleberry – Lingonberry	Slightly Dry to Moist Forest	2a	-	-	-	1
				3a	-	-	-	48
				3b	-	-	4	44
				4	-	-	-	51
				5	-	-	-	110
				6	-	-	3	78

(continued)

Table 11.7-9. Risk to Forested Ecosystems within the LSA (continued)

BEC Unit	Site Series/ Map Code	Name	General Ecosystem Type	Structural Stage	High (ha)	Moderate (ha)	Low (ha)	None (ha)
BWBSwk1 *(cont'd)*	110	Sw – Currant – Horsetail	Moist Forest		-	-	-	3
				2a	-	-	-	3
				3a	-	-	2	60
				3b	-	0	1	47
				5	-	-	-	47
				6	1	0	3	623
	111	Sb – Horsetail – Step moss	Moist Forest	3a	-	-	-	1
				3b	-	-	-	3
				5	-	-	-	12
				6	-	-	2	22
	00/FM	Forb Meadow	Dry to Mesic Herb	2	-	-	2	-
				2a	-	-	3	-
BWBSwk1 Total					**7**	**19**	**83**	**3,722**
ESSFmv2	01/FR	Bl - Rhododendron - Feathermoss	Mesic Forest	3a	-	-	-	128
				3b	-	-	2	23
				4	-	-	2	49
				5	-	-	2	419
				6	-	-	8	1,028
	02/FL	Bl - Lingonberry	Moderately Dry Forest	3a	-	-	2	2
				3b	-	-	4	15
				4	-	-	-	34
				5	-	-	9	118
				6	-	-	11	38
	03/BT	BlSb - Labrador tea	Slightly Dry to Moist Forest	3a	-	-	-	5
				4	-	-	5	19
				5	-	-	3	180
				6	-	-	2	187

(continued)

Table 11.7-9. Risk to Forested Ecosystems within the LSA (completed)

BEC Unit	Site Series/ Map Code	Name	General Ecosystem Type	Structural Stage	High (ha)	Moderate (ha)	Low (ha)	None (ha)
ESSFmv2 *(cont'd)*	04/FO	Bl - Oak fern - Knight's plume	Mesic Forest	3a	-	-	-	40
				3b	-	-	-	9
				4	-	-	-	3
				5	-	-	1	32
				6	-	-	4	224
	05/FD	Bl - Devil's club - Rhododendron	Moist Forest	3a	-	-	-	3
				3b	-	-	-	17
				5	-	-	-	51
				6	-	-	1	240
	00/FM	Forb Meadow	Dry to Mesic Herb	2a	-	-	7	-
ESSFmv2 Total							**63**	**2,864**
SBSwk2	01/SO	Sxw - Oak fern	Mesic Forest	5	-	-	-	2
				6	-	0	5	25
	02/LH	Pl - Huckleberry - Cladina	Moderately Dry Forest	3b	-	-	2	5
				4	-	-	-	2
				5	-	-	4	10
	03/SC	Sxw - Huckleberry – Highbush-cranberry	Moderately Dry Forest	4	-	-	-	2
				5	-	-	-	23
	05/SD	Sxw – Devil's club	Moist Forest	5	-	-	-	3
				6	-	-	-	21
	Fm02/CD	Cottonwood – Spruce – Red-osier dogwood	Mid Bench Floodplain	6	-	-	2	5
				7	-	-	-	2
SBSwk2 Total					**-**	**0**	**13**	**100**
Grand Total					**356**	**428**	**1,708**	**9,579**

The size and shape of the clearing determines the amount of edge created and influences the quality of the remaining interior habitat; the existing topography and site orientation will influence the amount and intensity of sunlight and wind exposure on ecosystems.

Windthrow

Ecosystems adjacent to the Coal Processing Site and the Shaft Site are at varying degrees of risk of windthrow, depending on their site-specific conditions and exposure to wind. Forest ecosystems develop in response to a variety of environmental conditions, including slope topography, soil moisture and nutrients. These environmental conditions influence species-dependent differences in rooting depths, height-to-diameter ratios, and height-to-crown length ratios (Stathers, Rollerson, and Mitchell 1994), all of which influence a site's ability to withstand windthrow.

Fragmentation

Fragmentation of forested ecosystems is expected to occur during Construction as a result of mine infrastructure development and during Operation as a result of the expansion of the Coarse Coal Reject (CCR) piles. In general, the overall effects of fragmentation on habitat may not be immediately identifiable after fragmentation occurs. The effects of fragmentation are discussed in more detail in Chapter 13, Assessment of Wildlife Effects.

Hydrological Connectivity

Construction of the contact water collection ditches, sedimentation pond(s) and water management structures may change hydrological connectivity through the interruption, re-routing, removal, or increase of surface and/or sub-surface flow These changes may results in changes to soil moisture regimes and alter ecosystem development, depending on the magnitude of the change and on the receiving topography, bedrock geology, surficial geology, soil type, and depth. Project effects on hydrology connectivity are expected to be localized because the Project will use existing roads.

Introduction of Invasive Plants

Construction activities cause the largest initial disturbances and create suitable conditions for both the introduction and spread of invasive plants. Vehicles of any size (e.g., heavy machinery to all-terrain vehicles) travelling along the Murray River FSR could inadvertently transport plant propagules in tires, the undercarriage, or in mud on the vehicle to previously unaffected areas.

Land Subsidence

While general mechanisms and effects of subsidence are known, predicting specific effects of subsidence on terrestrial ecology VC extent or functions are challenging due to the complex interactions between subsidence, water flow, and geology in areas with variable topography and geology. In order to determine the level of risk to each forested ecosystem type within the LSA, the area of subsidence was overlain on the terrestrial ecosystem mapping. Assuming that subsidence will occur equally throughout the predicted subsidence area, subsidence represents a high risk to 74 ha, a medium risk to 1,485 ha and a low risk to 587 ha of forested ecosystems. Table 11.7-10 summarizes the overlap of predicted subsidence with ecologically valuable soils.

Table 11.7-10. Summary of Subsidence Overlap with Ecosystem Consequence Rating

BEC Code	Site Series	Map Code	Structural Stage	High (ha)	Moderate (ha)	Low (ha)	Name	General Ecosystem Type	Harvestable Plants
BWBSmw	101$	101$	5	-	5.1	-	At – Rose – Creamy peavine	Mesic Forest	Highbush cranberry *(Viburnum edule)*, fireweed *(Epilobium angustifolium)*, bunchberry *(Cornus canadensis)*
	101	101	3b	-	1.7	0.8	Sw – Trailing raspberry – Step moss	Mesic Forest	Highbush cranberry *(Viburnum edule)*, trailing raspberry *(Rubus pubescens)*
			5	22.2	8.5	-			
			6	30.6	33.1	7.9			
	102	102	3b	-	1.8	3.0	Pl – Kinnikinnick – Lingonberry	Moderately Dry Forest	Kinnikinnick *(Actostaphyos uva-ursi)*, lingonberry *(Vaccinium viti-idaea)*
			4	-	2.7	15.2			
			5	-	25.4	12.5			
	103	103	3a	0.4	2.4	-	SwPl – Soopolallie – Fuzzy-spiked wildrye	Moderately Dry Forest	Soopalillie *(Shepherdia canadensis)*, fuzzy-spiked wildrye *(Leymus innovatus)*, bunchberry *(Cornus canadensis)*
			3b	-	0.7	-			
			4	-	1.8	3.0			
			5	0.4	5.0	3.0			
			6	0.5	8.2	9.5			
	103$	103$	4	-	0.1	12.9	At – Rose – Fuzzy-spiked wildrye	Moderately Dry Forest	Soopalillie *(Shepherdia canadensis)*, fireweed *(Epilobium angustifolium)*
	104$	104$	5	-	0.8	4.9	At – Labrador tea – Lingonberry	Slightly Dry to Moist Forest	highbush cranberry *(Viburnum edule)*, labrador tea *(Ledum groenlandicum)*, dwarf blueberry *(Vaccinium caespitosum)*
			6	-	9.3	2.8			
	104	104	4	-	1.3	11.9	Sb – Labrador tea – Step moss	Slightly Dry to Moist Forest	Labrador tea *(Ledum groenlandicum)*, lingonberry *(Vaccinium vitis-idaea)*, bunchberry *(cornus canadensis)*
			5	-	1.3	3.8			
			7	-	14.0	4.2			
	110	110	5	10.3	-	-	Sw – Oak fern – Sarsaparilla (blue listed)	Moist Forest	Highbush cranberry *(Viburnum edule)*, bunch berry *(cornus canadensis)*, trailing raspberry *(Rubus pubescens)*
			6	41.4	-	-			
			7	3.4	-	-			
	111	111	3b	-	0.1	0.5	Sw – Currant – Horsetail (blue listed)	Moist Forest	Highbush cranberry *(Viburnum edule)*, trailing raspberry *(Rubus pubescens)*
			6	2.3	-	-			

(continued)

Table 11.7-10. Summary of Subsidence Overlap with Ecosystem Consequence Rating (continued)

BEC Code	Site Series	Map Code	Structural Stage	High (ha)	Moderate (ha)	Low (ha)	Name	General Ecosystem Type	Harvestable Plants
BWBSwk1	101$	101$	4	-	0.7	0.4	At – Birch-leaved spirea – Huckle-berry	Mesic Forest	Fireweed *(Epilobium angustifolium)*, bunchberry *(Cornus canadensis)*
			5	0.2	32.7	19.9			
			6	0.5	12.1	30.2			
	101	101	3a	-	94.0	6.2	SwBl – Huckleberry – Feathermoss	Mesic Forest	Black huckleberry *(Vaccinium membranaceum)*, bunchberry *(Cornus canadensis)*
			3b	-	12.0	7.6			
			5	-	144.0	13.9			
			6	1.8	178.7	40.7			
	102$	102$	3b	-	-	2.8	At – Kinnikinnick – Fuzzy-spiked wildrye	Moderately Dry Forest	Lingonberry *(Vaccinium vitis-idaea)*
			4	-	-	5.0			
	102	102	3b	-	1.6	2.3	Pl – Lingonberry – Reindeer lichen	Moderately Dry Forest	Labrador tea *(Ledum groenlandicum)*, lingonberry *(Vaccinium vitis-idaea)*, bunchberry *(Cornus canadensis)*
			4	-	0.0	4.0			
			5	-	39.7	-			
			6	-	0.1	1.7			
	103$	103$	4	-	7.9	23.6	At – Rose – Fuzzy-spiked wildrye	Moderately Dry Forest	Highbush cranberry *(Viburnum edule)*
			5	-	16.1	29.7			
			6	-	-	2.4			
	103	103	3a	-	5.8	-	SwPl – Soopollalie – Showy aster (blue listed)	Moderately Dry Forest	Soopalillie *(Shepherdia canadensis)*, bunchberry *(Cornus canadensis)*
			3b	-	0.7	-			
			4	-	7.5	1.1			
			5	49.8	-	-			
			6	47.8	-	-			
	104	104	2a	-	1.3	-	Sb – Huckleberry – Lingonberry	Slightly Dry to Moist Forest	Labrador tea *(Ledum groenlandicum)*, black huckleberry *(Vaccinium membranaceum)*, lingonberry *(Vaccinium vitis-idaea)*
			3a	-	21.7	8.2			
			4	-	13.6	15.5			
			5	-	53.4	1.4			
			6	-	26.1	1.8			

(continued)

Table 11.7-10. Summary of Subsidence Overlap with Ecosystem Consequence Rating (continued)

BEC Code	Site Series	Map Code	Structural Stage	High (ha)	Moderate (ha)	Low (ha)	Name	General Ecosystem Type	Harvestable Plants
BWBSwk1 *(cont'd)*	104$	104$	5	-	15.6	-	At – Labrador tea – Lingonberry	Mesic Forest	Labrador tea *(Ledum groenlandicum)*, velvet-leaved blueberry *(Vaccinium myrtilloides)*, lingonberry *(Vaccinium vitis-idaea)*
	110	110	2a	-	2.9	-	Sw – Currant – Horsetail (blue listed)	Moist Forest	Highbush-cranberry *(Viburnum edule)*, black twinberry *(Lonicera innvolucrata)*, black gooseberry *(Ribes lacustre)*, trailing raspberry *(Rubus pubescens)*
			3a	-	28.8	1.8			
			3b	-	7.9	6.7			
			5	17.5	-	-			
			6	225.7	-	-			
	110$	110$	3b	0.3	0.4	-	AcbAt – Cow-parsnip	Moist Forest	Highbush-cranberry *(Viburnum edule)*, cow-parsnip *(Heracleum maximum)*
			5	-	3.1	2.1			
			6	-	4.3	7.0			
	110$.2	110$.2	6	-	1.4	0.3	At – Highbush-cranberry – Oak fern	Moist Forest	Highbush-cranberry *(Viburnum edule)*, black twinberry *(Lonicera involucrata)*, bunchberry *(Cornus canadensis)*
	111	111	3a	-	0.2	1.2	Sb – Horsetail – Step moss	Moist Forest	Labrador tea *(Ledum groenlandicum)*, lingonberry *(Vaccinium vitis-idaea)*, bunchberry *(cornus canadensis)*
			3b	-	0.1	-			
			5	-	0.2	0.3			
			6	-	2.5	1.2			
ESSFmv2	00	FM	2a	-	-	6.6	Forb Meadow	Dry to Mesic Herb	None identified
	01	FR	3a	-	25.2	0.8	Bl - Rhododendron - Feathermoss	Mesic Forest	Black huckleberry *(Vaccinium membranaceum)*, bunchberry *(Cornus canadensis)*
			3b	-	4.8	2.5			
			4	-	5.7	0.3			
			5	-	67.6	34.1			
			6	-	61.7	39.2			

(continued)

Table 11.7-10. Summary of Subsidence Overlap with Ecosystem Consequence Rating (completed)

BEC Code	Site Series	Map Code	Structural Stage	High (ha)	Moderate (ha)	Low (ha)	Name	General Ecosystem Type	Harvestable Plants
ESSFmv2 *(cont'd)*	02	FL	3b	-	0.0	7.1	Bl - Lingonberry	Moderately Dry Forest	Black huckleberry *(Vaccinium membranaceum)*
			3b	-	0.0	3.1			
			4	-	3.9	7.1			
			5	-	4.5	10.9			
			6	-	3.4	9.2			
	03	BT	3a	-	3.3	-	BlSb - Labrador tea	Slightly Dry to Moist Forest	Black huckleberry *(Vaccinium membranaceum),* Labrador tea *(Ledum groenlandicum),* Lingonberry *(Vaccinium vitis-idaea)*
			4	-	0.5	1.4			
			5	-	19.5	1.5			
			6	-	2.3	13.3			
	04	FO	3a	-	6.1	0.2	Bl - Oak fern - Knight's plume	Mesic Forest	Black huckleberry *(Vaccinium membranaceum)*
			4	-	0.6	0.7			
			5	-	8.5	0.4			
			6	-	3.8	9.4			
	05	FD	3a	-	1.0	-	Bl - Devil's club - Rhododendron	Moist Forest	Devil's club *(Oplopanax horridus),* bunchberry *(Cornus canadensis)*
			3b	-	1.4	-			
			5	-	12.3	0.3			
			6	5.6	16.7	2.7			
	06	FH	3a	-	3.5	-	Bl - Alder - Horsetail (Ws08 - Bl - Sitka valerian - Common horsetail)	Wet Forest	Bunchberry *(Cornus canadensis)*
			3b	-	1.2	2.1			
			5	-	4.0	2.3			
			6	-	17.1	17.3			
Grand Total				**20.7**	**1360.4**	**538.8**			

Note: It is expected that only blue listed ecosystems with structural stages 5, 6, and 7 would contain the plant community identified by the BC CDC as rare (shaded cells).

11.7.2.3 Key Effects on BC CDC Listed Ecosystems

Based on the current Project design, six blue-listed ecosystem types will be directly affected by the construction of Project infrastructure (Table 11.7-11). Construction activities are expected to result in the loss of 51 ha of rare ecosystems (Figure 11.7-7). The greatest risk to BC CDC listed ecosystems is attributable to the development of the Coal Processing Plant and the Secondary Shaft. The majority of the loss is associated with the white spruce/oak fern - wild sarsaparilla (BWBSmw 111) ecosystem, and the white spruce/oak fern - wild sarsaparilla (BWBSmw 110). According to the mapping, most of the effects to the BWBSmw 111 and BWBSmw 110 will occur to mature forest stands (structural stage 6).

Rare ecosystems may be affected by land subsidence, due to changes in the edaphic conditions that influence botanical composition and species diversity. Table 11.7-10 summarizes the overlap of subsidence with the rare ecosystems.

Rare ecosystem may also be indirectly impacted through fragmentation, edge effects, alteration of hydrology, dust deposition, and windthrow as a result of the ongoing activities of the Project. The distributions of rare ecosystems within the LSA and the amount of rare ecosystems that could be lost and altered are summarized below.

11.7.2.4 Key Effects on Harvestable Plants

Most of the vegetated ecosystems within the LSA have the potential to support harvestable plants. As such, the potential loss or alteration of ecosystems may result in effects to harvestable plants. The majority of the effects to harvestable plants will occur as a result of clearing activities at the Mine Site Assessment Footprint, which will remove approximately 287 ha of potential harvestable plant habitat (Table 11.7-12).

Ecosystems that support harvestable plants may be affected by land subsidence, due to changes in the edaphic conditions that influence botanical composition and species diversity. Table 11.7-10 summarizes the overlap of subsidence with harvestable plant habitat.

The remaining effects are likely to occur as a result of fugitive dust emissions, which could affect up to 778 ha of potential harvestable plant habitat. Dust can have various effects on vegetation, depending on deposition load, duration, and frequency of dusting (all of which contribute to cumulative buildup), as well as the chemical properties of the dust and the plant species involved. Figure 11.7-5 shows the extent of the area where the predicted dustfall will exceed 1.7 $mg/dm^2/day$.

11.7.2.5 Key Effects on Rare Plant and Lichens

Project activities associated with Construction may result in the loss of one red-listed species, *Drymocallis arguta* s. str. (tall cinquefoil) and two blue-listed species *Cardamine parviflora* (sand bittercress) and *Botrychium crenulatum* (dainty moonwort; Table 11.7-13 and Figure 11.7-8). According to the current Project design, the 230 kv Transmission Line could impact one population of dainty moonwort and the 10 kV transmission line could impact two additional but separate populations of dainty moonwort. *Cardamine parviflora* may be affected by the development of the discharge pipeline leading into Murray River from the Coal Processing Site.

Figure 11.7-7

Risk to BC CDC Listed Ecosystems

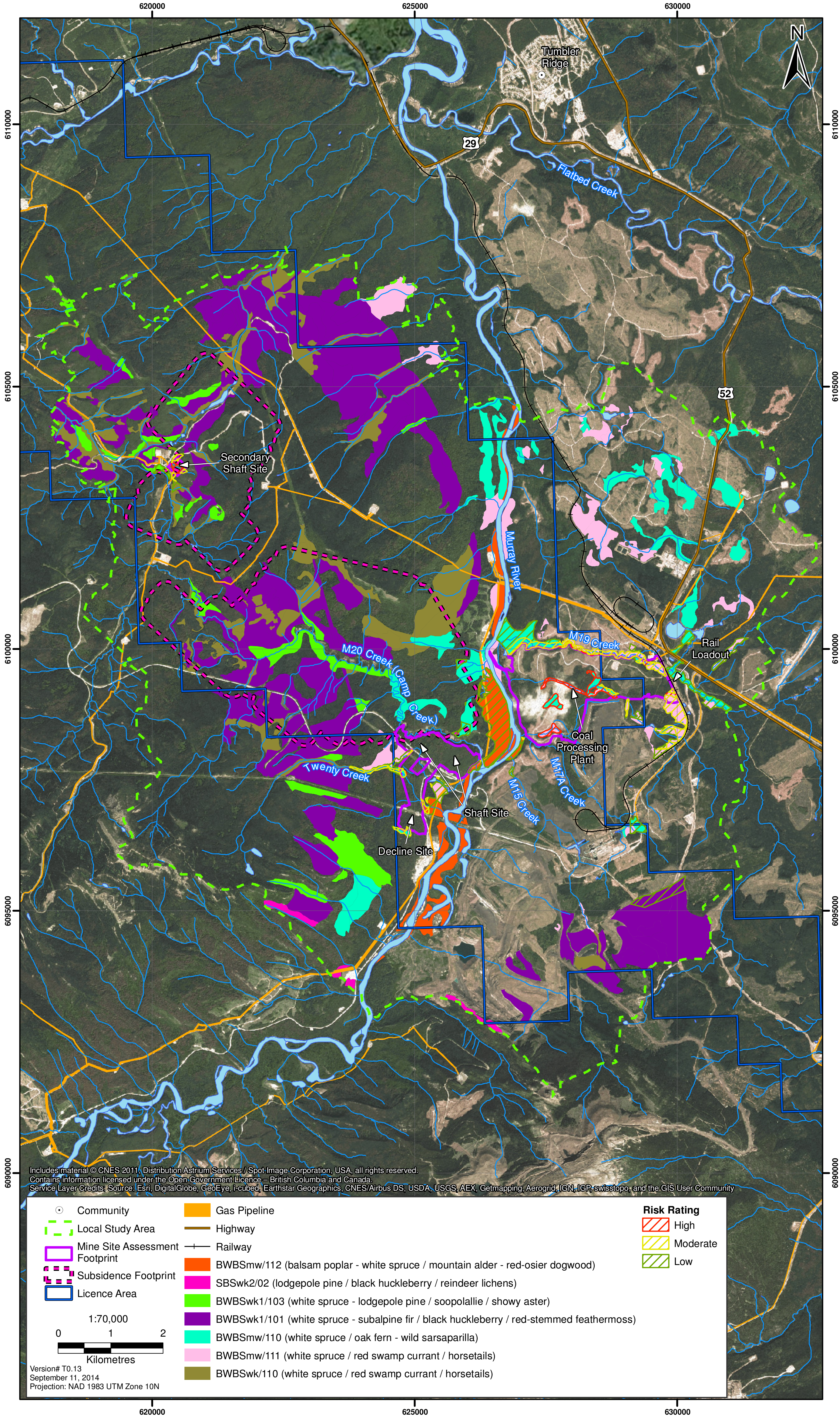


Table 11.7–11. Summary of Effects to BC Conservation Data Centre Listed Ecosystems

BC CDC Listed Ecosystem	English Name	Structural Stage	BC List	Loss (ha)	Altered (ha)	Unaltered (ha)	Total Mapped within LSA (ha)
BWBSmw/111 *(Picea glauca / Ribes triste / Equisetum* spp.)	white spruce / red swamp currant / horsetails	young forest (5)	Blue	8	3	87	98
		mature forest (6)		25	19	129	173
		old forest (7)		-	2	29	32
Total				**33**	**24**	**246**	**304**
BWBSmw/110 *(Picea glauca / Gymnocarpium dryopteris - Aralia nudicaulis)*	white spruce / oak fern - wild sarsaparilla	young forest (5)	Blue	4	2	118	123
		mature forest (6)		11	2	225	238
		old forest (7)		-	12	34	46
Total				**14**	**16**	**377**	**407**
BWBSmw/ 112 *(Populus balsamifera - Picea glauca / Alnus incana - Cornus stolonifera)*	balsam poplar - white spruce / mountain alder - red-osier dogwood	young forest (5)	Blue	-	-	8	8
		mature forest (6)		-	2	80	83
		old forest (7)		-	1	45	46
Total				**-**	**4**	**133**	**137**
BWBSwk1/101 *(Picea glauca - Abies lasiocarpa / Vaccinium membranaceum / Pleurozium schreberi)*	white spruce - subalpine fir / black huckleberry / red-stemmed feathermoss	young forest (5)	Blue	-	1	376	377
		mature forest (6)		1	1	895	897
Total				**1**	**2**	**1,271**	**1,273**
BWBSwk1/103 *(Picea glauca - Pinus contorta / Shepherdia canadensis / Eurybia conspicua)*	white spruce - lodgepole pine / soopolallie / showy aster	young forest (5)	Blue	1	2	141	144
		mature forest (6)		-	1	115	116
Total				**1**	**3**	**256**	**260**
BWBSwk1/110 *(Picea glauca / Ribes triste / Equisetum* spp.)	white spruce / red swamp currant / horsetails	young forest (5)	Blue	-	-	47	47
		mature forest (6)		1	-	626	628
Total				**1**	**-**	**674**	**675**
SBSwk2/02 *(Pinus contorta / Vaccinium membranaceum / Cladina* spp.)	lodgepole pine / black huckleberry / reindeer lichens	young forest (5)	Blue	-	-	14	14
Total				**-**	**-**	**14**	**14**
Grand Total				**51**	**51**	**3,227**	**3,330**

Table 11.7-12. Loss and Alteration of Ecosystems with Harvestable Plants

BEC Unit	Harvestable Species	Site Series	Structural Stage	Ecosystem Name	Loss (ha)	Alteration (ha)	No Effect (ha)
BWBSmw	Highbush cranberry (*Viburnum edule*), trailing raspberry (*Rubus pubescens*),	101	2a	Sw – Trailing raspberry – Step moss	16	14	6
			2b		-	-	18
			3a		36	30	383
			3b		-	44	78
			4		2	23	48
			5		46	103	383
			6		42	61	508
			7		0	1	7
	Black huckleberry (*Vaccinium membranaceum*), bunchberry (*Cornus canadensis*),	101	2a	SwBl – Huckleberry – Feathermoss	-	-	5
			3a		-	-	292
			3b		-	-	66
			4		-	-	69
			5		-	1	376
			6		1	1	883
	Highbush cranberry (*Viburnum edule*), fireweed (*Epilobium angustifolium*), bunchberry (*Cornus canadensis*)	101$	3a	At – Rose – Creamy peavine	-	-	7
			3b		20	1	1
			4		-	2	92
			5		-	11	99
			6		-	-	44
	Kinnikinnick (*Actostaphyos uva-ursi*), lingonberry (*Vaccinium viti-idaea*)	102	3a	Pl – Kinnikinnick – Lingonberry	-	-	8
			3b		-	1	18
			4		-	2	40
			5		18	19	87

(continued)

Table 11.7-12. Loss and Alteration of Ecosystems with Harvestable Plants (continued)

BEC Unit	Harvestable Species	Site Series	Structural Stage	Ecosystem Name	Loss (ha)	Alteration (ha)	No Effect (ha)
BWBSmw *(cont'd)*	Labrador tea (*Ledum groenlandicum*), lingonberry (*Vaccinium vitis-idaea*), bunchberry (*Cornus canadensis*)	102	3a	Pl – Lingonberry – Reindeer lichen	-	-	9
			3b		-	-	4
			4		-	-	5
			5		-	-	117
			6		-	-	4
	Saskatoon berries (*Amelanchier alnifolia*), common juniper (*Juniperus communis*)	102$	5	At – Soopolallie – Kinnikinnick	-	-	7
	Soopalillie (*Shepherdia canadensis*), fuzzy-spiked wildrye (*Leymus innovatus*), bunchberry (*Cornus canadensis*)	103	2a	SwPl – Soopolallie – Fuzzy-spiked wildrye	31	1	-
			3a		-	20	201
			3b		-	16	11
			4		-	31	127
			5		24	48	207
			6		1	10	90
	Soopalillie (*Shepherdia canadensis*), fireweed (*Epilobium angustifolium*)	103$	3b	At – Rose – Fuzzy-spiked wildrye	-	-	15
			3b		-	-	9
			4		1	2	46
			4		-	1	47
			5		-	2	96
			5		2	8	10
			6		-	-	12
			6		-	-	34

(continued)

Table 11.7-12. Loss and Alteration of Ecosystems with Harvestable Plants (continued)

BEC Unit	Harvestable Species	Site Series	Structural Stage	Ecosystem Name	Loss (ha)	Alteration (ha)	No Effect (ha)
BWBSmw *(cont'd)*	Highbush-cranberry (*Viburnum edule*), bunchberry (*Cornus canadensis*), trailing raspberry (*Rubus pubescens*)	110	3a	Sw – Oak fern – Sarsaparilla	-	1	44
			3b		-	5	4
			4		-	7	1
			5		2	39	82
			6		11	32	195
			7			12	34
	Labrador tea (*Ledum groenlandicum*), lingonberry (*Vaccinium vitis-idaea*), bunchberry (*Cornus canadensis*)	111	3a	Sb – Horsetail – Step moss	-	-	1
			3b		-	-	3
	Highbush-cranberry *(Viburnum edule)*, trailing raspberry *(Rubus pubescens)*	111	2a	Sw – Currant – Horsetail	-	-	3
			2b		-	-	18
			3a		-	-	16
			3b		-	1	5
			4		-	0	9
			5		3	17	78
			6		16	22	136
			7		-	2	30
	Highbush-cranberry (*Viburnum edule*)	111$	3b	Acb – Dogwood – Highbush-cranberry	-	-	2
			5		-	-	4
			6		-	4	2
	Highbush-cranberry (*Viburnum edule*)	112	3a	AcbSw – Mountain alder – Dogwood	-	-	4
			3b		-	-	8
			4		-	-	-
			5		-	-	8
			6		-	-	82
			7		-	1	45

(continued)

Table 11.7-12. Loss and Alteration of Ecosystems with Harvestable Plants (continued)

BEC Unit	Harvestable Species	Site Series	Structural Stage	Ecosystem Name	Loss (ha)	Alteration (ha)	No Effect (ha)
BWBSwk1	Fireweed (*Epilobium angustifolium*), bunchberry (*Cornus canadensis*)	101$	4	At – Birch-leaved spirea – Huckle-berry	-	-	35
			5		-	1	179
			6		-	-	60
	Lingonberry (*Vaccinium vitis-idaea*)	102$	3b	At – Kinnikinnick – Fuzzy-spiked wildrye	-	-	3
			4		-	-	13
	Soopalillie (*Shepherdia canadensis*), bunchbery (*Cornus canadensis*)	103	3a	SwPl – Soopollalie – Showy aster	-	-	9
			3b		-	-	1
			4		-	-	9
			5		1	2	141
			6		-	1	115
	Labrador tea (*Ledum groenlandicum*), black huckleberry (*Vaccinium membranaceum*), lingonberry (*Vaccinium vitis-idaea*)	104	2a	Sb – Huckleberry – Lingonberry	-	-	1
			3a		-	-	48
			3b		-	-	48
			4		-	-	51
			5		-	-	110
			6		-	-	82
	Labrador tea (*Ledum groenlandicum*), lingonberry (*Vaccinium vitis-idaea*), bunchberry (*cornus canadensis*)	104	3a	Sb – Labrador tea – Step moss	-	19	71
			3b		-	5	7
			4		1	33	105
			5		4	38	98
			6		6	83	400
			7		-	-	18
	Highbush-cranberry (*Viburnum edule*), labrador tea (*Ledum groenlandicum*), dwarf blueberry (*Vaccinium caespitosum*)	104$	4	At – Labrador tea – Lingonberry	-	-	7
			5		-	-	13
			5		-	-	16
			6		-	-	25

(continued)

Table 11.7-12. Loss and Alteration of Ecosystems with Harvestable Plants (continued)

BEC Unit	Harvestable Species	Site Series	Structural Stage	Ecosystem Name	Loss (ha)	Alteration (ha)	No Effect (ha)
BWBSwk1 *(cont'd)*	Highbush-cranberry (*Viburnum edule*), black twinberry (*Lonicera innvolucrata*), black gooseberry (*Ribes lacustre*), trailing raspberry (*Rubus pubescens*)	110		Sw – Currant – Horsetail	-	-	3
			2a		-	-	3
			3a		-	-	61
			3b		-	-	48
			5		-	-	47
			6		1	-	626
	Highbush-cranberry (*Viburnum edule*), cow-parsnip (*Heracleum maximum*)	110$	3b	AcbAt – Cow-parsnip	-	-	1
			5		1	-	20
			6		-	-	15
	Highbush-cranberry (*Viburnum edule*), black twinberry (*Lonicera involucrata*),	110$	4	At – Highbush-cranberry – Oak fern	-	-	11
	Highbush-cranberry (*Viburnum edule*), black twinberry (*Lonicera involucrata*), bunchberry (*Cornus canadensis*)	110$.2	6		-	-	10
	Labrador tea (*Ledum groenlandicum*), lingonberry (*Vaccinium vitis-idaea*), bunchberry (*Cornus canadensis*)	111	5	Sb – Horsetail – Step moss	-	-	12
			6		-	-	24
ESSFmv2	Black huckleberry (*Vaccinium membranaceum*)	02	3a	Bl - Lingonberry	-	-	4
			3b		-	-	19
			4		-	-	34
			5		-	-	127
			6		-	-	49
	Black huckleberry (*Vaccinium membranaceum*), Labrador tea (*Ledum groenlandicum*), Lingonberry (*Vaccinium vitis-idaea*)	03	3a	BlSb - Labrador tea	-	-	5
			4		-	-	24
			5		-	-	168
			6		-	-	188

(continued)

Table 11.7-12. Loss and Alteration of Ecosystems with Harvestable Plants (completed)

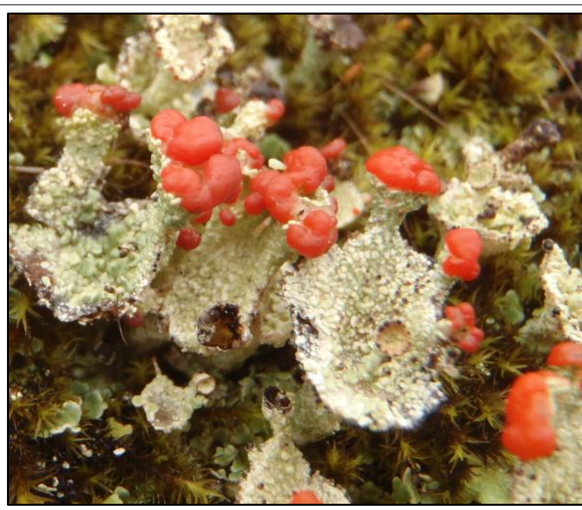
BEC Unit	Harvestable Species	Site Series	Structural Stage	Ecosystem Name	Loss (ha)	Alteration (ha)	No Effect (ha)
ESSFmv2 *(cont'd)*	Black huckleberry (*Vaccinium membranaceum*)	04	3a	Bl - Oak fern – Knight's plume	-	-	40
			3b		-	-	9
			4		-	-	3
			5		-	-	32
			6		-	-	228
	Devil's club (*Oplopanax horridus*), bunchberry (*Cornus canadensis*)	05	3a	Bl – Devil's club - Rhododendron	-	-	3
			3b		-	-	17
			5		-	-	51
			6		-	-	241
	Bunchberry (*Cornus canadensis*)	06	3a	Bl - Alder - Horsetail (Ws08 - Bl - Sitka valerian – Common horsetail)	-	-	24
			3b		-	-	15
			5		-	-	43
			6		-	-	166
SBSwk2	Bunchberry (*Cornus canadensis*)	01	5	Sxw - Oak fern	-	-	2
			6		-	-	30
	Black huckleberry (*Vaccinium membranaceum*)	02	3b	Pl - Huckleberry - Cladina	-	-	7
			4		-	-	2
			5		-	-	14
	Black huckleberry (*Vaccinium membranaceum*), bunchberry (*Cornus canadensis*)	03	4	Sxw - Huckleberry – Highbush-cranberry	-	-	2
			5		-	-	23
	Devil's club (*Oplopanax horridus*), bunchberry (*Cornus canadensis*)	05	5	Sxw – Devil's club	-	-	3
			6		-	-	21
Grand Total					**287**	**778**	**9,525**

Table 11.7-13. Rare Plant and Lichen Species Lost and Potentially Altered

Species and Conservation Rank	Species Photo	Project Effect
***Drymocallis arguta* s. str.** **(tall cinquefoil)** • Red-listed (endangered, extirpated or threatened) • S1S3 (provincially critically imperiled to vulnerable) • G5T5 (globally secure)		Direct effect (loss)
Cardamine parviflora **(sand bittercress)** • Blue-listed (of special concern) • S2S3 (provincially imperilled to vulnerable) • G5 (globally secure)		Direct effect (loss)

(continued)

Table 11.7-13. Rare Plant and Lichen Species Lost and Potentially Altered (continued)

Species and Conservation Rank	Species Photo	Project Effect
Botrychium crenulatum **(dainty moonwort)** • Blue-listed (of special concern) • S2S3 (provincially imperilled to vulnerable) • G3 (globally vulnerable)		Direct effect (loss) and indirect effects (dust and edge effects)
Cladonia coccifera **(madame pixie)** • Red-listed (endangered, extirpated or threatened) • S1 (provincially critically imperilled) • G5 (globally secure)		Direct effect (loss) and indirect effects (dust and edge effects)

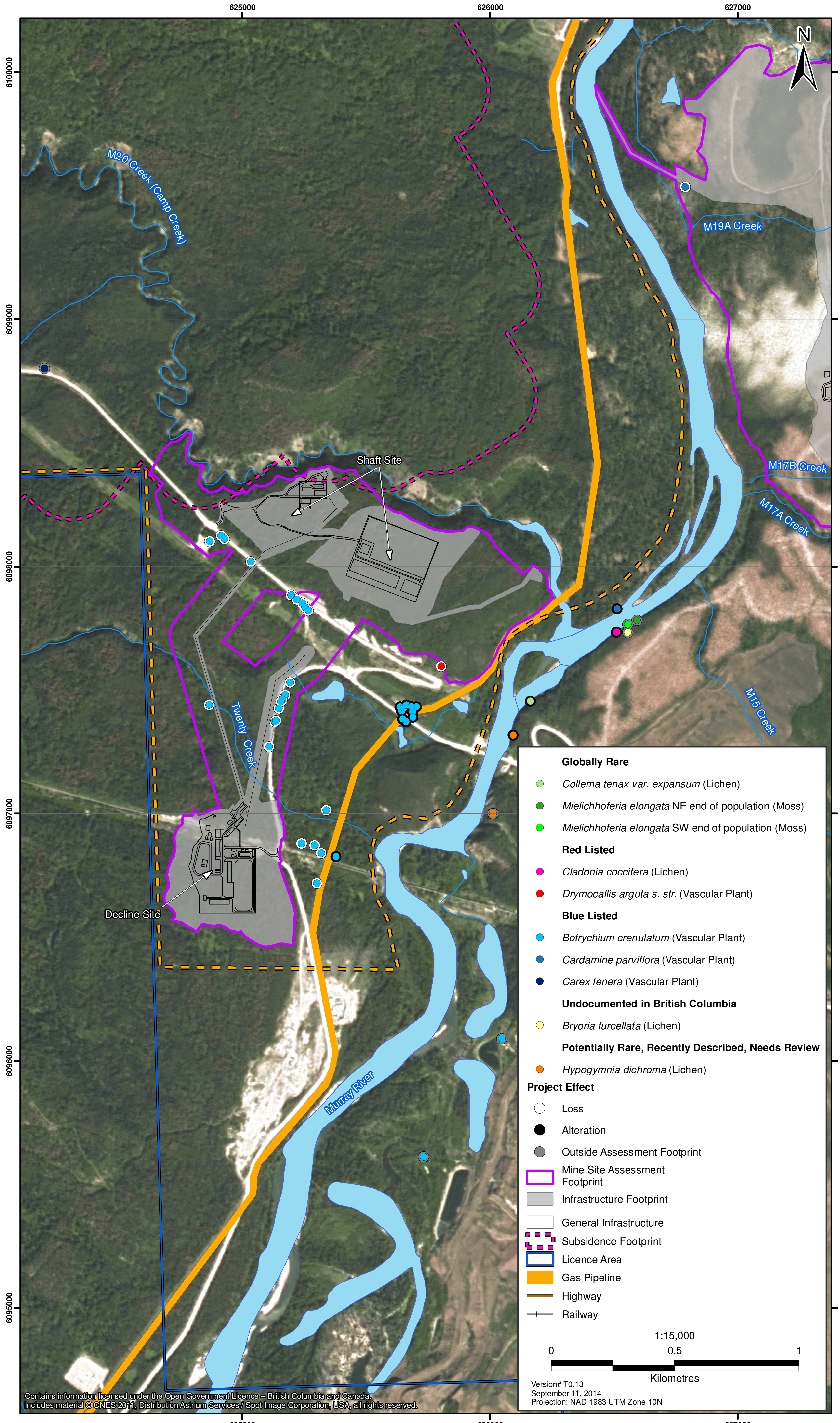
(continued)

Table 11.7-13. Rare Plant and Lichen Species Lost and Potentially Altered (completed)

Species and Conservation Rank	Species Photo	Project Effect
Carex tenera (quil sedge) • Blue-listed (of special concern) • S2S3 (provincially imperiled to vulnerable); • G5TNR (Globally secure, subspecies not rated nationally)		Indirect effects (subsidence)
Collema tenax* var. *expansum • No BC CDC rank • S Rank unavailable • G1 (globally rare)		Indirect effects (dust and edge effects)
Hypogymnia dichroma • No BC CDC rank • Species new to science		Indirect effects (dust and edge effects)

Figure 11.7-8

Loss and Alteration of Rare Plants and Lichens and Associated Habitat



Edge and/or dust effects may result in alteration of habitat of the rare lichen species, *Collema tenax* var. *expansum* and *Hypogymnia dichroma*. The *Collema tenax var. expansum* is located on the cliffs on the east bank of the Murray River north of the bridge along the Murray River FSR. This site is considered the most important in terms of rarity and the concentration of rare plants within the area surrounding the Mine Site Assessment Footprint (Curtis Björk-pers. comm.). The rare vascular plant species *Carex tenera* may also be affected by changes in ecosystem function due to subsidence.

11.7.3 Mitigation Measures for Terrestrial Ecology Valued Components

Mitigation and management measures were determined based on results of the risk model, professional judgement, and scientific literature. The results of the risk model serve to inform Project planning, management, and mitigation strategies in order to avoid, minimize, or restore adverse effects of the Project on terrestrial ecology VCs. Figure 11.7-9 provides a schematic representation of how probability and consequence (i.e., risk) can inform mitigation strategies (i.e., the level of mitigation and management increases/decreases in relation to probability and consequence).

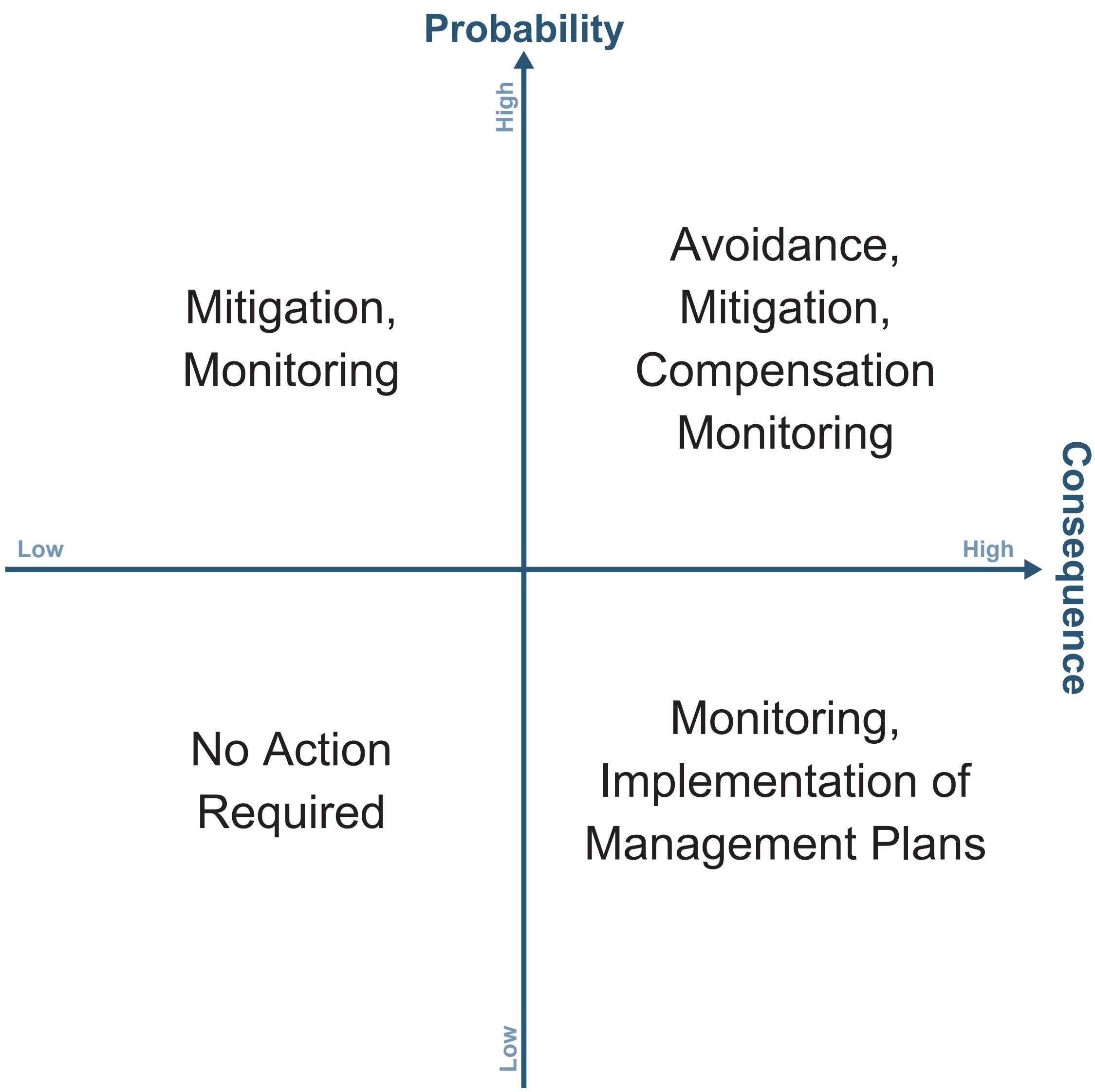
Mitigation and management measures for the Terrestrial Ecology VCs are described in the Site Preparation and Soil Salvage Management Plan, and the Invasive Plant Management Plan (Sections 24.4 and 24.11). The key objectives presented in these plans are summarized below.

11.7.3.1 Site Preparation and Soil Salvage Management Plan

The soils management and mitigation measures (Section 24.4). Site Preparation and Soil Salvage Management Plan for the Project include the following:

- ensure clearing activities are coordinated with other management plans including but not limited to the Air Quality Management Plan (Section 24.2), the Wildlife Management and Monitoring Plan (Section 24.12), and the Water Management Plan (Section 24.6);
- limit the extent of vegetation clearing during Construction activities to the required minimum. During Construction soil will be stripped and stockpiled for future reclamation. This process will continue on a smaller scale during Operation to match the expanding footprint of the Coarse Coal Reject storage facilities;
- minimize soil degradation (i.e., erosion) by salvaging soil during appropriate weather conditions, transporting to stockpiles in a timely manner, and establishing and implementing erosion control procedures early during the salvage process;
- carry out dust suppression on roads to prevent fugitive dust from impacting plants and soils;
- promptly re-vegetate exposed soil surfaces during the appropriate growing season and conditions using seeds (and/or plants) suitable for the local area and ecosystems to avoid erosion and sedimentation, introduction of invasive plants, and to facilitate the re-establishment of ecological functions in the affected areas;
- establish communication procedures between on the ground employees and the Environmental Manager to facilitate timely reporting of any incident or concern during each phase of the Project. Construction personnel will be required to communicate any concerns including erosion and sedimentation;

Probability and Consequence Assessment to Guide Risk Management



Risk Rating		Management Considerations
	Low Risk	No Intervention or Management
	Moderate Risk	Minimization, Mitigation, No Intervention
	High Risk	Avoidance, Minimization

- provide appropriate education and training for employees and contractors outlining how to minimize effects on ecosystems, soils, and vegetation. This information will be prepared and made available to all employees on-site (e.g., through the Project Safety Office or other designated location) in the form of fact sheets and/or handbooks; and
- conduct follow up monitoring of cleared sites to monitor erosion and sediment control.

11.7.3.2 Invasive Plant Management Plan

Management and mitigation measures incorporated in the Invasive Plant Management Plan (Section 24.11, Invasive Plant Management Plan) include the following:

- minimize soil degradation (i.e., erosion) by adhering to the Site Preparation and Soils Salvage Management Plan (Section 24.4). Soil will be salvaged during appropriate weather conditions and transported to stockpiles in a timely manner. Erosion control will be established in a timely manner, the methods of which will be determined by the timing of salvage;
- vehicle inspections for target invasive plants at designated Project checkpoints. Project vehicles (bulldozers, mine trucks, excavators, etc.) transported from other areas will be thoroughly inspected. Target species will be removed (if present), and vehicles will be properly washed at an appropriate location where the removal of dirt or plant propagules can be effectively achieved without harm to natural ecosystems;
- detection and eradication of invasive plants, through implementation of an effective early detection and inventory system and control and monitoring program. The ecological cause (disturbance, favourable light conditions, compacted soil, etc.) and likely succession of the invasive plant population will be used to help select an ecologically appropriate treatment option(s). Treatment options include mechanical, chemical, biological, or a combination of these methods using an ecology based approach, commonly referred to as integrated pest management; and
- monitor cleared sites once per year to ensure they are re-vegetated 1) with seeds (and/or plants) suitable for the local area and ecosystems; 2) during the appropriate growing season and conditions to ensure maximum survival rate and to avoid establishment of invasive plants; and 3) to facilitate the re-establishment of ecological functions and their associated attributes (e.g., species diversity and productivity).

11.7.3.3 Rare Plant and Lichen Mitigation

Management and mitigation measures for rare plants and lichens will include the following:

- include the location of known rare plants/lichens on project maps to allow for incorporation into project planning;
- create exclusion zones (i.e., temporary fences) around priority rare plant and lichen habitats (e.g., red listed, globally rare, etc.) to avoid disturbance;
- make site-specific adjustments, where feasible, to avoid identified rare plants/lichens (e.g., the discharge pipeline in relation to *Cardamine parviflora*);

- avoid use of all herbicide sprays within 200 m of rare plant and lichen populations and limit such use to direct application rather than broadcast sprays.

11.8 Residual Effects on Terrestrial Ecology

Management and mitigation measures will help avoid and minimize adverse effects to ecosystem functions and extent resulting from the Project's Construction, Operation, Decommissioning and Reclamation, and Post-closure phases. However, direct and indirect effects cannot be fully mitigated and thus residual effects are anticipated for ecologically valuable soils, forested ecosystems, rare ecosystems, and rare plants and lichens.

11.8.1 Residual Effects on Ecologically Valuable Soils

Loss and alteration of ecologically valuable soils are expected to be residual effects because Project activities will result in physical, chemical, and biological changes to soil conditions that cannot be fully mitigated by the proposed management measures. Specifically, soil loss under the footprints of the remaining Project components, soil erosion, acidification and contamination are expected to become residual effects of the Project. Furthermore, the magnitude of subsidence and the associated effects on ecologically valuable soils are not well understood but are expected to result in residual effects on this VC. Mitigation measures as outlined in the Site Preparation and Soil Salvage Plan (Section 24.4) are considered adequate to address potential effects related to soil contamination and thus are not discussed further. The summary of predicted residual effects on ecologically valuable soils and associated mitigation measures is summarized in Table 11.8-1.

11.8.2 Residual Effects on Forested Ecosystems

Loss and alteration of forested ecosystem function and extent is expected to be a residual effect because removal, windthrow, fragmentation, edge effects, and changes to hydrology can be minimized but not avoided. Furthermore, the magnitude of subsidence and the associated effects on ecosystem function are not well understood but are expected to result in residual effects on forested ecosystems. Mitigation measures as outlined in the Invasive Plant Management Plan are considered adequate to avoid the potential introduction and spread of invasive plants and thus are not considered a residual effect. However, the introduction and/or spread of invasive plants during any phase of the Project is possible and is dependent on the ability of staff to collectively recognize potential problems, availability of potential vectors of introduction (e.g., traffic along the Murray River FSR) as well as the success of eradication measures. The summary of predicted residual effects on forested ecosystems and associated mitigation measures is summarized in Table 11.8-2.

11.8.3 Residual Effects on BC CDC Listed Ecosystems

Loss and alteration of rare ecosystem function and extent is expected to be a residual effect because ecosystem removal, edge effects and fragmentation can be minimized but not avoided. Furthermore, the magnitude of subsidence and the associated effects on ecosystem function are not well understood but are expected to result in residual effects on rare ecosystems. The effects on each rare ecosystem will vary depending on the ecosystems intrinsic vulnerability, environmental specificity, and resilience to disturbance. The summary of predicted residual effects on rare ecosystems and associated mitigation measures is summarized in Table 11.8-3.

Table 11.8-1. Summary of Residual Effects on Ecologically Valuable Soils

Project Phase (timing of effect)	Project Component / Physical Activity	Description of Cause-Effect[1]	Description of Mitigation Measure(s)	Description of Residual Effect
Construction, Operation, Decommissioning and Reclamation	Site preparation and construction of infrastructure, travel on site; road maintenance, transportation, soil stripping and salvage, CCR pile development, subsidence, reclamation	Surface clearing, compaction, erosion, dust deposition, acidification	Minimize clearing dimensions, minimize soil degradation (i.e., erosion) by adhering to the Site Preparation and Soil Salvage Plan; ensure clearing activities are coordinated with other management plans; dust suppression; promptly re-vegetate exposed soil surfaces; effective and enforced communication and reporting procedures for environmental monitoring.	Soil loss and degradation (changes in soil quality and soil quantity)

[1] *Cause-effect" refers to the relationship between the Project component/physical activity that is causing the change or effect in the condition of the VC.*

Table 11.8-2. Summary of Residual Effects on Forested Ecosystems

Project Phase (timing of effect)	Project Component / Physical Activity	Description of Cause-Effect[1]	Description of Mitigation Measure(s)	Description of Residual Effect
Construction, Operation, Decommissioning and Reclamation	Site preparation and construction of infrastructure, travel on site; road maintenance, transportation, subsidence, reclamation	Surface clearing, dust deposition, creation of edges, fragmentation and windthrow, removal of productivity and carbon storage, alteration of hydrological connectivity	Minimize loss and adaptively manage effects through an ecosystem based approach, including, managing for hydrological connectivity; adherence to best management practices for forested ecosystems; dust suppression; education and training for employees; coordination with other management plans; effective communication and reporting procedures for environmental monitoring	Alteration of ecosystem function and extent

[1] *Cause-effect" refers to the relationship between the Project component/physical activity that is causing the change or effect in the condition of the VC.*

Table 11.8-3. Summary of Residual Effects on BC CDC Listed Ecosystems

Project Phase (timing of effect)	Project Component / Physical Activity	Description of Cause-Effect[1]	Description of Mitigation Measure(s)	Description of Residual Effect
Construction, Operation, Decommissioning and Reclamation	Site preparation and construction of infrastructure, travel on site; road maintenance, transportation, subsidence, reclamation	Surface clearing, dust deposition, creation of edges, fragmentation and windthrow, removal of productivity and carbon storage, alteration of hydrological connectivity	Minimize loss and adaptively manage effects through an ecosystem based approach, including, managing for hydrological connectivity; adherence to best management practices for forested ecosystems; dust suppression; education and training for employees; coordination with other management plans; effective communication and reporting procedures for environmental monitoring	Alteration of ecosystem function and extent

[1] *Cause-effect" refers to the relationship between the Project component/physical activity that is causing the change or effect in the condition of the VC.*

11.8.4 Residual Effects on Harvestable Plants

Alteration of harvestable plant habitat is considered a residual effect because the Project construction activities are expected to result in the removal of ecosystems that support harvestable plants. Soil moisture, nutrient, and light regimes may be affected during clearing activities, which could result in alteration of a site's potential to provide habitat for harvestable plants. Furthermore, the magnitude of subsidence and the associated effects on ecosystems that support harvestable plants are not well understood but are expected to result in residual effects on this VC. The summary of predicted residual effects on harvestable plants and associated mitigation measures is presented in Table 11.8-4.

11.8.5 Residual Effects on Rare Plants and Lichens

Alteration of rare plant and/or lichen habitat is considered a residual effect because the Project may alter critical rare plant or lichen habitat through indirect effects due to edge effects, dust deposition or changes to hydrology. Rare plants and lichens are habitat-specific and the unique combinations of environmental conditions that characterize their habitats are also rare and cannot be easily reproduced. These effects can be minimized but not avoided entirely. Furthermore, the magnitude of subsidence and the associated effects on rare plant and lichen habitat are not well understood but may result in residual effects on rare plants. The summary of predicted residual effects on rare plants and lichens as well as their associated habitat, together with proposed mitigation measures, is summarized in Table 11.8-5.

11.9 Characterizing Residual Effects, Significance, Likelihood and Confidence on Terrestrial Ecology

The residual effects on terrestrial ecology VCs were characterized in terms of magnitude, geographic extent, duration, frequency, reversibility, and resiliency according to the definitions in Table 11.9-1.

11.9.1 Residual Effects Characterization for Terrestrial Ecology

The magnitude of an effect on terrestrial ecology VCs was quantified based on results of a literature search on thresholds and is summarized in Tables 11.9-2, 11.9-3, and 11.9-4 (Mace et al. 1996; Mace and Waller 1997; Mace 2004; Schwartz et al. 2006; Interagency Conservation Strategy Team 2007; K. Price, Holt, and Kremsater 2007).

The magnitude of an effect on rare ecosystem was determined based on the BC CDC conservation ranks, which provide definitions on the level of risk to an ecosystem. This information can be used to prioritize management and monitoring of residual effects to rare ecosystems (Table 11.9-3).

The magnitude of an effect on rare plants and lichens or associated habitat was determined based on the SARA, BC CDC, and NatureServe conservation ranks, which provide definitions on the level of rarity of a species. This information was used to determine severity of residual effects to rare plants and lichens (Table 11.9-4).

Table 11.8-4. Summary of Residual Effects on Harvested Plants

Project Phase (timing of effect)	Project Component / Physical Activity	Description of Cause-Effect[1]	Description of Mitigation Measure(s)	Description of Residual Effect
Construction, Operation, Decommissioning and Reclamation	Site preparation and construction of infrastructure, travel on Murray River FSR, subsidence	Surface clearing, dust deposition, creation of edges, fragmentation and windthrow	Minimize loss and apply dust abatement	Loss of harvestable plants

[1] *"Cause-effect" refers to the relationship between the Project component/physical activity that is causing the change or effect in the condition of the VC.*

Table 11.8-5. Summary of Residual Effects on Rare Plants and Lichens

Project Phase (timing of effect)	Project Component / Physical Activity	Description of Cause-Effect[1]	Description of Mitigation Measure(s)	Description of Residual Effect
Construction and Operation	Site preparation and construction of infrastructure, travel on site; road maintenance, transportation, subsidence	Vehicular movement during general operation and maintenance; stripping and stockpiling throughout the life of the mine; dust deposition (acidification) and changes in hydrological connectivity	• Optimize alternatives to ensure that rare plant and lichen populations are avoided, where feasible • Create exclusion zones around priority rare plant and lichen habitats • Avoid use of all herbicide sprays within 200 m of rare plant and lichen populations	Loss or rare plants and lichens; alteration of rare plant and lichen habitat

[1] *Cause-effect" refers to the relationship between the Project component/physical activity that is causing the change or effect in the condition of the VC.*

Table 11.9-1. Definitions of Characterization Criteria for Residual Effects on Terrestrial Ecology Valued Components

							Likelihood of Effects	
Magnitude	**Duration**	**Frequency**	**Geographic Extent (Physical/Biophysical)**	**Reversibility**	**Resiliency**	**Ecological Context**	**Probability**	**Confidence Level**
How severe will the effect be?	*How long will the effect last?*	*How often will the effect occur?*	*How far will the effect reach?*	*To what degree is the effect reversible?*	*How resilient is the receiving environment or population?*	*What is the current condition of the ecosystem and how commonly is it represented in the LSA?*	*How likely is the effect to occur?*	*How certain is this analysis?*
Negligible: No or very little detectable change from baseline conditions	**Short-term:** Effect lasts approximately 10 years or less.	**Once:** Effect is confined to one discrete period in time during the life of the Project.	**Local:** Effect extends less than 500 m from infrastructure or activity.	**Reversible Short-term:** Effect can be reversed relatively quickly.	**Low:** The receiving environment or population has a low resilience to imposed stresses, and will not easily adapt to the effect.	**Low:** The receptor is considered to have little to no unique attributes or provision of functions is severely degraded.	**High:** It is highly likely that this effect will occur.	**High:** < 80% confidence. There is a good understanding of the cause-effect relationship and all necessary data are available for the Project area. There is a low degree of uncertainty and variation from the predicted effect is expected to be low.
Minor: Differs from the average value for baseline conditions to a small degree.	**Medium-term:** Effect lasts from 11 to 50 years.	**Sporadic:** Effect an effect that occurs at sporadic or intermittent intervals during any phase of the Project.	**Landscape:** Effect is limited to the LSA or one watershed (i.e., Sub-area).	**Reversible Long-term:** Within 20 years of Post Closure.	**Neutral:** The receiving environment or population has a neutral resilience to imposed stresses and may be able to respond and adapt to the effect.	**Neutral:** The receiving environment considered to have some unique attributes and provides most functions that an undisturbed environment would provide.	**Medium:** This effect is likely, but may not occur.	**Medium:** 50 to 80% confidence. The cause-effect relationships are not fully understood, there are a number of unknown external variables, or data for the Project area are incomplete. There is a moderate degree of uncertainty; while results may vary, predictions are relatively confident.
Medium: Differs substantially from the average value for baseline conditions and approaches the limits of natural variation.	**Long-term:** Effect lasts between 51 and 100 years.	**Regular:** Effect occurs on a regular basis during the life span of the Project.	**Regional:** Effect extends across the broader region (e.g., RSA, multiple watersheds, etc.).	**Irreversible:** Effect cannot be reversed (i.e., is permanent).	**High:** The receiving environment or population has a high natural resilience to imposed stresses, and can respond and adapt to the effect.	**High:** The receiving environment or population is uncommon and occurs in a natural state and provides functions at a maximum capacity.	**Low:** This effect is unlikely but could occur.	**Low:** < 50% confidence. The cause-effect relationships are poorly understood, there are a number of unknown external variables, and data for the Project area are incomplete. High degree of uncertainty and final results may vary considerably.
Major: Differs substantially from baseline conditions, resulting in a detectable change beyond the range of natural variation.	**Far Future:** Effect lasts more than 101 years.	**Continuous:** Effect occurs constantly during the life of the Project.	**Beyond Regional:** Effect extends beyond the regional scale, and may extend across or beyond the province.					

Table 11.9-2. Magnitude Threshold for Terrestrial Ecology Valued Component by Risk Category

Proportion of Mapped Ecosystems Within Risk Category		Magnitude of Effect
	> 90% in None or Low. No detectable change from baseline conditions	Negligible
	Moderate + High ≤ 20% and High < 20%	Minor
	Moderate + High < 30% and High ≤ 20%	Medium
	Moderate + High ≥ 30% and High .> 20%	Major

Table 11.9-3. Magnitude Threshold for Rare Ecosystems

Rank	Definition	Effect	Magnitude of Effect
Red Listed	Endangered or threatened	Loss or alteration of rare ecosystem structure, function and extent	Major
Blue Listed	Vulnerable; at risk		Moderate
Yellow Listed	Not at risk		Minor

Table 11.9-4. Magnitude Threshold for Rare Plants and Lichens

Rank Status	Definition	Effect	Magnitude of Effect
T	SARA- and COSEWIC-listed (Threatened)	Loss or alteration of species or habitat	Major
S1; Red Listed	Extremely rare at the provincial level; 5 or fewer occurrences in BC, or very few remaining individuals; critically imperilled and susceptible to extirpation due to a factor of its biology		Major
S2; Red Listed	Rare at the provincial level; 6 to 20 occurrences in BC or few remaining individuals; imperilled, may be susceptible to extirpation due to some factor of its biology		Major
S1S2; Red Listed	Extremely rare to rare at the provincial level		Major
S2S3: Red Listed	Rare to vulnerable at the provincial level		Major
S3; Blue Listed	Vulnerable at the provincial level; 21 to 100 occurrences in BC; may be rare and local throughout the province or may occur in a restricted provincial range (may be abundant in some places); may be susceptible to extirpation by large scale disturbances		Moderate
S4	Common at the provincial level; more than 100 occurrences; generally widespread and abundant but may be rare in parts of its range; apparently secure		Minor
S3S4	Vulnerable to common at the provincial level		Minor
S5	Very common and demonstrably secure at the provincial level; more than 100 occurrences; widespread and abundant, but may be rare in parts of its range		Minor
S4S5	Common to very common at the provincial level		Minor

11.9.1.1 Duration, Frequency, Reversibility, Resiliency and Ecological Context

The duration, frequency, reversibility, resiliency and ecological context of Project related effects were determined based on reviews of other similar Projects' monitoring results, relevant scientific literature, information attained through community consultation, and professional judgement.

11.9.1.2 Likelihood

The likelihood of a residual effect occurring is calculated as a measure of probability, to determine the potential for the Project to cause effects. The likelihood of a residual effect does not influence the determination of significance, rather it influences the risk of an effect occurring.

The likelihood or probability that a Project activity (mine construction, road use, tower installation etc.) will result in an effect to terrestrial ecology VC's was determined through reviews of relevant literature, proposed Project activities, baseline information, and/or professional judgement.

11.9.1.3 Confidence

Confidence, which can also be thought of as scientific certainty/uncertainty, is a measure of how well residual effects are understood. The predicted residual effects were assessed for their reliability to portray the certainty in the predicted outcome, based on the acceptability of the data inputs and analytical methods used in the characterization.

The confidence regarding how well residual effects are understood, which includes a consideration of the acceptability of the data inputs and analytical methods used to predict and assess project effects, was taken into consideration when characterizing residual effects.

11.9.1.4 Significance of Residual Effects

The evaluation of significance was completed by comparing predicted residual cumulative effects against thresholds, standards, trends, or objectives relevant to ecosystems, as defined below.

- **Not significant**: Residual effects have low or moderate magnitude, local to regional geographic extent, short- or medium-term duration, could occur at any frequency, and are reversible in either the short- or long-term. The effects on the VC (e.g., at a species or local population level) are either indistinguishable from background conditions (i.e., occur within the range of natural variation as influenced by physical, chemical, and biological processes), or distinguishable at the individual level. Land and resource management plan objectives will likely be met, but some management objectives may be impaired. There is a medium to high level of confidence in the analyses. Follow-up monitoring of these effects may be required if the magnitude is medium.
- **Significant**: Residual effects have high magnitude, regional or beyond regional geographic extent, long-term or far future duration, and occur at all frequencies. Residual effects on VCs are consequential (i.e., structural and functional changes in populations, communities, and ecosystems are predicted) and are irreversible. The ability to meet land and resource management plan objectives is impaired. Confidence in the conclusions can be high, medium, or low.

11.10 EVALUATION OF RESIDUAL EFFECTS AND SIGNIFICANCE FOR TERRESTRIAL ECOSYSTEMS

Management and mitigation measures will help avoid and minimize adverse effects to ecosystem functions and extent resulting from the Construction, Operation, Closure, Decommissioning and Reclamation and Post Closure activities of the Project; however, direct and indirect effects cannot be fully mitigated and thus loss and/or alteration/degradation of ecologically valuable soils, forested ecosystems, rare ecosystems, harvestable plants and rare plants and lichens are expected (Table 11.10-1).

11.10.1 Residual Effects Characterization for Ecologically Valuable Soils

Loss and degradation of ecologically valuable soils are considered not significant (moderate). The magnitude of effects is considered moderate because the affected soils will differ from the average value for baseline conditions and the effects will approach the limits of natural variation. The area that will be directly impacted by footprint development covers 2.4% of ecologically valuable soils (280 ha) and is very localized; however, indirect effects to soils as a result of subsidence will extend beyond the Mine Site Assessment Footprint. It is predicted that the total area of valuable soils affected by soil degradation (due to footprint development and subsidence) will cover 2,271 ha (20% of valuable soils in the LSA). The level of degradation will vary depending on the severity of subsidence and the soil type affected. Soil handling and stockpiling will reduce the quantity of soil lost but will not address the effects to soil quality. The effect will be long in duration due to the slow recovery rate of soils. The Project effects will occur sporadically at a local level within and surrounding Project infrastructure. Loss and degradation to ecologically valuable soils is considered reversible in the long-term depending on size of the affected area and the combination of effects. The ecological context of ecologically valuable soils is neutral as the affected soils have some unique attributes and provide most functions that an undisturbed environment would provide. The probability of effect to soils is high because surface clearing activities are known to result in the loss and degradation of soils; however, uncertainty exists regarding the magnitude and extent of subsidence and its associated effect on soils. The indirect effects on the physical, chemical, and biological soil conditions may result in a wide range of variability but are expected to occur based on the scientific literature related to effects of coal mining and soil properties. Confidence in the analysis is medium because the type and distribution of soils within the impacted area as well as the effects to these soils are well understood; however uncertainty exists regarding the effects to ecologically valuable soils due to subsidence.

11.10.2 Residual Effects Characterization for Forested Ecosystems

Loss and alteration of forested ecosystem function and/ or extent are considered not significant (moderate). According to the model results, there is a high risk to 2.9% and a moderate risk to 6.4% of the forested ecosystems. As a result, the magnitude of the effects to forested ecosystems is minor. A small portion of forested ecosystems will be affected directly. Indirect effects, including windthrow, fragmentation, edge effects, and changes to hydrology are expected in the majority of the affected ecosystems. The Project effects will occur sporadically at a landscape level within the LSA. Effects are considered reversible in the long term.

Table 11.10-1. Characterization of Residual Effects, Significance, Confidence and Likelihood on Terrestrial Ecology Valued Components

Residual Effects	Residual Effects Characterization Criteria						Significance of Adverse Residual Effects	Likelihood and Confidence	
	Magnitude (*minor, moderate, major*)	**Duration** (*short, medium, long, far future*)	**Frequency** (*once, sporadic, regular, continuous*)	**Geographic Extent** (*local, landscape, regional, beyond regional*)	**Reversibility** (*reversible short-term; reversible long-term; irreversible*)	**Context** (*low, neutral, high*)	**Not Significant** (*minor, moderate*); **Significant** (*major*)	**Probability** (*low, medium, high*)	**Confidence** (*low, medium, high*)
Loss and alteration of ecologically valuable soils	Moderate	Long	Sporadic	Local	Reversible long-term	Neutral	Not significant (moderate)	High	Medium
Loss and alteration of ecosystem function and/or extent on forested ecosystems	Moderate	Long	Sporadic	Landscape	Reversible long-term	Neutral	Not significant (moderate)	High	High
Loss and alteration of rare ecosystems	Moderate	Far future	Sporadic	Beyond regional	Irreversible	High	Not significant (moderate)	Medium	Medium
Loss and alteration of harvestable plants	Minor	Medium to long	Sporadic	Local	Reversible short- to long-term	Neutral	Not significant (minor)	Medium	Medium
Loss and alteration of rare plants and lichens	Moderate to major	Far future	Sporadic	Beyond regional	Irreversible	High	Not significant (moderate)	High	High

In an ecological context, forested ecosystems are considered neutral according to the definitions provided in Table 11.10-1, Definitions of Characterization Criteria for Residual Effects on Terrestrial Ecology. The probability of the effects is high because surface clearing activities are known to result in the loss and alteration of forested ecosystems. There is a high level of confidence in the data sources (i.e., field verified Terrestrial Ecosystem Mapping within areas of proposed infrastructure) used for this analysis but uncertainty exists with respect to where and to what degree alteration of functions may occur.

11.10.3 Residual Effects Characterization for Rare Ecosystems

Loss and alteration of rare ecosystems are considered not significant. The magnitude of the effect is moderate because all of the rare ecosystems affected are blue listed. The majority of the effects to rare ecosystems are expected to occur as a result of subsidence within the LSA and surface clearing within the Mine Site Assessment Footprint. Project effects may contribute to the decline of this resource in the short, medium and long term. Loss of rare ecosystems is considered irreversible as these ecosystems contain unique attributes that are not easily replicable. The effects of surface clearing will occur once and the remainder of effects will occur sporadically. All of the effects are considered local in extent and will extend into the far future. In an ecological context, rare ecosystems are rated high as they have unique attributes that are uncommon and of conservation interest in the province. There is a low level of confidence in the analyses because uncertainty exists regarding how the unique combinations of environmental conditions that characterize rare ecosystems will respond to potential Project effects.

11.10.4 Residual Effects Characterization for Harvestable Plants

Loss and alteration of harvestable plants are considered not significant. The magnitude of the direct effects to harvestable plants is considered minor because the Project will remove a small portion of forested ecosystems that may support harvestable plants. Indirect effects, including windthrow, fragmentation, edge effects, and changes to hydrology are also considered moderate in magnitude because the majority of these effects will be very limited in extent in terms of their effect on harvestable plants. The majority of the indirect effects will occur adjacent to the Mine Site Assessment Footprint at the interface between the cleared areas and the forest. The Project effects will occur sporadically at a landscape level within the LSA. All of the effects are considered local in extent and will extend into the far future. The duration of effects are expected to occur over the medium to long term depending on the relevant plant and its associated habitat requirements. In an ecological context, harvestable plants are considered neutral as they have some unique attributes, particularly to the local communities (discussed further in Chapter 16, Assessment of Land Use Effects). There is a medium level of confidence in the analyses because the Project related effects to harvestable plants is generally well understood; however, uncertainty exists regarding the magnitude of alteration.

11.10.5 Residual Effects Characterization for Rare Plants and Lichens

Alteration of rare plants and lichens are considered not significant. The magnitude of the alteration of rare plants and lichens or their associated habitat will vary from moderate to major depending on the species affected, their associated conservation rank and the level of alteration. Rare plants and lichens represent at-risk components of regional, provincial, federal, or global biodiversity. These species are often highly habitat-specific with low resiliency to habitat loss or degradation, invasive alien species, changes in ecological dynamics or natural processes, and disturbance (Province of British Columbia 2013). The effect is beyond regional, will occur once and will last into the far future. Loss of rare plans and lichens is considered an irreversible effect as transplantation is usually ineffective (BC *Mines Act* 1998; Environment 2005; Northwest Invasive Plant Council 2012; Barker 2013). Furthermore, rare plants and lichens can have limited dispersal ability, poor recruitment or reproduction, population fluctuations, inbreeding, and/ or restricted ranges. There is a high level of confidence in the specific location of the species as well as the identification of the species that have been surveyed to date; however, the spatial coverage of surveys regionally is very sparse, and as a result, uncertainty exists with respect to where and to what degree loss or alteration of rare plant and lichen populations may occur. In an ecological context, rare plants and lichens (depending on their conservation rank) are considered unique attributes according to the definitions in Table 11.10-1, Definitions of Characterization Criteria for Residual Effects on Terrestrial Ecology.

11.11 SUMMARY OF RESIDUAL EFFECTS ASSESSMENT AND SIGNIFICANCE FOR TERRESTRIAL ECOLOGY

In summary, the Project-related residual effects of direct (i.e., loss) and indirect (i.e., degradation or alteration) effects on soil quality and quantity and on ecosystem function and extent will result in not significant effects on ecologically valuable soils, forested ecosystem, rare ecosystems, harvestable plants and rare plants and lichens. The residual effects, mitigation, and significance on terrestrial ecology VCs are summarized in Table 11.11-1.

Table 11.11-1. Summary of Residual Effects, Mitigation, and Significance on Terrestrial Ecology Valued Components

Residual Effects	Project Phase	Mitigation Measures	Significance
Loss and alteration of ecologically valuable soil	All Phases	Minimize loss of soil quality and quantity by adhering to the Site Preparation and Soil Salvage Plan.	Not significant
Loss and alteration of forested ecosystems	All Phases	Minimize loss and adaptively manage effects through an ecosystem based approach.	Not significant
Loss and alteration of rare ecosystems	Construction and Operation	Minimize loss and adaptively manage effects through an ecosystem based approach.	Not significant
Loss and alteration of harvestable plants	Construction and Operation	Minimize clearing; dust abatement; invasive plant control.	Not significant
Loss and alteration of rare plants and lichens and associated habitat	Construction and Operation	Optimize alternatives; minimize clearing; dust abatement; invasive plant control.	Not significant

11.12 CUMULATIVE EFFECTS ASSESSMENT

Cumulative effects are the result of a project-related effect interacting with the effects of other human actions (i.e., anthropogenic developments, projects, or activities) to produce a combined effect. Cumulative effects are assessed in each of the assessment chapters, as required by the BC EAO (2013a). A synthesis of these sections is provided as Chapter 21, to address CEA Agency (2013) requirements.

The method for assessing cumulative effects generally follows the same steps as the Project-specific effects assessment, as described in Sections 5.6 to 5.9: (1) scoping and identification of potential effects; (2) description of potential effects and mitigation measures, with subsequent identification of residual cumulative effects, and (3) identification and characterization of residual cumulative effects. However, because of the broader scope and greater uncertainties inherent in CEA (e.g., data limitations associated with some human actions, particularly future actions), there is greater dependency on qualitative methods and expert judgement. This framework for the CEA facilitates comparison between the two levels of assessment (project-specific and CEA) and between assessment categories, and is tailored to how much information is available.

11.12.1 Establishing the Scope of the Cumulative Effects Assessment

The scoping process involves identification of the VCs for which residual effects are predicted, definition of the spatio-temporal boundaries of the assessment, and an examination of the relationship between the residual effects of the Project and those of other projects and activities.

Residual effects carried forward from the Project-specific assessment are considered in combination with the residual effects of past, present, and future human actions, where some spatial and temporal overlap occurs. For terrestrial ecology VCs, cumulative effects can occur in the following ways:

- Physical-chemical transport – A physical or chemical constituent is transported away from the action under review where it then interacts with another action. An example of this would be the spread of invasive plants.
- Nibbling loss – The gradual disturbance and loss of land and habitat. This occurs with removal of terrestrial ecosystems from the landscape.
- Spatial and temporal crowding – Cumulative effects can occur when too much is happening within too small an area and in too brief a period of time. A threshold may be exceeded and the environment may not be able to recover to pre-disturbance conditions. This occurs with the fragmentation of ecosystems.
- Synergistic – Combined effects along a pathway that collectively result in an increased effect that may not have existed if the effect occurred in isolation.
- Additive – Combined effects along a pathway that equal the sum of the individual effects. For example, the accumulation of metals in the soil due to the deposition of dust.
- Growth inducing – Each new action can induce further actions to occur. For example, creation of edges could lead to windthrow and introduction of invasive plants.

11.12.1.1 Spatial Boundaries

The RSA was selected as a suitable boundary upon which to base the cumulative effects assessment. The RSA encompasses the maximum area within which the Project effects to terrestrial ecology are expected to interact with residual effects from other past, present of reasonably foreseeable future projects and activities. It encompasses the regional setting for the Project and implicitly considers ecological factors, such as height of land in boundary delineation (Figure 11.12-1).

11.12.1.2 Temporal Boundaries

The temporal boundaries for the CEA go beyond the phases of the Project, beginning before major human actions were undertaken in the region, and extending into the future. While precisely forecasting which other human actions will occur at the end of the Project's post-closure phase would be pure conjecture, an extrapolation of a likely future development scenario for the next several decades—based on information available today—is attempted.

The following temporal periods are evaluated as part of the CEA:

- **Past:** 1940 (to capture the early non-Aboriginal human activities in the region) to 2010 (when baseline studies at the Murray River Project began);
- **Present:** 2010 (from the start of the Project baseline studies) to 2014 (completion of the environmental assessment); and
- **Future:** temporal boundaries are stated in each assessment chapter, and vary according to the time estimated for VCs to recover to baseline conditions (taking into account natural cycles of ecosystem change).

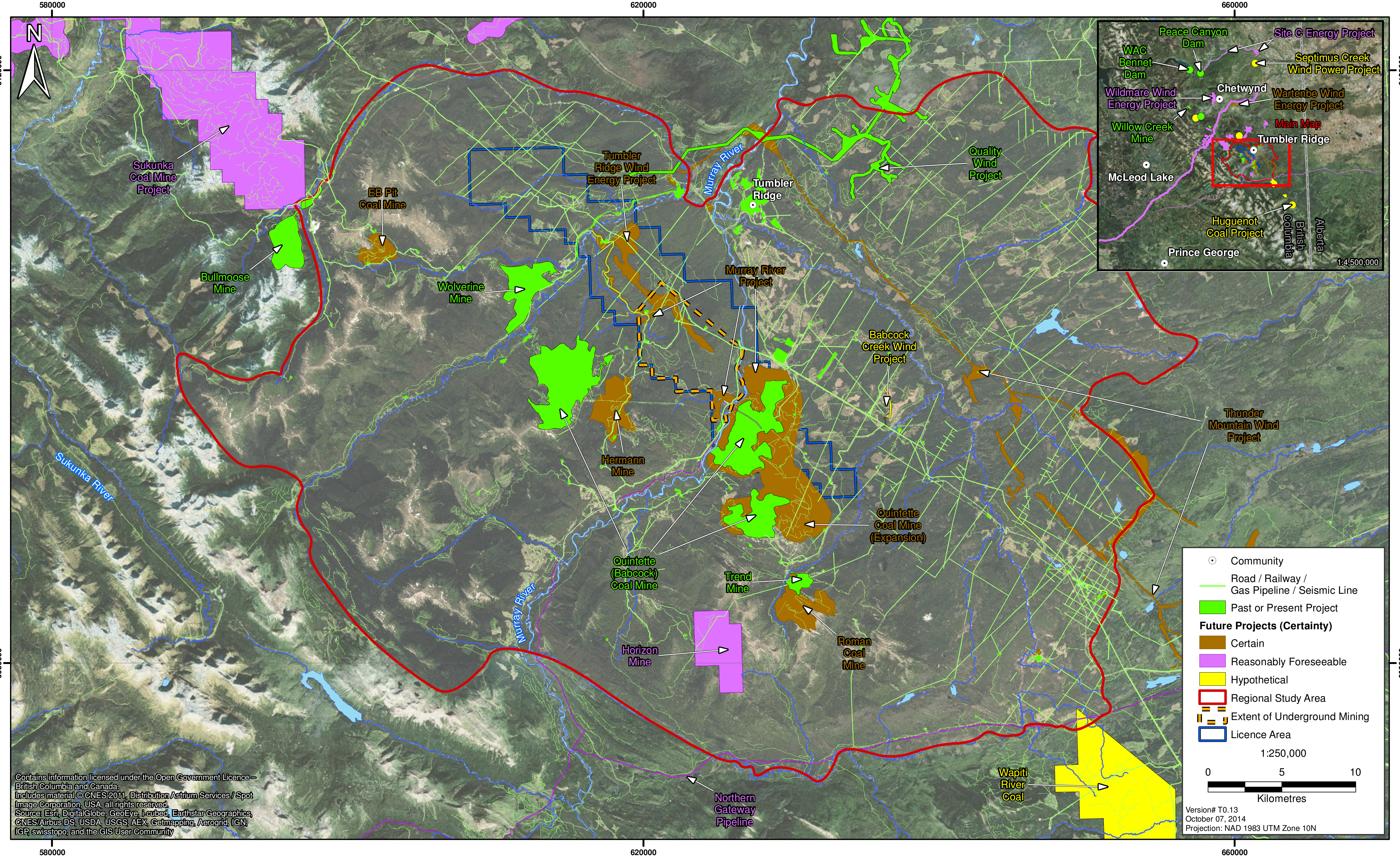
The other human actions considered in the CEA (described in Section 5.10.5) fall into the following temporal categories:

- **Past** (closed) human actions;
- **Present** (continuing and active) human actions; and
- **Future** human actions, which may be:
  - **certain actions:** those actions that have received regulatory authorizations but are not as yet built or operating;
  - **reasonably foreseeable actions:** those actions that are currently in some stage of a regulatory authorization process, and for which a general concept is available from which potential cumulative effects may be anticipated; and
  - **hypothetical actions:** those actions that are conjectural but probable, based on best professional judgement of currently available information, including leases, licences, and extrapolations from historical development patterns; the potential cumulative effects of such actions are discussed on a conceptual basis only in this CEA.

ERM

Figure 11.12-1

Past, Present, and Future Projects within the Cumulative Effects Assessment Regional Study Area



11.12.1.3 Identification of Potential Cumulative Effects

A review of the interaction between potential residual effects of the Project and the residual effects of other projects and activities on terrestrial ecology VCs was undertaken to determine the potential cumulative effects on ecologically valuable soils, terrestrial ecosystems, rare ecosystems, and rare lichens and plants (including their habitats). A matrix identifying the potential cumulative effect interactions for terrestrial ecology VCs is provided in Table 11.12-1.

If there is no spatial and temporal overlap between the residual effects of the Project and those of another human action, the relevant cell is marked with a dash (-). Where there is spatial and temporal overlap, but no interaction is anticipated, the cell is marked with a grey box, and a rationale as to why no interaction is predicted is given in the table. If there is overlap, and an interaction is anticipated, the cell is marked with a green, yellow, or red box (these are summarized in the footnotes to Table 11.12-1).

As in the Project-specific effects assessment, only potential adverse effects ranked as moderate or major (yellow or red) before active application of mitigation measures are carried forward in the CEA.

An initial list of past, present, and future human actions to be considered in the CEA was developed as part of the Murray River Land Use Baseline Report via desk-based review of existing information and field research conducted between 2010 and 2014 (see Appendix 16-A; Non-traditional Land Use Baseline) for a detailed description of this methodology). For the purposes of the CEA, this list was augmented with information on past historic mining operations retrieved from the BC Ministry of Energy, Mines, and Natural Gas, information on current and future hydroelectric projects from BC Hydro, FortisBC, and Columbia Power Corporation, and information on future actions from the BC EAO and the BC Ministry of Forests, Lands, and Natural Resource Operations.

Information was found to be deficient for many of the historic land uses in the RSA. To supplement the desk based information, interpretation of available spot imagery was used to identify disturbance footprints in the RSA using ArcMap. While the imagery comes from multiple years (2005, 2008, and 2009) and has 250 cm pixel resolution, it was sufficient to provide a base from which to identify and delineate anthropogenic disturbances in the RSA. To avoid duplication of existing data, only disturbances that were not well recorded in available spatial datasets were delineated. Existing road shapes were used, although in some areas new roads were digitized as line features in ArcMap as they were not present in existing datasets. The main disturbance footprints digitized as polygons in ArcMap included the community of Tumbler Ridge, mine sites, gas wells (historic and currently active), seismic lines, gravel pits, airstrips, railways, pipelines, hydro lines and other disturbances that result in the removal or alteration of vegetation. Where existing data was available and accurate, these were used. Due to the relatively coarse scale of the imagery, some errors in attributing the cause of the disturbance may have occurred. Identifying differences between older gas well footprints and gravel pits was difficult to determine is some cases. This, however, does not affect the use of this data for determining cumulative anthropogenic impacts in the RSA; it only reduces the accuracy of determining the land use that resulted in the effect.

Table 11.12-1. **Potential for Residual Effects to Interact Cumulatively with Effects of Other Human Actions on Terrestrial Ecology**

Timeframe		Name of Action	Dates Active	Proponent (if applicable)	Potential Cumulative Effects	Comments
Past	Historical	Hasler Coal Mine	1941 - 1945	Hasler Creek Coal Company	-	No spatial overlap with the RSA
		Sukunka (Bullmoose) Mine	1972 – 1975	BP Exploration Canada Ltd.	H	Overlay mine footprints and calculate distribution of ecosystems based on RSA PEM
	Recent	Bullmoose Mine	1983 – 2003	Teck Corporation	-	No spatial overlap with the RSA
		Dillon Coal Mine	2004 – 2007	Walter Energy / Western Coal	-	No spatial overlap with the RSA
		Quintette (Babcock) Mine	1983 - 2000	Teck Corporation	H	Source: EA historic TEM mapping
		Quintette (MESA Pit) Mine	1983 - 2000	Teck Corporation	H	Overlay mine footprints and calculate distribution of ecosystems based on RSA PEM
		Willow Creek Mine	2000 - 2013	Walter Energy	-	No spatial overlap with the RSA
		Major Forest Licensees			M	Overlay cut block distribution and identify potential overlap of effects
		Roads/Gravel Pits			H	Buffer roads and intersect with backdated RSA PEM
		Oil and Gas Footprints			H	Overlay O&G footprints and intersect with backdated RSA PEM
		Oil and Gas Seismic Lines			H	Buffer O&G seismic lines and intersect with backdated RSA PEM
Present		Brule Mine	2005 - 2016	Walter Energy	-	-
		Trend Mine	2003 - 2016	Peace River Coal	H	Spatial overlap with the RSA
		Quality Wind Project	2013 - unknown	Capital Power	L	Spatial overlap with the RSA
		Peace Canyon Dam	1980 – unknown	BC Hydro	-	-

(continued)

Table 11.12-1. Potential for Residual Effects to Interact Cumulatively with Effects of Other Human Actions on Terrestrial Ecology (continued)

Timeframe		Name of Action	Dates Active	Proponent (if applicable)	Potential Cumulative Effects	Comments
Present (*cont'd*)		Wolverine Mine (Perry Creek) and EB Pit	2004 - 2016	Walter Energy	M	Overlay mine footprints and calculate distribution of ecosystems based on RSA PEM
		WAC Bennett Dam	1961 – unknown	BC Hydro	-	No spatial overlap with the RSA
		Major Forest Licensees			L	Riparian buffers used by forest companies adjacent to cut blocks
		Roads/ Oil and Gas Footprints/Seismic Lines			H	Buffer roads and intersect with backdated RSA PEM. Overlay O&G footprints and intersect with backdated RSA PEM. Buffer O&G seismic lines and intersect with backdated RSA PEM
		Community of Tumbler Ridge			M	Overlay town footprint and calculate distribution of ecosystems based on RSA PEM
		Tumbler Ridge Community Forest			L	Overlay footprint and calculate distribution of ecosystems based on RSA PEM
Future	Certain	Hermann Mine	2014 - 2025	Walter Energy	M	Overlay footprint and calculate distribution of ecosystems based on RSA PEM
		Quintette Mine	2013 - 2025	Teck Corporation	M	Overlay footprint and calculate distribution of ecosystems based on RSA PEM
		Roman Mine Project	2013 - 2024	Peace River Coal	M	Overlay footprint and calculate distribution of ecosystems based on RSA PEM
		Thunder Mountain Wind Park	2014 – unknown	Aeolis Wind	M	Overlay footprint and calculate distribution of ecosystems based on RSA PEM
		Tumbler Ridge Wind Project	2013 - unknown	Pattern Energy Group	M	Overlay footprint and calculate distribution of ecosystems based on RSA PEM
		Wartenbe Wind Project	2014 - unknown	Avro Wind Energy Inc.	-	No spatial overlap with the RSA

(continued)

Table 11.12-1. Potential for Residual Effects to Interact Cumulatively with Effects of Other Human Actions on Terrestrial Ecology (continued)

Timeframe		Name of Action	Dates Active	Proponent (if applicable)	Cumulative Effects	Comments
Future (*cont'd*)	Certain (*cont'd*)	Major Forest Licensees			L	Overlay footprint and calculate distribution of ecosystems based on RSA PEM
		Roads			H	No available data
		Oil and Gas Footprints				No available data
		Oil and Gas Sesimic Lines			M	No available data
		Tumbler Ridge Community Forest			L	Overlay footprint and calculate distribution of ecosystems based on RSA PEM
	Reasonably Foreseeable	Echo Hill Mine	2015 - 2029	Hillsborough Resources Ltd.	-	No spatial overlap with the RSA
		Coastal Gaslink Project	2015 – 2048	TransCanada Pipelines	-	No spatial overlap with the RSA
		Horizon Mine	2015 - 2038	Peace River Coal	M	Overlay footprint and calculate distribution of ecosystems based on RSA PEM
		Meikle Wind Energy Project	2015 – 2041	Meikle Wind Energy Partnership	-	No spatial overlap with the RSA
		Northern Gateway Pipeline	2016 – 2068	Enbridge Northern Gateway Pipelines	M	Footprint loss determined using PEM and identified pipeline route and ROW width.
		Rocky Creek Energy Project	2015 – unknown	Rupert Peace Power Corporation	-	No spatial overlap with the RSA
		Site C Clean Energy Project	2015 – unknown	BC Hydro	-	No spatial overlap with the RSA
		Sukunka Coal Mine Project	2015 – 2038	Glencore	-	No spatial overlap of development with the RSA
		Sundance Wind Project	2015 - unknown	EDF Energies Nouvelles	-	No spatial overlap with the RSA
		Wildmare Wind Energy Project	2015 – unknown	Pattern Energy Group	-	No spatial overlap with the RSA

(continued)

Table 11.12-1. Potential for Residual Effects to Interact Cumulatively with Effects of Other Human Actions on Terrestrial Ecology (completed)

Timeframe		Name of Action	Dates Active	Proponent (if applicable)	Cumulative Effects	Comments
Future (*cont'd*)	Hypothetical	Babcock Creek Wind Project	Unknown	Babcock Ridge Wind Limited Partnership	-	Spatial overlap with the RSA
		Belcourt Saxon Coal Project	Unknown	Xstrata Coal Canada Ltd.	-	No spatial overlap with the RSA
		Huguenot Mine	Unknown	Colonial Coal International	-	No spatial overlap with the RSA
		Moose Lake Wind Power	Unknown	Moose Lake Wind Power Corporation	-	No spatial overlap with the RSA
		Septimus Creek Wind Power Project	Unknown	Zero Emission Energy Developments	-	No spatial overlap with the RSA
		Suska Mine	Unknown	Xstrata Coal Canada Ltd.	-	No spatial overlap with the RSA
		Wapiti River Coal Project	Unknown	Canadian Dehua International Mines Group Inc.	L	Spatial overlap with the RSA

Notes:

-	*No spatial or temporal overlap.*
O	*No interaction anticipated.*
L	*Negligible to minor adverse effect expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.*
M	*Potential moderate adverse effect requiring unique active management/monitoring/mitigation; warrants further consideration.*
H	*Key interaction resulting in potential significant major adverse effect or significant concern; warrants further consideration.*

11.12.2 Description of Potential Cumulative Effects

11.12.2.1 Analytical Approach

The potential Project-related residual effects in combination with residual effects from other past, present, or future project or development activities in the CEA study area on the terrestrial ecology VCs were identified through reviews of relevant literature and assessed through GIS analysis as well as professional judgement and experience.

In order to account for historic effects in the CEA boundary, a pre-disturbance inventory of terrestrial ecosystems was created. To accomplish this, a moving window filter was used to fill the barren values in the PEM that were associated with anthropogenic footprints. All barren cells associated with infrastructure footprints (excluding barren cells in the alpine BEC zones) were set to 0 and removed. Then a raster calculator was used to create a 20 × 20 pixel moving window around each barren cell. The barren cell was replaced with the ecosystem type which occurs most frequently within the specified moving window. The window samples the raster cells adjacent to the barren cells and then populates them based on the neighbouring raster cells. As the barren raster cell footprints are small, this provides a reasonable approximation of pre-existing ecosystems.

As barren cells are calculated for naturally occurring features (rock outcrops and other un-vegetated areas), the barren cells that the moving filter was applied to were identified in the PEM by using the digitized disturbance footprints. Linear and other small features like roads, wells, or other small footprints were back-dated using the moving window. Large footprints associated with mines, development such as the community of Tumbler Ridge, or other infrastructure could not be back dated using the moving window method.

To fill these larger holes, historic TEM data was used where available from other projects. However, for many older projects, no PEM or TEM data exists. To identify cumulative losses for these areas, the area of the Biogeoclimatic (BEC) subzones and variants in each footprint was calculated. Then the distribution of site series for each BEC unit in the RSA was calculated and these distributions were assigned to the footprints that had not BEC data to approximate pre-disturbance ecosystems distributions in the footprints.

To calculate cumulative loss for projects, the digitized disturbance footprints were overlaid on the back-dated PEM. The footprints were then clipped out of the PEM and assumed as lost. For mine footprints and other polygonal features, loss was determined by polygon size. For linear features, buffers were applied. A 10 m buffer was applied to roads and 4 m buffers were applied to seismic lines to account for footprints.

Alteration of ecosystem function was calculated using 100 m buffers of all polygons and roads to account for changes in hydrology, dust inputs, increased potential for invasive species, fragmentation, and edge effects. Seismic lines were not buffered due to their narrow footprints and lack of anticipated edge effects, dust, and fragmentation.

The alteration of ecologically valuable soils was assessed in terms of the ecological function that soils provide for forested ecosystems but was not assessed directly for each ecologically valuable soils type as this information was unavailable for the region.

11.12.2.2 Cumulative Effects on Terrestrial Ecology Valued Components

The cumulative loss and alteration on terrestrial ecology VCs were assessed according to the pre-pre-disturbance conditions as described in Section 11.12.2. The loss and alteration of each terrestrial ecology VC is summarized in Table 11.12-2 and discussed below.

Table 11.12-2. Summary of Cumulative Loss and Alteration from Past, Present and Reasonably Foreseeable Future Projects within the CEA Boundary for Terrestrial Ecosystems

Terrestrial Ecology Valued Component	Project Timeframe	Past / Present Contribution		Future Project Contribution		Past, Present and Future Contribution Total		Total Mapped in RSA
	Units	ha	%	ha	%	ha	%	ha
Ecologically Valuable Soil	Loss	10,723	5.5	5,726	2.9	16,449	8.5	194,326
	Total Loss	**10,723**	**5.5**	**5,726**	**2.9**	**16,449**	**8.5**	
Forested Ecosystems	Loss	10,723	5.5	5,726	2.9	16,449	8.5	194,326
	Alteration	42,257	22	6,933	3.9	49,190	26	
	Total Loss and Alteration	**52,980**	**27.2**	**12,659**	**7**	**65,639**	**33.7**	
Rare Ecosystems	Loss	1,910	5.8	455	1.4	2,366	7.1	33,128
	Alteration	7,841	24.0	936	3.0	8,777	26.0	
	Total Loss and Alteration	**9,751**	**29.8**	**1,391**	**4.4**	**11,143**	**33.1**	
Harvestable Plant Habitat	Loss	10,723	5.5	5,726	2.9	16,449	8.5	194,326
	Alteration	42,257	22	6,933	4	49,190	25	
	Total Loss and Alteration	**52,980**	**27.2**	**12,659**	**7**	**65,639**	**33.7**	

Note:
Totals are approximate due to rounding errors.

The cumulative loss on ecologically valuable soils and forested ecosystems from past and present projects is 10,723 ha (5.5%). The cumulative loss of ecologically valuable soils including reasonably foreseeable future projects – excluding the Project – is 15,983 ha (8.3%). The Murray River Coal Project will contribute 466 ha (0.24%) to equal 16,449 (8.5%) total cumulative loss.

The cumulative alteration of forested ecosystems from past and present projects is 42,257 ha (22%). The cumulative loss of forested ecosystems including reasonably foreseeable future projects – excluding the Project – is 49,026 ha (25%). The Murray River Coal Project will contribute 164 ha (0.1%) to equal 49,190 (25%) total cumulative alteration.

Collectively the cumulative loss and alteration of forested ecosystem from past and present projects is 52,980 ha (27.2%). The cumulative loss and alteration of forested ecosystem including reasonably foreseeable future projects within the CEA boundary is 65,639 ha (33.7%). The detailed summary of the cumulative loss and alteration of terrestrial ecosystems is presented in Appendix 11-E and Appendix 11-F, respectively.

The cumulative loss on BC CDC listed ecosystems from past and present projects is 1,910 ha (5.8%). The cumulative loss of BC CDC listed ecosystems including reasonably foreseeable future projects – excluding the Project – is 2,320 ha (7.0%). The Murray River Coal Project will remove 45 ha (0.14%) to equal 2,366 (7.1%) total cumulative loss.

The cumulative alteration on BC CDC listed ecosystems from past and present projects is 7,841 ha (24%). The cumulative alteration of BC CDC listed including reasonably foreseeable future projects – excluding the Project – is 8,753 ha (26%). The Murray River Coal Project may affect 24 ha (< 1%) to equal 8,777 ha (26%) total cumulative alteration.

Collectively the cumulative loss and alteration of BC CDC listed ecosystems from past and present projects is 52,980 ha (27.2%). The cumulative loss and alteration of BC CDC listed ecosystems including reasonably foreseeable future projects within the CEA boundary is 9,751 ha (29.8%). The detailed summary of the cumulative loss and alteration of terrestrial ecosystems is presented in Appendix 11-E and Appendix 11-F, respectively.

The cumulative loss and alteration to harvestable plant habitat is difficult to accurately characterize because the location, type and quantity of harvestable plants within the region is unknown. Many of the ecosystems within the region can provide suitable habitat for harvestable plants and as such harvestable plant habitat was assessed in relation to effects on forested ecosystems. However, the effects to harvestable plant habitat are expected to be considerably less in extent than the loss and alteration reported for forested ecosystem. Furthermore, in certain cases, human derived alteration will increase the amount of harvestable plant habitat.

11.12.2.3 Rare Plants and Lichens

The spatial coverage of rare plant and lichen survey data regionally is very sparse, and as a result uncertainty exists with respect to the presence of rare plants and lichens throughout the CEA study area. Of the information available, 16 blue-listed and 3 red-listed plant or lichens may be impacted by human activities within the CEA boundary. Noteworthy species include whitebark pine (*Pinus albicaulis*), which is listed on Schedule 1 of the SARA and *Collema tenax* var. *expansum***,** which is listed as globally rare. The cumulative loss of rare plants and lichens within the CEA, summarized by project species and rarity rank, is presented in Table 11.12-3.

11.12.3 Mitigation Measures to Address Cumulative Effects

Ecosystem management and mitigation plans are designed to avoid and minimize adverse effects to ecosystems and plants resulting from project activities within the feasible limits of project design and activities. Each past, present, and future project would have had or will have different mitigation and management for terrestrial ecosystems and plants; however, it is assumed any present and future projects will take into consideration the goals and objectives outlined in the *Dawson Creek Land & Resource Management Plan (LRMP).* It is also assumed that the following general mitigation measures will be common amongst any present and future projects or activities:

- avoid and minimize detrimental effects to terrestrial ecosystems and wetlands through strategic planning;

Table 11.12-3. Summary of Cumulative Loss or Alteration of Rare Plants and Lichens within the CEA Boundary

	Project Name	Data Status	Scientific Name	English Name	Global Rank	Provincial Rank	BC CDC Rank	SARA Listed
Past / Present Projects	Wolverine	No red- or blue-listed plants identified during sampling	-	-	-	-	-	-
	Tumbler Ridge Wind Energy	No red- or blue-listed plants identified during sampling	-	-	-	-	-	-
	Trend	2 vascular plants	*Polemonium occidentale* var. *occidentale*	Western Jacob's ladder	G5?T5?	S2S3	blue	-
			Silene involucrata ssp. *involucrata*	Arctic campion	G5T5	S2S3	blue	-
	Sukunka (Bullmoose)	Data unavailable	-	-	-	-	-	-
	Quality Wind Project	Data unavailable	-	-	-	-	-	-
	Quintette	2 mosses	*Brachythecium holzingeri*	None	GU	S2S3	blue	-
			Scorpidium cossonii	None	GU	S2S4	blue	-
	Roads and all other infrastructure	Data unavailable	-	-	-	-	-	-
	EB Pit Coal Mine	Data unavailable	-	-	-	-	-	-
Future Projects	Hermann Mine	10 vascular plants	*Carex tenera*		G5	S2S3	blue	-
			Carex xerantica	Dryland sedge	G5	S2	red	-
			Draba alpina	Alpine draba	-	-	not listed	-
			Draba lactea	Milky draba	G5	S2S3	blue	-
			Draba lonchocarpa var. *thompsonii*	Lance-fruited draba	G5T3T4Q	S2S3	blue	-
			Erigeron trifidus	Three lobed daisy	G2G3Q	S2	red	-
			Euphrasia arctica var. *disjuncta*	Arctic eyebright	-	S3S4	yellow	-

(continued)

Table 11.12-3. Summary of Cumulative Loss or Alteration of Rare Plants and Lichens within the CEA Boundary (completed)

	Project Name	Data Status	Scientific Name	English Name	Global Rank	Provincial Rank	BC CDC Rank	SARA Listed
Future Projects *(cont'd)*	Hermann Mine *(cont'd)*	10 vascular plants *(cont'd)*	*Glyceria pulchella*	Slender managrass	G5	S2S3	blue	-
			Oxytropis jordalii var. *jordalii*	Jordal's locoweed	G5T4	S2S3	blue	-
			Ranunculus eschscholtzii var. *suksdorfii*	Subalpine butercup	-	S3S4	yellow	-
	Horizon Mine	data unavailable	-	-	-	-	-	-
	Northern Gateway Pipeline	1 vascular plant	*Pinus albicaulis*	Whitebark pine	G3G4	S2S3	blue	Schedule 1
	Quintette Coal Mine	2 mosses	*Brachythecium holzingeri*	-	GU	S2S3	blue	-
			Scorpidium cossonii	-	GU	S2S4	blue	-
	Roman Coal Mine	3 vascular plants	*Polemonium occidentale* var. *occidentale*	Western Jacob's ladder	G5?T5?	S2S3	blue	-
			Silene involucrata ssp. *involucrata*	Arctic campion	G5T5	S2S3	blue	-
			Draba porsilidii	Porsild's draba	G3G4	S2S3	blue	-
	Murray River - MSAF	3 vascular plants and 2 lichens	*Drymocallis arguta*	Tall cinquefoil	G5T5	S1S3	red	-
			Cardamine parviflora	Small-flowered bittercress	G5	S2S3	blue	-
			Botrychium crenulatum	Dainty moonwort	G3G4	S2S3	blue	-
			Collema tenax var. *expansum*	-	G1	SU	currently not ranked	-
			Hypogymnia dichroma	-	GU	SU	currently not ranked (species new to science)	-

Note:
Report is being prepared for the CDC suggesting its provincial status be changed to the Yellow List (McIntosh 2012, pers. comm.); this change in ranking will occur in 2012 or 2013. It will be included with Brachythecium oedipodium in the revised status (and given a new name: Sciuro-hypnum oedipodium).

- minimize all clearing dimensions during any construction activities;
- minimize soil degradation through best management practices for soil stripping, handling and stockpiling;
- minimize soil loss and degradation (i.e., compaction, erosion, and soil horizon mixing);
- avoid the introduction and spread of invasive plants;
- avoid and minimize detrimental effects to rare plants and lichens, including rare plant and lichen habitat;
- avoid and minimize loss or alteration of ecosystem functions due to clearing activities, dust deposition, fragmentation, edge effects, windthrow, and altered hydrology;
- ensure clearing activities are coordinated with other management plans; and
- maintain natural levels of plant and lichen biodiversity through avoidance, offsetting, and other mitigation strategies;
- avoid direct harm to rare plant and lichen populations through realignment of footprint boundaries when possible;
- avoid use of all herbicide sprays within 200 m of rare plant and lichen populations and limit such use to direct application rather than broadcast sprays; and
- create exclusion zones around priority rare plant and lichen (e.g., red-listed and globally rare species) habitats to avoid direct disturbance and to minimize effects related to fugitive dust transport, weed invasion, and vehicular activities.

Collaborative approaches to address cumulative effects to the terrestrial ecology receptor VC have been initiated through data sharing agreements between some proponents regionally. Further collaborative efforts with additional proponents, and to maximize the effectiveness of monitoring programs and other biodiversity initiatives should be pursued.

11.12.4 Characterization of Residual Cumulative Effects for Terrestrial Ecology

Management and mitigation measures will help avoid and minimize adverse effects to ecologically valuable soil quantity and quality, ecosystem functions and extent, as well as to rare plants and lichens, resulting from the activities of the present and future projects. Nevertheless, residual cumulative effects are expected due to historic activities and due to present and/or future planned activities where residual effects persist. Thus, residual cumulative effects are anticipated for ecologically valuable soil, forested ecosystems, rare ecosystems for rare plants and lichens. Cumulative residual effects are those effects remaining after the implementation of all mitigation measures and are summarized in Table 11.12-4. The residual cumulative effects for the relevant terrestrial ecology VCs were characterized by considering the Project's incremental contribution to the cumulative residual effect under two scenarios:

- Future case without the Project: a consideration of residual effects from all other past, existing, and future projects and activities on VCs <u>without</u> the Project.
- Future case with the Project: a consideration of all residual effects from past, existing, and future projects and activities on VCs <u>with</u> the Project.

Table 11.12-4. Summary of Residual Cumulative Effects on Terrestrial Ecology Valued Components

Valued Component	Murray River Activity	Other Human Action Activity	Description of Potential Cumulative Effect	Description of Mitigation Measure(s)	Description of Residual Cumulative Effect
Ecologically Valuable Soil	Site preparation and construction of infrastructure, travel on site; road maintenance, transportation, soil stripping and salvage, CCR pile development, subsidence, reclamation	Footprints for roads, oil and gas wells, railways, hydro lines, seismic lines, mines, wind projects, pipeline's, railways, Community of Tumbler Ridge	Loss of soil quality and/or quantity	Minimize clearing dimensions, dust suppression, promptly re-vegetate exposed soil surfaces, effective and communication and reporting procedures for environmental monitoring	Loss of soil quality and quantity
Forested Ecosystems	Site preparation and construction of infrastructure, travel on site; road maintenance, transportation, subsidence, reclamation	Footprints for roads, oil and gas wells, railways, hydro lines, seismic lines, mines, wind projects, pipeline's, railways, Community of Tumbler Ridge	Loss and/or alteration of ecosystem function and extent	Minimize clearing dimensions, dust suppression, promptly re-vegetate exposed soil surfaces, effective and communication and reporting procedures for environmental monitoring	Loss and alteration of ecosystem function and/or extent
Rare Ecosystems	Site preparation and construction of infrastructure, travel on site; road maintenance, transportation	Footprints for roads, oil and gas wells, railways, hydro lines, seismic lines, mines, wind projects, pipeline's, railways, Community of Tumbler Ridge	Loss and alteration of biodiversity, ecosystem function and/or extent	Minimize clearing dimensions, dust suppression, promptly re-vegetate exposed soil surfaces, effective communication and reporting procedures for environmental monitoring	Loss and alteration of biodiversity, ecosystem function and/or extent
Harvestable Plants	Surface clearing, deposition of fugitive dust	Surface clearing, deposition of fugitive dust	Loss or alteration of harvestable plant quantity or quality	Minimize clearing areas, dust suppression; effective communication and reporting procedures for environmental monitoring	Loss or alteration of harvestable plant quantity or quality
Rare Plants and Lichens	Site preparation and construction of infrastructure, deposition of fugitive dust; road maintenance, transportation	Footprints for roads, oil and gas wells, railways, hydro lines, seismic lines, mines, wind projects, pipeline's, railways, Community of Tumbler Ridge	Loss of biodiversity, rare plants and lichens; loss and alteration of rare plant and lichen habitat	Optimize alternatives to ensure that rare plant and lichen populations are avoided, where feasible; create exclusion zones around priority rare plant and lichen habitats; avoid use of all herbicide sprays within 200 m of rare plant and lichen populations	Loss of biodiversity, rare plants and lichens; loss and alteration of rare plant and lichen habitat

This approach helps predict the relative influence of the Project on the residual cumulative effect for each relevant VC, while also considering the role of other projects and activities in causing that effect.

11.12.5 Characterization of Residual Cumulative Effects, Significance, Likelihood, and Confidence

The residual cumulative effects to VCs are characterized in Table 11.12-5 using criteria from Table 11.9-1.

It is very difficult to accurately determine the magnitude of loss and alteration of terrestrial ecology VCs within a cumulative context due to data limitations, disparate methodologies between projects, and an overall absence of measurable criteria and indicators. Nevertheless, there is some empirical information on amount of habitat loss (i.e., ecosystems) beyond which effects to wildlife species is predicted to be unacceptably high. Therefore, the magnitude of loss and alteration of terrestrial ecosystems was based on threshold levels for habitat loss.

The magnitude threshold takes into consideration the amounts of landscape disturbance beyond which measures of ecological degradation increase in intensity. This idea has been supported empirically, and has been useful in determining risks to wildlife species from landscape disturbance, which include not only habitat loss but also other ecological changes that negatively affect species (Scrimgeour, Hvenegaard, and Tchir 2008). Habitat thresholds also can be defined based on perceived risk. For example, habitat loss thresholds for the Great Bear Rainforest in BC were defined based on expert opinion: greater than 30% habitat loss was identified as a threshold amount representing a transition from low risk to higher risk of uncertain magnitude (Price et al. 2009). Combining these two approaches (i.e., landscape disturbance thresholds and expert-derived risk thresholds), thresholds for habitat loss of greater than 30 to 40% can be defined as amounts of habitat loss predicted to cause unacceptable risks to species (Scrimgeour, Hvenegaard, and Tchir 2008; Karen Price, Roburn, and MacKinnon 2009).

Applying a precautionary approach, a high magnitude effect was designated at 30% loss of the total amount of habitat available. The magnitude of the effect on relevant terrestrial ecology VCs within the CEA was calculated relative to the amount of each VC available within the CEA boundary. The magnitude of the effect on relevant terrestrial ecology VCs within the CEA was calculated relative to the amount of each VC available within the CEA boundary. The magnitude of cumulative effects on terrestrial ecosystems was determined based on the definitions provided in Table 11.12-6.

The magnitude of cumulative effects on rare ecosystems was determined based on the BC CDC conservation ranks (Table 11.9-3) and on a magnitude threshold specific to rare ecosystems (Table 11.12-7). There is little information regarding quantitative thresholds for BC CDC listed ecosystems; however, it is recognized that these ecosystems represent at risk ecosystems and thus merit a more conservative magnitude threshold. The magnitude threshold for BC CDC listed ecosystems is provided in Table 11.12-7.

The magnitude threshold for rare plants and lichens was determined based on the BC CDC conservation ranks as outlined in BC CDC and NatureServe Ranks in Table 11.9-4. This information was used to determine severity of residual effects to rare plants and lichens.

Table 11.12-5. Characterization of Cumulative Residual Effects, Significance, Confidence and Likelihood

Residual Effect	Effect Characterization						Significance	Probability	Confidence
	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Context			
Loss of soil quality and quantity	moderate	far future	once, sporadic, regular	regional	reversible far future	neutral	not significant (moderate)	high	medium
Loss and alteration of forested ecosystem function and/or extent	major	far future	once, sporadic, regular and continuous	regional	reversible far future	neutral	significant (major)	high	medium
Loss and alteration of rare ecosystem function and/or extent	major	far future	once, sporadic	beyond regional	irreversible	high	significant (major)	medium	low
loss or alteration of harvestable plant quantity or quality	moderate	medium to long	sporadic	regional	reversible long-term	neutral	not significant (moderate)	medium	medium
Loss of biodiversity, rare plants and lichens; loss and alteration of rare plant and lichen habitat	moderate to major	far future	once	beyond regional	irreversible	high	significant (major)	medium	low

Table 11.12-6. Magnitude Threshold for Terrestrial Ecology Valued Components

Magnitude Rating	Definition
Negligible	< 1% loss of amount of habitat available in the CEA boundary
Minor	1-10% loss of amount of habitat available in the CEA boundary
Moderate	11-30% loss of amount of habitat available in the CEA boundary
Major	> 30% loss of amount of habitat available in the CEA boundary

Table 11.12-7. Magnitude Threshold for BC CDC Listed Ecosystems

Magnitude Rating	Definition
Negligible	> 90% not altered or lost. No detectable change from baseline conditions
Minor	Alteration + Loss ≤ 20% and Loss < 20%
Moderate	Alteration + Loss < 30% and > 20; and Loss ≤ 20%
Major	Alteration + Loss ≥ 30% or Loss .> 20%

Figures 5.10-1 and 5.10-2 respectively present the spatial locations and timelines of these human actions relative to the Project. Sections 5.10.5.1 to 5.10.5.5 provide high-level descriptions of each human action. For the purposes of the CEA, where relevant data on these actions are not available, professional judgement and data from comparable projects are used to predict trends.

11.12.5.1 Ecologically Valuable Soils

The cumulative loss of ecologically valuable soils is considered not significant. The magnitude of effects is considered moderate because 8.5% of all ecologically valuable soils will be affected. Cumulative effects to ecologically valuable soils include, nibbling losses to soil quality and quantity by many projects and synergistic effects on soil moisture regime associated with land clearing, tree harvesting, road construction, and subsidence. The effect will extend into the far future due to the slow recovery rate of soils. Frequency of effects will vary, but most typically will be sporadic. The effects will occur at a regional level. Loss of some ecologically valuable soils is considered reversible in the far future depending on quality of mitigation and effectiveness of reclamation. The ecological context of ecologically valuable soils is neutral as the affected soils have some unique attributes, and some of their functions will have been degraded. The probability of the effects to soils is high because surface clearing activities and soil handling practices are known to result in the loss and degradation of soils. Confidence in the analysis is medium, however, because, while the type and distribution of soils within the impacted area are well understood, there is a considerable uncertainty regarding the range of potential ecological responses of soils to a combination of various effects within the region.

11.12.5.2 Forested Ecosystems

Loss and alteration of forested ecosystem function and/or extent are considered significant. The magnitude of effects is considered major because more than 33.7% of all forested ecosystems will have been affected by past, present and future projects. Cumulative effects to forested ecosystems include nibbling loss of forested land, physical transport of invasive plant propagules, chemical transport of dust from various sources, spatial and temporal crowding in areas where multiple project effects intersect with forested ecosystems as well as growth inducing effects due to the creation of new forest edges that could lead to windthrow and introduction of invasive plant species. The frequency of cumulative effects range from once to continuous depending on the effect. Effects will occur within a regional level and the majority of effects are considered reversible in the far future. Forested ecosystems are considered to be of neutral resiliency. In an ecological context, forested ecosystems are considered neutral according to the definitions provided in Table 11.11-1, Definitions of Characterization Criteria for Residual Effects on Terrestrial Ecology. The probability of the effects is high because there are already known cumulative effects within the CEA study area, notably nibbling effects. Any further effects resulting from past, present or future projects will contribute to the existing cumulative effects within the CEA boundary. There is an overall moderate level of confidence in the data sources used for this analysis. The predictive ecosystem mapping is a landscape level tool that can be used to determine potential effects on ecosystem type and distribution and to guide mitigation and management strategies. However, the accuracy of the PEM is limited by the availability of site level data as well as the resolution at which it is mapped. Furthermore, uncertainty exists with respect to where and to what degree alteration of functions may occur due to the complexity of ecological processes between components and their response to cumulative effects. Nevertheless, there is a high level of probability that effects to forested ecosystems will occur. The majority of the effects to forested ecosystems, including fragmentation and edge effects are well understood and well documented in the scientific literature. Therefore, there is an overall medium confidence level in the assessment of effects on forested ecosystems.

11.12.5.3 Rare Ecosystems

Loss and alteration of rare ecosystems are considered significant. The magnitude of the effects is considered major based on the determination of magnitude outlined in Table 11.9-3 as well as the magnitude ratings outlined in Table 11.12-7. Cumulative effects to rare ecosystems include nibbling loss of rare ecosystems and relevant surrounding ecosystem that contribute to the ecological function of rare ecosystems, physical transport of invasive plant propagules, chemical transport of dust from various sources, spatial and temporal crowding in areas where multiple project effects intersect with rare ecosystems as well as growth inducing effects due to the creation of new forest edges that could lead to windthrow and introduction of invasive plant species. The effects are expected to affect the viability of this resource in the short, medium and long term. Loss of rare ecosystems is considered irreversible as these ecosystems contain unique attributes that are not easily replicable. The effects of surface clearing will occur once and the remainder of effects will occur sporadically. All of the effects are considered beyond regional in extent and will extend into the far future. In an ecological context, rare ecosystems are rated high as they have unique attributes that are uncommon and of conservation interest in the province. There is a low level of confidence in the analyses because uncertainty exists regarding how the unique combinations of environmental conditions that characterize rare ecosystems will respond to potential cumulative effects.

11.12.5.4 Harvestable Plants

Loss and alteration of harvestable plants are considered not significant. The magnitude of the direct effects to harvestable plants is considered moderate because although 33.7% of the available habitat could be lost or altered by cumulative effects, some of the human derived alteration will increase the amount of harvestable plants. Development activities such as timber harvesting can favour berry production by increasing the light available to plants and by reducing competing vegetation. Other cumulative effects to harvestable plants include nibbling loss of relevant habitat, physical transport of invasive plant propagules, spatial and temporal crowding in areas where multiple project effects intersect with harvestable plant habitat as well as additive effects from the accumulation of metals in some soils and subsequent plant uptake as well as growth inducing effects due to the creation of new edges. All of the effects are considered regional in extent and reversible in the long term. The duration of effects are expected to occur over the medium to long term depending on the relevant plant and its associated habitat requirements. In an ecological context, harvestable plants are considered neutral as they have some unique attributes, particularly to the local communities (discussed further in Chapter 16, Land Use). There is a medium level of confidence in the analyses because the effects to harvestable plants are generally well understood; however, uncertainty exists regarding the magnitude of alteration.

11.12.5.5 Rare Plants and Lichens

Additional knowledge of local and regional floral biodiversity is required in order to evaluate the significance of the Project effects on many of the rare plant and lichen populations. Nevertheless, the magnitude of the removal or alteration of rare plants and lichens or their associated habitat will vary from moderate to major depending on the species affected and their associated conservation rank. The conservation rank for each species takes into consideration the rarity, current trends and threats to the species. Of the plant or lichen species impacted, there are several with less than 20 known occurrences in the province, one with less than 5 known occurrences in the province and one with less than 20 documented occurrences in the world. One species, white bark pine is listed on Schedule 1 of SARA. Rare plants and lichens represent at-risk components of regional, provincial, federal or global biodiversity. These species are often highly habitat-specific with low resiliency to habitat loss or degradation, invasive alien species, changes in ecological dynamics or natural processes, and disturbance (Province of British Columbia 2013). The effect is beyond regional, will occur once and will last into the far future. Loss of rare plans and lichens is considered an irreversible effect as transplantation is usually ineffective (BC *Mines Act* 1998; Environment 2005; Northwest Invasive Plant Council 2012; Barker 2013). Furthermore, rare plants and lichens can have limited dispersal ability, poor recruitment or reproduction, population fluctuations, inbreeding, and/or restricted ranges. There is a high level of confidence in the specific location of the species as well as the identification of the species that have been surveyed to date for the Project; however, the spatial coverage of surveys regionally is very sparse, and as a result uncertainty exists with respect to the presence of rare plants and lichens throughout the CEA study area. Furthermore, information regarding the magnitude of effects discussed in this chapter to rare plants and lichens is limited. Further uncertainty exists regarding the magnitude of the effect on rare plant and lichens as well the individual species response to the effect. In an ecological context, rare plants and lichens (depending on their conservation rank) are considered unique attributes according to the definitions in Table 11.11-1, Definitions of Characterization Criteria for Residual Effects on Terrestrial Ecology.

11.13 EFFECTS ASSESSMENT CONCLUSIONS FOR TERRESTRIAL ECOLOGY

Management and mitigation measures will help avoid and minimize adverse effects to ecosystem functions and extent resulting from the Project's Construction, Operation, Decommissioning and Reclamation, and Post Closure phases. However, direct and indirect effects cannot be fully mitigated and thus residual effects are anticipated for ecologically valuable soils, forested ecosystems, rare ecosystems, harvestable plants and rare plants and lichens.

Project-related residual effects of direct (i.e., loss) and indirect (i.e., degradation or alteration) effects on soil quality and quantity and on ecosystem function and extent will result in not significant effects on ecologically valuable soils, forested ecosystem, rare ecosystems harvestable plants and rare plants and lichens. The residual effects, mitigation, and significance on terrestrial ecology VCs are summarized in Table 11.13-1.

Table 11.13-1. Summary of Residual Effects, Mitigation, and Significance on Terrestrial Ecology Valued Components

			Significance of Residual Effects	
Residual Effects	Project Phase	Mitigation Measures	Project	Cumulative
Loss and alteration of ecologically valuable soil	All Phases	Minimize loss of soil quality and quantity by adhering to the Site Preparation and Soil Salvage Plan	Not significant	Not Significant (Moderate)
Loss and alteration of forested ecosystems	All Phases	Minimize loss and adaptively manage effects through an ecosystem based approach	Not significant	Significant (major)
Loss and alteration of rare ecosystems	Construction and Operation	Minimize loss and adaptively manage effects through an ecosystem based approach	Not significant	Significant (major)
Loss and alteration of harvestable plants	Construction and Operation	Minimize clearing; dust abatement; invasive plant control	Not significant	Not significant (moderate)
Loss and alteration of rare plants and lichens and associated habitat	Construction and Operation	Minimize clearing; dust abatement; invasive plant control	Not significant	Significant (major)

Each past, present and future project would have had or will have different mitigation and management for soils, ecosystems and plants; however, it is assumed that any past, present and future projects will have some level of mitigation and management depending on existing management practices at that time of development. Nevertheless, direct and indirect cumulative effects cannot be fully mitigated and thus residual cumulative effects are anticipated for ecologically valuable soils, forested ecosystems, rare ecosystems, harvestable plants and rare plants and lichens.

The residual effects of past, present, and future projects will result in not significant effects on ecologically valuable soils, and harvestable plants and significant effects on forested ecosystems, rare ecosystems, and rare plants and lichens. The significance of cumulative residual effects of loss and/or alteration of rare plant and lichen species or associated habitat cannot be determined based on currently available information.

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