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Vegetation and Wetlands Assessment
Grassy Mountain Coal Project

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1.0 INTRODUCTION

1.1 Project Overview

Benga Mining Limited (Benga), a wholly owned subsidiary of Riversdale Resources Limited (Riversdale), is proposing to develop the Grassy Mountain Coal Project (the Project). The Project is located in southwest Alberta near the Crowsnest Pass, approximately 7 km north of the community of Blairmore. The Project involves a surface metallurgical coal mine, a coal handling and preparation plant (CHPP), and associated infrastructure including a coal conveyor system, a rail load-out facility, an access corridor, maintenance shops, and other pertinent facilities.

The purpose of this report is to provide a description and evaluation of the potential effects on vegetation and wetlands associated with the construction, operations, and reclamation of the proposed Project, and to assess the potential effects along with those of existing, approved, and planned developments.

1.2 Terms of Reference

This assessment follows the Terms of Reference (TOR) established for the Project Environmental Impact Assessment (EIA) issued by the Alberta Energy Regulator (AER) and *Guidelines for the Preparation of an Environmental Impact Statement* (EIS) issued by the Canadian Environmental Assessment Agency (CEA Agency). In addition to these guidance documents, the *Guide to Preparing Environmental Impact Assessment Reports in Alberta* (Government of Alberta (2013a) and the *Draft Technical Guidance for Assessing Cumulative Environmental Effects* under the *Canadian Environmental Assessment Act, 2012* (CEA Agency 2014) were also referred to.

This Vegetation and Wetlands Resource Assessment report outlines baseline conditions and provides an impact assessment and mitigation measures for terrestrial, riparian, and wetland vegetation for the Project. All assessment and mitigation is based on field data collection as well as aerial imagery and environmental and baseline information gathered from existing sources. Cumulative effects are based on the regional environment and planned projects or activities. Mitigation measures and vegetation monitoring plans proposed to minimize the effects of the Project on the vegetation and wetland resources are also discussed.

Based on the TOR and CEA Agency guidelines, the overall objectives of this report are to:

- map and describe existing vegetation communities in upland and wetland settings, and describe and discuss their distribution and relative abundance;
- map and describe rare plants, rare plant communities, traditional use vegetation, old growth forests, and communities of limited distribution, including their distribution and relative abundance;
- describe and quantify the current extent of habitat fragmentation;
- provide forest timber productivity ratings for both the project area and the local study area and identify productive, non-productive and non-forested lands;
- describe the composition, distribution, relative abundance, and habitat requirements of rare plants and address species listed as "at Risk, May be at Risk and Sensitive" in *The General Status of Alberta Wild Species* (AESRD 2010a), species listed in Schedule 1 of the federal *Species at Risk Act* (Government of Canada 2015); and species listed as "at risk" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2015);
- discuss the potential of each ecosite phase to support rare plant species; plants for traditional, medicinal and cultural purposes; and old growth forests and consider their importance for local and regional habitat, sustained forest growth, and rare plant habitat;
- describe and assess the potential impacts of the Project on vegetation communities;
- discuss any potential impacts the Project may have on rare plants or endangered species;
- identify key vegetation indicators used to assess the Project impacts. Discuss the rationale for the indicator's selection;
- discuss temporary (include timeframe) and permanent changes to vegetation and wetland communities including comment on the impacts and their implications for other environmental resources, the impacts and their implications to recreation, aboriginal and other uses and their sensitivity to disturbance;
- describe the regional impact of any ecosite phase to be removed;
- discuss from an ecological perspective, the expected timelines for establishment and recovery of vegetative communities and the expected differences in the resulting vegetative community structures;
- provide a predicted ecological land classification (ELC) map that shows the reclaimed vegetation;
- discuss the impact of any loss of wetlands, including how the loss will affect land use;
- discuss weeds and non-native invasive species and describe how these species will be assessed and controlled prior to and during operation and reclamation; and

- discuss at multiple spatial scales, the predicted changes to upland, riparian and wetland habitats resulting from increased fragmentation.

The complete final TOR and CEA Agency guidelines for the Project are provided in the EIA application, Appendix 1 and 2, respectively. AER clauses specific to the vegetation and wetland assessment are provided in the concordance table in Appendix A.

1.3 Vegetation and Wetlands Study Areas

The Vegetation and Wetlands study areas consist of the Project Footprint, Local Study Area (LSA) and Regional Study Area (RSA) (Figure 1.3-1). The areas occupied by each of these components are summarized in Table 1.3-1; detailed descriptions are provided in Sections 1.3.1 - 1.3.3.

Table 1.3-1 Vegetation and Wetlands Study Areas

Project Component	Area (ha)
Project Footprint	1,582.4
Local Study Area	4,776.2
Regional Study Area	284,024.8

1.3.1 Project Footprint

The Project Footprint includes the area that will be directly disturbed by Project development (Figure 1.3-1). The proposed Project Footprint involves the open pit coal mine, a north and south disposal area, surrounding surface water management ponds and drainage ditches, a CHPP with associated infrastructure, an overland (covered) conveyor system, a coal load-out facility, a section of rail loop, and an access corridor. Full details of each Project component are provided in the Application, Section C (Benga 2015).

1.3.2 Local Study Area (LSA)

The LSA is located approximately 7 km north of Blairmore, Alberta and is 4,776 ha in area. The LSA was set as the Project's proposed mine permit boundary, with additional buffer of 500 m of land around Project Footprint components that extended close to the proposed permit boundary (Figure 1.3-2). The LSA occurs in portion of Township 9 Ranges 3 and 4, Township 8 Ranges 3 and 4, and the buffer extends into a small portion of Township 7 Range 4, all west of the 4th Meridian.

The physical extent of the LSA is of sufficient size to capture potential Project effects to vegetation or wetland VCs that will result from direct disturbance to resources within the Project Footprint. It will also capture changes to vegetation communities adjacent to the Project Footprint resulting from alterations to physical components such as water quantity (wetlands) and quality, air emissions, and dust. Direct Project effects are assessed within the LSA.

1.3.3 Regional Study Area

The RSA consists of the LSA and a 25-km buffer surrounding the LSA (Figure 1.3-1). The RSA is approximately 2,840 km² and is predominantly within the province of Alberta (2,362 km², 83%), with a portion occurring within British Columbia (478 km², 17%).

The RSA was defined to ensure that it captured the Project's effects in the LSA as well as the farthest measurable cumulative effects (*i.e.,* effects from other projects and land uses that potentially overlap with those of the Project) and residual effects of the Project on vegetation and wetland resources. As ecological communities define wildlife species ranges, the Project RSA was based on the home range area of a female grizzly bear (*Ursus arctos horribilis)* (Russell *et al.* 1979, Carr 1989, Carra 2010, COSEWIC 2012). Other considerations for selection of the RSA were that it be large enough to capture the existing disturbances, historical mines, and settlements in the region that may be affected or contribute to cumulative effects but not so large that project effects are overwhelmed or minimized in the assessment. Cumulative effects and residual effects are assessed within the RSA.

1.3.4 Study Area Physiography

The Project is located in the Rocky Mountain Natural Region, which is characterized by highly variable topography, geology, and vegetation. The north to south and east to west variation in bedrocks across this Natural Region result in the highly variable physiographic nature of this region and the characteristic vegetation distributions.

The vegetation LSA is located within the Montane and Subalpine Natural Subregions, which are characterized as follows:

- **Montane Natural Subregion** – Characterized by a pattern of open forests and grasslands, with modal sites having forested stands of Douglas fir, lodgepole pine, white spruce, aspen, or mixtures of all. The Montane Subregion occurs at lower elevations than the Subalpine Subregion and has warmer and drier climatic conditions as a result. Limber pine may be present, but is commonly restricted to dry, exposed ridge tops. Abrupt changes in vegetation can occur over very short distances due to high variability in microclimates from differing aspects, slope positions, and wind exposure (Natural Regions Committee 2006).

  Chernozoic soils tend to develop beneath grasslands under warmer and drier conditions, while Luvisols form under coniferous stands in moister, cooler areas with accumulations of litter.

- **Subalpine Natural Subregion** – Occurs at high elevations on strongly rolling ridges and lower slopes of mountains, often with bedrock near the surface (Archibald *et al.* 1996). A broad range of vegetation species are characteristic of on mesic sites due to significant variations in elevation. Vegetation communities at lower elevations are characterized by closed canopy forests of lodgepole pine, Engelmann spruce, and subalpine fir. Whitebark pine is found at higher elevations where the forest canopy is generally more open (Archibald *et al.* 1996).

  This Natural Subregion is characterized by Brunisolic and Luvisolic soils. Litter layers tend to be thin and acidic as a result of high moisture regimes and coniferous forest cover (Natural Regions Committee 2006).

The vegetation RSA also includes the third natural subregion in the Rocky Mountain Natural Region – Alpine Natural Subregion – and the Foothills Fescue Natural Subregion within the Grassland Natural Region of Alberta.

The Alpine Natural Subregion occupies the highest elevations of the natural region, and has a cold harsh climate and steep unstable rocky substrates that collectively limit plant growth and soil development (Natural Regions Committee 2006). The Project lies close to the provincial border with British Columbia, for which ecosystems are classified using the Biogeoclimatic Ecosystem Classification (BEC) (BC Forest Service 2015). The BEC biogeoclimatic zones and subzones included in the RSA are Montane Spruce dry cool (MS), Engelmann Spruce Subalpine Fir dry cool (ESSF), Interior Douglas Fir (IDF), and Interior Mountain-heather Alpine (IMA). The MS zone is similar to Alberta's Montane Natural Subregion, the ESSF zone has similarities to both the Montane and Subalpine Natural Subregions, and the IMA zone is similar to the Alpine Natural Subregion.

The Foothills Fescue Natural Subregion is located along the eastern flanks of the Rocky Mountains and typically consists of rolling to hummocky uplands within the RSA. This subregion is characterized by cool summers and mild winters; vegetation dominated by oatgrasses, rough fescue, and Idaho fescue; and Orthic Black Chernozemic soils (Natural Regions Committee 2006).

1.3.5 Study Area Climate

The Rocky Mountain Natural Region is characterized by cool summers, short growing season, and high annual precipitation (Natural Regions Committee 2006). The Montane Natural Subregion has milder winters and less annual precipitation than the Subalpine Natural Subregion.

1.4 Vegetation and Wetland Assessment Scope

Vegetation is a key component in the diversity and functioning of natural ecosystems. Vegetation is a valuable environmental resource and contributes to maintaining air quality, storage of atmospheric carbon, filtering water, regulating water yield, stabilizing soils, and providing wildlife habitat. As well, vegetation provides valuable resources for human use including food, medicine, wood products, fuel, and traditional technology (clothing, shelter, tools, and utensils). It also provides opportunities for recreation, aesthetically pleasing environments, and spiritual and/or psychological needs (AENV 2003a).

Vegetation elements that can be directly or indirectly affected by project activities include species abundance and distribution, ecological communities (ecosites and ecosite phases) abundance and distribution, rare plants and rare plant communities, forestry resources and old growth forests, abundance and distribution of weeds and non-native invasive species, traditionally used (TEK) plant species, and wetland communities. Also, project emissions and chemical deposition (*e.g.*, acid influx and nitrogen deposition) can affect any of the abovementioned vegetation resources.

Changes in the spatial distribution and abundance of vegetation resources modify the intensity of direct and indirect effects to the vegetation and can affect the overall biodiversity of an area. The following sections provide a general overview of the specific vegetation and wetland assessment scope of work.

1.4.1 Vegetation Community Classification

Plant communities are characterized by plant species occurrence, the assemblage of species present, species distribution and frequency and the abiotic characteristics of a site. Indicator species are those plants that are commonly associated with a particular set of environmental conditions, and that are often used to identify a plant community.

Plant species occurrence and distribution were assessed during baseline field sampling, which focused on representative ecosite phases. Field data collection was used to verify baseline mapping of upland and wetland communities, and species inventories and rare plant surveys were conducted. This information was used to assess and compile baseline conditions for vegetation resources and to determine overall baseline biodiversity conditions.

Ecological Land Classification (ELC) is defined as being a cartographical delineation of distinct ecological areas identified by their geology, topography, soils, vegetation, climate conditions, species assemblages, habitats, water resources, and anthropogenic factors. These factors control and influence biotic composition and ecological processes. Different methods are used to delineate or classify ecological areas. This report utilizes the widely used ecosite classification system first described by Archibald *et al.* (1996) for the Province of Alberta. The Natural Regions and Subregions of Alberta (Natural Regions Committee 2006) form the base of the ecosite classification system and represent distinct landscapes that are delimited and classified based on unique climatic, geomorphological, physiographical, and ecological characteristics.

Based on the principles of ELC, the ecosite classification system uses a combination of biotic and abiotic variables to create a hierarchical, or nested, ecological classification structure by incorporating vegetation, soil, site, and productivity information to classify ecosystems to ecosite phase. At the coarsest level of classification, ecological areas and subregions are defined based on broad ecological and climatic factors. Ecosites are defined relative to a modal or reference site within a particular natural subregion. Modal or reference sites are strongly influenced by the regional climate other than edaphic (soil) or landscape features and are therefore characterised by moderate soil moisture and nutrient conditions.

Ecological classification within the ecosite classification framework is used to distinguish, classify, and map ecosystems and associated plant communities as follows:

- Ecosite, which forms the functional unit, is defined on the edatopic grid by nutrient and moisture regimes in an area with similar climatic and environmental conditions. Ecosite is identified by a letter increasing from "a" to the last letter used; in the case of the Montane and Subalpine Natural Subregions, letters go from "a" to "g" and "a" to "h", respectively.
- Ecosite phase, which is based on the dominant tree species, or tallest physiognomic vegetation layer if trees are not present (*i.e.,* shrubs), represents the smallest unit that can be mapped. Ecosite phase correlates well with traditional forest cover maps and is identified with a letter number combination with the letter representing the ecosite and the number representing the phase within that ecosite (*e.g.,* b1, d2, f3).
- Plant community type is characterized by the dominant understory plant species but also includes the overall plant community. Plant community type is identified by a number that follows the ecosite phase (*e.g.*, b1.1, g1.2, k2.3). Plant communities are identified during field surveys.

Mapping scales used to delineate the different units follow a hierarchical order (from largest to smallest) as follows:

- natural region and subregion/ecological area (mapped at 1:250,000 scale);
- ecosite (mapped at 1:20,000 scale); and
- ecosite phase (mapped at 1:15,000 scale).

Vegetation communities of limited distribution are those ecosite phases that have limited or restricted spatial extent (area) or distribution (number of individual polygons or patches) and occupy less than

1%. Communities of limited distribution are more susceptible to loss from development or disturbance (Izco 1998) and consequently are important contributors to landscape level biodiversity.

1.4.2 Species at Risk and Rare Plants

1.4.2.1 Federal Species at Risk

At the time of submission, 12 vascular plant species and two moss species present in Alberta were federally designated by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) or under the Species at Risk Act (SARA) as Endangered, Threatened, or Special Concern. The definitions for federal conservation status are provided in Table 1.4-1.

Table 1.4-1 Definitions of Federal Status Categories for Vegetation

Status	Definitions[1]
Extinct	A species that no longer exists.
Extirpated	A species that no longer exists in the wild in Canada, but occurs elsewhere.
Endangered	A species that is facing imminent extinction or extirpation.
Threatened	A species that is likely to become endangered if limiting factors are not reversed.
Special Concern	A species that might become "Threatened" or "Endangered" because of a combination of biological characteristics and identified threats.
Data Deficient	A species for which there is inadequate information to make a direct or indirect, assessment of its risk of extinction.
Not At Risk	A species that has been evaluated and found to be not at risk of extinction given the current circumstances.

[1] Source: *Species at Risk Act* (Government of Canada 2015)

1.4.2.2 Rare Plants and Rare Plant Communities

As many as 65 percent of Alberta's rare plant species occur in the Rocky Mountain Natural Region (Kershaw *et al.* 2001). Rare plant surveys were conducted to locate and map rare plants and rare plant communities, if present, within the LSA. The specific objectives of rare plant surveys were to:

- locate, map and describe rare plant species and rare plant communities;
- describe and assess potential environmental effects of the Project construction and operation on rare plant species and communities;
- describe and discuss measures to be implemented to mitigate and or monitor potential effects of the Project on rare plants and communities; and

- discuss how monitoring programs will be used to adaptively manage the mitigation measures and monitoring programs.

A rare plant is defined by the Alberta Native Plant Council (ANPC) as "*any native vascular or non-vascular (mosses, hornworts, liverworts) plant that, because of its biological characteristics or for some other reason, exists in low numbers or in very restricted areas in Alberta*" (ANPC 2012). This definition also applies to lichens and fungi. Lichens are included in rare plant surveys; however, there is too little existing information on fungal distributions for fungi to be included in rare plant surveys.

A rare plant community is any community (*i.e.,* distinct assemblage of plant species found to reoccur under the same environmental conditions) that is uncommon, of limited extent, or locally significant (Gould 2006). A special community is one that is not considered rare, but is unusual, either locally or regionally. While rare plant communities are less likely to compete with common communities in areas with optimal conditions (*e.g*., nutrients, moisture), they are more likely to thrive in areas with more extreme conditions. The Alberta Conservation Information Management System (ACIMS) assesses and tracks rare plant species (vascular plants, bryophytes, and lichens) and rare plant communities (each referred to as a tracking element) in Alberta. ACIMS's ranking method is based on a system developed by the Nature Conservancy that is used throughout North America and is as follows (S = Alberta, G = global):

- S1/G1 – Five or fewer recorded occurrences, or with few individuals remaining;
- S2/G2 – Six to 20 occurrences or many individuals in fewer occurrences;
- S3/G3 – From 21 to 100 occurrences; might be rare and local throughout its range, or its range might be restricted (may be abundant at some locations or may be vulnerable to extirpation because of some biological factor);
- S4/G4 – Secure under present conditions, typically with more than 100 occurrences; or, fewer with many large populations (may be rare in parts of its range, especially at the periphery);
- S5/G5 – Secure under present conditions with more than 100 occurrences; may be rare in part of its range, especially the periphery;
- SNR – Status not yet ranked;
- SU/GU – Status uncertain, often because of low search effort or cryptic nature of the element; possibly in peril, not rankable, more information needed; and
- S?/G? – Rank questionable.

For the purposes of this survey, the ranking of a plant species or community as rare follows ACIMS's definition; that is, all S1, S2, and tracked S3 species are considered rare (ACIMS 2014a). A combined rank (*e.g.*, S1/S2) is given to species with an uncertain status; the first rank indicates the rarity status given current documentation and the second rank indicates the rarity status that will most likely be assigned after all historical data and likely habitats have been checked.

Elements with S1 to S2/S3 ranks are recorded on ACIMS's tracking lists because they are species of high priority or conservation concern; some species with ranks of S3 or S3/S4 are placed on watch lists. Species on watch lists are usually those that have restricted distributions but are common within their range. Elements on the tracking and watch lists are evaluated annually and may move from one list to another based on reported changes in populations (Gould 2006). Species are also ranked globally according to their worldwide distribution and population size (NatureServe 2015).

1.4.3 Rangeland Resources

The term 'rangeland' is used to describe natural grasslands as well as areas where cultivation is unsuitable due to erratic precipitation, cool temperatures, rough topography, or poor drainage. Healthy rangelands are a source of water, wildlife, and forage for wildlife and livestock (AESRD 2007) and are composed of native grassland species assemblages or agronomic or introduced vegetation that either is grazed or has the potential to be grazed. Rangelands are typically managed as a natural ecosystem (AESRD 2009). These systems usually do not require the input of fertilizers or other soil amendments and they provide important habitat for many wildlife species. Healthy rangelands also assist with watershed protection, prevent soil erosion, and provide esthetic landscape values for the public (AESRD 2009). Rangeland functions and their importance are provided in Table 1.4-2.

Table 1.4-2 Rangeland Function and Importance

Rangeland Function	Importance
Productivity	Range plant communities utilize existing energy and water resources to produce biomass. This biomass is suitable for livestock and wildlife grazing. Rangeland biomass also provides a source of food for other lifeforms such as insects and decomposers.
Site stability	Supports long term biomass production and protects soils that have developed over time.
Capture and beneficial release of water	Rangelands effectively store moisture that vegetation species utilize for plant growth. Moisture is retained during periods of drought and slowly released. This reduces runoff and the potential of soil erosion.
Nutrient cycling	Rangelands conserve and recycle available nutrients for plant growth.
Plant species diversity	Native rangelands are an important niche habitat for a diversity of grasses, forbs and shrubs. All rangelands, native and agronomic, support quality forage for livestock and wildlife.

Source: AESRD 2009

The modal grassland community in the Blairmore foothills, at an elevation of 1,300 m to 1,900 m, is the rough fescue (*Festuca campestris*)-Idaho fescue (*Festuca idahoensis*)-Parry oatgrass (*Danthonia parryi*) community (Willoughby *et al.* 2005). Rough fescue produces substantial litter that serves to conserve moisture, thereby enhancing moisture retention and infiltration (Desserud 2006). It is a highly nutritious plant, and provides valuable fall and winter forage for livestock and wildlife (AESRD 2011). Rough fescue is recognized by the ranching community, government agencies, and stewardship groups for its role in moisture retention, forage production, and playing a role in capturing and storing carbon (AESRD 2011). Rough fescue is sensitive to disturbance during its growing season (April to July) and to soil disturbance (Desserud 2006).

Communication with AEP (formerly AESRD) and the proponent regarding the proposed Project was initiated during the initial stages of the Project planning process. It was determined that there was potential for rough fescue grasslands to occur within the LSA, and that a range health assessment should be conducted on rough fescue grassland communities observed within the LSA to determine their pre-disturbance condition. Range health assessments are utilized to provide a rapid determination of the ecological status of rangeland (Willoughby and Alexander 2006) and the ability of a rangeland to perform certain key functions (AESRD 2009).

Five key indicators are utilized to measure range health and determine if proper ecological functions are being performed (AESRD 2009).

- The first indicator, integrity and ecological status, refers to the plant species composition that influences a site's ability to perform rangeland functions. Relative to early seral communities, late seral communities are more efficient in capturing solar energy, cycling organic matter and nutrients, retaining moisture, supporting wildlife habitat, and providing the highest potential for productivity.
- The second indicator, community structure, refers to the different layers within a plant community (*i.e.,* tall grasses, forbs, moss, and lichen). Nutrient cycling and energy flow are more efficient in community structures with varied canopy layers and rooting depths, which can use sunlight, water, and nutrients from different zones in the canopy and the soil (AESRD 2009).
- Hydrological function and nutrient cycling is the third indicator of range health. This indicator is measured by the amount of litter on a site, which provides moisture retention, reduces evaporation, reduces raindrop impact, slows runoff, and reduces soil erosion from wind and water.
- The fourth indicator is site stability, which is aided by the amount of litter on a site (AESRD 2009). Some eroded soils such as badlands and blowout areas are natural processes.

Anthropogenic processes such as overgrazing, scouring, rutting, and clearing of vegetation cover may also result in soil loss.

- The final indicator of range health is the presence and density of noxious weeds. The presence of noxious weeds can diminish the productivity of a site; reduce the biodiversity, structure, and function of native plant communities; and reduce the multiple uses and values that a healthy rangeland is capable of producing (AESRD 2009).

Range health scores fall into three qualitative categories: healthy, healthy with problems, and unhealthy. A range health score of healthy indicates that all key functions of range health are being performed, while a range health score of healthy with problems indicates that some key range health functions such as plant community type and structure, litter, site stability, or invasive species are not being performed properly. It indicates that while the site is reasonably healthy some management strategies are required to bring the range health rating back to healthy, normally within a few years. A range health rating of unhealthy indicates that many key functions are not being performed, and that management strategies are essential to bring the site back to a healthy rating, usually over several years (AESRD 2011).

1.4.4 Forestry Resources

Alberta's forested lands support approximately 1,300 species of vascular plants, 600 species of non-vascular plants, 460 species of vertebrates, and 10,000 species of invertebrates (Alberta Research Council 1998). They also provide aesthetic, spiritual, and cultural values to society (Alberta Environment 2003a). Forests help maintain air quality, store atmospheric carbon, provide cover habitat for wildlife, keep soil in place, filter and regulate water supplies, and support recreational activities. Forests also supply resources such as timber and fuel, and traditional land uses such as berry picking and plant harvesting (Alberta Research Council 1998, Alberta Environment 2003a,).

Forested ecosite phases (refer to Appendix C for descriptions) are important to the hydrologic regime. On the land surface, forest vegetation directly influences the volume of water available for water bodies through the capture of precipitation, the evaporation of intercepted water, and through transpiration. Within the Montane and Subalpine subregions, forests can have an important impact on water balances that contribute to stream flow. In particular, forested areas trap more snow in the winter and by shading reduces the rate at which snow melts in the spring. Slower melting reduces the rate of soil moisture recharge and downslope flow acting as flood mitigation, especially in steep locations like the Project area (Winkler *et al.* 2012).

Timber harvesting is the leading commercial use of forest resources in the region. The commercial value of a forest is contingent upon the structure and composition of the forest stands. Timber productivity ratings (TPR), which rate forest stand productivity based on height and age of the dominant and co-dominant tree species, are provided in the Alberta Vegetation Inventory (AVI) dataset for each mapped polygon within Alberta (ASRD 2005). TPR values can be used to determine the proportion of productive and non-productive forested stands within an area and to calculate merchantable timber volumes.

1.4.5 Old Growth Forests

Old growth forests are important to biodiversity because they contain structure and functions less abundant or absent from younger forests. The key characteristic of old growth forest is the opening of the canopy from tree mortality that accompanies the later successional stages of forest development (Burton *et al*. 1999). With canopy opening understory vegetation is released, woody debris accumulates, and secondary canopy characteristics often develop. The increase in structural diversity within old growth forest has an influence on unique vegetation and animal species and species richness (Timoney 2001; Burton *et al.* 1999).

In Alberta, there is no universally accepted definition for old growth forests (Lee *et al.* 2000). Thus, the definition of what constitutes an old growth forest varies and is contingent upon the classification system used. This assessment uses the age-based classification system proposed by Schneider (2002). According to Schneider (2002), an old growth forest is defined by forest attributes such as age and/or stand characteristics. This classification system was chosen as age-based definitions can be easily applied using AVI data that include stand origin classes based on fire and timber harvesting history. Although more rigorous criteria exist for classifying old growth forests (*e.g*., Andison 1998, Bonar *et al.* 2003, Morgantini and Kansas 2003), information required (*i.e.,* dead woody material decay stage, elevation, slope aspect, slope angle, soil properties) to remotely classify old growth was not readily available.

For this report, old growth forests are classified according to tree species, using the following age criteria, which are available from AVI data:

- white spruce, black spruce, and Douglas or sub-alpine fir forests are 140 years or older;
- pine forests and mixed pine-spruce/fir forests are 120 years or older; and
- deciduous and mixed coniferous-deciduous forests are 100 years or older.

Mixed stands are defined as those with less than 80% cover of the dominant tree species, and more than 20% of the tree type that would otherwise denote younger old growth criteria. Stand origin data from AVI database for the LSA were used to determine the stand ages as described in the methods Section 2.3.5.

Trees in old growth stands are typically larger than those in younger stands where stands have equivalent tree species composition and abiotic site characteristics. Old-growth stand structure, *i.e.*, the number of vegetation strata present, is generally more complex and developed than in younger tree stands. The structural complexity of old stands results primarily from the mortality of individual trees as they reach maturity. Fallen trees cause openings in the forest stand and result in the accumulation of large logs on the forest floor. With time, the stand is comprised of trees of many different ages (ACBS 2001, Schneider 2002). The structural complexity of old growth stands provides a higher frequency of important habitat types for wildlife species and vegetation. For example, vegetation species that colonize slowly and have slow growth rates, such as certain lichens, are found only in old growth stands. The accumulation of dead wood and the complexity of vegetation strata also support unique groups of wood-decomposing species, and provide shelter and food for many birds and small mammal species. Old growth stands in Alberta have the highest diversity and abundance of species, relative to all other forest age classes (ACBS 2001, Schneider 2002).

1.4.6 Traditional Ecological Knowledge Valued Component Vegetation Resources

Traditional Ecological Knowledge (TEK) valued component (VC) vegetation resources include those plant species that are traditionally used by, or considered culturally important to Aboriginal Groups. For the purposes of this assessment, this includes vegetation species valued by Aboriginal Groups for medicine, food, technology (clothing, shelter, tools, and utensils), and other purposes. Species that meet these criteria will be termed TEK vegetation.

Traditional land use and TEK studies commonly involve consultation with local or regional Aboriginal Groups to determine vegetation and wildlife species that are locally used and of importance, as well as geographic areas that are used for hunting, fishing, and harvesting. The consultations undertaken for the Project are described in Volume 1, Section H.

This vegetation and wetlands assessment includes information about TEK vegetation in the LSA collected during the vegetation field surveys and during Treaty 7 First Nations consultation and traditional land use studies. TEK data are derived from historical and current uses of vegetation as identified by the Treaty 7 First Nations groups.

1.4.7 Wetlands

The purpose of the wetland assessment was to acquire baseline information on all wetlands present in the LSA (including bogs, fens, swamps, and marshes). All wetlands identified within the LSA were classified and digitally mapped.

The specific objectives required to accomplish the environmental assessment for wetlands are as follows:

- classify all wetlands within the LSA, according to the appropriate classification system;
- describe wetland distribution, structure, and diversity; and
- discuss the effects of the Project on wetlands within the LSA.

Wetlands are defined by the National Wetlands Working Group (NWWG 1997) as "*land that is saturated with water long enough to promote wetland or aquatic processes as indicated by poorly drained soils, hydrophytic vegetation and various kinds of biological activity which are adapted to a wet environment*."

Wetlands and wetland ecosite phases are important to the hydrologic regime. Like forested areas, they provide flood mitigation by storing and slowly releasing large volumes of surficial runoff. Wetlands also function as natural filtration systems by inhibiting sediment discharges and potentially up-taking pollutants. A wetland can be either a groundwater recharge and discharge zone, and therefore connects surficial waters with aquifers (Government of Alberta 2013b).

Wetlands are categorized into two groups: peatlands and non-peat forming wetlands. Peatlands (described in the Glossary of Terms) usually contain more than 40 cm of accumulated organic matter, and are subdivided into bogs and fens. Non-peat forming wetlands, usually having fewer than 40 cm of accumulated organic matter, are sub-divided into three groups: shallow open water, marsh, and swamps. Each of these wetlands is formed by a combination of geomorphic, hydrologic, edaphic, climatic, or biological factors (Halsey *et al.* 2004).

The five main categories of wetlands are:

- marshes – early succession wetland ecosystems that are the most used wetland type for many wetland-dependent wildlife species. Marshes support a large standing crop of palatable vegetation, plankton, and aquatic invertebrates (MacKenzie and Moran 2004).
- swamps – provide important avifauna and bat habitat due to a greater diversity of vertical structure for nesting and feeding (MacKenzie and Moran 2004).
- bogs – contain a diversity of lichen species used by caribou (Bradshaw *et al.* 1995), and consist of vegetation species that are not typically tolerant of flooding and are outcompeted by minerotrophic species when nutrient availability is moderate. The removal of water from bogs will lead to an increase in upland community vegetation and the loss of obligate hydrophytes (MacKenzie and Moran 2004).

- fens – have moderate wildlife habitat values, and support avian and mammalian insectivores when there is standing water where aquatic insect populations are abundant. Fens persist even with extreme flooding, sedimentation, or burning; however, extended fundamental alterations to the water regime, such as permanent water table elevation or draining will convert vegetation communities to other types (MacKenzie and Moran 2004).
- shallow waters – these permanently-flooded wetlands that are often in the form of ponds, sloughs, or transition stages between lakes and marshes. Similar to marshes, these wetlands are very important habitats for wildlife and fish.

Wetlands and riparian areas are unique ecosystems and have many values and functions. They serve as important and specialized habitats, enhance water quality, and sequester carbon.

1.4.8 Biodiversity and Fragmentation

Biodiversity is a measure of the health of an ecosystem and defines the degree of variation among living organisms within an ecosystem. The Canadian Biodiversity Strategy defines biodiversity as "*the variability among living organisms and the ecological complexes of which they are part, [including] within species, between species, and diversity of ecosystems*". The Strategy further states that "*conservation of biodiversity means managing human uses of resources to maintain ecosystem, species and genetic diversity*" (Minister of Supply and Services Canada 1995). These three levels of diversity are defined as:

- genetic diversity – the variety of genetic material in all living things;
- species diversity – the variety of species on earth; and
- landscape or ecosystem diversity – the variety of living communities and the environments in which they occur.

Vegetation is a key component of biodiversity. Alberta's mandate to support the Canadian Biodiversity Strategy and to achieve the goals of Alberta's Biodiversity Strategy has led to the establishment of many initiatives to demonstrate the importance of vegetation to biodiversity. For example, the setting aside of protected areas and Special Places, the creation of the Alberta Forest Conservation Strategy, and the establishment of model forests for research all demonstrate the important role vegetation plays in the conservation of Alberta's biodiversity (Alberta Environmental Protection 1998).

It is not practical to directly measure genetic diversity for large areas containing complex communities and many populations of species (Franklin 1993); however, it is possible to assess factors that would impact genetic diversity, or the diversity within individual species. For the purpose of this report, vegetation biodiversity is measured at the species level, community level, and landscape level.

Species level biodiversity is a major contributor to, and a fundamental component of, the sustainability of an ecosystem (Oil Sands Vegetation Reclamation Committee 1998). In this report, species diversity assessment will include the number of species and rare species, as well as the potential to sustain these species through time.

Community diversity includes species composition (number and abundance of species), the structure of the community (presence of different layers or stages of vegetation/community development), the functioning of the community (overall health), and the physical characteristics of the site. In this report, plant communities are mapped as ecosite phases or RSA ELC units. The effect of the Project on mapped communities and the restoration or reclamation of plant communities is assessed.

Landscape level biodiversity refers to overall diversity in the ecosystems within the region. It includes all the species and all the communities within a defined geographical region (*e.g.*, LSA or RSA, or the Montane Natural Subregion). In the context of this environmental assessment, landscape diversity includes plant communities and their distribution on the landscape (LSA and RSA).

A key influence on biodiversity is the effects of fragmentation. Ecosystem fragmentation refers to the break-up of habitat expanses into smaller and more isolated units. Increased fragmentation may result in a wide range of threats to biodiversity, such as an increase in invasive and non-native species, reduction, or restriction of wildlife movement, reduction of genetic diversity and population viability, loss of resilience, alteration of natural disturbance patterns, and interruption of succession. Fragmentation and biodiversity are inversely related: as fragmentation of natural landscapes increases, biodiversity generally decreases.

1.4.9 Noxious and Invasive Species

Noxious and invasive vegetation species pose a threat to the natural dynamics and functioning of ecosystems as they can have a competitive advantage over native species and can remain within a plant community for lengthy periods of time (McClay *et al.* 2004, Adams *et al.* 2009).

While noxious weeds are regulated, invasive species are not regulated despite their potential negative impact on an ecosystem. The introduction of these species has the potential to negatively affect the biodiversity of an ecosystem as these plants are more effective at competing for resources such as light, water, nutrients, and space. When noxious and invasive vegetation begins to dominate an area, the habitat becomes altered and organisms that previously relied on the native vegetation can be impacted. When noxious and invasive vegetation dominates an area, it is very difficult to remove this vegetation and return the ecosystem back to its natural state (McClay *et al.* 2004, Adams *et al.* 2009).

1.4.10 Potential Acid Input and Nitrogen Deposition

Alberta established the Alberta Acid Deposition Management Framework (AADMF) for long-term evaluation and monitoring of acid deposition within the province, as well as a process to address exceedances of critical, target and monitoring loads should they occur (AENV 2008). This framework is directly applied on a provincial scale, specifically to grid cells measuring 1° latitude x 1° longitude.

Acid emissions have the potential to negatively affect vegetation if sufficient amounts are absorbed directly from the air on to plant surfaces or if deposition into the soil exceeds a soil's buffering capacity. The negative effects can be either direct or indirect. Direct effects on plants include reduced plant vigor, discoloration, growth alteration, susceptibility to insect damage, disease, and ultimately die-back. Acid deposition can generally be considered in terms of indirect effects of acid deposition from acidifying components including nitrogen and sulfur compounds. The key acidifying compounds are NO_2 and SO_2.

From an assessment perspective, the direct effects of acid influx on vegetation are not often considered because effects on soil and water, which have an indirect impact on vegetation, occur earlier, and are more easily measured (AENV 2008). Plant communities on soils that are sensitive to potential acid input (PAI) may be affected depending on the rates of deposition and changes in soil chemistry. The Project assessment focused on indirect effects of acid deposition and direct effects from nitrogen deposition correlated with changes in soil chemistry.

2.0 METHODS

To understand the existing environmental conditions within the LSA, baseline surveys of vegetation and wetland plant communities were conducted. Results from these surveys were subsequently used in the environmental assessment to determine direct and cumulative effects of the project development on the plant species, vegetation, and wetland communities. Mitigation measures were then formulated based on the findings of the assessment and are summarized in Section 5.0 of this report.

Data sources and the general methodology used to assess baseline vegetation and wetland resources are described below. Specific data collection methods for rare plants and rare plant communities (Section 2.3.2), rangelands and range health (Section 2.3.3), wetlands (Section 2.3.7), and biodiversity (Section 2.3.8) are discussed further in their respective sections.

2.1 Data Sources

The following data sources were used in the classification and delineation of vegetation and wetland communities within the vegetation and wetlands study areas as part of the baseline and assessment components of this report.

2.1.1 Alberta Vegetation Inventory

Alberta Vegetation Inventory (AVI) data (ASRD 2005) were used for ELC and ecosite phase mapping, calculating forest resources, and estimating the extent and distribution of old growth forest within the LSA and the portion of the RSA that is located within the boundaries of the province of Alberta.

AVI data are a GIS-ready photo-based digital inventory of dominant vegetation types across Alberta. The inventory, which is managed by Alberta Environment and Parks, was developed to identify vegetation types and the extent and conditions of vegetation in forested areas, and identify changes in vegetation cover and extent throughout the province. AVI data include tree species, percent cover, canopy heights, stand origin, timber productivity rating, disturbance type (*e.g.*, insect kill, wind storm damage, fire, clearings, cut blocks, agriculture), and understory attributes. The data scale is 1:20,000.

2.1.2 Alberta Biodiversity Monitoring Institute

Alberta Biodiversity Monitoring Institute (ABMI) data resources were used for RSA mapping (1:15,000 scale) (ABMI 2015). These spatial data provide classifications of temporal and permanent alterations to natural ecosystems in support of industrial, residential, and recreational land uses. Permanent transformations of ecosystems consist of roads, cities, surface mines, and agriculture, while temporary anthropogenic disturbances include cut blocks and seismic lines. The spatial dataset consists of linear features of railway, pipelines, transmission lines, seismic lines, trails, and various classes of roads. Non-linear features consist of urban areas, rural development, recreational sites, grave yards, airports, feed lots, mines, wind generation facilities, borrow pits, dug-outs, sumps, municipal sewage sites, reservoirs, canals, cultivation, cut blocks, and well sites.

2.1.3 Remote Imagery

Remote imagery was used to map the LSA to ecosite phase level, refine the RSA to ecological land cover classes including anthropogenic and water features, and calculate forest resources within the LSA. Remote imagery used included a high-resolution colour MrSID 0.1-metre pixel orthophoto, 5-m infrared Rapid-eye satellite imagery, a LiDAR hillshade, and aerial photo imagery. LiDAR bare earth and full feature data were used to extract topographic and vegetation heights within the LSA.

2.1.4 Vegetation Resource Inventory

The Vegetation Resource Inventory (VRI) is British Columbia's forestry inventory that includes forest cover, water features, roads, land ownership, and parks data (BC MFLNRO 2015). VRI data are air photo interpreted, digital spatial data and consist of attributes similar to AVI: tree species, percent cover, stand age, canopy height, and understory height.

VRI was one of the resources used for mapping the BC portion of the RSA. Because this is a forestry inventory, it provides minimal detail for the subalpine and alpine zones within the BC portion of the RSA. The data scale is 1:20,000.

2.1.5 Alberta Conservation Information Management System

The Alberta Conservation Information Management System (ACIMS) maintains a database of all plant and animals; species and plant communities that are of conservation importance ("rare") are placed on a list of tracked and watched elements so that their populations and occurrences are monitored for conservation planning. This database was used to determine rare species potential for the Grassy Mountain LSA prior to field work, as well as to determine which of the species observed in the LSA were being tracked or watched within the province, and which species are weeds and / or invasive.

2.1.6 Species at Risk Databases

The General Status of Alberta Wild Species (AESRD 2010a), COSEWIC (2015), and the Species at Risk Public Registry (Government of Canada 2015) databases were searched prior to conducting all field surveys to determine whether any of their listed species were likely to occur in the LSA. Updates to statuses were noted during the report preparation stage and taken into consideration in this assessment. This information was used during post-survey data processing to compile a list of species of conservation concern, to determine project impacts, and to formulate mitigation measures for these species in the Project's LSA and RSA.

2.1.7 Vegetation and Wetlands Surveys (Baseline Data Collection)

The baseline surveys completed between June and September 2014 for the Project yielded information about upland and lowland (wetlands) vegetation communities gathered from 116 plots located within the Grassy Mountain LSA. Information gathered included detailed species inventories (rare, TEK, and weed species), range health assessment, vegetation cover, habitat and soil characteristics, as well as ecosite phase and wetlands classification (see Section 3.0 Baseline Case for results).

2.1.8 Other Resources

The following vegetation and wetlands classification systems were used to classify vegetation and wetland communities at all stages of the classification process:

- *Field Guide to Ecosites of Southwestern Alberta* (Archibald *et al.* 1996) – Ecosite phase classification for Montane and Subalpine Natural Subregions;
- *Alberta Wetland Inventory Classification System Version 2.0* (AWI) (Halsey *et al.* 2004) – Wetland classification; and

- *Canadian Wetland Classification System* (NWWG 1997) – Wetland classification.

2.2 General Vegetation Methods

The methodology for collecting baseline data for the vegetation and wetland assessment included preliminary mapping and plot selection, field surveys, post-survey verifications, data management and processing, and final mapping.

2.2.1 Preliminary Mapping and Plot Selection

Prior to conducting field surveys, preliminary ecosite phase maps were created using available remote imagery and AVI dataset. All naturally vegetated lands in the LSA were classified to ecosite phases following the *Field Guide to Ecosites of Southwestern Alberta* (Archibald *et al.* 1996). Vegetation community polygons split by the boundary between the Montane and Subalpine natural regions were assigned an ecosite for one natural region only, based on community composition and 'best fit' for an ecosite phase in either the Montane or Subalpine natural region. Areas in the LSA that did not fit into ecosite phase description (*e.g.*, anthropogenic disturbance, natural non-forested and non-vegetated land and open water) were mapped and described based on AVI inventory standards (ASRD 2005). The following AVI codes were used to describe areas that fell under this category:

- AIH – Permanent rights of way; roads, highways, railroads, dam sites, reservoirs
- AII – Industrial (Plant sites), sewage, lagoons
- AIM – Surface mines
- ASC – Cities, towns, villages, hamlets
- CC – Clearcut/partial cut
- CIP – Pipelines, transmission lines, airstrips, microwave tower sites, golf courses, cemeteries
- CIW – Geophysical activities, included well sites that have been seeded with annual crop
- CL – Clearing (extent not required)
- CO – Non-linear clearings
- CP – Perennial forage crops
- HG – Herbaceous - Grassland
- NMR – Rock barren
- NWF – Flooded (areas periodically inundated with water)
- NWL – Seasonal thaws, lakes, ponds
- NWR – River
- SC – Closed shrub
- SO – Open shrub

The AVI database does not effectively delineate bogs and fens or accommodate changes in elevation. Therefore, AVI polygons were modified using remote imagery and LiDAR. Because understory plant species cannot be identified through the use of aerial photos alone, polygons were classified to ecosite phase rather than to plant community type level. If a polygon contained multiple ecosite phases, only the two most dominant ecosite phases were mapped.

Preliminary ecosite phase maps were used to locate and stratify survey plot locations for vegetation and wetlands surveys (ground-truthing). Plot locations were selected to encompass a wide range of ecosite phases within the LSA preliminary ecosite map. Wherever possible, a minimum of five sample plots per ecosite phase was targeted. In addition, grassland sites within the LSA and one outside the LSA were identified for detailed range health assessment of the grassland ecosites within the LSA and RSA. Detailed methods of range health assessment are provided in Section 2.3.3.

Within the RSA, vegetation and wetlands were mapped into broader ELC units. RSA mapping is a desktop exercise only using available data, spatial sources, and imagery. The RSA ELC identifies vegetation patches (*e.g.*, closed conifer forest, open broadleaf forest) and un-vegetated patches (*e.g.*, barren land, industrial) and incorporates a rough estimate of forest patch age. The RSA ELC map is used to assess the Project in a regional context and to assess biodiversity.

2.2.2 Field Survey Methods

Vegetation and wetland surveys were conducted June 19-22, July 22-31, and September 19-22, 2014. Field surveys occurred at pre-selected survey plots, within a survey area of 10 m x 10 m that best represented conditions within each plot. Universal Transverse Mercator (UTM) coordinates were recorded at the centre of each plot with a hand-held GPS unit.

Detailed vegetation surveys involved a complete site investigation of vegetation, soil, and landscape characteristics at each plot location. All vascular plant species, mosses, and lichens observed within each 10 m x 10 m plot were identified to species (when possible) and their associated percent cover estimated and recorded to the nearest percent.

If a plant could not be identified in the field, a sample (voucher specimen) was collected as specified in the *Plant Collection Guidelines for Researchers, Students and Consultants* (ANPC 2006). Voucher specimens were collected only if the plant's removal would not lead to an immediate population loss greater than 4%, to ensure that the potential for future plant propagation was not compromised. Collected vouchers included the minimum amount of material (leaf, seeds, twigs) required for proper identification. Whole plants were collected only if the population was sufficiently large.

Data collection protocols followed the guidelines outlined in the *Ecological Land Survey Site Description Manual* (AESRD 2003). Table 2.2-1 provides a summary of information collected at each sampling location. This information was used to assess baseline vegetation and wetland resources.

Table 2.2-1 General Information Collected for Field Surveys

Plot Information	Project ID Date Survey Type (Early, Late, Biodiversity, Rare or both) Plot Type Plot Label Elevation GPS Filename Photo Number Surveyor(s) Preliminary Mapped As UTM Zone, Easting, Northing
Field AVI Type Data	Overstory density, height, 1-5 dominant species 1-5, Latin Name Understory density, height, 1-5 dominant species 1-5, Latin Name Stand structure Number of layers Height of each layer Succession stage
Site Characteristics	Slope Aspect (degrees) Structural stage Surface expression Surface shape Slope position Moisture regime Nutrient regime
Ecological Classification[1]	Ecosite Ecosite phase Plant community type Classification fit (Good, Fair, Poor)
Surface Substrate	Decaying wood, bedrock, cobbles/stones, mineral soil, organic matter, water

Table 2.2-1	General Information Collected for Field Surveys
Soils	Organic thickness and humus form Texture, coarse fragments (%), coarse fragments (type), mottles description, gleying (description), rooting zone (depth), water table (depth), bedrock/frozen (depth), bottom of pedon (depth), drainage, parent material, soil type
Vegetation	Latin name Strata[2] % Cover

[1] Archibald *et al.* 1996.

[2] Plant species were assigned to a stratum from 1-9 based on the vertical vegetative stratum in which they occurred as follows: 1. Overstory tree canopy; 2. Understory tree canopy; 3. Tall shrub (2.5 – 5 m); 4. Short shrub (<2.5 m); 5. Forb; 6. Graminoid; 7. Ground bryophytes; 8. Ground lichens; and 9. Epiphytic lichens and bryophytes.

2.2.3 Post-Field Methods

Voucher specimens collected during field surveys were identified by qualified plant taxonomists. Species that could not be identified or those suspected to be rare were sent for identification and/or verification by an external qualified taxonomist. Likewise, unknown non-vascular species (mosses, liverworts, and lichens) were sent to a qualified lichenologist and bryologist for identification and determination of rarity.

2.2.4 Data Processing and Analysis

A comprehensive inventory of plant species observed within the LSA was compiled. Species distribution by ecosite phase and land cover class was calculated. Additionally, species abundance (% cover) and richness (# of species per plot) data for each survey plot were compiled and used to calculate species relative abundances, species richness, species diversity, and species evenness within each ecosite phase surveyed. This information was used to assess overall biodiversity and to determine differences in diversity between ecosite phases observed within the LSA (further biodiversity methodology details are provided in Section 2.3.8).

This comprehensive species list for the LSA was compared to various project-specific, provincial, and national species status' databases to compile lists of key resource indicators:

- TEK (Traditional Ecological Knowledge) vegetation list to determine species with traditional ecological value (*e.g.*, plants traditionally used as country foods and medicines, Section 2.3.6);
- *Alberta Regulation 19/2010 Weed Control Act* & *Weed Control Regulation* (Government of Alberta 2010a) and ACIMS database (ACIMS 2014b) to determine regulated and invasive species, respectively (Section 2.3.9); and

- COSEWIC, SARA, and *General Status of Alberta Wild Species* lists to determine if any of the species observed in the LSA were of conservation importance in Alberta or in Canada (Section 2.3.2).

2.3 Baseline Methodology

The specific methodologies used for collecting baseline data for the vegetation and wetland elements are described below.

2.3.1 Vegetation Community Classification

2.3.1.1 Field Survey Methods

At each vegetation survey site, ecosite classification was completed by evaluating plant indicator species and landscape features. In areas where ecosite phase was difficult to distinguish based on this information alone, a shallow soil pit was dug to determine basic soil properties and the moisture regime of the site. Ecosite classification and ground-truthing of the preliminary ecosite map was also performed while in transit between survey site locations. The *Field Guide to Ecosites of Southwestern Alberta* (Archibald *et al.* 1996) was used to classify and describe ecological units for the Montane and Subalpine Natural Subregions. When possible, field data descriptions and mapping conventions followed AVI standards.

2.3.1.2 Data Processing and Analysis

2.3.1.2.1 Ecosite Phases in the LSA

Field data were used to modify the ecosite and ecosite phase attributes assigned to polygon units during preliminary mapping where modification was necessary. Preliminary landscape mapping was also refined based on soil survey data and site photos. Additional soil data for the LSA was obtained from the results of the soil survey conducted within the LSA as a component of the EIA (refer to Soils Report, CR #7 of the Project Application).

2.3.1.2.2 Ecological Land Classification Classes in the LSA and RSA

The LSA is nested within the RSA; therefore, each mapped polygon was also assigned an ELC class to be concurrent with RSA mapping. As the RSA spans the Alberta / British Columbia border, two methodologies were used for mapping ELC Classes.

The portion of the RSA in Alberta was mapped using reference information obtained from the:

- Alberta Vegetation Inventory (AVI), including crown cut blocks;
- 2012 Human Footprint Inventory (ABMI 2015); and
- historical forest wildfire data (Alberta Agriculture and Forestry 2015a, b).

This combination of information sources provided the most current land cover conditions available at the time of mapping. Due to the difference in scales, data protocols, and standards between AVI and ABMI data, AVI classifications were used to assign ELC values whenever possible. Features that were too small to map based on AVI data alone were mapped using ABMI land classifications data. Stand ages for forested polygons were derived from the modifier year from AVI and/or the disturbance year from ABMI data, respectively.

The portion of the RSA in British Columbia was mapped using reference information obtained from:

- infrared Rapid-eye satellite imagery (5-m pixel);
- Vegetation Resource Inventory (VRI, equivalent to Alberta's AVI);
- provincial road class spatial files; and
- provincial cutblock data.

Using these British Columbia data, ecological land classes, as similar as possible to the Alberta ELC categories, were determined. Road and cutblock data visible on the satellite imagery were coded according to ABMI protocols (ABMI 2015).

Final ELC mapping for RSA was completed using modified ELC classes based the Foothills Research Institute (FRI) Grizzly Bear Program Habitat Mapping Project (FRI 2009), whereby ELC classes were subdivided into age classes based on the year of stand origin. Wetland classes in the RSA were inferred from ELC classes; methods for describing wetland classes are described further in Section 2.3.7. A summary of ELC classes used in the RSA mapping can be found in Table 2.2-2.

Table 2.2-2 Ecological Land Classification Classes

ELC Class	Canopy Closure (%)	Succession Stage	Age (Years)	Age Class	Proportion Conifer (%)[1]
Upland Forested Communities					
Dense Deciduous Mature Forest	71 - 100	Dense Forest	61 – 99	Mature	≤20
Dense Deciduous Old Forest	71 - 100	Dense Forest	≥100	Old	≤20

Table 2.2-2 Ecological Land Classification Classes

ELC Class	Canopy Closure (%)	Succession Stage	Age (Years)	Age Class	Proportion Conifer (%)[1]
Dense Mixed Young Forest	71 - 100	Dense Forest	30 – 60	Young	21 – 79
Dense Mixed Mature Forest	71 - 100	Dense Forest	61 – 99	Mature	21– 79
Dense Mixed Old Forest	71 - 100	Dense Forest	≥ 100	Old	21 – 79
Dense Conifer Young Forest	71 - 100	Dense Forest	30 – 70	Young	80 – 100
Dense Conifer Mature Forest	71 - 100	Dense Forest	71 – 119 or 71 – 139	Mature	80 – 100
Dense Conifer Old Forest	71 - 100	Dense Forest	≥120 or ≥140	NA	80 – 100
Dense Deciduous Young Forest	71 - 100	Dense Forest	30 – 60	NA	≤20
Closed Deciduous Young Forest	51 - 70	Closed Forest	30 – 60	Young	≤20
Closed Deciduous Mature Forest	51 - 70	Closed Forest	61 – 99	Mature	≤20
Closed Deciduous Old Forest	51 - 70	Closed Forest	≥100	Old	≤20
Closed Mixed Young Forest	51 - 70	Closed Forest	30 – 60	Young	21 - 79
Closed Mixed Mature Forest	51 - 70	Closed Forest	61 – 99	Mature	21 - 79
Closed Mixed Old Forest	51 - 70	Closed Forest	≥100	Old	21 – 79
Closed Conifer Young Forest	51 - 70	Closed Forest	30 – 70	Young	80 – 100
Closed Conifer Mature Forest	51 - 70	Closed Forest	71 – 119 or 71 – 139	Mature	80 – 100
Closed Conifer Old Forest	51 - 70	Closed Forest	≥120 or ≥ 140	Old	80 – 100
Moderate Deciduous Young Forest	31 - 50	Moderate Forest	30 – 60	Young	≤20
Moderate Deciduous Mature Forest	31 - 50	Moderate Forest	61 – 99	Mature	≤20
Moderate Deciduous Old Forest	31 - 50	Moderate Forest	≥100	Old	≤20
Moderate Mixed Young Forest	31 - 50	Moderate Forest	30 – 60	Young	21 – 79
Moderate Mixed Mature Forest	31 - 50	Moderate Forest	61 – 99	Mature	21– 79
Moderate Mixed Old Forest	31 - 50	Moderate Forest	≥100	Old	21 – 79
Moderate Conifer Young Forest	31 - 50	Moderate Forest	30 – 70	Young	80 – 100
Moderate Conifer Mature Forest	31 - 50	Moderate Forest	71 – 119 or	Mature	80 – 100

Table 2.2-2 Ecological Land Classification Classes

ELC Class	Canopy Closure (%)	Succession Stage	Age (Years)	Age Class	Proportion Conifer (%)[1]
			71 -139		
Moderate Conifer Old Forest	31 - 50	Moderate Forest	≥120 or ≥ 140	Old	80 – 100
Open Deciduous Young Forest	6 - 30	Open Forest	30 – 60	Young	≤20
Open Deciduous Mature Forest	6 - 30	Open Forest	61 – 99	Mature	≤20
Open Deciduous Old Forest	6 - 30	Open Forest	≥ 100	Old	≤20
Open Mixed Young Forest	6 - 30	Open Forest	30 – 60	Young	21 – 79
Open Mixed Mature Forest	6 - 30	Open Forest	61 – 99	Mature	21 –79
Open Mixed Old Forest	6 - 30	Open Forest	≥100	Old	21 – 79
Open Conifer Young Forest	6 - 30	Open Forest	30 – 70	Young	80 – 100
Open Conifer Mature Forest	6 - 30	Open Forest	71 – 119 or 71 – 139	Mature	80 – 100
Open Conifer Old Forest	6 - 30	Open Forest	≥120 or ≥140	Old	80 – 100
Wetland Communities					
Natural Graminoid Wetland	<6	Graminoid	NA	Non-Forest	NA
Natural Shrub Wetland	<6	Shrubby	NA	Non-Forest	NA
Treed Wetland	≥6	Treed or Forested	NA	Non-Forest	NA
Open Water	NA	NA	NA	Non-Forest	NA
Natural Non-Forested Land					
Lush Herb	NA	Herbaceous	NA	Non-Forest	NA
Natural Shrub	<6	Shrubby	NA	Non-Forest	NA
Natural Upland Herbaceous	<6	Herbaceous	NA	Non-Forest	NA
Barren Land	0	Non-vegetated	Variable	Non-Forest	NA
Disturbed Land					
Agriculture	NA	NA	NA	Non-Forest	NA
Open Regeneration - Herbaceous	0 - 5	Herbaceous	0 - 5	Non-Forest	NA
Open Regeneration - Shrub	<6	Shrubby	6 - 14	Non-Forest	NA

Table 2.2-2 Ecological Land Classification Classes

ELC Class	Canopy Closure (%)	Succession Stage	Age (Years)	Age Class	Proportion Conifer (%)[1]
Closed Regeneration - Forest	6 - 29	Treed	15 - 29	Non-Forest	NA
Settlements	NA	NA	NA	Non-Forest	NA
Linear Disturbance	NA	NA	NA	Non-Forest	NA
Industrial (Mining)	NA	NA	NA	Non-Forest	NA

[1] NA – not applicable

2.3.2 Species at Risk, Rare Plants and Rare Plant Communities

2.3.2.1 Pre-Survey Methods

A list of federal and provincial species at risk along with provincial rare plants and rare plant communities likely to occur within the LSA was compiled using the ACIMS database (ACIMS 2014a, c, d, and e) prior to rare plant surveys. ACIMS data on rare species occurrences were mapped using ESRI's (Environmental Systems Research Institute) ArcGIS to determine which at-risk and rare plants and/or rare plant communities had been previously reported in the LSA. Rare plant and rare plant community survey protocols (ANPC 2012) were reviewed to ensure compliance with standard survey methods and protocols.

2.3.2.2 Field Survey Methods

The LSA was surveyed for at-risk species, rare plants, and rare plant community occurrences concurrently with other vegetation resources surveys (June 19-22, July 22-3, and September 19-22, 2014), following methods described in Section 2.2. At-risk and rare plant surveys were conducted at each vegetation inventory and ecosite classification survey plot location. Several additional at-risk and rare plant survey locations were chosen based on their potential to harbour at-risk and rare plants or their location within the Project Footprint. At these sites, an at-risk/rare plant survey was conducted and an inventory of species was recorded, but cover values were not assigned as a 10 m x 10 m plot was not established. Vegetation field survey dates were chosen to be at peak flowering times within the region in order to maximize the chance of identifying at-risk and rare plant species. Early and late surveys were performed as per the ANPC (2012) Guidelines for Rare Vascular Plant Surveys in Alberta.

Rare plant survey protocol followed methods outlined in the ANPC (2012) *Guidelines for Rare Vascular Plant Surveys in Alberta*. Survey plots were assessed for the presence of at-risk or rare species using the floristic survey method whereby the surveyor searches for rare plant species via a meander-style search pattern. The meander search involves the surveyor walking roughly parallel transect meanders or in widening circles from a centre point, generally this is plot centre if a 10 m x 10 m plot was established. The surveyor records all vegetation species until no additional species are encountered. The breadth of the search is defined by the perimeter of the vegetation community as well as the species diversity within the community. Unique or special landscape features such as microhabitats (rocks, logs, *etc.*), ephemeral habitats, wet areas, or transition zones are given special attention because these areas are important habitats for rare plants. Surveyors looked for any special, unique, or rare plant communities while performing rare plant surveys and while travelling between vegetation survey plots. Rare plants and/or rare plant communities are usually closely linked with soil moisture, nutrient levels, and substrate type. It is important to note that failure to observe an at-risk or rare plant occurrence does not mean absence of these species within a vegetation community.

Where a rare species was encountered, an ACIMS native rare plant report form was filled out to ensure an accurate record of the occurrence. Field data recorded on rare plant forms included:

- location of the plant community (recorded as plot number and / or GPS coordinates);
- extent and density of the population;
- number of individual plants in the population;
- phenology stage;
- habitat description; and
- associated (neighbouring) species.

Where a rare species population was large enough to allow collection of specimens with no adverse effects to the population, voucher specimens were collected in accordance with ANPC plant collection guidelines (ANPC 2012). Where the population was not large enough to allow for voucher collection, photographs were taken and supplemented with detailed field notes.

2.3.2.3 Post-Survey Methods

Qualified plant taxonomists confirmed rare vascular plant identifications, while bryophyte and lichen species were sent to a professional bryologist and lichenologist, respectively, for identification and determination of status ranking. All rare plant names in this report follow ACIMS (2014a) and NatureServe (2015). At-risk and rare plant species within the LSA were mapped using UTM coordinates from the GPS waypoints of locations where they were found. All rare species observation data from the Project will be submitted to the ACIMS database of rare and tracked elements.

2.3.2.4 Data Processing and Analysis

A list of all at-risk, rare, and tracked species found in the LSA was compiled and at-risk and rare species occurrences mapped using the UTM coordinates of locations where they were observed. Results of the at-risk and rare species survey are discussed in Section 3.2.

Rare plant potential in the LSA was assigned based on rare species occurrence within individual ecosite phases in the LSA, historical rare plant records for the Montane and Subalpine Natural Subregions (ACIMS 2014c, d), rare plant species ranges, professional judgement, and available literature. A rare plant potential (low, moderate or high) was assigned to each LSA ecosite phase, as well as vegetated but non-forested land classes (herbaceous graminoid, closed and open shrub, and barren land). Areas of anthropogenic disturbance (*i.e.,* AIM, AIH, CC, CIW, CIP, and NMR) were assigned 'low' rare plant potential. While anthropogenic disturbances are not typical of communities where rare plants occur, certain rare plant species grow in disturbed locations due to reduced competition from other plant species. As rare plant potential was assigned based on considerations other than observed rare plant species, certain ecosite phases may have moderate to high rare plant potential even though no rare plants were identified in these ecosite phases during 2014 surveys.

2.3.3 Rangeland Resources

2.3.3.1 Pre-Survey Methods

Following discussion with AESRD, a range health assessment of grassland areas within the LSA was completed. Potential grassland sites within the LSA were identified for sampling during vegetation pre-mapping for the project (see Section 2.2 for preliminary mapping and plot selection methods).

2.3.3.2 Field Survey Methods

Field survey methods for range health assessments followed the protocol of the *Range Health Assessment for Grassland, Forest and Tame Pasture* (AESRD 2009). As several grassland sites were observed on steep slopes, a three plot transect method was used to allow species to be assessed at an upper slope, mid-slope, and lower slope plot location. Transects measuring 30 m in length were traversed at each site, and vegetation species, cover, slope position, surface expression, and nutrient and moisture regimes were recorded. Noxious weed species and their densities were also recorded.

An AESRD *Grassland Range Health Assessment Form* was filled out at each site to assign the range health of the site, and was based on a composite of the data collected at each of the three transect plots. The reference plant communities for the range health assessments were determined by referencing the range plant community types and carrying capacity guides developed by AESRD for the Montane and Subalpine Natural Subregions within the Rocky Mountain Natural Region. The reference plant communities within the guides were determined by AESRD based on data gathered from range assessment inventories conducted for AESRD and from AESRD grazing exclosures (monitoring plots) located in various locations throughout the Rocky Mountain Natural Region. The reference communities for the site were referenced from Willoughby *et al.* (2005) and Willoughby and Alexander (2006).

2.3.3.3 Data Processing and Analysis

The overall dominant vegetation at each site was summarized, and plant community, plant structure, plant litter, site stability, and noxious weed scores were assigned as per the Grassland Range Health Assessment Form requirements. Scores were then totaled, and an overall range health score was calculated. Total scores may range from a low of 0 to a high of 100, with categories determined as follows:

- 75 – 100: Healthy;
- 50 – 75: Healthy with problems; and
- <50: Unhealthy.

2.3.4 Forestry Resources

Forestry resources were determined using the AVI dataset for the region, supplemented with ABMI data, and air photo interpretation. ABMI and air photos were used to refine the AVI dataset to account for recent disturbances or other changes to the AVI forest inventory. This combined dataset was then used to determine crown closure, tree height, dominant tree species, non-forested area, and Timber Productivity Rating (TPR) for each mapped polygon.

The TPR reflects the environmental factors that affect tree growth such as soil type, topography, and moisture. TPRs are listed in the AVI database for each stand polygon and can be used to determine the presence of productive and non-productive forested stands in an area. Productive stands have a TPR rating of Good (G), Moderate (M), or Fair (F), while unproductive stands have a TPR rating of Unproductive (U). Non-forested stands, and mapped classes lacking vegetation structure (industrial and open water), are labelled as NF and given no TPR rating. Timber productivity rating (TPR) was used to determine the proportion of productive and non-productive forested stands within the Grassy Mountain study LSA and Project Footprint.

To estimate volume of forest resources the *2015-2016 Stand Volume Timber Damage Assessment Tables* (TDA) (Alberta Environment 2015) were used. These tables estimate the volume of timber from stand height, density, and mixture (diameter-at-breast height [dbh] is not required so that AVI data can be used). Within a TDA table, volume is calculated separately for deciduous, spruce, and pine components of a stand. The merchantable volume was calculated as stands with tree heights 12 m or greater with no upper or lower limit for dbh.

2.3.5 Old Growth Forests

Old Growth Forests are defined in this report based on forest stand age. Stand age was determined using forest stand origin data from the AVI (ASRD 2005) for Alberta, and VRI (BC MFLNRO 2015) for British Columbia, databases. Where required, ages were corrected to account for fire and timber harvesting that occurred after the inventory date. In British Columbia, VRI data were used in lieu of AVI, and recent disturbances were determined using Rapid-eye satellite imagery, cut block, and road data. All stands classified as old based on age class (Schneider 2002) were considered old growth forest:

- >100 years for deciduous (<20% coniferous) and mixed stands (neither coniferous nor deciduous comprise 80% or more of the stand);
- >110 years for pine-dominated stands (*i.e.*, 80% or more pine); and
- >140 years for coniferous (*i.e.*, conifer stands with <20% pine).

2.3.6 Traditional Ecological Knowledge (TEK) VC Vegetation Resources

Vegetation species that have current or historical uses and importance to Aboriginal Groups are considered Traditional Ecological Knowledge (TEK) resources. TEK vegetation resource identification and the TEK vegetation resource assessment were performed using the following methodology:

- compilation of TEK vegetation species lists based on the importance of individual species to the Treaty 7 First Nations with traditional lands in the vicinity of The Project. This list was created via:
  - consultation with Treaty 7 First Nations groups;
  - review of reports prepared by the Piikani Nation (2015), Kainai Nation (2015), Tsuut'ina Nation (2015), and Siksika Nation (2015);
- the TEK vegetation list was compared with the results of vegetation and wetland field sampling information collected in 2014;
- occurrences of TEK vegetation in ecosite phases within the LSA were identified;
- TEK vegetation and vegetation community information was used to formulate the potential for each ecosite phase to support the TEK vegetation resources assessment; and
- an impact rating of the Project on TEK vegetation was assigned based on the cultural importance of the species, the sensitivity of the species to disturbance and the uniqueness of the species at the local or regional scale.

2.3.6.1 Pre-Survey Methods

Refer to the Application, Section H (Benga 2015) for details on how TEK species were identified.

2.3.6.2 Field Survey Methods

TEK vegetation was recorded as a component of vegetation species inventories during 2014 field surveys. See Section 2.2.2 and Section 2.2.3 for description of how vegetation species were recorded and mapped.

2.3.6.3 Post-Survey Methods

No additional post survey methods were required.

2.3.6.4 Data Processing and Analysis

The TEK species list was compared to the primary list of all species (vascular and non-vascular) identified during 2014 field sampling. All occurrences of TEK vegetation within each ecosite phase were identified. The total occurrences of TEK vegetation within each ecosite phase were then used to formulate the potential for each ecosite phase to support TEK vegetation.

2.3.7 Wetlands

2.3.7.1 Pre-Survey Methods

The Project is located within the Montane and Subalpine Natural Subregions of the Rocky Mountain Natural Region (Archibald *et al.* 1996). The *Field guide to Ecosites of Southwestern Alberta* follows the general structure for wetland classification, but while attempts were made to follow the functional divisions for wetland classification as identified by the National Wetlands Working Group, morphological stratification was not practical (Archibald *et al.* 1996). Therefore, within the Montane Natural Subregion, no classes of wetlands are listed at the ecosite or ecosite phase levels, and only one class of wetland is listed within the Subalpine Natural Subregion to the ecosite phase level (horsetail fen) (Archibald *et al.* 1996).

Wetland classification was performed using Halsey *et al.*'s (2004) *Alberta Wetland Inventory Classification System Version 2.0* (AWI) and the *Canadian Wetland Classification System* (CWCS) (NWWG 1997). There are five classes of wetlands listed in Halsey *et al.* (2004): bogs, fens, swamps, marshes, and shallow open water. These classes are further delineated using vegetation, wetland landform, and local landform modifiers (Halsey *et al.* 2004). The CWCS (NWWG 1997) can be used to classify wetlands where the scope of Halsey *et al.* (2004) is insufficient to differentiate other classes of wetlands not described in the AWI classification. All wetlands identified during preliminary mapping were assigned a wetland classification as per Halsey *et al.* (2004).

2.3.7.2 Field Survey Methods

Wetlands within the LSA were classified using the CWCS (NWWG 1997) and the AWI (Halsey *et al.* 2004). In addition to the collection of the general field parameters listed in Table 2.2-2, the following parameters were collected at wetland sites to ensure proper classification of each observed wetland in the LSA (following Halsey *et al.* 2004):

- wetland class (NWWG 1997);
- vegetation modifier (*i.e.,* forested, wooded, open);
- wetland complex landform modifier (permafrost, patterning); and
- local landform/vegetation modifier.

2.3.7.3 Post-Survey Methods

The AWI classes and modifiers are denoted with a single letter, providing a four-letter code for each wetland type (Table 2.3-1). All identified wetlands were mapped and labeled with a four letter code.

Table 2.3-1 Alberta Wetland Inventory Classification System

Level	Criteria	Code
Wetland Class	Bog	B
	Fen	F
	Swamp	S
	Marsh	M
	Shallow Open Water	W
Vegetation Modifier	Forested: closed canopy >70% tree coverage	F
	Wooded: open canopy >6–70% tree coverage	T
	Open: shrubs, sedges, graminoids, herbs, *etc.* <6% tree cover	O
Wetland Complex Modifier	Permafrost is present	X
	Patterning is present	P
	Permafrost or patterning is not present	N
Local Landform Modifier	Collapse scar	C
	Internal lawn with islands of forested peat plateau	R
	Internal lawns	I
	No internal lawns are present	N
	Shrub cover >25% when tree cover ≤6%	S
	Graminoid dominated with shrub cover ≤25% and tree cover ≤6%	G

Source: Halsey *et al.* 2004

2.3.7.4 Data Processing and Analysis

Field data were reviewed to confirm all preliminary wetland classifications and additional wetlands identified in the field were mapped. Areas for each wetland type within the LSA were calculated. In polygons with both upland and wetland components, only the percentage of the polygon that was wetland was used to calculate the area. A map was then produced showing the distribution of each wetland type within the LSA.

Wetlands in the RSA were also mapped and areal coverage determined, but without field-verification data. The RSA wetlands were classified according to the ELC classes defined for the LSA. To generate the RSA wetland maps, the following data sources were used:

- ABMI (ABMI 2015); and
- AVI (ASRD 2005).

Part of the RSA is located in the province of British Columbia (BC), which is not covered by the Alberta datasets. Therefore, wetlands in the BC portion of the RSA were mapped with the use of:

- Infrared Rapid-eye 5-m pixel satellite imagery; and
- VRI information.

2.3.8 Biodiversity and Fragmentation

The objectives of the biodiversity component of this vegetation and wetland study were to assess abundance and distribution of species and ecological units at several scales across the landscape, as well as to assess fragmentation of the landscape within the LSA and the RSA. Specific objectives were to:

- determine biodiversity indicators within the LSA and RSA;
- assess the biodiversity potential of each ecosite phase;
- rank the rarity of area of ecosite phases and land cover classes;
- determine the levels of fragmentation at the community and landscape level in the LSA and RSA; and
- discuss the Project effects on biodiversity and fragmentation.

Table 2.3-2 lists the biodiversity indicators that were used to characterize baseline biodiversity and assess the effects of the Project on biodiversity in the LSA and the RSA.

Table 2.3-2 Biodiversity and Fragmentation Indicators in the Local Study Area and Regional Study Area

Indicator	Rationale for selection
Species Level	
Total species richness (LSA)	Indicates total number of plant species within each ecosite phase or land cover type.
Vascular plant species richness (LSA)	Indicates the total number of vascular plant species within each ecosite phase or land cover type
Plant species diversity (LSA)	Indicates the vascular and non-vascular vegetation richness, Shannon's diversity index, and species evenness index within each ecosite phase or land cover type.
Community Level	
Rare plant potential (LSA)	Describes the functioning of an ecosystem. Stable systems have potential to support rare species and increase biodiversity.
Abundance and distribution of plant species (LSA)	Describes the potential of a habitat to support a certain composition and abundance of vegetation (plants) and how plants are distributed across communities. Measured as species composition and richness.
Number of unique species (LSA)	Indicates unique vegetation species - habitat relationships.
Number of vascular species (LSA)	Indicates vascular plant species - habitat relationships.
Proportion of ecosite phase (LSA) and land cover unit (RSA)	Indicates the rarity of a plant community type on the landscape. Related to ecosites or land cover classes of limited distribution.
Non-native invasive species (LSA)	Indicates invasive vegetation species - habitat relationships. Non-native and invasive species often occur in habitats that are disturbed or stressed, and these species tend to reduce biodiversity.
Shannon's Diversity Index (LSA)	Indicates relative community composition (per ecosite phase and land cover type) by taking into account the number of species and the relative abundance of those species within a community.
Core area(LSA/RSA)	Indicator of fragmentation. For each ecosite phase or land cover type, the total area (ha) of patches that is not within 10 m of patch edge.
Landscape Level	
Ecological landscape cover (LSA and RSA)	Indicates area and % cover for each ecosite phases (LSA) and land cover class (RSA). Each unit of cover is referred to as a patch.
Limited distribution ecosite phases and cover classes (LSA and RSA)	Indicates the ecosite phases within the LSA and RSA that are limited in distribution, based on % cover.
Number of patches (LSA and RSA)	Index of fragmentation. The number of patches within the LSA and RSA.
Total length of edge (LSA and RSA)	Index of fragmentation. Indicates the sum of the length (m) of the perimeter of all ecosite phase or land cover class patches.
Patch size (LSA and RSA)	Describes the average (mean) size (ha) of patches within ecosite phases.

Table 2.3-2 Biodiversity and Fragmentation Indicators in the Local Study Area and Regional Study Area

Indicator	Rationale for selection
Perimeter-area ratio (LSA and RSA)	Indicates the patch perimeter in relation to the area, indicating the relative amount of edge for each ecosite phase or cover class. Linear patches have higher P-A ratios than square or circular patches of the same area.
Nearest neighbour (LSA and RSA)	Indicates the mean distance, for each ecosite phase or cover class, that must be traveled from the centre of a patch to the centre of another patch of the same type.
Core area index (LSA and RSA)	Indicates the percentage of each patch type that is core area.

2.3.8.1 Species Level Biodiversity

Species level biodiversity was measured in terms of species richness, Shannon's diversity, and Shannon's evenness. These indices were calculated from field survey data collected as part of the baseline vegetation and wetland survey.

Field data provided the required information to calculate species richness, diversity, and evenness of each ecosite phase. Survey plots located within each identified ecosite phase were treated as replicates and assumed to reflect the average and range in species richness and abundance for the whole community (ecosite phase) within the LSA. Survey data were also used in the estimation of biodiversity potential (*i.e.,* rare species occurrence, unique species occurrence, non-native and invasive species occurrence).

Species richness (S) was calculated as the number of species encountered, and was calculated for all species identified (vascular and nonvascular) and for vascular species only. Species diversity was calculated using Shannon's diversity index (*aka* Shannon-Wiener index, Shannon-Weaver Index), which is based on the number of species and the relative abundance of species (Krebs 1989). This measurement of species diversity provides an index of heterogeneity within a community, with higher indices indicating higher heterogeneity (*i.e.,* more species and more equal relative abundance).

To calculate Shannon's diversity index (H') for vegetation, plant percent cover was used as a measure of relative abundance, such that:

$$H' = -\sum_{i=1}^{k} p_i \, ln p_i \text{ (MacArthur and MacArthur 1961)}$$

Where: H' = Shannon's diversity index; p_i = proportion of individuals in the sample belonging to species i; k is the number of species observed in the sample; and ln is the natural logarithm.

Evenness (*J′*) was calculated as a function of species richness and *H′* by applying the formula:

$$J' = H' / lnS$$

Where *H′* is Shannon's diversity index and *ln(S)* is the natural logarithm of species richness.

2.3.8.2 Community Level Biodiversity

Unlike the species level assessment that focused on species within each ecosite phase, the community level assessment focused on number of ecosite phases within the LSA and the biodiversity potential of each ecosite phase. Biodiversity potential describes the potential of each ecosite phase or community to support a variety of self-sustaining plant and animal populations. It incorporates the structure and composition of each ecosite phase as well as the rarity of the ecosite phase at a landscape level. In this context, the following were used to score and rank biodiversity potential of each ecosite phase:

- rare plant occurrences of each ecosite phase;
- rare plant potential of each ecosite phase;
- number of structural layers;
- number of unique species found in each ecosite phase (species that occurred in only one ecosite phase);
- number of noxious and invasive species in each ecosite phase;
- total number of species in each ecosite phase as a percentage of the total species in the LSA;
- mean species richness in each ecosite phase;
- mean species evenness in each ecosite phase;
- mean Shannon diversity index in each ecosite phase; and
- proportion of the landscape covered by each ecosite phase.

The metrics used to rank biodiversity potential in each ecosite phase are provided in Table 2.3-3.

The scored parameters were tallied using data collected during field surveys and sorted to find natural breaks in each parameter's data. The natural breaks were then used to determine the range and interval or ranking assigned to each natural break. Consideration was given to the number of survey plots sampled within an ecosite phase and the relative abundance of the ecosite on the landscape. For example, an ecosite phase that is limited in distribution in the LSA was given higher rank for the number of rare species or unique species identified relative to an ecosite phase with a high percentage cover in the LSA and where more plots were surveyed. The relative rarity of each ecosite phase was given more weight in determining the overall biodiversity potential because the loss of such habitats would have a greater effect on landscape biodiversity than the loss of the more common ecosite phases.

Table 2.3-3 Biodiversity Potential Rating Index

Rare Plant Occurrence	Rare Plant Potential[1]	Layers of Structure[2]	Unique Species	Noxious Species	Richness (mean)	Shannon's Evenness (mean)	Shannon's Diversity Index (mean)	Ecosite Phase Cover in LSA (%)	Biodiversity Potential Rating		
									Final Sum	Numeric Rating	Nominal Rating
0	Low	1-2	0		<25	<0.70	<2.16	>1%	<1	0	**Very Low**
1		3-4		>0					1 - 1.99	1	**Low**
2	Moderate or Unknown	5-6			26-29	0.70-0.75	2.16-2.49		2 - 2.5	2	**Moderate**
3		7-8							2.5 – 3.5	3	**High**
>3	High	>8	>0	0	>29	>0.750	>2.49	<1%	>3.5	4	**Very High**

[1] Rare Plant Potential was derived from Alberta Conservation Information Mgt. System.
[2] Layers of structure are: 1) Over-story tree, 2) Under-storey tree, 3) Tall shrub (2.5m-5m), 4) Short shrub (<2.5m), 5) Forb, 6) Grass, 7) Moss, 8) Lichen, 9) Epiphyte.

2.3.8.3 Landscape Level Biodiversity and Fragmentation

The number and type of ecosite phases in the LSA and land cover classes in the RSA, as well as the level of habitat fragmentation, were used to determine biodiversity at the landscape level. Ecosite areas used in the biodiversity assessment were based on the dominant ecosites phase assigned to each polygon on the LSA map (Refer to Section 2.3.1.2 for details on ecosite phase mapping). The number and type of plant communities were obtained from ELC maps of the LSA and RSA. Details of the methodology used to map ecosite phases and land cover classes are reported in Section 2.3.1.

Habitat fragmentation is the process whereby a continuous area of habitat is divided into smaller patches; this is generally accompanied by a loss of habitat area (Neel *et al.* 2004). Patches are disconnected or detached areas with homogeneous environmental conditions that are dissimilar from the surrounding landscape (McGarigal and Marks 1995). Fragmentation was assessed through analysis of the size, shape, number, and distribution of patches within the LSA (ecosite phases) and RSA (ecological land cover classes), along with other associated metrics (Table 2.3-4).

Table 2.3-4 Fragmentation Metrics used to Quantify Landscape Structure

Metric	Landscape	Units	Interpretation of Metric
Patch area	LSA & RSA	hectare (ha)	Area of each patch and patch type in the landscape.
Number of patches	LSA & RSA	number	Number of patches in the landscape.
Perimeter length (edge)	LSA & RSA	metre (m)	Total perimeter length of each patch and patch type. Most adverse effects of forest fragmentation on organisms seem to be directly or indirectly related to edge effects.
Perimeter to area ratio (edge/area)	LSA & RSA	m/ha	Ratio of patch perimeter length to area.
Mean perimeter to area ratio	LSA & RSA	m/ha	Average ratio of patch perimeter to area for each patch type. Ratio sensitive to patch complexity and patch size. May indicate change in patch complexity and or edge.
Mean patch size	LSA & RSA	ha	Average area of each patch type in a landscape. Higher values indicate spatial fragmentation of a particular habitat type.
Patch density (Number/100 km^2)	LSA & RSA	number	Patch density expresses the number of patches per 100 km^2. A landscape with a greater density of patches of a target patch type (*e.g.*, anthropogenic) would serve as an indicator that the landscape is more fragmented.
Nearest neighbour	LSA & RSA	m	Distance from a patch to another patch of the same type.
Mean nearest Neighbour	LSA & RSA	m	Average distance between each neighbouring patch type. A shorter distance between each type is preferential for wildlife movement and propagule dissemination.

Table 2.3-4 Fragmentation Metrics used to Quantify Landscape Structure

Metric	Landscape	Units	Interpretation of Metric
Core area	LSA & RSA	ha	Area of each patch excluding the edge (10 m). Reduction of core area may indicate increased edge effects and greater fragmentation.
Core area index (core area/total patch area) X 100	LSA & RSA	%	The % of the patch type that is comprised of core area. Reduction in % of core area indicates increased fragmentation.

Software used for analyses were ArcGIS 10.1, R with the Psych package, and MS Access 10.

2.3.9 Noxious and Invasive Species

Noxious and invasive vegetation species observations were recorded during the vegetation and wetland surveys within the LSA. The Government of Alberta's *Weed Control Regulation* (2010a) was used to determine noxious and prohibited noxious status of each species observed. For non-regulated species, the ACIMS (2014b) list of all elements was used to determine which vegetation species were categorized as invasive. All locations of observed noxious and invasive species were recorded with a handheld GPS unit.

2.3.10 Potential Acid Input and Nitrogen Deposition

Potential acid input and nitrogen deposition critical loads were used to examine potential direct and indirect effects of industrial air emissions on vegetation communities. An increase in acid deposition from air emissions can result in acidification of the surface horizon of sensitive mineral and organic soils. The loading rate of PAI is measured in terms of the amount of hydrogen ions (acid) deposited on a hectare of land in a single year (keq H+/ha/yr). PAI includes both wet and dry deposition, and accounts for base cation deposition (Turchenek *et al.* 1998). The degree to which soils are affected by acid deposition is contingent upon the PAI loading rate and sensitivity of the soil to acid inputs.

Based upon a review and evaluation of the critical loads applied in other jurisdictions, the Target Loading Subgroup recommended Alberta's adoption of the generic critical load classification system used for soils in Europe (WHO 1995). The selection of critical loads was based on the assumption that sensitive mineral soils in Alberta are no more sensitive than the most sensitive European mineral soils. The application levels developed by the Alberta framework include:

- critical load – the highest load that will not lead to long-term, harmful changes to a receptor;
- target load – the level of deposition that consider the critical load and is practically and politically achievable; and

- monitoring load – the level of deposition predicted or estimated by a dispersion model and deposition model that trigger monitoring and/or research.

When a critical PAI load is exceeded, soil chemistry may be adversely affected.

Nitrogen deposition is known to affect plant growth rates and competitive interactions (Bytnerowicz *et al.* 2010), and can therefore affect plant community composition (Köchy and Wilson 2001). Although the effects of nitrogen deposition depend on the species within communities (Heijmans 2001), nitrogen-limited ecosystems are considered to be among the most sensitive to increased nitrogen. The majority of ecosystems in Alberta are nitrogen-limited (Vitousek and Howarth 1991, Fenn *et al.* 2003). These systems are all sensitive to nitrogen deposition, with bogs being particularly sensitive (Verhoeven *et al.* 2011). Acceptable limits of nitrogen deposition are measured in critical loads (kg/ha/yr). A critical load is the highest load of nitrogen deposition that will not cause chemical changes leading to long-term harmful effects on the most sensitive ecological systems (AENV 2008).

Vegetation may also suffer deleterious effects from fumigation with NO_2 and SO_2 emissions. The direct impacts from these emissions include chlorosis and loss of leaves in vascular plants (Malhotra and Blauel 1980). Vegetation and ecosystem specific acceptable exposure limits for both NO_2 and SO_2 are published in the *Alberta Ambient Air Quality Objectives and Guidelines Summary* (AESRD 2013). These limits are represented as an annual average of 45 $\mu g/m^3$ and 20 $\mu g/m^3$ for NO_2 and SO_2, respectively.

Air modeling showing PAI and nitrogen deposition provides a spatial representation of predicted air quality by connecting areas of equal concentration via isopleth lines. Isopleths were created for the Baseline Case and Application Case scenarios based on spatially variable ambient background conditions and collected annual data. A more in-depth discussion of air quality modelling and methods is provided in the Project Application, and in the CR#1, Air Quality.

Critical loads for PAI within the LSA and RSA were assigned by rating soil sensitivity to acid deposition based on the *Alberta Acid Deposition Management Framework* (AENV 2008) with the following critical load thresholds:

- 0.25 keq H^+/ha/yr for soils with high sensitivity;
- 0.50 keq H^+/ha/yr for soils with moderate sensitivity; and
- 1.00 keq H^+/ha/yr for soils with low sensitivity.

Methods for derivation of PAI critical loads are provided in the Project Application, CR #7 Soils Report, (Benga 2015b). PAI critical loads were compared against Baseline and Application Case PAI isopleths to determine the proposed Project's potential impact on soil acidification and consequently on plant communities within the LSA and RSA.

The critical loads for nitrogen deposition were based on published values for relevant ecosystems (Table 2.3-5).

Table 2.3-5 Proposed Range of Nitrogen Deposition Critical Loads

Ecosystem	N Critical Loads (kg/ha/yr)	Source
Alpine and forested lakes	0.5-4.0	Baron 2006, Pardo *et al.* 2011
Subalpine forest	4	Pardo *et al.* 2011
Mixed conifer forest	17	Pardo *et al.* 2011
Alpine/sub-alpine grassland	4-10	Pardo *et al.* 2011, Bobbink *et al.* 2010
Mountain meadows	10-30	Bobbink *et al.* 2010
Raised and blanket bogs	5-18	Lamers *et al.* 2000, Bobbink *et al.* 2010
Poor fens	10-20	Bobbink *et al.* 2010
Mountain rich fens	15-25	Bobbink *et al.* 2010
Boreal forest	>3-10	Pardo *et al.* 2011, Bobbink *et al.* 2010

The critical loads were compared to the nitrogen deposition isopleths generated for the Baseline and Application Cases of the Project and used to determine the potential effects on the plant communities in the LSA and RSA.

2.4 Environmental Assessment

2.4.1 Assessment Approach

The assessment approach involved defining vegetation and wetland VCs and subsequently completing impact analyses related to abundance, distribution, and quality of vegetation and wetland resources in the LSA and RSA. The assessment involved three development scenarios: Baseline Case, Application Case, and Planned Development Case (PDC).

The Baseline Case, which provides the benchmark for the impact assessment, describes the existing environmental conditions prior to development of the proposed Project, and includes the effects resulting from existing and approved projects or activities. The Application Case describes the Baseline Case with the addition of potential Project effects. The Planned Development Case (PDC) describes the environmental effects of the Application Case, along with the potential effects of planned developments in the region and residual effects of the Project after mitigation. The developments included in the Baseline Case, Application Case, and PDC are presented in Table 2.4-1:

Table 2.4-1 Inclusion List of Existing, Approved and Planned Projects in the Regional Study Area

Company	Project	Existing & Approved Activity (Baseline Case)	Project (Application Case)	Planned Projects (PDC)
Mining Operations				
Benga Mining Limited	Grassy Mountain Coal Project		x	
Various	Historic Mining Development ~1890 to 1990	x		
Teck Coal Limited	Coal Mountain Operations	x		
	Coal Mountain Phase 2			x
	Elkview Operations	x		
Timber Operations				
Crown	Operations to end of 2015	x		
	Operations to 2025			x
	Operations to 2030			x
	Operations to 2041 - predicted			x
	Operations to 2056 - predicted			x
Oil and Gas Operations				
Devon Canada Corporation	Multiwell Gas Battery 02-19-011-03 W5M	x		
	Compressor Station 04-13-009-04 W5M	x		

Table 2.4-1 Inclusion List of Existing, Approved and Planned Projects in the Regional Study Area

Company	Project	Existing & Approved Activity (Baseline Case)	Project (Application Case)	Planned Projects (PDC)
Harvest Operations Corp.	Burmis Gas Test Battery 12-19-007-02 W5M	x		
HOC Energy Corp.	Single Well Gas Battery 10-07-006-02 W5M	x		
Legacy Oil & Gas Inc.	Gas Single-Well Battery 13-35-007-03 W5M	x		
Nova Gas Transmission Ltd.	Interconnect 01-15-008-05 W5M	x		
	Interconnect 09-11-008-05 W5M	x		
Shell Canada Limited	Single Well Gas Battery 10-01-006-03 W5M	x		
	Compressor Station 06-12-006-03 W5M	x		
	Multiwell Gas Battery 02-20-006-03 W5M	x		
	Gas Gathering System 16-07-007-02 W5M	x		
Misc.	Wellsites	x		
	Access Roads	x		
	Pipelines	x		
Rural Development				
MD of Crowsnest Pass	Community of Coleman	x		
	Community of Blairmore	x		
	Community of Frank	x		

In the Application Case, Project effects to vegetation and wetlands resources are described for the maximum Project disturbance (*i.e.*, the construction and operations scenario) without mitigation (reclamation). While for the PDC Project effects to vegetation and wetlands resources are described for the Project disturbance after mitigation measures have been implemented at different time scenarios (*i.e.,* the closure scenario) and residual effects of the Project after mitigation. For the purposes of the impact assessment, Project disturbance assumes all the Project facilities and infrastructure are being constructed simultaneously. This adds a level of conservatism to the impact assessment, as development of the Project will be sequential over the lifetime of the Project. In addition, a progressive reclamation approach will be used for the life of the Project.

Residual effects from the Project will be determined based on all applicable mitigation measures being implemented. For the Project, the primary mitigation measure for vegetation and wetlands will be reclamation following Project closure. Successful reclamation involves establishing a land capability equivalent (including previously disturbed un-reclaimed lands from mining and oil and gas developments in the Project Footprint) to that which existed prior to disturbance, such that the land can support uses that are similar to but not necessarily the same as those present at Baseline. Mitigation measures for vegetation and wetlands are described in Section 4.0 and summarised in Section 5.0. The Conservation and Reclamation (C&R) Plan is presented in Section F of the EIA Report.

2.4.1.1 Temporal Boundaries

Temporal boundaries are defined as those that will exist during the life of the Project including the construction, operation, reclamation, and closure phases. It is anticipated that the lifespan of the Project (including reclamation) will be approximately 27 (T27) years. The temporal boundaries for cumulative effects were extended beyond Project closure, up to 41 years (T41) following Project initiation.

The project will be developed over a period of time with reclamation completed at 27 years. Based on the planned development of the Project over time, construction and clearing of lands for mining will outpace reclamation for the first 15 years. After 15 years progressive reclamation will occur until closure when final reclamation of facilities and related infrastructure is scheduled. The PDC environmental assessment will be conducted using four time increments.

1. T0 - Current (2014) Baseline condition.
2. T14 – Fourteen years after construction representing the maximum spatial extent of disturbance with the least amount of Project Footprint area progressively reclaimed. Used to assess the anticipated maximum project extent.
3. T27 – Project close where Project activities have ceased and initial reclamation across the Project Footprint has occurred.
4. T41 – Fifteen years after project close. This time period represents an aged reclaimed landscape across the entire Project Footprint. Used to assess final project effects.

The time increments are used to assist in the assessment of residual project effects by comparing T41 with the Project and T41 without the Project. The time increments also assist in assessing incremental project effects by comparing the Application Case to the Planned Development Case.

2.4.1.2 Spatial Boundaries

The spatial boundaries used in the assessment are those defined for the study areas. The LSA and the RSA described in Section 1.3.2 and Section 1.3.3 have been selected to define the areas where there is a reasonable potential for immediate and cumulative environmental effects to result from Project activities.

2.4.2 Valued Components

The vegetation and wetland resources within the Project area include hundreds of vascular and non-vascular plant species and many vegetation communities and land cover types that will or may be affected by the proposed Project. Assessing the Project's potential effects on all vegetation and wetland resource components is not possible; subsequently, in accordance with current practice, this assessment focuses on a number of vegetation and wetland elements that were selected as VCs. These VCs represent vegetation and wetland resources that may be affected by the proposed Project. All chosen VCs are known to occur in the LSA and can be monitored by accepted scientific methods. Additionally, VCs must fit into one of the following categories:

- is an important contributor to biodiversity at the local, landscape, or regional level;
- is considered to be a threatened or endangered species at the provincial or federal level, or is known to be declining in the region;
- is valued by Aboriginal Group traditional users (specifically Treaty 7 First Nations); and
- is a unique habitat type that is limited in area and may be impacted by Project.

To determine the VCs for the vegetation and wetlands assessment, regulatory requirements and guidelines were reviewed along with the information needs of stakeholders (*e.g.*, government agencies, the public, industry). Additionally, the specific requirements outlined in the TOR for the Project, as well as previous EIA reports for coal mining projects and other industries (Teck Coal Limited 2014, Cardinal River Coals Ltd. 1996, Coal Valley Resources Inc. 2012) and the C5 Forest Management Plan (Government of Alberta 2010b) were considered. More importantly, the vegetation and wetland VCs were discussed with and compared to VCs identified by Treaty 7 First Nations.

The assessment of the potential effects of the Project on vegetation and wetland resources was based on the selected Project VCs (Table 2.4-2). The rationale for choosing each VC is also provided in this table.

Table 2.4-2 Identified Vegetation Valued Components

VC	Key Indicator	Rationale for Indicator
Vegetation Communities	Ecosite phases Communities of limited distribution	Baseline vegetation conditions are used for determining potential impacts to critical wildlife habitat, and other ecosystem components; and they are important for determining conservation and re-vegetation goals following Project closure.
Rare Plants	SARA/COSEWIC listed species (*e.g.*, whitebark pine, limber pine) and all vegetation species included in Federal and/or Provincial Tracking Lists	A vegetation species is considered rare if it is uncommon or scarce. Rare species are generally considered threatened because of the inability for their small population size to recover from stochastic events. Rare plants contribute to biodiversity, may possess medicinal uses, are legally protected, and may be of spiritual or traditional value.
Rangeland Resources	Fescue community grasslands	Rangelands are a source of water, wildlife, and forage for wildlife and livestock, and are important contributors of landscape-level biodiversity.
Forest Resources	Timber productivity	Forests are a valuable resource because they help maintain air quality, store atmospheric carbon, provide habitat for wildlife, keep soil in place, filter and regulate water supplies, support recreational activities, and house valuable resources such as timber, fuel, and traditional medicinal, food and other use vegetation.
Old Growth Forests	Age of a forest stand	Old growth forests have a complex structure which provides a large variety of habitat types for use by species with specialized requirements. These forests have the highest diversity of species, relative to other age classes, with representation of many rare species having their greatest abundance in old-growth stands. Vegetation species that require a long time for colonization and growth, such as lichens, are often only found in old-growth forest stands. Accumulation of large decaying wood, characteristic of old-growth stands, supports unique groups of wood-decomposing species, as well as shelter and food for many other species.
Traditionally Used Species (TEK Vegetation)	Occurrence & distribution of vegetation valued by Aboriginal groups	Vegetation used by Aboriginal Groups for country foods, medicine, technology and other uses are valued and should be managed sustainably for future generations (UN 2008:11). The baseline abundance and distribution of TEK vegetation will serve as a benchmark for the sustainable management of TEK vegetation.

Table 2.4-2 Identified Vegetation Valued Components

VC	Key Indicator	Rationale for Indicator
Wetlands	Obligate and facultative vegetation	Wetlands are highly valued and beneficial by virtue of their diverse functions that include water filtration; flood attenuation; wildlife habitat; moderating climates; storing nutrients and carbon; providing recreational and educational opportunities; and providing a source for subsistence and medicinal vegetation.
Biodiversity	Measures of abundance, distribution and variation in vegetation species and communities	Biodiversity is the degree of variation in biological species in a given area, and is a measure of the health of an ecosystem. Greater biodiversity implies greater health, and the reduction of biodiversity can adversely impact ecosystem integrity (composition, structure and functioning) and re-vegetation success.
Habitat Fragmentation	Measure of all landscape areas that are divided by human disturbance	Forest fragmentation is one of the greatest threats to the biodiversity of forests. Fragmented areas are less likely to support viable populations (especially of large vertebrates) due to edge effects that alter conditions, including increases in some species and decreases in others. The effect of fragmentation on the vegetation and wildlife of a forest depends on a) the size of the patch, and b) its degree of isolation.

2.4.3 Impact Assessment Criteria

The level of an environmental effect was determined after considering mitigation. Residual effects were considered those effects that may occur after mitigation(*i.e.*, project impacts that extend beyond the life of the project and not interim project impacts). Following a precautionary approach, an assessment was conducted for all vegetation and wetland VCs, regardless of residual effects. This approach was used to identify potential threats to vegetation VCs that were used in the development of mitigation measures that can be employed at a regional scale. A VC's sensitivity and ability to recover from residual effects was then considered when required.

Criteria used to assess the potential effects of the Project on vegetation and wetland resources included: geographic extent, duration, frequency, permanence, magnitude, direction, and level of confidence (Noble 2009) (Table 2.4-3). The scientific basis for the vegetation assessment criteria was provided by extensive data from field surveys and desktop reviews that enabled the classification and delineation of vegetation and wetland communities within the LSA and RSA.

The overall significance of each effect was rated as insignificant (predicted to be within the range of natural variability and below guideline or threshold levels) or significant (predicted to cause irreversible changes to the sustainability or integrity of a population or resource). The Canadian Environmental Assessment Agency (CEAA) has prepared a reference guide to assist proponents and project reviewers in determining whether a project is likely to cause high adverse environmental effects (Hegmann *et al.* 1999). This reference document was used to help predict whether an environmental effect was deemed high, moderate or low.

Table 2.4-3 Evaluation Criteria for Assessing the Environmental Effects of the Project

Criteria	Criteria Definition	
Geographic Extent	Local	Effects occurring mainly within or close proximity to the proposed development area.
	Regional	Effects extending outside of the Project boundary to regional surroundings
	Provincial	Effects extending outside of regional surroundings, but within provincial boundary
	National	Effects extending outside of the provincial surroundings, but within national boundary
	Global	Effects extending outside of national boundary
Duration	Short	Effects occurring within development phase
	Long	Effects occurring after development and during operation of facility
	Extended	Effects occurring after facility closes but diminishing with time
	Residual	Effects persisting after facility closed for a long period of time
Frequency	Continuous	Effects occurring continually over assessment periods
	Isolated	Effects confined to a specified period (*e.g.*, construction)
	Periodic	Effects occurring intermittently but repeatedly over assessment period (*e.g.*, routine maintenance activities)
	Occasional	Effects occurring intermittently and sporadically over assessment period
Ability for Recovery	Reversible In Short-Term	Effects which are reversible and diminish upon cessation of activities
	Reversible in Long-Term	Effects which remain after cessation of activities but diminish with time
	Irreversible	Effects which are not reversible and do not diminish upon cessation of activities and do not diminish with time.
Magnitude	Nil	No change from background conditions anticipated after mitigation.
	Low	Disturbance predicted to be somewhat above typical background

Table 2.4-3 Evaluation Criteria for Assessing the Environmental Effects of the Project

Criteria	Criteria Definition	
		conditions, but well within established or accepted protective standards and normal socio-economic fluctuations, or to cause no detectable change in ecological, social, or economic parameters.
	Moderate	Disturbance predicted to be considerably above background conditions but within scientific and socio-economic effects thresholds, or to cause a detectable change in ecological, social, or economic parameters within range of natural variability.
	High	Disturbance predicted to exceed established criteria or scientific and socio-economic effects thresholds associated with potential adverse effect, or to cause a detectable change in ecological, social, or economic parameters beyond the range of natural variability
Project Contribution	Neutral	No net benefit or loss to the resource, communities, region, or province
	Positive	Net benefit to the resource, community, region, or province
	Negative	Net loss to the resource, community, region, or province
Confidence Rating	Low	Based on incomplete understanding of cause-effect relationships and incomplete data pertinent to study area
	Moderate	Based on good understanding of cause-effect relationships using data from elsewhere or incompletely understood cause-effect relationship using data pertinent to study area.
	High	Based on good understanding of cause-effect relationships and data pertinent to study
Probability of Occurrence – Ecological Context	Low	Unlikely
	Moderate	Possible or probable
	High	Certain
Significance	Insignificant	Effects are predicted to be within the range of natural variability and below guideline or threshold levels
	Significant	Effects of the Project are predicted to cause irreversible changes to the sustainability or integrity of a population or resource

2.4.4 Potential Project Effects

Potential effects of the Project on vegetation and wetland resources are predominantly related to clearing of vegetation and physical alteration of the landscape for the Project's mine pit and associated waste rock dumps and infrastructure. These potential effects were assessed using the indicators provided in Table 2.4-3.

The assessed effects of vegetation clearing and landscape alteration include:

- loss or removal of terrestrial vegetation and wetland resources;
- loss of riparian vegetation communities;
- loss of communities of limited distribution;
- loss of forestry resources;
- loss of old growth forests;
- loss of at-risk and rare plants and rare plant communities;
- loss of traditional and medicinal plants;
- loss of fescue grasslands and reduced range health;
- reduction in native biodiversity; and
- increase in noxious and invasive weed species.

In addition, air emissions released into the atmosphere during Project construction and operations may result in direct and indirect effects on vegetation arising from acid deposition. This was assessed by comparing modeled PAI levels with critical loads for soils and land cover classes.

2.5 Quality Assurance and Quality Control

The following general principles of quality assurance and quality control were determined and applied in preparation for fieldwork, field data collection, data processing, data analyses, mapping, and preparation of the assessment report.

Quality assurance and quality control (QAQC) measures applied at the pre-field and field data collection stages included, but were not limited to, the following:

- a list of potential rare plant species and communities was compiled using the most up-to-date ACIMS database before field surveys;
- survey sites were selected to attempt equal representation of all ecosites and wetlands represented in the preliminary ecosite map;
- plots were located within the most homogenous site within a polygon to ensure accurate ecosite phase and wetland classification; and
- daily field data QAQC was conducted to ensure that data cards were completely and legibly filled out, and plant specimens were properly preserved and labelled.

QAQC measures applied at the post-field stage of the assessment included, but were not limited to, the following:

- baseline field data and historical reports from adjacent areas were consulted and incorporated in regional data (RSA);
- a comprehensive data entry and database QAQC was conducted prior to data summarization and analysis;
- plant specimens suspected to be rare species or those that were just difficult to identify were sent to a qualified plant taxonomist for identification and confirmation of status;
- all non-vascular plants species were sent to a qualified bryologist and a qualified lichenologist for identification and confirmation of status; and
- only the most recent aerial photographs were used in mapping to supplement ecosite phase and wetland classification completed during field surveys.

3.0 BASELINE ASSESSMENT CASE

The Grassy Mountain property has had considerable previous surface and underground coal mining activities, in addition coal exploration using drilling and trenching from 1970 to 1972, and bulk sample extraction of 54,000 tonnes from 1973 to 1975. Surface disturbance is present throughout much of the LSA and this is reflected in the baseline conditions described below (Figure 1.3-2).

In total, 116 sites were surveyed in the LSA for vegetation and wetlands during June 19-22, July 22-31, and September 19-22, 2014. These included 53 detailed vegetation inventory plots (ecosite and wetland classification, rare plants, TEK plants, and invasive species surveys), 15 plots for surveying only rare plant, 43 plots assessing the presence of *Festuca* spp., and five range health assessment plots (Figure 3.0-1 and Figure 3.0-2).

Four hundred and eighty (480) plant species were identified in the LSA during these surveys. These included 298 vascular plants, 77 mosses and liverworts, and 105 lichen species. Of these, 41 species are listed as tracked or watched in Alberta (ACIMS 2014a), nine species are classified as noxious or prohibited noxious weeds, and 20 species are considered invasive in Alberta.

A complete list of the flora identified in the study area is presented in Appendix B.

3.1 Vegetation Community Classification

3.1.1 Ecosites in the Local Study Area

The LSA covers a total area of 4,776.2 ha. The final ecosite phase map of the LSA consisted of 587 ecosite phase polygons, along with 76 polygons of naturally vegetated non-forested land, 339 polygons of previously disturbed area (including previously un-reclaimed mined areas, roads and oil and gas development in the Project Footprint), and 20 open water (lakes, rivers and flood zones) polygons (Table 3.1-1 and Figure 3.1-1). Table 3.1-1 provides a summary of ecosite phases and AVI land description types (*e.g.*, non-vegetated natural and anthropogenic) mapped in the LSA. Detailed descriptions of ecosites and ecosite phases used in the LSA mapping are provided in Appendix C.

The Montane and the Subalpine Natural Subregions occupy 2,630.7 ha and 2,145.5 ha of the LSA, respectively. Seventeen ecosite phases were mapped in the Montane and 10 in the Subalpine Natural Subregion. The dominant ecosite phases mapped in the Montane Subregion are d2 – creeping mahonia-white meadowsweet Fd (594 ha, 12.4% of LSA), e1 – thimbleberry/pine grass Pl (290 ha, 6.1%), and b1 – bearberry Pl (222 ha, 4.6%). In the Subalpine Subregion, the dominant ecosite phases are e1 – false azalea-grouseberry Pl (992 ha, 20.8%), e3 – false azalea-grouseberry Se (207 ha, 4.3%), and b1 – bearberry/hairy wild rye Pl (136 ha, 3.4%).

Approximately 75.5% of the LSA is upland vegetation (*i.e.,* ecosites a1 – g1 in Montane and a1 – h1 in Subalpine Natural Subregion); less than 1% is lowland area (*i.e.,* ecosite g2 in Montane Natural Subregion). Lowland ecosites that were assigned a wetland designation are further discussed in Section 3.7. Close to 24% (1,135 ha) of the LSA is occupied by existing disturbances including well sites, gravel pits, and permanent rights of way; along with 288.7 ha previous mining operations, and roads and oil and gas development in the Project Footprint (165.3 ha of which is 55 year old previously un-reclaimed mined areas that have only partially naturally revegetated).

3.1.2 Ecosites Phases of Limited Distribution in the Local Study Area

Twelve ecosite phases occupy less than 1% of the LSA and are therefore of limited distribution (Table 3.1-1). These include Montane upland ecosite phases b2, b3, c3, d3, f1, and g1, Montane lowland g2 ecosite phase, and Subalpine upland a1, d1, e2, e4 and h1 ecosite phases.

Table 3.1-1 Baseline Ecosite Phases in the Local Study Area

Montane			Subalpine		
Ecosite Phase / Land Description[1]	**Area (ha) [2]**	**% LSA**	**Ecosite Phase / Land Description1**	**Area (ha) [2]**	**% LSA**
Ecosite Phases					
a1 - limber pine/juniper Fd-Pf	52.5	1.1	*a1 - lichen Pl*	11.5	0.2
b1 - bearberry Pl	221.9	4.6	b1 - bearberry/hairy wild rye Pl	163.4	3.4
*b2 - bearberry Aw**	22.5	0.5	-	-	-
*b3 - bearberry Aw-Sw-Pl**	33.8	0.7	-	-	-
c1 - Canada buffalo-berry/hairy wild rye Fd	150.7	3.2	-	-	-
c2 - Canada buffalo-berry/hairy wild rye Pl	135.8	2.8	-	-	-
c3 - Canada buffalo-berry/hairy wild rye Aw	22.9	0.5	-	-	-
c4 - Canada buffalo-berry/hairy wild rye Aw-Sw-Pl-Fd	173.9	3.6	-	-	-
d1 - creeping mahonia – white meadowsweet Fd	89.0	1.9	*d1 - spruce/heather Se**	0.8	<0.1
d2 - creeping mahonia – white meadowsweet Pl	593.5	12.4	-	-	-
*d3 - creeping mahonia – white meadowsweet Sw**	25.7	0.5	-	-	-
e1 - thimbleberry/pine grass Pl	289.8	6.1	e1 - false azalea – grouse-berry Pl	992.2	20.8
e2 - thimbleberry/pine grass Aw*	75.4	1.6	*e2 - false azalea – grouse-berry Pw**	3.4	0.1
e3 - thimbleberry/pine grass Se*	81.8	1.7	e3 - false azalea – grouse-berry Se	207.0	4.3
-	-	-	*e4 - false azalea – grouse-berry Fa**	19.9	0.4
*f1 - balsam poplar Pb**	16.8	0.4	f1 - thimbleberry Pl	97.6	2.0
-	-	-	f2 - thimbleberry Fa-Se*	47.3	1.0
g1 - horsetail Sw-Pb	42.6	0.9	-	-	-

Table 3.1-1 Baseline Ecosite Phases in the Local Study Area

Montante			Subalpine		
Ecosite Phase / Land Description[1]	**Area (ha)[2]**	**% LSA**	**Ecosite Phase / Land Description1**	**Area (ha)[2]**	**% LSA**
g2 - horsetail Sw	35.5	0.7	-	-	-
-	-	-	*h1 - horsetail Se*	34.1	0.7
Total Ecosite Phase Area	**2064.0**	**43.2**	**-**	**1577.2**	33.0
Natural Non-forested Land					
HG - Herbaceous – Grassland	155.2	3.2	HG - Herbaceous - Grassland	165.5	3.5
SC - Closed shrub	0.3	<0.01	-	-	-
SO - Open shrub	6.3	0.1	SO - Open shrub	3.6	0.1
NMR - Rock barren	2.9	0.1	NMR - Rock barren	35.9	0.8
Total Natural Non-forested Area	**164.7**	**3.4**	**-**	**205.0**	**4.3**
Water					
NWF - Flooded (areas periodically inundated with water)	0.8	0.0	-	-	-
NWL - Seasonally thaws, lakes, ponds	0.3	0.0	-	-	-
NWR – River	0.0	0.0	-	-	-
Total Area	**1.1**	**0.0**		**-**	**-**
Anthropogenic Disturbances					
AIH - Permanent rights of way; roads, highways, railroads, dam sites, reservoirs	73.0	1.5	AIH - Permanent rights of way; roads, highways, railroads, dam sites, reservoirs	24.8	0.5
-	-	0.0	AII - Industrial (Plant sites), sewage, lagoons	0.2	0.0

Table 3.1-1 Baseline Ecosite Phases in the Local Study Area

Montante			Subalpine		
Ecosite Phase / Land Description[1]	**Area (ha)[2]**	**% LSA**	**Ecosite Phase / Land Description1**	**Area (ha)[2]**	**% LSA**
AIM - Surface mines	34.3	0.7	AIM - Surface mines	131.0	2.7
ASC - Cities, towns, villages, hamlets	81.3	1.7	ASC - Cities, towns, villages, hamlets	-	0.0
CC - Clearcut/partial cut	50.7	1.1	CC	176.7	3.7
CIP - Pipelines, transmission lines, airstrips, microwave tower sites, golf courses, cemeteries	39.1	0.8	CIP - Pipelines, transmission lines, airstrips, microwave tower sites, golf courses, cemeteries	-	0.0
CIW - Geophysical activities, included well sites that have been seeded with annual crop	9.3	0.2	CIW - Geophysical activities, included well sites that have been seeded with annual crop	7.9	0.2
CL - Clearing (extent not required)	26.8	0.6	CL - Clearing (extent not required)	22.7	0.5
CO – Non-linear clearings	52.2	1.1	CO - Non-linear clearings	-	0.0
CP - Perennial forage crops	34.2	0.7	CP – Perennial forage crops	-	0.0
Total Anthropogenic Disturbance	**400.9**	8.4	**-**	**363.4**	**7.6**
Grand Total in LSA	**2,630.7**	**55.1**	**-**	**2,145.5**	**44.9**

[1] Ecosite phases are from on Archibald *et al.* 1996.

[2] Due to rounding of numbers, total values may not equal the sum of the individual values.

* Ecosite phases were not surveyed.

Note: ecosite phases shown in *italics* are of limited distribution.

Note: anthropogenic disturbances & non-vegetated lands are AVI codes for land classification (ASRD 2005).

3.1.3 Ecological Land Classes in the Local Study Area

Of the 51 ELC classes identified in Section 2.3.1.2.2 and mapped in the RSA (Section 3.14), 22 also occur within the LSA (Table 3.1-2 and Figure 3.1-2). Approximately 78% (3,730.4 ha) of the LSA is upland forest; 1.1% (54.7 ha) is naturally non-vegetated land, and 20.2% (965 ha) is disturbed land. As mentioned previously, this disturbed land includes 288.7 ha previous un-reclaimed mined areas (165.3 ha), roads and oil and gas developments within the Project Footprint. The un-reclaimed mined areas have only partially revegetated naturally.

Barren land and wetlands each occupy less than 1% of the LSA. Upland forests consist of conifer, deciduous, and mixed forests. Mature stands (30 to 60 years old deciduous and 30 to 70 years old coniferous) are the most predominant age class, occupying 3,549.7 ha (0.7% of the LSA) and accounting for about 95% of the total upland forest in the LSA. Young and old growth stands collectively comprise approximately 180.7 ha or (of slightly less than 5% of the LSA. Of the total forested area 33% (1,232.6 ha) is closed canopy (primarily of mature conifers), 28.1% (1,048.7 ha) is moderate, 22% (821.4 ha) is open, and 13.2% (491.5 ha) consist of dense mature conifer.

Wetlands are of limited distribution because they occupy less than 1% of the LSA. Treed wetlands and shrubby wetlands are the most extensive and occupy 14.5 ha or approximately 9% of the total wetland area in the LSA.

Detailed descriptions of ELC classes mapped in the LSA are provided in Appendix C.

Table 3.1-2 Ecological Land Classes in the Local Study Area

ELC Class	Forest Age Class[1]			Area (ha)[2]	% of LSA
	Young	Mature	Old		
Upland Forested Communities[3]					
Dense Conifer Forest	-	491.5	-	491.5	10.3
Closed Coniferous Forest	-	1,232.6	-	1,232.6	25.8
Closed Deciduous Forest	-	17.4	-	17.4	0.4
Closed Mixed Forest	-	16.7	8.7	25.4	0.5
Moderate Conifer Forest	11.9	958.0	78.8	1,048.7	22.0
Moderate Deciduous Forest	-	-	18.4	18.4	0.4
Moderate Mixed Forest	-	44.4	30.5	74.9	1.6
Open Coniferous Forest	-	767.4	0.0	767.4	16.1
Open Deciduous Forest	-	8.1	32.3	40.5	0.8

Table 3.1-2 Ecological Land Classes in the Local Study Area

ELC Class	Forest Age Class[1]			Area (ha)[2]	% of LSA
	Young	Mature	Old		
Open Mixed Forest	-	13.5	-	13.5	0.3
Total Upland Forest	**11.9**	**3,549.7**	**168.8**	**3,730.4**	**78.1**
Wetland Communities					
Natural Graminoid Wetland	-	-	-	1.5	<0.1
Treed Wetland	-	-	-	14.5	0.3
Open Water	-	-	-	1.4	<0.1
Total Wetland	-	-	-	**17.4**	**0.4**
Natural Non-Forested Land					
Natural Shrub	-	-	-	1.9	<0.1
Natural Upland Herbaceous	-	-	-	52.8	1.1
Total Natural Non-Forested Land	-	-	-	**54.7**	**1.1**
Disturbed Land					
Open Regeneration - Herbaceous	-	-	-	170.0	3.6
Open Regeneration - Shrub	-	-	-	296.2	6.2
Settlements	-	-	-	56.0	1.2
Linear Disturbance	-	-	-	202.0	4.2
Industrial (Mining)	-	-	-	240.8	5.0
Total Disturbed Land	-	-	-	**965.0**	**20.2**
Total Barren Land	-	-	-	**8.6**	**0.2**
Total LSA	-	-	-	**4,776.2**	**100.0**

[1] Age classes are derived from AVI stand origin data as follows:

- young deciduous and mixed = 30-60 years;
- mature deciduous and mixed = 61 – 100;
- young conifer stands = 30-70;
- mature pine dominated conifer = 71-119;
- mature non-pine conifer = 71-139;
- old deciduous and mixed stands >100;
- old pine stands >120; and
- old conifer (non-pine) stands >140.

[2] Due to rounding of numbers, total values may not equal the sum of the individual values.
[3] Crown closure classes are AVI codes of canopy closure (measured in %) as follows: Dense = 71-100, Closed = 51-70, Moderate = 31-50, and open = 6-30. Cover types are based on the proportion of conifer or Deciduous species in the canopy. Deciduous = >80% Deciduous, mixed = 30-79% conifer / deciduous, conifer ≥80% conifer (ASRD 2005).

3.1.4 Ecological Land Classes in the Regional Study Area

The RSA occupies 284,024.8 ha (Table 3.1-3, Figure 3.1-2). Approximately 49% (143,006.8 ha) of the RSA is forested, 16% (46,421.3 ha) is naturally non-vegetated land, 27% (76,292.5 ha) is disturbed land, 7% is barren land, and less than 1% (2,591.7 ha) is wetland. Upland forests consist of deciduous, conifer, and mixed forests. Of the total forested area 32.3% (46,385.9) has closed canopy cover, 14.2% (20,369.8 ha) has dense canopy cover, 25.7% (36,796.7 ha) has moderate cover, and 27.7 (39,700 ha) has open canopy. Mature stands (30 to 60 years old deciduous and 30 to 70 years old coniferous) are the most predominant age class, occupying 114,224 ha (40.2%) of the RSA and over 40% of the forested land. Young and old growth stands collectively comprise approximately 18.5% of the total forested area, with each occupying slightly less than 5% of the RSA.

Wetlands are of limited distribution in the RSA occupying less than 1% of the RSA. Open water and shrubby wetlands are the most extensive wetland types, and occupy 0.5% (1,544.0 ha) and 0.3% (762.7 ha) of the RSA, respectively.

Existing disturbance in the RSA consist of agricultural lands, open and closed regeneration (includes forest harvest blocks), settlement, and linear disturbances. Agricultural lands are the most extensive form of disturbance and occupy 9.5% (27,010.6 ha) of the RSA. Regenerating lands (closed and open regeneration) account for 13.3% (37,876.7 ha) of the RSA. The distribution of ecological land cover classes identified in the RSA are summarized in Table 3.1-3 and mapped in Figure 3.1-2; detailed descriptions are provided in Appendix C.

Table 3.1-3 Ecological Land Classes in the Regional Study Area

ELC Class	Forest Age Class[1]			Area (ha)[2]	% of RSA
	Young	Mature	Old		
Upland Forested Communities[3]					
Dense Conifer Forest	528.5	14,883.8	438.5	15,850.8	5.6
Dense Deciduous Forest	79.2	1,144.3	6.9	1,230.4	0.4
Dense Mixed Forest	3.7	101.4	-	105.1	<0.1
Closed Coniferous Forest	2,249.8	34,268.2	2,774.2	39,292.3	13.8
Closed Deciduous Forest	904.4	4,916.6	287.3	6,108.3	2.2
Closed Mixed Forest	81.5	824.2	79.6	985.3	0.3
Moderate Conifer Forest	2,940.1	21,596.0	4,223.7	28,759.8	10.1

Table 3.1-3 Ecological Land Classes in the Regional Study Area

ELC Class	Forest Age Class[1]			Area (ha)[2]	% of RSA
	Young	Mature	Old		
Moderate Deciduous Forest	465.6	3,167.4	437.3	4,070.2	1.4
Moderate Mixed Forest	172.1	3,496.6	297.9	3,966.6	1.4
Open Coniferous Forest	4,066.2	26,698.2	4,403.4	35,167.8	12.4
Open Deciduous Forest	421.5	1,546.4	378.8	2,346.7	0.8
Open Mixed Forest	471.0	1,581.4	133.1	2,185.5	0.8
Total Upland Forest	**12,383.6**	**114,224.5**	**13,460.8**	**140,068.8**	**49.3**
Wetland Communities					
Natural Graminoid Wetland	NA			158.5	0.1
Natural Shrub Wetland				762.7	0.3
Treed Wetland				126.5	<0.1
Open Water				1,544.0	0.5
Total Wetland	-			**2,591.7**	**0.9**
Natural Non-Forested Land					
Lush Herb	NA			352.0	0.1
Natural Shrub				7,555.5	2.7
Natural Upland Herbaceous				38,513.7	13.6
Total Natural Non-Forested Land	-			**46,421.3**	**16.3**
Disturbed Land					
Agriculture	NA			27,010.6	9.5
Open Regeneration - Herbaceous				17,991.2	6.3
Closed Regeneration - Forest				2,253.7	0.8
Open Regeneration - Shrub				17,631.8	6.2
Settlement				595.4	0.2
Linear Disturbance				7,626.1	2.7
Industrial (Mining)				3,183.6	1.1

Table 3.1-3 Ecological Land Classes in the Regional Study Area					
ELC Class	**Forest Age Class**[1]			**Area (ha)** [2]	**% of RSA**
	Young	**Mature**	**Old**		
Total Disturbed Land		_		**76,292.5**	**26.9**
Total Barren Land		_		**18,650.5**	**6.6**
Total RSA		_		**284,024.8**	**100**

[1] Age classes are derived from the AVI stand origin data as follows:

- young deciduous and mixed = 30-60 years;
- mature deciduous and mixed = 61 – 100;
- young conifer stands = 30-70;
- mature pine dominated conifer = 71-119;
- mature non-pine conifer = 71-139
- old deciduous and mixed stands >100;
- old pine stands >120; and
- old non-pine conifer stands >140.

[2] Due to rounding of numbers, total values may not equal the sum of the individual values.

[3] Crown closure classes are AVI codes of canopy closure (measured in %) as follows: Dense = 71-100, Closed = 51-70, Moderate = 31-50, and open = 6-30. Cover types are based on the proportion of conifer or Deciduous species in the canopy. Deciduous = >80% Deciduous, mixed = 30-79% conifer / eciduous, conifer ≥80% conifer (ASRD 2005).

3.2 Species at Risk, Rare Plants and Rare Plant Communities in the Local Study Area

3.2.1 Species at Risk and Rare Plants in the Local Study Area

Sixty-eight (68) plots were surveyed for rare plant occurrences (Figure 3.0-1). Forty-one (41) species (total of 94 occurrences) identified in the LSA (Table 3.2-1, Figure 3.2-1) were on the Alberta Rare Plant Tracking and Watch Lists (ACIMS 2014a) at the time of report submission. In total, 18 species (27 occurrences) of these 41species were observed in the Montane Natural Subregion and 32 species (67 occurrences) were identified in the Subalpine Natural Subregion.

Two species identified in the LSA are federally listed by COSEWIC and SARA: *Pinus albicaulis* (whitebark pine) and *Pinus flexilis* (limber pine). Whitebark pine is listed as Endangered in Alberta and British Columbia under SARA Schedule 1. Limber pine was designated as Endangered throughout its range in Alberta and British Columbia by COSEWIC in November 2014.

All but three provincially rare/watched species found in the LSA (two liverworts and one lichen) are on the *Alberta Wild Species General Status Listing - 2010* (AESRD 2010a). The majority have a status of Sensitive or May be at Risk. However, whitebark pine and limber pine are ranked as “At Risk.”

Additionally, these two pine species are ranked as "Endangered" under Alberta's *Wildlife Act* (Government of Alberta 2014). All species except white bark pine are listed as globally secure under present conditions (G4 or G5); whitebark pine is listed as G3/G4.

The highest number of rare species occurrences were recorded in the Subalpine e1 ecosite phase (41 occurrences) followed by the Montane b1 ecosite phase (31 occurrences). Within the Subalpine Natural Subregion, the e1, e3, and e4 ecosite phases contained the most rare plant occurrences, with 23, 11, and nine occurrences, respectively. In the Montane Natural Subregion, the highest numbers of rare plant occurrences were observed in the d2 (eight occurrences) and c4 (five occurrences) ecosite phases.

Locations of at-risk and rare species observed in the LSA and their descriptions are provided in Appendix D; and mapped in Figure 3.2-1.

Table 3.2-1 Rare Plant Occurrences in the Local Study Area

Scientific Name	Common Name	#[1]	Habitat[2]	Rank or Conservation Status				
				GRANK[3]	SRANK[3]	Tracked[4]	COSEWIC / SARA[5]	Provincial[6]
Montane								
Vascular plants (9 species, 12 occurrences)								
Angelica dawsonii	Yellow angelica	1	e1	G4	S3	W	-	Sensitive
Berberis repens	Creeping mahonia	1	c4	G5	S3	W	-	Sensitive
Carex petasata	Pasture sedge	1	c4	G5	S1S2	Y	-	May be at risk
Crepis atribarba	Slender hawk's-beard	1	AIH	G5	S2	Y	-	May be at risk
Pinus flexilis	Limber pine	1	c3	G4	S2	Y	Endangered	At risk (Endangered)
Piperia unalascensis	Alaska bog orchid	3	c4, d2	G5	S2?	Y	-	Sensitive
Streptopus roseus	Rose mandarin	2	c1, g2	G5	S1	Y	-	May be at risk
Streptopus streptopoides	Twisted-stalk	1	c4	G5	S1	Y	-	May be at risk
Tellima grandiflora	Fringe-cups	1	e3	G5	S1	Y	-	May be at risk
Mosses and liverworts (4 species, 8 occurrences)								
Anastrophyllum helleranum	Liverwort	1	g1	G5	S2	Y	-	May be at risk
Aulacomnium androgynum	Little groove moss	2	c4, d1	G5	S2	Y	-	Sensitive
Conocephalum salebrosum	Liverwort	1	d2	G5	S2	Y	-	May be at risk
Dicranum tauricum	Broken-leaf moss	4	c1, c4, d2	G4	S1S2	Y	-	Sensitive
Lichens (6 species, 7 occurrences)								
Caloplaca sinapisperma	Firedot lichen	1	c4	GNR	S2S3	Y	-	-
Cladonia symphycarpia	Split-peg lichen	1	c4	G5	S2	Y	-	May be at risk
Cladonia umbricola	Shaded cladonia	1	e3	G3G5	S1	Y	-	May be at risk
Hypogymnia rugosa	Wrinkled tube lichen	2	c2, c4	G4G5	S1S2	Y	-	May be at risk

Table 3.2-1 Rare Plant Occurrences in the Local Study Area

Scientific Name	Common Name	#[1]	Habitat[2]	Rank or Conservation Status				
				GRANK[3]	SRANK[3]	Tracked[4]	COSEWIC / SARA[5]	Provincial[6]
Nodobryoria abbreviata	Tufted foxtail lichen	1	c4	G4?	S1	Y	-	May be at risk
Peltigera cinnamomea	Cinnamon dog pelt lichen	1	c1, g1	GNR	S2	Y	-	May be at risk
Subalpine								
Vascular plants (10 species, 36 occurrences)								
Angelica dawsonii	Yellow angelica	10	e1, e3, f1	G4	S3	W	-	Sensitive
Bromus vulgaris	Woodland brome	1	e1	G5	S3	W	-	May be at risk
Carex petasata	Pasture sedge	2	a1	G5	S1S2	Y	-	May be at risk
Eriogonum cernuum	Nodding umbrella-plant	1	e1	G5	S2	Y	-	May be at risk
Eucephalus engelmannii	Elegant aster	1	e1	G4G5	S3S4	W	-	May be at risk
Phacelia hastata	Silver-leaved scorpionweed	5	a1, e1	G5	S3	W	-	Sensitive
Pinus albicaulis	Whitebark pine	10	a1, e1, e2, e4	G3G4	S2	Y	Endangered	At risk (Endangered)
Pinus flexilis	Limber pine	3	a1, e4	G4	S2	Y	Endangered	At risk (Endangered)
Piperia unalascensis	Alaska bog orchid	2	e1	G5	S2?	Y	-	Sensitive
Streptopus roseus	Rose mandarin	1	e1	G5	S1	Y	--	May be at risk
Mosses and liverworts (13 species, 17 occurrences)								
Buxbaumia aphylla	Bug on a stick moss	1	e1	G4G5	S2	Y	-	Sensitive
Chiloscyphus polyanthos	Liverwort	2	e1, HG	G5	S1	Y	-	May be at risk
Dicranella crispa	Curl-leaved fork moss	1	e1	G3G5	S2	Y	-	Sensitive
Dicranum tauricum	Broken-leaf moss	2	e1, f1	G4	S1S2	Y	-	Sensitive
Jungermannia exsertifolia	Liverwort	1	e1	G5?	S1	Y	-	May be at risk
Lophozia ascendens	Liverwort	1	e1	G4	S1	Y	-	May be at risk

Table 3.2-1 Rare Plant Occurrences in the Local Study Area

Scientific Name	Common Name	#[1]	Habitat[2]	Rank or Conservation Status				
				GRANK[3]	SRANK[3]	Tracked[4]	COSEWIC / SARA[5]	Provincial[6]
Lophozia longidens	Liverwort	1	e1	G5	S1	Y	-	May be at risk
Lophozia wenzelii	Liverwort	1	e1	G4G5	S1	Y	-	May be at risk
Pellia endiviifolia	Liverwort	1	e3	G5	S2	Y	-	-
Pellia neesiana	Liverwort	2	e1	G5	S2	Y	-	-
Racomitrium aciculare	Moss	2	e1, f1	G5	S1	Y	-	Sensitive
Rhytidiopsis robusta	Pipecleaner moss	1	e1	G4	S3	W	-	Sensitive
Schistidium tenerum	Thread bloom moss	1	e1	G5?	S2	Y	-	Sensitive
Lichens (8 species, 14 occurrences)								
Cladonia ochrochlora	Smooth-footed powderhorn	1	e1	G4G5	S1?	Y	-	May be at risk
Cladonia symphycarpia	Split-peg lichen	2	e1, e3	G5	S2	Y	-	May be at risk
Hypogymnia enteromorpha	Budding tube lichen	1	e3	G4	S2	Y	-	May be at risk
Nodobryoria abbreviata	Tufted foxtail lichen	4	e1, f1	G4?	S1	Y	-	May be at risk
Peltigera cinnamomea	Cinnamon dog pelt lichen	2	e1	GNR	S2	Y	-	May be at risk
Umbilicaria americana	American rock tripe lichen	1	e1	G5?	S2S3	Y	-	May be at risk
Vulpicida canadensis	Brown-eyed sunshine lichen	2	e1	G3G5	S2	Y	-	Sensitive
Xylographa parallela	Black woodscript lichen	1	f1	G5	S2S4	Y	-	May be at risk

[1] Number of occurrences

[2] Ecosite phases are from Archibald *et al.* 1996. Vegetated (HG) and non-vegetated (AIH, AIM, NMR) are AVI codes for land classification (Section 2.2.1). M: Montane. SA: Subalpine.

[3] GRANK refers to global conservation rank and SRANK refers to subnational conservation rank). See Section 1.6.3 for definitions of rankings.

[4] Y – species is tracked, W – species is watched (ACIMS 2014a).

[5] COSEWIC (2014), SARA (2014).

[5] General Status of Alberta Wild Species database (Government of Alberta 2010). (Endangered) refers to Endangered under Alberta's *Wildlife Act* (Government of Alberta 2014).

3.2.1.1 Whitebark Pine and Limber Pine Baseline Conditions

Whitebark pine is listed as Endangered on SARA's Schedule 1 in both Alberta and British Columbia. Limber pine is designated as Endangered throughout its range in Alberta and British Columbia by COSEWIC. These species are very similar in terms of growth form, habitat preferences, ecological roles, and major threats to their ongoing existence. Although limber pine tend to grow at lower elevations than whitebark pine, their ranges overlap in the LSA and both may occur on the slopes located in the LSA, making it potentially difficult to distinguish the two species.

Whitebark pine and limber pine are two of the few tree species capable of establishing under the harsh and poor conditions of higher elevation steep rocky slopes. These species are important components of high-mountain ecosystems where their large seeds support many species of mammals and birds, including grizzly bear (*Ursus arctos horribilis*) and Clark's nutcracker (*Nucifraga columbiana*). Both species also play a role in high elevation hydrology by trapping snow and providing shade that extends melting times into dryer summer months.

A threat to whitebark pine and limber pine is white bark pine blister rust (*Cronartium ribicola*), which is an introduced pathogen that is threatening trees throughout the range. In addition to this disease, the mountain pine beetle (*Dendroctonus ponderosae*) has accelerated the decline of both pine species, as the beetle prefers mature trees that produce the most cones (Murray and Krakowski 2013). In some areas, fire suppression has also resulted in increased competition from Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*).

For this assessment, whitebark pine and limber pine have been mapped using Alberta provincial AVI forest inventory, British Columbia VRI, and ACIMS occurrences, which have indicated that a substantial number of whitebark pine and limber pine stands are scattered throughout the RSA (Figure 3.2-2). Within the LSA, whitebark pine was identified at ten locations in the Subalpine Natural Subregion and limber pine was identified at three locations in the Subalpine Natural Subregion and one location in the Montane Natural Subregion (Table 3.2-1, Figure 3.2-3). Limber pine was observed at four locations, once in the Montane and three locations in the Subalpine Natural subregions (Table 3.2-1, Figure 3.2-3). Populations of whitebark pine and limber pine (within the LSA) were found to be at low densities and were commonly found to occur in heterogeneous stands with lodgepole pine (*Pinus contorta*) and/or with each other, and as sparse stands adjacent to open grasslands. Point locations are not representative of the spatial breadth of these populations; whitebark pine and limber pine occurrences extended along specific topographical features such as ridgelines.

The whitebark pine and limber pine identified within the LSA appeared relatively healthy (note: some trees adjacent to confirmed individuals had branches with no needles, and some trees had died). Trees were of varying sizes and heights indicating that several age classes were present. In some instances, cones were not present, or individual trees were deemed young and non-reproductive; subsequently, positive species identification of individual trees was not possible in the field. For mature cone-bearing trees, however, occurrences were positively identified and independently confirmed.

Recovery plans for whitebark pine and limber pine have been established in Alberta (Alberta Whitebark and Limber Pine Recovery Team 2014a, b) and forest harvest plans (*e.g.*, C5 and R11 Forest Management Units) have included retention and management guidelines. The most critical component identified within the recovery plans is the identification of blister rust disease-resistant trees, collection of seeds, propagation, and planting resistant strains.

3.2.2 Rare Plant Potential in the Local Study Area

Rare plant potential was determined by taking into account the number of rare species occurrences (Appendix D), historical data, available literature, and professional judgement. Results of rare plant potential in the LSA are provided in Table 3.2-2 and mapped in Figure 3.2-4. Ecosite phases assigned 'high' rare plant potential include the Montane b1, f1, and g1, and Subalpine e1, h1, and grassland (HG).

Unnatural units including anthropogenic disturbances and non-vegetated lands, were not assigned a rare plant potential and are not represented in Table 3.2-2 as they are not natural vegetation communities.

Table 3.2-2 Rare Plant Potential in the Local Study Area

Ecosite Phase / Land Class Description[1]	Area in LSA (ha)[2]	% of LSA	# of Rare Plant Occurrences	Rare Plant Potential
Montane				
a1 - limber pine/juniper Fd-Pf	52.5	1.1	7	Moderate
b1 - bearberry Pl	221.9	4.6	31	High
*b2 - bearberry Aw**	22.5	0.5	2	Low
*b3 - bearberry Aw-Sw-Pl**	33.8	0.7	6	Low
c1 - Canada buffalo-berry/hairy wild rye Fd	150.7	3.2	15	Moderate
c2 - Canada buffalo-berry/hairy wild rye Pl	135.8	2.8	17	Moderate
c3 - Canada buffalo-berry/hairy wild rye Aw	22.9	0.5	2	Low

Table 3.2-2 Rare Plant Potential in the Local Study Area

Ecosite Phase / Land Class Description[1]	Area in LSA (ha)[2]	% of LSA	# of Rare Plant Occurrences	Rare Plant Potential
c4 - Canada buffalo-berry/hairy wild rye Aw-Sw-Pl-Fd	173.9	3.6	11	Moderate
d1 - creeping mahonia – white meadowsweet Fd	89	1.9	8	Low
d2 - creeping mahonia – white meadowsweet Pl	593.5	12.4	16	Moderate
*d3 - creeping mahonia – white meadowsweet Sw**	25.7	0.5	0	Moderate
e1 - thimbleberry/pine grass Pl	289.8	6.1	14	Moderate
e2 - thimbleberry/pine grass Aw*	75.4	1.6	0	Moderate
e3 - thimbleberry/pine grass Se*	81.8	1.7	0	Moderate
*f1 - balsam poplar Pb**	16.8	0.4	0	High
g1 - horsetail Sw-Pb	42.6	0.9	0	High
g2 - horsetail Sw	35.5	0.7	0	Moderate
Natural vegetated non-forested land				
HG - Herbaceous – Grassland	155.2	3.2	0	Moderate
NMR - Rock barren	2.9	0.1	0	Low
SC - Closed shrub	0.272	<0.1	0	Moderate
SO - Open shrub	6.3	0.1	0	Low
Subalpine				
a1 - lichen Pl	11.5	0.2	4	Moderate
b1 - bearberry/hairy wild rye Pl	163.4	3.4	5	Low
*d1 - spruce/heather Se**	0.8	<0.1	0	Moderate
e1 - false azalea – grouse-berry Pl	992.2	20.8	42	High
*e2 - false azalea – grouse-berry Pw**	3.4	0.1	10	Moderate
e3 - false azalea – grouse-berry Se	207	4.3	1	Moderate
*e4 - false azalea – grouse-berry Fa**	19.9	0.4	0	Low
f1 - thimbleberry Pl	97.6	2	0	Moderate
f2 - thimbleberry Fa-Se*	47.3	1	0	Moderate
h1 - horsetail Se	34.1	0.7	0	High

Table 3.2-2 Rare Plant Potential in the Local Study Area				
Ecosite Phase / Land Class Description[1]	**Area in LSA (ha)[2]**	**% of LSA**	**# of Rare Plant Occurrences**	**Rare Plant Potential**
Natural vegetated non-forested land				
HG - Herbaceous – Grassland	165.5	3.5	0	High
SO - Open shrub	3.6	0.1	0	Low
NMR - Rock barren	35.9	0.8	0	Low

[1] Ecosite phases are from Archibald *et.al.* 1996.
* Ecosite phases were not surveyed.
Note: ecosite phases shown in *italics* are of limited distribution in the LSA.

3.2.3 Rare Plant Communities in the Local Study Area

During project-specific field surveys within the LSA, there were no observations of rare plant communities. A search of the ACIMS database of rare and tracked plant communities revealed that one rare plant community, *Populus tremuloides* / *Rubus parviflorus* forest (aspen / thimbleberry forest; S2 ranking), was observed at four locations near the LSA. Of these four locations, three locations were in the Montane Natural Subregion and one was in the Subalpine Natural Subregion.

3.2.4 Rare Plant Community Potential in the Local Study Area

Rare plant community potential was determined by considering rare plant communities historically reported near the Project (ACIMS 2014c, d), a review of available literature, and professional judgement. All ecosite phases as well as natural vegetated non-forested lands (herbaceous graminoid, closed and open shrub, and barren land) were assessed for rare plant community potential.

Approximately 100 types of rare plant communities are tracked or watched in the Montane and Subalpine Natural Subregions (ACIMS 2014c, d), most of which occur in both Subregions. The highest numbers of rare plant communities have been reported from Montane and Subalpine grasslands, in addition to Montane closed shrub. The Montane a1, Subalpine e2, closed shrub (SC) and grassland (HG) ecosite phases / natural non-forested land classes were assigned high rare plant community potential based on the number of communities (as per ACIMS 2014c; d) that could occur in these ecosites (Table 3.2-3). Figure 3.2-5 illustrates rare plant community potential in the LSA.

Table 3.2-3 Rare Plant Community Potential in the Local Study Area

Ecosite Phase / Land Description[1]	Area in LSA (ha)[2]	% of LSA	# of Rare plant communities (ACIMS database)	Rare Plant Community Potential
Montane Natural Subregion				
a1 - limber pine/juniper Fd-Pf	52.5	1.1	9	High
b1 - bearberry Pl	221.9	4.6	1	Very Low
*b2 - bearberry Aw**	22.5	0.5	3	Low
*b3 - bearberry Aw-Sw-Pl**	33.8	0.7	4	Moderate
c1 - Canada buffalo-berry/hairy wild rye Fd	150.7	3.2	1	Very Low
c2 - Canada buffalo-berry/hairy wild rye Pl	135.8	2.8	1	Very Low
c3 - Canada buffalo-berry/hairy wild rye Aw	22.9	0.5	3	Low
c4 - Canada buffalo-berry/hairy wild rye Aw-Sw-Pl-Fd	173.9	3.6	4	Moderate
d1 - creeping mahonia – white meadowsweet Fd	89	1.9	2	Low
d2 - creeping mahonia – white meadowsweet Pl	593.5	12.4	1	Very Low
*d3 - creeping mahonia – white meadowsweet Sw**	25.7	0.5	4	Moderate
e1 - thimbleberry/pine grass Pl	289.8	6.1	1	Very Low
e2 - thimbleberry/pine grass Aw*	75.4	1.6	4	Moderate
e3 - thimbleberry/pine grass Se*	81.8	1.7	4	Moderate
*f1 - balsam poplar Pb**	16.8	0.4	3	Low
g1 - horsetail Sw-Pb	42.6	0.9	6	Moderate
g2 - horsetail Sw	35.5	0.7	4	Moderate
HG - Herbaceous - Grassland	155.2	3.2	0	Very High
NMR - Rock barren	2.9	0.1	0	Moderate
SO - Open shrub	6.3	0.1	0	Very Low
SC - Closed shrub	0.3	0.0	0	High

Table 3.2-3 Rare Plant Community Potential in the Local Study Area				
Ecosite Phase / Land Description[1]	**Area in LSA (ha) [2]**	**% of LSA**	**# of Rare plant communities (ACIMS database)**	**Rare Plant Community Potential**
Subalpine Natural Subregion				
a1 - lichen Pl	11.5	0.2	4	Moderate
b1 - bearberry/hairy wild rye Pl	163.4	3.4	3	Low
*d1 - spruce/heather Se**	0.8	<0.1	6	Moderate
e1 - false azalea – grouse-berry Pl	992.2	20.8	3	Low
*e2 - false azalea – grouse-berry Pw**	3.4	0.1	8	High
e3 - false azalea – grouse-berry Se	207	4.3	6	Moderate
*e4 - false azalea – grouse-berry Fa**	19.9	0.4	5	Moderate
f1 - thimbleberry Pl	97.6	2	3	Low
f2 - thimbleberry Fa-Se*	47.3	1	7	Moderate
h1 - horsetail Se	34.1	0.7	3	Low
Natural Non-forested Land				
HG - Herbaceous - Grassland	165.5	3.5	11	High
SO - Open shrub	3.6	0.1	6	Moderate
NMR - Rock barren	35.9	0.8	4	Moderate

[1]Ecosite phases are from Archibald et.al. 1996.
Rare plant community potential was not assessed for anthropogenic disturbances and waterbodies reported in the baseline results
Ecosite phases shown in *italics* are of limited distribution in the LSA
*Ecosite phases were not surveyed

3.3 Rangeland Resources

3.3.1 Rangeland within the Local Study Area

Each of the grassland sites where range health assessments were performed was situated on steep, subxeric to mesic, south to southeast facing slopes. Four of these sites (GM200BE, GM404BE, GM406BE, and GM005BE) fall within the ultimate pit and dump extent boundaries (Figure 3.3-1). GM200BE is situated near the edge of the project Footprint boundary. GM401RE is located outside of the Project Footprint. The reference plant community and range health rating for each range health assessment are identified in Table 3.3-1.

Table 3.3-1 Summary of Plant Community Types and Range Health of Sites Within Local Study Area

Plot Label	Reference Plant Community	Range Health Rating
GM200BE	Montane: b1 ecosite phase[1] Rough Fescue-Idaho Fescue-Parry Oatgrass	Unhealthy
GM005BE	Montane: b1 ecosite phase[1] Rough Fescue-Idaho Fescue-Parry Oatgrass	Healthy
GM401RE	SASMA2[2] Rough Fescue-Sedge	Healthy with Problems
GM404BE	SASMA2[2] Rough Fescue-Sedge	Healthy
GM406BE	Montane: b1 ecosite phase[1] Rough Fescue-Idaho Fescue-Parry Oatgrass	Healthy

[1] Willoughby *et al*. 2005.

[2] Willoughby and Alexander 2006.

The components of the rangelands within the LSA appear to be functioning properly. Three of the five grassland sites assessed were assigned a range health rating of 'healthy' (*i.e.*, GM005BE, GM404BE, and GM406BE). GM401RE was classified as 'healthy with problems' due to the distribution of dandelion (*Taraxacum officinale*). GM200BE was classified as 'unhealthy,' due to the presence and distribution of yellow toadflax (*Linaria vulgaris*), a noxious weed.

Two of the sites, GM200BE and GM404BE, were previously disturbed by mining activities; however, these sites had recolonized with several native plant species, including rough fescue, which is characteristic of natural grasslands in the region. The remaining three sites were not previously disturbed and are representative of native grassland communities. Grazing intensity was light to moderate on GM200BE and either ungrazed or lightly grazed on all other sites. Reference plant communities are dominated by rough fescue and are discussed in Section 3.3.2.

3.3.2 Fescue Community within the Local Study Area

The natural range plant community and species diversity were intact throughout most of the LSA. Rough fescue was prevalent throughout the five grassland sites assessed within the LSA, with cover at each site ranging from 20% to 40%. The plant community in site GM200BE was assessed as having minor alteration due to the steep slope of the site, with the remaining sites showing little or no alteration to the modal plant community type for the region. All plant community layers were present in GM200BE and GM404BE, with only the tall forb layer missing in plot GM401RE, and the low forb and moss/lichen layers were absent in GM406BE. The moss / lichen layer were also absent in plot GM005BE.

Litter accumulation was moderate to high in four of the plots, indicating that the productivity, moisture retention, and nutrient cycling functions of the rangelands within the LSA are good. There was little litter at sites GM401RE and GM200BE, likely attributed to the steepness of slopes at these sites. The steep topography also likely contributed to the erosion observed at plots GM404BE and GM406BE. There were no observations of bare soil arising from human activity at any of the rangeland health assessment locations.

Weed cover across grassland sites was low. No weedy species were identified at GM406BE or GM404BE. Site GM005BE had 1% cover of woolly mullein (*Verbascum thapsus*) and site GM200BE had 5% cover of yellow toadflax. However, weed cover at both sites was sporadic with a patchy distribution. Site GM401RE had continuous patches of dandelion, which comprised 3% of the total vegetation cover at the plot.

3.4 Forestry Resources

3.4.1 Timber Productivity in the Local Study Area

Timber productivity ratings (TPR) by forest cover classes (coniferous, deciduous, and mixed) in the LSA are summarized in Table 3.4-1. Forested land, which includes any treed wetlands and regenerating forest stands, occupies 4186.4 ha and accounts for 87.7% of the LSA. This land contains an estimated 584,776 m^3 of total volume, of which 10.1% (58,776 m^3) is assigned a TPR of Good and 73.1% (427,750 m^3) rated Medium. Approximately 590 ha of the LSA is non-forested and consists of non-vegetated natural land (*e.g.*, herbaceous and shrubby lands, barren land, and open water) and land dominated by anthropogenic disturbance.

Timber volume in the LSA was also calculated by species (Table 3.4-2). Lodgepole pine (Pl) makes up 64.8% of the total volume calculated followed by white spruce (SW) at 15.3%, and Douglas fir (Fd) at 12.6%.

Table 3.4-1 Timber Productivity Rating by Cover Class in the Local Study Area[1]

Cover Class	TPR	Volume		Area	
		m³	% of LSA	ha	% of LSA
Coniferous	Good	58,776.2	10.1	259.0	5.4
Coniferous	Medium	406,553.9	73.1	2696.8	56.5
Coniferous Leading		765.5			
Deciduous Leading		12,039.8			
Deciduous		8390.9			
Coniferous	Fair	85,432.5	16.4	1194.3	25.0
Deciduous Leading		6620.2			
Deciduous		3961.8			
Coniferous	Unproductive	2234.8	0.4	36.3	0.8
Non-forested	Not rated	-	-	589.8	12.3
Total		**584,775.6**	**100.0**	**4,776.24**	**100**

[1] The volumes provided in Tables 3.4-1 are total volumes and include trees of all sizes.

- not applicable

Table 3.4-2 Volume of Timber by Leading Species in the Local Study Area[1]

Leading Species	Volume	
	m³	% of LSA
Populus tremuloides (Aw)	29,612.3	5.1
Abies lasiocarpa (Fa)	2503.9	0.4
Abies basamea (Fb)	353.7	0.1
Pseudostuga menziensii (Fd)	73,737.4	12.6
Pinus flexilis (P)	2126.8	0.4
Pinus albicaulis (Pa)	786.6	0.1
Populus balsamifera (Pb)	3123.1	0.5
Pinus contorta (Pl)	378,800.0	64.8
Picea engelmannii (Se)	4139.8	0.7

Table 3.4-2 Volume of Timber by Leading Species in the Local Study Area[1]

Leading Species	Volume	
	m³	% of LSA
Picea glauca (Sw)	89,592.0	15.3
Total	**584,775.6**	**100.0**

[1] The volumes provided in Tables 3.4-2 are total volumes and include trees of all sizes.

3.5 Old Growth Forests

3.5.1 Old Growth Occurrence in the Local Study Area

Old growth forest occupies 168.8 ha and accounts for 3.5% of the LSA; subsequently, the forested areas within the LSA were predominantly early- (young stands) or mid- (mature stands) successional stages. Of the 168.8 ha of old growth, coniferous stands with a moderate canopy closure (31-50%) occupy the largest area (78.8 ha) of old growth, accounting for close to 2% of the total old growth area in the LSA. All other old growth stand types represented in the LSA were of limited distribution occupying less than 1% of the LSA each. The total area of old growth forests as well as areas occupied by each cover-type and canopy closure category is provided in Table 3.5-1. Old growth distribution within the LSA is mapped in Figure 3.5-1.

Table 3.5-1 Area of Old Growth Forest within the Local Study Area

ELC Class[1]	Area (ha)[2]	% of LSA
Open Deciduous Forest	32.3	0.7
Open Coniferous Forest	<0.1	<0.001
Moderate Deciduous Forest	18.4	0.4
Moderate Mixed Forest	30.5	0.6
Moderate Coniferous Forest	78.8	1.7
Closed Mixed Forest	8.7	0.2
Total Old Growth Area	**168.8**	**3.5**

[1] Crown closure classes are AVI codes of canopy closure (measured in %) as follows: Dense = 71-100, Closed = 51-70, Moderate = 31-50, and open = 6-30. Cover types are based on the proportion of conifer or deciduous species in the canopy. Deciduous = >80% deciduous, mixed = 30-79% conifer / deciduous, coniferous = >80% coniferous (ASRD 2005). Age cut off for old growth is as follows: deciduous and mixed stands >100 yr, pine stands >120 yr, and coniferous (non-pine) stands >140 yr.
[2] Due to rounding of numbers, total values may not equal the sum of the individual values.

3.5.2 Old Growth Potential in the Local Study Area

Old growth potential in a specific area is dependent on tree species composition, topography, susceptibility to stand replacing disturbance (*e.g.*, fire) and land use (*e.g.*, logging). For comparison purposes, for the RSA, the fire return interval was found to vary from 49 to 196 years with a mean interval of 78 years (Rogan 2005). This fire interval is based on historical fire data but varied considerably with method of calculation or model used. The Montane and Subalpine natural regions of the LSA were found to be similar in fire return interval and generally reflected spatial terrain variables and canopy species (*i.e.*, closed canopy pine has shorter interval, with other conifers burning less often and deciduous forests burn the least frequently) (Rogan 2005). Within the LSA, logging is the largest disturbance type on the regional landscape, exceeding other anthropogenic developments.

Typically, Montane ecosite phases b2, b3, c3, c4, d3, e2, e3, f1, g1, and g2 and Subalpine ecosite phases c1, d1, e3, e4, f2, and h1 have high old growth potential (Table 3.5-2). Due to the intensity of forest harvesting at the landscape level, all ecosite phases in the LSA have been adjusted to a lower ranking than typical Montane and Subalpine Natural Subregion old growth potential (Table 3.5-2; Figure 3.5-2).

Table 3.5-2 Old Growth Potential in the Local Study Area

Ecosite Phase / Land Class Description[1]	Area in the LSA	% of LSA	Old Growth Potential in LSA
Montane			
a1 - limber pine/juniper Fd-Pf	52.5	1.1	Low
b1 - bearberry Pl	221.9	4.6	Low
*b2 - bearberry Aw**	22.5	0.5	Moderate
*b3 - bearberry Aw-Sw-Pl**	33.8	0.7	Moderate
c1 - Canada buffalo-berry/hairy wild rye Fd	150.7	3.2	Low
c2 - Canada buffalo-berry/hairy wild rye Pl	135.8	2.8	Low
c3 - Canada buffalo-berry/hairy wild rye Aw	22.9	0.5	Moderate
c4 - Canada buffalo-berry/hairy wild rye Aw-Sw-Pl-Fd	173.9	3.6	Moderate
d1 - creeping mahonia – white meadowsweet Fd	89	1.9	Low
d2 - creeping mahonia – white meadowsweet Pl	593.5	12.4	Low
*d3 - creeping mahonia – white meadowsweet Sw**	25.7	0.5	Moderate
e1 - thimbleberry/pine grass Pl	289.8	6.1	Low

Table 3.5-2 Old Growth Potential in the Local Study Area			
Ecosite Phase / Land Class Description[1]	**Area in the LSA**	**% of LSA**	**Old Growth Potential in LSA**
e2 - thimbleberry/pine grass Aw*	75.4	1.6	Moderate
e3 - thimbleberry/pine grass Se*	81.8	1.7	Moderate
*f1 - balsam poplar Pb**	16.8	0.4	Moderate
g1 - horsetail Sw-Pb	42.6	0.9	Moderate
g2 - horsetail Sw	35.5	0.7	Moderate
Subalpine			
a1 - lichen Pl	11.5	0.2	Low
b1 - bearberry/hairy wild rye Pl	163.4	3.4	Low
*d1 - spruce/heather Se**	0.8	<0.1	Moderate
e1 - false azalea – grouse-berry Pl	992.2	20.8	Moderate
*e2 - false azalea – grouse-berry Pw**	3.4	0.1	Low
e3 - false azalea – grouse-berry Se	207	4.3	Low
*e4 - false azalea – grouse-berry Fa**	19.9	0.4	Moderate
f1 - thimbleberry Pl	97.6	2	Moderate
f2 - thimbleberry Fa-Se*	47.3	1	Low
h1 - horsetail Se	34.1	0.7	Moderate
a1 - lichen Pl	11.5	0.2	Moderate

[1] Ecosite phases are from Archibald *et al.* 1996 .

* Ecosite phases were not surveyed.

Note: Ecosite phases shown in *italics* are of limited distribution.

Note: Old growth potential was not assessed for anthropogenic disturbances & non-forested lands reported in the baseline results.

3.5.3 Old Growth Occurrence in the Regional Study Area

Old growth forest occupies a small proportion (4.7%) of the RSA. Of the 13,460 ha occupied by old growth forest in the RSA, 4,403.4 ha (1.6% of the RSA) is open coniferous and 1.5% (4,223 ha) is moderate coniferous forest. The total area of old growth forests and areas occupied by each cover-type and canopy closure class is provided in Table 3.5-3. Old growth distribution within the RSA is mapped in Figure 3.5-3.

Table 3.5-3 Area of Old Growth Forest within the Regional Study Area

ELC Class[1]	Area (ha)[2]	% of RSA
Dense Deciduous Forest	6.9	<0.01
Dense Coniferous Forest	438.5	0.2
Closed Deciduous Forest	287.3	0.1
Closed Mixed Forest	79.6	<0.1
Closed Coniferous Forest	2,774.2	1.0
Moderate Deciduous Forest	437.3	0.2
Moderate Mixed Forest	297.9	0.1
Moderate Coniferous Forest	4,223.7	1.5
Open Deciduous Forest	378.8	0.1
Open Mixed Forest	133.1	<0.1
Open Coniferous Forest	4,403.4	1.6
Total old growth in RSA	**13,460.8**	**4.7**

[1] Crown closure classes are AVI codes of canopy closure (measured in %) as follows: Dense = 71-100, Closed = 51-70, Moderate = 31-50, and open = 6-30. Cover types are based on the proportion of conifer or deciduous species in the canopy. Deciduous = >80% deciduous, mixed = 30-79% conifer / deciduous, coniferous = >80% coniferous (ASRD 2005). The age cut off for old growth is as follows: deciduous and mixed stands >100, pine stands >120, and coniferous (non-pine) stands >140.

[2] Due to rounding of numbers, total values may not equal the sum of the individual values.

3.5.4 Old Growth Potential in the Regional Study Area

Logging and agriculture are two of the main disturbances in the RSA. Forest fires were found to have less impact than forestry and agriculture; however, fires contributed more disturbance within the RSA than roads and industrial activities combined. Similar to the LSA, relative to what is typical for the Montane and Subalpine Natural Subregions, the old growth potential was reduced in the RSA, which can be attributed to the effects of logging and other development on forest communities. At the ELC level, pine and other conifers are grouped together to determine old growth potential. In terms of likelihood to burn, ELC coniferous forest types are the most likely, followed by mixed and deciduous forest types. Table 3.5-4 and Figure 3.5.4 provide the baseline RSA old growth potential.

Table 3.5-4 Old Growth Potential in the Regional Study Area

Ecological Land Cover Class	Area in RSA	% of RSA	Old Growth Potential in the RSA
Dense Deciduous Forest	6.9	<0.01	Moderate
Dense Mixed Forest	105.1	<0.1	Moderate
Dense Coniferous Forest	438.5	0.2	Low
Closed Deciduous Forest	287.3	0.1	Moderate
Closed Mixed Forest	79.6	<0.1	Moderate
Closed Coniferous Forest	2,774.2	1	Low
Moderate Deciduous Forest	437.3	0.2	Moderate
Moderate Mixed Forest	297.9	0.1	Moderate
Moderate Coniferous Forest	4,223.7	1.5	Low
Open Deciduous Forest	378.8	0.1	Moderate
Open Mixed Forest	133.1	<0.1	Moderate
Open Coniferous Forest	4,403.4	1.6	Moderate
Treed Wetland	126.5	<0.1	Moderate

[1] Old growth potential was not assessed for non- forested ELCs reported in Table 3.1.3, including shrub and graminoid wetlands, natural vegetated non-forested lands (SO, SC, HG and Rock barren), water and anthropogenic disturbances.

3.6 Traditional Ecological Knowledge Vegetation Resources

3.6.1 Traditional Use of Vegetation Resources in the Project Area

The Treaty 7 First Nation groups have traditional uses and vast knowledge of the vegetation community present in the LSA and RSA. The following quotes from their TEK reports illustrate the nature of their traditional uses and TEK.

"The area in and around Grassy Mountain has several hundred plant species that were and are used for medicinal, spiritual, and food purposes." (Kainai Nation 2015)

"Up in the mountains are all our original plants." ~ Piikani Technician (Pikani Nation 2015)

"Another Elder shared teachings from his grandfather who told him that the most important part of the land is the grass. Without grass, there is nothing for moose and elk to eat. The wildlife depends on the grass. In this way, the different parts of the land are connected and reliant on one another." (Kainai Nation 2015)

"*Multiple alpine plants found at Grassy Mountain that are crucial to Tsuut'ina Nation ceremony, healing practices, cultural identity, and spirituality are not found at lower elevations near Tsuut'ina Nation communities. The medicinal power of a plant can be derived from the root, flowers, leaves, and bark* (Tsuut'ina Nation 2015)."

"*Medicinal and ceremonial plants were found in several locations on the project site, particularly in fertile micro-ecosystems and others on sunny slopes*(Siksika 2015)."

"*Plants give the gift of colours [dyes]. Yellow, blue, green, to make those colours. … During the headdress ceremonies, the colour yellow symbolizes Natosi (the sun). So, when they paint that Natosi recognizes with the raven on the outside. So, those are the significance of these kinds of colours, to paint us, to recognize us, and the gifts that were given to us*." ~ Piikani Elder (Piikani Nation 2015)

"*Mushrooms grow on the dark side of mountains, so are useful in navigation*." ~Kainai Elder (Kainai Nation 2015)

"*Lichen, moss and several types of fungus found in the area continue to be used for traditional, ceremonial, and medicinal purposes*(Tsuut'ina Nation 2015)."

"*When the Elders went to Wintering Rock, there was this big sage about that high. Billy told that lady, "Give me a bag, or something. Get some of these sage, because one of us is going to put up the Sundance and they use that." Oh yeah, the seasonal around – they knew that Sundance was coming around somewhere. The location was already identified. So, wherever they were in the territory, they start gathering whatever they need that was needed at that Sundance. … They brought all these, you know, plants, berries, food that they needed for the unity. They were unified at Sundance."* ~ Piikani Elder (Piikani Nation 2015)

"*Lodgepole pine is for building tipis. The typical lifespan of tipis is about 15 years. Then new tipi poles need to be harvested to replace the old ones. So the tipi building is staggered. We do not cut down lodgepole for tipis all at the same time. So, there is a continuous harvest of lodgepole pine. We mostly harvest in the spring when they have more sap, which makes them easier to peel."* ~ Kainai Elder (Kainai Nation 2015)

"*The Piikani technicians have a strong interest in harvesting lodgepole pine as they are important to making tipis for various celebrations throughout the summer*(Piikani Nation 2015)."

"*This area is a "teepee pole heaven." There is an abundance of straight lodgepole pine. Tsuut'ina would like the opportunity to harvest the lodgepole pines for their use*(Tsuut'ina Nation 2015)."

3.6.2 Traditional Ecological Knowledge Vegetation Occurrence

During the Aboriginal Consultation process, a list of VC species used by Aboriginal Groups (specifically Treaty 7 First Nations) was compiled. Additional species were later added to the list upon reviewing TEK reports prepared by or with four of these First Nations – Blood Tribe (Kainai Nation 2015), Piikani Nation (2015), Siksika Nation (SCO 2015), and Tsuut'ina Nation (2015). TEK species (vascular and non-vascular) observed in the LSA during vegetation field surveys are provided in Table 3.6-1. Additional species noted in the First Nations TEK report, but not identified during the systematic vegetation field surveys, are also provided in Table 3.6-1. A list of TEK species identified in the LSA and the ecosite phases from which they were observed is provided in Appendix E.

Table 3.6-1 Traditional Ecological Knowledge Vegetation Valued Component Species Identified in the Local Study Area

Life Form	Name			# of occurrences in LSA[1]	First Nations Identified VCs				
	Provided TEK	Scientific	Common		Piikani Nation [2]	Blood Tribe [3]	Siksika Nation [4]	Tsuut'ina Nation [5]	Stoney Nakoda First Nation [6]
Tree	Sweet pine	*Abies lasiocarpa*	Subalpine fir	44	x	x		x	x
Tree	Lodgepole pine	*Pinus contorta*	Lodgepole pine	93	x	x		x	x
Tree	Poplar	*Populus balsamifera*	Balsam poplar	12	x			x	
Tree	Cottonwood or poplar	*Populus tremuloides*	Aspen	28	x	x			
Shrub	Saskatoon berry	*Amelanchier alnifolia*	Saskatoon	34	x	x		x	
Shrub	Bearberry	*Arctostaphylos uva-ursi*	Common bearberry	30	x	x		x	
Shrub	Mountain sage	*Artemisia* sp.	Sage	2	x			x	x
Shrub	Dogberry	*Cornus stolonifera*	Red-osier dogwood	4				x	
Shrub	Juniper	*Juniperus communis*	Ground juniper	59	x	x		x	
Shrub	Juniper	*Juniperus scopulorum*	Rocky mountain juniper	1	x	x		x	
Shrub	Rose hip	*Rosa acicularis*	Prickly rose	41		x			
Shrub	Rose hip	*Rosa woodsii*	Common wild rose	10		x			

Table 3.6-1 Traditional Ecological Knowledge Vegetation Valued Component Species Identified in the Local Study Area

Life Form	Name			# of occurrences in LSA[1]	First Nations Identified VCs				
	Provided TEK	Scientific	Common		Piikani Nation [2]	Blood Tribe [3]	Siksika Nation [4]	Tsuut'ina Nation [5]	Stoney Nakoda First Nation [6]
Shrub	Raspberry	*Rubus idaeus*	Wild red raspberry	8		x		x	
Shrub	Thimbleberry	*Rubus parviflorus*	Thimbleberry	19		x		x	
Shrub	Willow	*Salix bebbiana*	Beaked willow	4	x	x		x	
Shrub	Willow	*Salix scouleriana*	Scouler's willow	11	x	x		x	
Shrub	Black elderberry	*Sambucus racemosa*	Red elderberry	1				x	
Shrub	Low-bush cranberry	*Viburnum edule*	Low-bush cranberry	2				x	
Forb	Prince's pine	*Chimaphila umbellata*	Prince's-pine	25				x	
Forb	Ferns	*Cystopteris fragilis*	Fragile bladder fern	2					x
Forb	Fireweed	*Epilobium angustifolium*	Common fireweed	54				x	
Forb	Horsetail	*Equisetum arvense*	Common horsetail	10		x		x	
Forb	Horsetail	*Equisetum fluviatile*	Swamp horsetail	1		x		x	
Forb	Scouring-rush	*Equisetum scirpoides*	Dwarf scouring-rush	7		x		x	

Table 3.6-1 Traditional Ecological Knowledge Vegetation Valued Component Species Identified in the Local Study Area

Life Form	Name			# of occurrences in LSA[1]	First Nations Identified VCs				
	Provided TEK	Scientific	Common		Piikani Nation [2]	Blood Tribe [3]	Siksika Nation [4]	Tsuut'ina Nation [5]	Stoney Nakoda First Nation [6]
Forb	Strawberry	*Fragaria virginiana*	Wild strawberry	56					x
Forb	Three-flowered avens	*Geum triflorum*	Three-flowered avens	7					x
Forb	Cream-coloured vetchling	*Lathyrus ochroleucus*	Cream-coloured vetchling	31					x
Forb	Lupine	*Lupinus arbustus*	Longspur lupine	2					x
Forb	Lupine	*Lupinus arcticus*	Arctic lupine	8					x
Forb	Lupine	*Lupinus argenteus*	Silvery perennial lupine	12					x
Forb	Lupine	*Lupinus sericeus*	Silky perennial lupine	21					x
Forb	Lupine	*Lupinus sulphureus*	Sulphur lupine	8					x
Forb		*Phacelia hastata*	Silver-leaved scorpionweed	4					x
Forb	Silky scorpionweed	*Phacelia sericea*	Silky scorpionweed	3					x
Forb	Lance-leaved stonecrop	*Sedum lanceolatum*	Lance-leaved stonecrop	22					x
Forb	Clasping-leaved twisted-stalk	*Streptopus amplexifolius*	Clasping-leaved twisted-stalk	3				x	

Table 3.6-1 Traditional Ecological Knowledge Vegetation Valued Component Species Identified in the Local Study Area

Life Form	Name			# of occurrences in LSA[1]	First Nations Identified VCs				
	Provided TEK	Scientific	Common		Piikani Nation [2]	Blood Tribe [3]	Siksika Nation [4]	Tsuut'ina Nation [5]	Stoney Nakoda First Nation [6]
Herb	Yarrow	*Achillea millefolium*	Common yarrow	35	x	x			x
Herb	Tall everlasting	*Antennaria anaphaloides*	Tall everlasting	4					x
Herb	Heart-leaved arnica	*Arnica cordifolia*	Heart-leaved arnica	42					x
Herb	Balsamroot	*Balsamorhiza sagittata*	Balsamroot	4					x
Herb	Thistle	*Cirsium edule*	Edible thistle	1				x	
Herb	Bear root or Indian potato	*Heracleum lanatum*	Cow parsnip	18				x	
Herb	Dandelion	*Taraxacum officinale*	Common dandelion	14		x			x
Grass	Common sweetgrass	*Hierochloe hirta*	Sweet grass	6				x	
Lichen - ground	Buffalo horn lichen	*Cladonia* spp. (n=20 species)	Cladonia	156				x	
Lichen	Tree lichen	*Letharia vulpina*	Wolf lichen	47	x	x		x	
Lichen - epiphyte	Tree lichen	*Usnea* and *Bryoria* spp. (n=8 species)	Old man's beard	55	x	x		x	

Table 3.6-1 Traditional Ecological Knowledge Vegetation Valued Component Species Identified in the Local Study Area

Life Form	Name			# of occurrences in LSA[1]	First Nations Identified VCs				
	Provided TEK	Scientific	Common		Piikani Nation [2]	Blood Tribe [3]	Siksika Nation [4]	Tsuut'ina Nation [5]	Stoney Nakoda First Nation [6]
Additional Species Noted in First Nation TEK Reports [2, 3, 4, 5]									
Tree	Birch	*Betula* sp.	Birch		x	x			
Tree	Choke cherry	*Prunus virginiana*	Choke cherry			x			
Shrub	Poison ivy	*Rhus radicans*	Poison ivy			x			
Shrub	Lingonberry	*Vaccinium vitis-idaea*	Lingonberry, northern mountain cranberry					x	
Shrub	Muskeg tea	*Ledum groenlandicum*	Labrador tea					x	
Forb	Alpine fern	*Woodsia alpina*	Alpine fern		x				
Forb	Wild licorice	*Glycyrrhiza lepidota*	Wild licorice			x			
Forb	Mountain holly fern	Note: this common name is not known to occur in Alberta, identification not confirmed			x				
Bryophyte	Moss				x			x	
Bryophyte	Dry tree moss					x			
Bryophyte	Moist ground moss					x			
Fungus	Mushrooms					x			

Table 3.6-1 Traditional Ecological Knowledge Vegetation Valued Component Species Identified in the Local Study Area

Life Form	Name			# of occurrences in LSA[1]	First Nations Identified VCs				
	Provided TEK	Scientific	Common		Piikani Nation [2]	Blood Tribe [3]	Siksika Nation [4]	Tsuut'ina Nation [5]	Stoney Nakoda First Nation [6]
Fungus	Tree fungus							x	

[1] Number of observations during the vegetation surveys of the LSA.
[2] Source: Consultation information and Piikani Nation (2015).
[3] Source: Consultation information and Kanai Nation (2015).
[4] Source: No species were identified. SCO (2015) indicated site visit in October 2014 was not sufficient for providing a list of TEK in the Project area and further visits would be required.
[5] Source: Consultation information and Tsuut'ina Nation (2015).
[6] Source: Consultation information.

3.6.3 Traditional Ecological Knowledge Vegetation Potential

The potential for ecosite phases to support TEK species was determined based on the number of TEK species found in each ecosite phase (Appendix E), other studies in the area, and information gathered during consultation with the Treaty 7 First Nations. Three ecosite phases in the Montane Natural Subregion (c1, c4, and g1) and one ecosite phase in the Subalpine Natural Subregion (e1) have high or very high TEK vegetation potential (Table 3.6-2, Figure 3.6-1).

Table 3.6-2 Baseline Traditional Ecological Knowledge Vegetation Potential Within the Local Study Area

Ecosite Phase/AVI Code	Ecosite Phase Descriptions	Number of TEK Species Found in LSA	TEK Vegetation Ranking Results	
			Potential Ranking	Total Area in LSA (ha)
Montane				
a1	limber pine/juniper Fd-Pf	10	Low	52.5
b1	bearberry Pl	21	Moderate	221.9
b2	bearberry Aw*	NA	Moderate	22.5
b3	bearberry Aw-Sw-Pl*	NA	Moderate	33.8
c1	Canada buffalo-berry/hairy wild rye Fd	25	High	150.7
c2	Canada buffalo-berry/hairy wild rye Pl	18	Moderate	135.8
c3	Canada buffalo-berry/hairy wild rye Aw	23	Moderate	22.9
c4	Canada buffalo-berry/hairy wild rye Aw-Sw-Pl-Fd	38	High	173.9
d1	creeping mahonia – white meadowsweet Fd	15	Moderate	89.0
d2	creeping mahonia – white meadowsweet Pl	13	Moderate	593.5
d3	creeping mahonia – white meadowsweet Sw*	NA	Moderate	
e1	thimbleberry/pine grass Pl	19	Moderate	289.8
e2	thimbleberry/pine grass Aw*	NA	Moderate	75.4
e3	thimbleberry/pine grass Se*	NA	Moderate	81.8
f1	*balsam poplar Pb**	NA	Moderate	16.8

Table 3.6-2 Baseline Traditional Ecological Knowledge Vegetation Potential Within the Local Study Area

Ecosite Phase/AVI Code	Ecosite Phase Descriptions	Number of TEK Species Found in LSA	TEK Vegetation Ranking Results	
			Potential Ranking	Total Area in LSA (ha)
g1	horsetail Sw-Pb	29	High	42.6
g2	horsetail Sw	8	Low	35.5
Subalpine				
a1	lichen Pl	20	Moderate	11.5
b1	bearberry/hairy wild rye Pl bearberry/hairy wild rye Pl	16	Moderate	163.4
d1	*spruce/heather Se**	NA	High	0.8
e1	false azalea – grouse-berry Pl	53	Low	992.2
e2	*false azalea – grouse-berry Pw**	NA	Low	3.4
e3	false azalea – grouse-berry Se	6	Moderate	207.0
e4	*false azalea – grouse-berry Fa**	NA	Moderate	19.9
f1	thimbleberry Pl	22	Low	97.6
f2	thimbleberry Fa-Se	NA	Moderate	47.3
h1	horsetail Se	2	Moderate	34.1

NA – not applicable (Ecosite phase not surveyed)

3.7 Wetlands

3.7.1 Distribution of Wetlands in the Local Study Area

In total, wetlands covered 16.9 ha, or 0.37%, of the LSA. Four wetland classes were identified within the LSA (Table 3.7-1; Figure 3.7-1, and all are of limited distribution. Descriptions of each of the four wetland classes are provided in Appendix F.

Table 3.7-1 Distribution of Wetland Classes in the Local Study Area

AWI Wetland Class	Area in LSA (ha)[1]	% of LSA[1]
FONS – Shrubby open fen	11.2	0.35
STNN – Wooded open canopy (6-70% cover) swamp	4.8	0.10
WONN – Open water (<2 m deep)	0.5	0.01
MONG – Open graminoid dominated marsh	0.4	<0.01
Total	**16.9**	**0.37**

[1] Due to rounding, totals may be different from sums.

Non-patterned, open shrubby fens (FONS) were the most dominant wetland type in the LSA (11.25 ha, 0.25%), followed by wooded coniferous swamps (STNN) (4.78 ha, 0.10%), open water (WONN) (0.2 ha, 0.01%), and marshes (MONG) (0.3 ha, <0.01%) (Table 3.7-1). Secondary wetland classes (minor inclusion of other wetland types) that were not continuous and were found in scattered or isolated pockets were too small to map at the scale used.

Two occurrences of FONS were identified in the LSA. The larger fen occurs mostly within the proposed Footprint. The smaller fen exists outside of the Footprint and is not expected to be affected by the Project.

The single STNN identified in the LSA is located at the western edge of the Mine Permit Boundary, across the Blairmore Creek valley from the Project Footprint. Due to its location, the STNN will not have any Project disturbance associated with it.

The occurrences of WONN and MONG within the LSA are located immediately adjacent to the existing railroad between Blairmore and Coleman. They are located together at the northwest extent of the proposed railway loop within the Project Footprint.

3.7.2 Distribution of Wetlands in the Regional Study Area

Table 3.7-2 provides a summary of wetland classes found in the RSA. Wetlands occupy 0.9% (2,592 ha) of the RSA. Open waterbodies are the most common wetland type and occupy 0.5% (1,544 ha) of the RSA (Figure 3.7-2). Shrubby wetlands comprise 0.3% of the RSA, graminoid wetlands occupy <0.1% of the RSA, and treed wetlands are <0.1% of the RSA. Within the RSA, all identified wetland types are of limited distribution (*i.e.*, each occupy <1% of the RSA).

Table 3.7-2 Distribution of Wetland Classes in the Regional Study Area				
Land Cover Class	Ecosite Phase/AVI Equivalent	AWIS Wetland Class Equivalent	Total Area (ha)[1]	% of RSA[1]
Graminoid Wetland	NA	FONG/MONG	158.5	0.1
Shrubby Wetland	Subalpine g1, h2	FONS	762.7	0.3
Open Water	NWF	WONN	1,544.0	0.5
Treed Wetland	Subalpine h1	FTNN & STNN	126.5	<0.1
Total Wetlands			**2,591.7**	**0.9**

[1] Due to rounding, totals may be different from sums.

3.8 Biodiversity and Fragmentation

3.8.1 Baseline Biodiversity in the Local Study Area

Within the LSA, eleven Montane and six Subalpine ecosite phases were sampled for biodiversity. Baseline species level and community level biodiversity indicators for these sampled ecosite phases are summarised in Tables 3.8-1 and 3.8-2. A total of 37 ecosite phases and 10 naturally occurring non-ecosite units were mapped within the LSA. Twenty-one of the naturally occurring mapped units occupied <1% of the LSA each. Subalpine ecosite phase e1 was the most common occupying 20.8% of the LSA followed by Montane ecosite phase d2 (12.4%) and e1 (6.1%). All other mapped ecosite phases occupied <5% each.

Table 3.8-1 Baseline Species Level Biodiversity Indicators in the Local Study Area							
Description of Ecosite Phase	Ecosite Phase	Total # Species[1]	# Plots	Species Richness[2]		Shannon Diversity Index[2]	Evenness[2]
				All Plants	Vascular Plants		
Montane							
subxeric-poor, limber pine-juniper	a1	26	1	17.0	15	2.15	0.76
submesic-poor, bearberry	b1	55	1	25.0	25	2.16	0.67
submesic-medium, Canada buffaloberry-hairy wild rye	c1	97	3	29.7	25.7	2.24	0.66
submesic-medium, canada buffaloberry-hairy wild rye	c2	92	2	26.5	26	2.03	0.62

Table 3.8-1 Baseline Species Level Biodiversity Indicators in the Local Study Area

Description of Ecosite Phase	Ecosite Phase	Total # Species[1]	# Plots	Species Richness[2]		Shannon Diversity Index[2]	Evenness[2]
				All Plants	Vascular Plants		
submesic-medium, canada buffaloberry-hairy wild rye	c3	89	2	34.5	34.5	2.69	0.76
submesic-medium, canada buffaloberry-hairy wild rye	c4	163	4	29.6	25.0	2.31	0.69
mesic-medium, creeping mahonia-white meadowsweet	d1	58	1	36.0	27.0	2.51	0.70
mesic-medium, creeping mahonia-white meadowsweet	d2	56	1	26.0	26.0	2.47	0.76
mesic-rich, thimbleberry-pine grass	e1	56	1	28.0	27.0	2.49	0.75
hygric-rich, horsetail	g1	103	2	35.5	34.0	2.60	0.73
hydric-rich, horsetail	g2	52	1	42.0	32.0	2.55	0.68
Subalpine							
xeric-poor, lichen	a1	96	3	22.7	18.7	2.04	0.65
subxeric-medium, bearberry- hairy wild rye	b1	52	2	21.0	20.5	2.17	0.72
mesic-medium, false azalea-grouseberry	e1	245	18	22.8	18.4	2.11	0.68
mesic-medium, false azalea-grouseberry	e3	37	1	20.0	18.0	2.13	0.71
subhygric-rich, thimbleberry	f1	99	4	25.5	21.5	2.38	0.74
subhydric-rich, horsetail engelmann spruce	h1	26	1	14.0	14.0	1.57	0.59

[1] Total species is from all surveys where ecosite phase was identified in the field.

[2] Where more than one biodiversity plot was assessed per ecosite phase (# biodiversity plots >1), species richness, Shannon's diversity and evenness represent the mean across plots.

Table 3.8-2 Baseline Community Level Biodiversity Indicators in the LSA

Natural Subregion[1]	Ecosite Phase	Rare Plants		Layers (#)[4]	Unique Species (#)	Total # of Species	Noxious Species (#)	Species Richness (mean)	Shannon's Diversity (mean)	Shannon's Evenness (mean)	Rare (<1%) in LSA
		Occurrences[2]	Potential[3]								
MN	a1	0	Low	6	4	26	0	17.0	2.15	0.76	-
MN	b1	0	High	9	0	55	1	25.0	2.16	0.67	-
MN	c1	3	Moderate	9	4	97	0	29.7	2.24	0.66	-
MN	c2	0	Moderate	9	6	92	1	26.5	2.03	0.62	-
MN	c3	0	Low	8	8	89	2	34.5	2.69	0.76	Yes
MN	c4	5	Moderate	9	8	163	0	29.6	2.31	0.69	-
MN	d1	1	Low	9	0	58	0	36.0	2.51	0.70	-
MN	d2	8	Moderate	8	2	56	0	26.0	2.47	0.76	-
MN	e1	3	Moderate	9	0	56	1	28.0	2.49	0.75	-
MN	g1	0	Not ranked	9	5	103	3	35.5	2.60	0.73	Yes
MN	g2	0	Not ranked	9	6	52	1	42.0	2.55	0.68	Yes
SA	a1	6	Low	9	7	96	0	22.7	2.04	0.65	Yes
SA	b1	0	Low	9	1	52	0	21.0	2.17	0.72	-
SA	e1	23	High	9	62	245	0	22.8	2.11	0.68	-
SA	e3	11	Not ranked	7	1	37	0	20.0	2.13	0.71	-
SA	f1	4	Not ranked	9	5	99	0	25.5	2.38	0.74	-
SA	h1	0	Not ranked	3	11	26	2	14.0	1.57	0.59	-

Table 3.8-2 Baseline Community Level Biodiversity Indicators in the LSA

Natural Subregion[1]	Ecosite Phase	Rare Plants		Layers (#)[4]	Unique Species (#)	Total # of Species	Noxious Species (#)	Species Richness (mean)	Shannon's Diversity (mean)	Shannon's Evenness (mean)	Rare (<1%) in LSA
		Occurrences[2]	Potential[3]								

[1] MN = Montane, SA = Subalpine.

[2] Number of rare plant sightings during field surveys.

[3] Potential is based on historical # of rare plant sightings (ACIMS 2014c; d).

[4] Layers of structure are: 1) Over-story tree, 2) Under-storey tree, 3) Tall shrub (2.5m-5m), 4) Short shrub (<2.5m), 5) Forb, 6) Grass, 7) Moss, 8) Lichen, 9) Epiphyte.

- not applicable.

3.8.1.1 Baseline Biodiversity Potential in the Local Study Area

Biodiversity indicators were used to assign biodiversity potential for each ecosite phase as described in Section 2.3.8. The biodiversity potential of mapped ecosite phases not sampled in the field was assigned based on ecosite phase descriptions (Archibald *et al.* 1996), professional judgement, and observations relative to sampled ecosite phases. For example, ecosite phases b2 and b3 of the Montane Natural Subregion contain greater structural diversity and species diversity than ecosite phase b1. Within the LSA, some natural map units could not be assigned to an ecosite phase as they were not covered by the classification system (*e.g.*, NMR – Barren Rock) and/or were better classified as other natural units for purposes of assessment (*e.g.*, HG – Herbaceous Grassland). Anthropogenic (disturbed) map units (*e.g.*, farmland, roads) were not assessed for biodiversity potential. The biodiversity potential for all ecosite phases and naturally occurring map units are provided in Table 3.8-3.

Table 3.8-4 summarizes the ecosite phases and natural map units by biodiversity potential rank within the LSA. Combined, 36.6% of the LSA is assessed as potentially high in biodiversity and 31.9% as moderate. Unnatural and disturbed areas not assigned a biodiversity rating are 16.1% of the LSA. Biodiversity potential in the LSA is mapped in Figure 3.8-1.

Table 3.8-3 Biodiversity Potential by Map Unit in the Local Study Area

Natural Subregion	Ecosite Phase/ Map Unit*	Ecosite Phase Area (ha)[1]	Proportion of LSA (%)[1]	Ecosite Phase Rare in LSA[2]	Biodiversity Ranking
Ecosite Phase					
MN	a1	52.5	1.1	No	Low
MN	b1	221.9	4.7	No	Low
MN	b2*	22.5	0.5	Yes	Moderate
MN	b3*	33.8	0.7	Yes	Moderate
MN	c1	150.7	3.2	No	Moderate
MN	c2	135.8	2.8	No	Low
MN	c3	22.9	0.5	Yes	High
MN	c4	173.9	3.6	No	High
MN	d1	89.0	1.9	No	Moderate
MN	d2	593.5	12.4	No	Moderate
MN	d3*	25.7	0.5	Yes	Moderate
MN	e1	289.8	6.1	No	Low

Table 3.8-3 Biodiversity Potential by Map Unit in the Local Study Area

Natural Subregion	Ecosite Phase/ Map Unit*	Ecosite Phase Area (ha)[1]	Proportion of LSA (%)[1]	Ecosite Phase Rare in LSA[2]	Biodiversity Ranking
MN	e2*	75.4	1.6	No	Moderate
MN	e3*	81.8	1.7	No	Moderate
MN	f1*	16.8	0.4	Yes	High
MN	g1	42.6	0.9	Yes	High
MN	g2	35.5	0.7	Yes	High
SA	a1	11.5	0.2	Yes	Moderate
SA	b1	163.4	3.4	No	Moderate
SA	d1*	0.8	<0.01	Yes	Moderate
SA	e1	992.2	20.8	No	High
SA	e2*	3.4	0.1	Yes	Moderate
SA	e3	207.0	4.3	No	Moderate
SA	e4*	19.9	0.4	Yes	Moderate
SA	f1	97.6	2.0	No	High
SA	f2*	47.3	1.0	Yes	High
SA	h1	34.1	0.7	Yes	Very Low
Non-ecosite Map Unit					
MN	HG	155.2	3.3	No	High
MN	NMR	2.9	0.1	Yes	Low
MN	NWF	0.8	<0.01	Yes	Low
MN	NWL	0.3	<0.01	Yes	Low
MN	NWR	0.0	0.0	Yes	Low
MN	SC	0.3	<0.01	Yes	Moderate
MN	SO	6.3	0.1	Yes	Moderate
SA	HG	165.5	3.5	No	High
SA	NMR	35.9	0.8	Yes	Moderate
SA	SO	3.6	0.1	Yes	Moderate

[1] Due to rounding, totals may be different from sums.

[2] Rare is defined as comprising <1% of the LSA.

* Ecosite phase not surveyed.

MN = Montane and SA = Subalpine.

Table 3.8-4 Biodiversity Potential in the Local Study Area

Biodiversity Potential	Ecosite Phases	Area (ha)[1]	% of LSA[1]
Very High	None	0.0	0.0
High	MN: c3, c4, f1, g1, g2, HG SA: e1, F1, F2, HG	1749.5	36.6
Moderate	MN: b2, b3, c1, d1, d2, e2, e3, SC, SO SA: a1, b1, d1, e2, e3, e4, NMR, SO	1,524.5	31.9
Low	MN: a1, b1, e1, NMR, NWF, NWL, NWR	738.1	15.4
Very Low	SA: h1	0.0	0.0

[1] Due to rounding, totals may be different from sums.
MN = Montane and SA = Subalpine.

3.8.2 Baseline Fragmentation in the Local Study Area

Baseline fragmentation was described using the following parameters and metrics:

- number of patches (by type) (#);
- mean patch size (ha);
- total area of each patch type (ha);
- core area for each patch type (ha);
- patch density (#/100 km^2);
- percentage (%) of LSA (% occupied by each patch type);
- total length of perimeter (edge) (m);
- mean perimeter to area ratio (m/ha);
- core area index (%); and
- mean distance to nearest neighbour (metres); and at the landscape level.

The natural distribution and size of patches within the LSA is determined by the terrain and its effect on moisture. Steep slopes show a rapid progression of patch types from crest to toe and this progression is often different on northerly aspects when compared south facing slopes. Within the LSA, large homogeneous patches are found only where the terrain is more subdued. The largest mean natural patch types in the Montane Natural Subregion of the LSA are e1 (thimbleberry-pine grass), e3 (thimbleberry/pine grass Se) and d2 (creeping mahonia-white meadowsweet Pl). The largest mean patch types in the Subalpine Natural Subregion are e4 (False azalea-grouse-berry Se), e1 (false azalea-grouse-berry Pl), and a1 (Lichen Pl) (Table 3.8-5).

The LSA contains a substantial amount of existing disturbance, including 166.7 ha of previous mining disturbance in the Footprint, with 339 anthropogenic patches covering 16.3% of the LSA. The mean size of anthropogenic patches is 2.3 ha, and the mean size of natural patches is 5.8 ha (Table 3.8-6). Differences in the mean size and number of patches account for differences in perimeter length and core area between the patches where abundant smaller and predominantly anthropogenic patches have large perimeter length and less core area.

Most adverse effects of forest fragmentation on organisms seem to be directly, or indirectly, related to edge effect differences (McGarigal and Marks 1994). The abundance of anthropogenic patches will affect adjacent natural patches by increasing the amount of edge and decreasing the area of core interior habitat. Larger contiguous anthropogenic patches (*e.g.*, AIM-surface mines in the LSA) have less effect on edge than more dispersed and or linear shaped patches. As a result of existing anthropogenic disturbances, the Baseline LSA is moderately fragmented.

Table 3.8-5 Baseline Fragmentation in the Local Study Area

Ecosite Phase	# Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)[1,2]	Core Area (ha)[2]	Patch Density (#/100 km^2)	% of LSA[2]	Perimeter Length (m)[2]	Mean Perimeter Area (m/ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
Montane Natural Subregion										
a1	11	4.8	52.8	37.1	23.0	1.1	16,676	315.7	70.3	507.7
b1	38	5.8	218.7	170.7	79.6	4.6	51,492.3	235.5	78.1	311.4
b2	4	3.5	14.1	11.0	8.4	0.3	3,321.1	235.5	77.8	1,043.7
b3	12	2.7	32.5	22.7	25.1	0.7	10,832.7	333.4	69.8	625.7
c1	22	6.8	150.5	127.9	46.1	3.2	24,727.2	164.3	85.0	425.2
c2	26	5.6	146.3	116.5	54.4	3.1	31,636.4	216.3	79.6	298.7
c3	9	2.2	19.5	14.0	18.8	0.4	6,024.6	308.5	71.9	494.2
c4	43	4.6	197.4	149.4	90.0	4.1	51,843.5	262.6	75.7	251.0
d1	16	6.9	110.7	88.8	33.5	2.3	22,949.2	207.3	80.2	479.2
d2	90	7.1	643.2	514.9	188.4	13.5	137,796.6	214.2	80.0	239.2
d3	2	5.8	11.6	7.5	4.2	0.2	4,202.5	363.2	64.8	1,879.9
e1	23	11.6	266.8	227.7	48.2	5.6	40,746.2	152.7	85.3	566.6
e2	21	3.4	70.6	51.5	44.0	1.5	21,489.8	304.4	72.9	420.9
e3	11	8.6	94.1	69.0	23.0	2.0	26,485.3	281.3	73.3	1,029.8
f1	5	4.9	24.5	18.3	10.5	0.5	6,998.1	285.5	74.7	550.0
g1	8	5.4	43.4	33.6	16.7	0.9	10,339	238.1	77.3	773.9

Table 3.8-5 Baseline Fragmentation in the Local Study Area

Ecosite Phase	# Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)[1,2]	Core Area (ha)[2]	Patch Density (#/100 km^2)	% of LSA[2]	Perimeter Length (m)[2]	Mean Perimeter Area (m/ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
g2	8	3.2	25.4	16.5	16.7	0.5	9,993	393.2	65.0	175.7
NMR	2	0.7	1.4	0.8	4.2	0	688.1	489.3	57.8	50.9
NWF	2	0.4	0.8	0.02	4.2	0	1,443	1,720.8	2.6	133.3
NWL	3	0.1	0.3	0.01	6.3	0	796.1	2,978.4	2.2	51.1
NWR	1	0.0	0.0	-	2.1	0	69.4	3,007.5	-	-
HG	36	2.3	82.9	57.5	75.4	1.7	27,948.9	337.2	69.4	233.2
SC	1	0.2	0.2	-	2.1	0	625.7	4,123.7	-	-
SO	1	0.3	0.3	0.1	2.1	0	244.8	823.4	32.8	-
Subalpine Natural Subregion										
a1	3	6.8	20.3	15.2	6.3	0.4	5,344.1	262.6	74.6	1,899.0
b1	28	4.5	126.0	100.1	58.6	2.6	27,707.2	220	79.5	281.2
e1	133	8.3	1,110.4	890.7	278.5	23.2	235,484.4	212.1	80.2	202.3
e3	54	3.8	207.5	155.5	113.1	4.3	57,716.4	278.1	74.9	162.9
e4	1	27.7	27.7	23.4	2.1	0.6	4,390.5	158.3	84.5	-
f1	10	3.7	36.9	27.1	20.9	0.8	11,028.5	299.1	73.5	247.3
f2	7	4.3	29.9	20.7	14.7	0.6	9,994.9	334	69.3	552.2
h1	2	4.7	9.3	5.9	4.2	0.2	4,018.4	431.6	63.2	79.1

Table 3.8-5 Baseline Fragmentation in the Local Study Area

Ecosite Phase	# Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)[1,2]	Core Area (ha)[2]	Patch Density (#/100 km^2)	% of LSA[2]	Perimeter Length (m)[2]	Mean Perimeter Area (m/ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
HG	38	4.5	170.8	121.9	79.6	3.6	53,374.7	312.5	71.4	258.0
NMR	12	3.8	45.3	33.9	25.1	0.9	12,232.4	270.1	74.8	580.3
Montane Natural Subregion Anthropogenic Patches										
AIH	23	3.2	73.3	24.9	48.2	1.5	55,422.9	756.0	34.0	456.6
AIM	2	18	35.9	30.4	4.2	0.8	5,709.3	159.0	84.8	876.5
ASC	9	9	81.3	71.3	18.8	1.7	10,929.3	134.4	87.7	231.0
CC	17	3.6	60.9	45.5	35.6	1.3	16,785.9	275.6	74.8	381.8
CIP	9	3.8	34	16.6	18.8	0.7	17,890.4	526.1	48.9	1033.4
CIW	4	2	7.9	6.0	8.4	0.2	2,119.3	267.6	75.1	1452.2
CL	96	0.2	22.6	-	201.0	0.5	104,566.6	4622	-	246.7
CO	24	2.4	58.7	39.2	50.2	1.2	21,783.2	371	66.8	430.1
CP	3	12.4	37.3	27.8	6.3	0.8	10,228.6	274.1	74.6	390.5
Subalpine Natural Region Anthropogenic Patches										
AIH	11	2.3	24.8	5.5	23.0	0.5	30,264.4	1,218	22.1	459.9
AII	1	0.2	0.2	0.1	2.1	0.0	213.2	1,017.6	25.7	-
AIM	9	14.4	129.3	110.3	18.8	2.7	20,209.3	156.3	85.3	343.2
CC	18	9.8	176.4	140.3	37.7	3.7	38,544.9	218.5	79.5	334.8

Table 3.8-5 Baseline Fragmentation in the Local Study Area

Ecosite Phase	# Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)[1,2]	Core Area (ha)[2]	Patch Density (#/100 km^2)	% of LSA[2]	Perimeter Length (m)[2]	Mean Perimeter Area (m/ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
CIP	3	1.7	5.1	0.8	6.3	0.1	4,526.1	894.1	15.2	677.6
CIW	9	1.0	9.3	6.4	18.8	0.2	3,431.1	367.3	68.0	258.8
CL	101	0.3	26.8	-	211.5	0.6	104,357.1	3,890	-	185.2
Totals										
Natural	683	-	3,992.1	3,129.9	-	83.4	930,661.0	-	-	-
Anthropogenic	339	-	783.8	525.1	-	16.5	446,981.0	-	-	-
LSA	1,022	-	4,776.0	3,655	-	100	1,377,642.0	-	-	-

[1] Areas (ha) may be different from baseline ecosite phase areas presented in Table 3.1.1 because biodiversity assessment was based on the dominant ecosites phase assigned to each polygon on the LSA map (See Section 2.3.1.2 for details on ecosite phase mapping).

[2] Due to rounding, totals may be different from sums, including from other Tables.

- Note Applicable.

Table 3.8-6 Baseline Landscape Level Fragmentation in the Local Study Area

Land Cover Type	# Patches	Mean Patch Area (ha)	Total Patch Area (ha)	Core Area (ha)	Patch Density (#/100 km^2)	Perimeter Length (m)	Mean Patch Perimeter : Area (m/ha)	Core Area Index (%)
Natural	683	5.8	3,992.1	3,129.9	143	930,661.0	233.1	78.4
Anthropogenic	339	2.3	783.8	525.1	71.0	446,982.0	570.3	67.0
Combined	**1,022**	**4.7**	**4,776.0**	**3,655.0**	**214.0**	**1,377,643.0**	**288.5**	**76.5**

3.8.3 Baseline Biodiversity and Fragmentation in the Regional Study Area

Analysis of the vegetation RSA at baseline identified 51 ELC classes. Of the total classes identified, seven are disturbed land, four are wetland communities, four are natural non-forested, and the remainder are upland forest classes. The disturbed cover classes include settlement and linear disturbance (*i.e.* roads, pipelines). The baseline condition and fragmentation measures for ELC classes mapped in the vegetation RSA are presented in Table 3.8-7.

Of the natural ELC classes, 26 are rare, including closed regenerating forest (0.79% of RSA) (which is classified as disturbed land)and settlement (0.21%) map units. Mature closed coniferous forest (12.07%), mature open conifer forest (9.4%), and natural upland herb (13.56%) are the most abundant natural ELC classes within the RSA. Agriculture (9.51%) is the most abundant disturbed ELC class. At baseline, the industrial ELC class accounts for 1.12% of the area within the RSA. This is expected, as the RSA was selected to be large enough to accommodate wildlife species of interest to this assessment and to capture the existing and historical mines and settlements in the region. Mature dense mixed forest had the greatest mean distance to its nearest neighbour (5,440.6 m), barren land had the highest core index (90.9%), and mature open conifer forest had the highest patch density (99.9/km^2). Young dense mixed forest has the lowest mean patch area (0.9) and comprises <0.01% of the RSA, while barren lands had the lowest mean perimeter area (96.4 m/ha).

Table 3.8-7 Baseline Fragmentation in the Regional Study Area

ELC Class	# Patches	Patch Area (ha)		% of RSA[1]	Core Area		Patch Density (#/100 km²)	Total Perimeter (m)[1]	Mean Perimeter : Area (m/ha)	Mean Distance to Nearest Neighbour (m)
		Mean	Total[1]		Total (ha)[1]	Index (%)				
Upland Forested Communities										
Dense Conifer Forest – Young	83	6.4	528.5	0.20	418.9	79.3	2.9	117,393	222.1	713.5
Dense Conifer Forest – Mature	1,256	11.9	14,883.8	5.24	12,401.6	83.3	44.2	2,610,382	175.4	351.1
Dense Conifer Forest – Old	35	12.5	438.5	0.15	357.5	81.5	1.2	85,277	194.5	1,874.1
Dense Deciduous Forest - Young	9	8.8	79.2	0.03	63.2	79.8	0.3	16,690	210.7	4,665.3
Dense Deciduous Forest - Mature	184	6.2	1,144.3	0.40	888.5	77.7	77.7	272,072	237.8	481
Dense Deciduous Forest – Old	1	6.9	6.9	<0.01	4.4	64.2	64.2	2,797	404.1	-
Dense Mixed Forest – Young	4	0.9	3.7	<0.01	1.9	51.8	51.8	2,039	557.0	97.6
Dense Mixed Forest – Mature	10	10.1	101.4	0.04	79.9	78.8	78.8	22,976	226.6	5,440.6
Closed Conifer Forest – Young	327	6.9	2,249.8	0.79	1,813.9	80.6	80.6	473,652	210.5	518.6
Closed Conifer Forest – Mature	2,825	12.1	34,268.2	12.07	28,251.5	82.4	82.4	6,314,272	184.3	347.9
Closed Conifer Forest – Old	224	12.4	2,774.2	0.98	2,288.5	82.5	82.5	515,840	185.9	653.8
Closed Deciduous Forest - Young	110	8.2	900	0.32	695.4	77.3	77.3	214,729	238.6	809
Closed Deciduous Forest - Mature	671	7.3	4,921	1.73	3,776.5	76.7	76.7	1,201,574	244.2	472.5
Closed Deciduous Forest – Old	40	7.2	287.3	0.10	228.5	79.5	79.5	63,388	220.6	1,778.5
Closed Mixed Forest – Young	6	13.6	81.5	0.03	64.9	79.6	79.6	16,976	208.2	1,421.2
Closed Mixed Forest – Mature	135	6.1	824.2	0.29	612.8	74.3	74.3	224,325	272.2	748.6

Table 3.8-7 Baseline Fragmentation in the Regional Study Area

ELC Class	# Patches	Patch Area (ha)		% of RSA[1]	Core Area		Patch Density (#/100 km²)	Total Perimeter (m)[1]	Mean Perimeter : Area (m/ha)	Mean Distance to Nearest Neighbour (m)
		Mean	Total[1]		Total (ha)[1]	Index (%)				
Closed Mixed Forest – Old	16	5.0	79.6	0.03	58.8	73.9	73.9	22,292	280.2	1,939.7
Moderate Conifer Forest - Young	523	5.6	2,940.1	1.04	2,315.5	78.8	78.8	686,705	233.6	459.5
Moderate Conifer Forest - Mature	2,497	8.6	21,596	7.60	17,150.7	79.4	79.4	4,692,365	217.3	387.2
Moderate Conifer Forest – Old	435	9.7	4,223.7	1.49	3,417.8	80.9	80.9	878,987	208.1	535.2
Moderate Deciduous Forest - Young	96	4.8	465.6	0.16	343.5	73.8	73.8	130,851	281.1	1,023.8
Moderate Deciduous Forest - Mature	906	3.5	3,167.4	1.12	2,243.9	70.8	70.8	998,990	315.4	405.0
Moderate Deciduous Forest - Old	93	4.7	437.3	0.15	325.5	74.4	74.4	120,566	275.7	1,229.5
Moderate Mixed Forest - Young	15	11.5	172.1	0.06	139.7	81.1	81.1	33,304	193.5	1,736.0
Moderate Mixed Forest - Mature	976	3.6	3,496.6	1.23	2,353.9	67.3	67.3	1,252,686	358.3	301.0
Moderate Mixed Forest – Old	54	5.5	297.9	0.10	217.86	73.1	1.9	85,939	288.5	993.9
Open Conifer Forest – Young	578	7.0	4,066.2	1.43	3,226.1	79.3	20.4	903,237	222.1	471.5
Open Conifer Forest – Mature	2,837	9.4	26,698.2	9.40	21,508.2	80.6	99.9	5,469,809	204.9	367.1
Open Conifer Forest – Old	556	7.9	4,403.4	1.55	3,506.9	79.6	19.6	962,438	218.6	475.1
Open Deciduous Forest - Young	93	4.5	421.5	0.15	311	73.8	3.3	121,742	288.8	817.8
Open Deciduous Forest - Mature	256	6.0	1,546.4	0.54	1,166.9	75.5	9	405,568	262.3	697.3
Open Deciduous Forest – Old	54	7.0	378.8	0.13	293.8	77.5	1.9	90,335	238.5	1,447.1
Open Mixed Forest – Young	42	11.2	471	0.17	393.6	83.6	1.5	82,827	175.9	817.3

Table 3.8-7 Baseline Fragmentation in the Regional Study Area

ELC Class	# Patches	Patch Area (ha)		% of RSA[1]	Core Area		Patch Density (#/100 km²)	Total Perimeter (m)[1]	Mean Perimeter : Area (m/ha)	Mean Distance to Nearest Neighbour (m)
		Mean	Total[1]		Total (ha)[1]	Index (%)				
Open Mixed Forest – Mature	194	8.2	1,581.4	0.56	1,207.4	76.4	6.8	398,352	251.9	720.0
Open Mixed Forest – Old	29	4.6	133.1	0.05	96.5	72.5	1	38,840	291.8	1,757.8
Wetland Communities										
Graminoid Wetland	41	3.9	158.5	0.06	116	73.2	1.4	45,281	285.6	2,541.7
Shrubby Wetland	92	8.3	762.7	0.27	593.5	77.8	3.2	180,002	236.0	1,363.4
Treed Wetland	50	2.5	126.5	0.04	83.4	65.9	1.8	47,361	374.5	2,486.5
Open Water	404	3.8	1,544.0	0.54	1,032.1	66.8	14.2	543,614	352.1	759.4
Natural Non-Forested Land										
Lush Herb	142	2.5	352.0	0.12	207.6	59.0	5.0	157,694	447.9	284.5
Natural Shrubby	1,541	4.9	7,555.5	2.66	5,718.9	75.7	54.3	1,966,808	260.3	381.7
Natural Upland Herb	2,132	18.1	38,513.7	13.56	33,710.7	87.5	75.1	5,080,126	131.9	382.6
Barren Land	972	19.2	18,650.5	6.57	16,958.6	90.9	90.9	1,797,520	96.4	420.6
Disturbed Land										
Agriculture	855	31.6	27,010.6	9.51	24,505.6	90.7	90.7	2,647,318	98.0	443.9
Open Regeneration - Herbaceous	1,393	12.9	17,991.2	6.33	15,550.5	86.4	86.4	2,643,949	147.0	333.2
Closed Regeneration Forest	316	7.1	2,253.7	0.79	1,819.7	80.7	80.7	473,814	210.2	448.0

Table 3.8-7 Baseline Fragmentation in the Regional Study Area

ELC Class	# Patches	Patch Area (ha)		% of RSA[1]	Core Area		Patch Density (#/100 km²)	Total Perimeter (m)[1]	Mean Perimeter : Area (m/ha)	Mean Distance to Nearest Neighbour (m)
		Mean	Total[1]		Total (ha)[1]	Index (%)				
Open Regeneration – Shrub	1,453	12.1	17,631.8	6.21	15,030.3	85.2	85.2	2,782,662	157.8	335.6
Settlement	391	1.5	595.4	0.21	364.7	61.2	61.2	276,640	464.6	236.7
Linear Disturbance	4,936	1.5	7,626.1	2.69	2,711.2	35.6	35.6	8,975,492	1,176.9	265.1
Industrial (Mining)	647	4.9	3,183.6	1.12	2,638	82.9	82.9	605,254	190.1	426.9
Total (entire RSA)	**31,535**	**9.0**	**284,025**	**100.00**	**233,266.0**	**82.1**	**1,110.0**	**57,753,747**	**203.3**	**-**

[1] Due to rounding, totals may be different than sums, including from other Tables.

- not applicable.

3.9 Noxious and Invasive Species

The baseline field surveys identified nine noxious weeds, and 20 invasive vegetation species within the LSA (Table 3.9-1 and Appendix E). Locations of noxious weed and invasive species occurrences are presented in Figure 3.9-1 (noxious weeds only) and Appendix G. The majority of the noxious and invasive species were observed in areas with existing disturbance (*i.e.*, pipelines, well sites, clearings, pastures, cutblocks, and along roads).

Table 3.9-1 Noxious Weed and Invasive Species Identified in the Local Study Area

Scientific Name	Common Name
Noxious Weeds	
Bromus tectorum	downy brome
Chrysanthemum leucanthemum	ox-eye daisy
Cirsium arvense	canada thistle
Cynoglossum officinale	hound's-tongue
Echium vulgare	blueweed
Linaria dalmatica	dalmatian toadflax
Linaria vulgaris	common toadflax
Ranunculus acris	tall buttercup
Verbascum thapsus	common mullein
Invasive Species	
Agropyron repens	quack grass
Bromus inermis	smooth brome
Cerastium arvense	field chickweed
Cirsium vulgare	bull thistle
Dactylis glomerata	orchard grass
Glyceria grandis	great manna grass
Medicago lupulina	black medick
Phleum pratense	timothy
Plantago major	common plantain
Poa pratensis	kentucky bluegrass

Table 3.9-1 Noxious Weed and Invasive Species Identified in the Local Study Area

Scientific Name	Common Name
Potentilla argentea	silvery cinquefoil
Rumex crispus	curled dock
Senecio vulgaris	common groundsel
Taraxacum officinale	dandelion
Thlaspi arvense	stinkweed
Tragopogon dubius	common goat's-beard
Trifolium aureum	yellow clover
Trifolium hybridum	alsike clover
Trifolium pratense	red clover
Trifolium repens	white clover

3.10 Potential Acid Input and Nitrogen Deposition

The modelled baseline levels of PAI within the LSA and RSA ranged from 0.17 to 0.40 keq H^+/ha/yr. Modelled baseline levels for nitrogen deposition within the LSA and RSA ranged from 2.5 to 5.8 kg/ha/yr.

Baseline values of PAI exceed the critical values of soils with high sensitivity (0.25 keq H^+/ha/yr) and the Baseline Case for nitrogen deposition may exceed critical loads in isolated locations of conifer forest. Areas of exceedance are related to the settlements and transportation infrastructure currently in the study area.

4.0 ASSESSMENT CASES

This section will provide the assessment for the Application and Planned Development Cases (PDC). The assessments will focus on the Valued Components (VCs) that were identified for the Project.

4.1 Vegetation Community Classification

4.1.1 Application Case Effects on Ecosite Phases

The Project Footprint occupies 1,582.4 ha, which for the Application Case (maximum possible disturbance scenario) represents the disturbance of 22% of the LSA (Table 4.1-1). All ecosite phases mapped in the LSA also occur in the Project Footprint. Under the Application Case, the Project would remove 557.9 ha and 541.7 ha of ecosite phases in the Montane and Subalpine Natural Subregions, respectively. These include 1,096.5 ha (30.4% change from baseline) of land occupied by upland ecosite phases in both Subregions, and 3.1 ha (8.9% change from baseline) of lowlands mapped in the Montane Subregion. Project development would also reduce the baseline area of non-forested land by 52.8% (193.1 ha) and natural non-vegetated land by 10.7% (0.1 ha). The Project Footprint also encompasses approximately 288.7 ha of pre-existing anthropogenic disturbance associated with previous mining operations (165.3 ha), roads, and oil and gas developments. The previous mining operations are approximately 55 years old and have only partially revegetated by natural processes and require reclamation. The Project would add an additional 44.9% (1,293.7 ha) to the total anthropogenic disturbance in the LSA.

Table 4.1-1 Application Case Effects on Ecosite Phases in the Local Study Area

Ecosite Phase / Land Description[1]	Area[2]		Change from Baseline (Without Mitigation)	
	Baseline Case	Application Case	Area (ha)[2]	Percent Change (%)
Montane Ecosite Phases				
a1 - limber pine/juniper Fd-Pf	52.5	52.2	-0.3	-0.6
b1 - bearberry Pl	221.9	199.8	-22.1	-10.0
b2 - bearberry Aw	22.5	20.6	-1.9	-8.4
b3 - bearberry Aw-Sw-Pl	33.8	32.9	-0.9	-2.8
c1 - Canada buffalo-berry/hairy wild rye Fd	150.7	103.0	-47.7	-31.7
c2 - Canada buffalo-berry/hairy wild rye Pl	135.8	127.4	-8.5	-6.2
c3 - Canada buffalo-berry/hairy wild rye Aw	22.9	21.9	-1.0	-4.5
c4 - Canada buffalo-berry/hairy wild rye Aw-Sw-Pl-Fd	173.9	134.7	-39.2	-22.5
d1 - creeping mahonia – white meadowsweet Fd	89.0	59.4	-29.6	-33.3
d2 - creeping mahonia – white meadowsweet Pl	593.5	395.3	-198.3	-33.4
d3 - creeping mahonia – white meadowsweet Sw	25.7	19.0	-6.8	-26.3
e1 - thimbleberry/pine grass Pl	289.8	159.9	-129.9	-44.8
e2 - thimbleberry/pine grass Aw	75.4	26.2	-49.1	-65.2
e3 - thimbleberry/pine grass Se	81.8	77.0	-4.8	-5.9

Table 4.1-1 Application Case Effects on Ecosite Phases in the Local Study Area

Ecosite Phase / Land Description[1]	Area[2]		Change from Baseline (Without Mitigation)	
	Baseline Case	Application Case	Area (ha)[2]	Percent Change (%)
f1 - balsam poplar Pb	16.8	16.5	-0.3	-1.8
g1 - horsetail Sw-Pb	42.6	28.2	-14.4	-33.7
g2 - horsetail Sw	35.5	32.3	-3.1	-8.9
Total Montane Ecosite Phases	**2064.0**	**1506.1**	**-557.9**	**-27.0**
Subalpine Ecosite Phases				
a1 - lichen Pl	11.5	4.8	-6.6	-57.9
b1 - bearberry/hairy wild rye Pl	163.4	113.4	-50.0	-30.6
d1 - spruce/heather Se	0.8	0	-0.8	-100.0
e1 - false azalea – grouse-berry Pl	992.2	625.4	-366.8	-37.0
e2 - false azalea – grouse-berry Pw	3.4	0	-3.4	-100.0
e3 - false azalea – grouse-berry Se	207.0	196.5	-10.4	-5.0
e4 - false azalea – grouse-berry Fa	19.9	2.1	-17.9	-89.6
f1 - thimbleberry Pl	97.6	27.6	-70.0	-71.7
f2 - thimbleberry Fa-Se	47.3	42.4	-4.8	-10.2
h1 - horsetail Se	34.1	22.3	-11.8	-34.6
Total Subalpine Ecosite Phases	**1577.2**	**1034.6**	**-542.6**	**-34.4**
Non-Forested Land				
HG - Herbaceous – Grassland	320.6	160.0	-160.6	-50.1
NMR - Rock barren	38.8	10.7	-28.0	-72.3
SC - Closed shrub	0.3	0.2	0.0	-16.6
SO - Open shrub	10.0	5.6	-4.4	-43.9
Total Non-Forested Lands	**369.6**	**176.6**	**-193.1**	**-52.2**
Natural Non-Vegetated				
NWF - Flooded (areas periodically inundated with water)	0.8	0.8	-0.1	-6.3

Table 4.1-1 Application Case Effects on Ecosite Phases in the Local Study Area

Ecosite Phase / Land Description[1]	Area[2]		Change from Baseline (Without Mitigation)	
	Baseline Case	Application Case	Area (ha)[2]	Percent Change (%)
NWL - Seasonally thaws, lakes, ponds	0.3	0.2	-0.1	-25.8
NWR - River	<0.1	<0.1	0.0	0.0
Total Natural Non-Vegetated Land	**1.1**	**1.0**	**-0.1**	**-10.7**
Anthropogenic Disturbances[3]				
AIH - Permanent rights of way; roads, highways, railroads, dam sites, reservoirs	97.8	112.2	14.4	14.7
AII - Industrial (Plant sites), sewage, lagoons	0.2	0.2	0.0	0.0
AIM - Surface mines	165.4	1528.6	1363.2	824.4
ASC - Cities, towns, villages, hamlets	81.3	55.0	-26.3	-32.3
CC - Clearcut/partial cut	227.3	209.2	-18.1	-8.0
CIP - Pipelines, transmission lines, airstrips, microwave tower sites, golf courses, cemeteries	39.1	50.9	11.8	30.3
CIW - Geophysical activities, included well sites that have been seeded with annual crop	17.3	13.2	-4.1	-23.7
CL - Clearing (extent not required)	49.5	37.3	-12.2	-24.7
CO – Non-linear clearings	52.2	19.5	-32.7	-62.7
CP - Perennial forage crops	34.2	31.8	-2.4	-7.0
Total Anthropogenic Disturbances	**764.3**	**2057.9**	**1293.6**	**169.3**
Total Change (LSA)	**4776.2**	**4776.2**	**0.0**	**44.9**

[1] Ecosite phases are based on Archibald *et.al.* 1996. Anthropogenic disturbances, non-vegetated lands and other non-ecosite phase lands use AVI codes for land classification (ASRD 2005).

[2] Due to rounding of numbers, total values may not equal the sum of the individual values.

[3] Mine components were grouped into four anthropogenic map units (AIM, AIH, CIP, CL) for assessment of the maximum mine disturbance.

Table 4.1-1 provides the changes in area of various ecosite phases in the LSA as a result of the Project disturbance. The calculations were made without consideration of any mitigation. Mitigation measures will include recontouring, coversoil replacement, revegetation and reforestation activities that are discussed in Section 4.1.5 and in the Application, Section F – Reclamation Plan, (Benga 2015).

A portion of all ecosite phases of limited distribution occur in the Project Footprint and will be subject to removal. Their removal would represent a loss of 14.2% or 28.4 ha of ecosites of limited distribution in the LSA. Two ecosite phases, Subalpine ecosite phases d1 and e1, would be completely removed (100% change from baseline) from the LSA.

4.1.2 Application Case Effects on Ecological Land Classes

The proposed Project Footprint, which is 1,582.4 ha of the total LSA, would result in in a change of the ELC Classes mapped in the LSA (Table 4.1-2). Prior to mitigation, the baseline area of upland forest would be reduced by 29.3% (1, 093.8 ha) following Project development; the wetland areas would be reduced by 69.8% (12.2 ha), the natural non-forested land by 74.4% (47.1 ha), and the disturbed land by 44.5% (429.3 ha), including removing previously unreclaimed mining operations, roads and oil and gas developments.

Table 4.1-2 Application Case Effects on Ecological Land Cover Classes in the Local Study Area

ELC Class[1]	Area (ha)[2]		Change in Baseline (Without Mitigation)	
	Baseline Case	Application Case	Area (ha)[2]	% Change
Upland Forested Communities				
Dense Conifer Mature Forest	491.5	278.7	-212.8	-43.3
Closed Coniferous Mature Forest	1232.6	883.6	-349.0	-28.3
Closed Deciduous Mature Forest	17.4	17.4	0.0	0.0
Closed Mixed Mature Forest	16.7	0.0	-16.7	-100.0
Closed Mixed Old Forest	8.7	2.9	-5.9	-67.1
Moderate Conifer Young Forest	11.9	0.2	-11.7	-98.2
Moderate Conifer Mature Forest	958.0	688.6	-269.5	-28.1
Moderate Conifer Old Forest	78.8	77.6	-1.2	-1.6
Moderate Deciduous Old Forest	18.4	18.4	0.0	0.0
Moderate Mixed Mature Forest	44.4	10.9	-33.5	-75.5
Moderate Mixed Old Forest	30.5	29.3	-1.2	-3.9
Open Coniferous Mature Forest	767.4	594.0	-173.3	-22.6

Table 4.1-2 Application Case Effects on Ecological Land Cover Classes in the Local Study Area

ELC Class[1]	Area (ha)[2]		Change in Baseline (Without Mitigation)	
	Baseline Case	Application Case	Area (ha)[2]	% Change
Open Coniferous Old Forest	0.0	0.0	0.0	0.0
Open Deciduous Mature Forest	8.1	0.0	-8.1	-100.0
Open Deciduous Old Forest	32.3	32.3	0.0	0.0
Open Mixed Mature Forest	13.5	2.7	-10.9	-80.4
Total Upland Forest	**3730.4**	**2636.6**	**-1093.8**	**-29.3**
Wetland Communities				
Natural Graminoid Wetland	1.5	1.5	0.0	0.0
Treed Wetland	14.5	3.7	-10.7	-74.3
Open Water	1.4	0.0	-1.4	-100.0
Total Wetlands	**17.4**	**5.3**	**-12.2**	**-69.8**
Natural Non-Forested Land				
Natural Shrub	1.9	1.5	-0.3	-16.8
Natural Upland Herbaceous	52.8	10.5	-42.4	-80.2
Total Barren Land	8.6	4.2	-4.4	-51.0
Total Natural Non-Forested Land	**63.3**	**16.2**	**-47.1**	**-74.4**
Disturbed Land				
Open Regeneration – Herbaceous	170.0	101.5	-68.5	-40.3
Open Regeneration – Shrub	296.2	215.7	-80.5	-27.2
Settlement	56.0	46.6	-9.4	-16.8
Linear Disturbance	202.0	147.3	-54.7	-27.1
Industrial (Mining)	240.8	24.6	-216.1	-89.8
Total Disturbed Land	**965.0**	**535.7**	**-429.3**	**-44.5**
Total LSA	**4776.2**	**3193.8**	**-1582.4**	**-33.1**

[1] ELC Age classes are derived from the AVI stand origin data as follows:

- young deciduous and mixed =30-60 years;
- mature deciduous and mixed =61- 100;

Table 4.1-2 Application Case Effects on Ecological Land Cover Classes in the Local Study Area

ELC Class[1]	Area (ha)[2]		Change in Baseline (Without Mitigation)	
	Baseline Case	Application Case	Area (ha)[2]	% Change

- young conifer stands =30-70;
- mature pine dominated conifer =71-119;
- mature non-pine conifer =71-139;
- old growth deciduous and mixed stands >100;
- old pine stands >120; and
- old conifer (non-pine) stands >140.
- Crown closure classes are AVI codes of canopy closure (measured in %) as follows: Dense = 71-100, Closed = 51-70, Moderate = 31-50, and open = 6-30. Cover types are based on the proportion of conifer or deciduous species in the canopy. Deciduous ≥80% Deciduous, mixed =30-79% conifer / deciduous, conifer ≥80% conifer (ASRD 2005).

[2] Due to rounding of numbers, total values may not equal the sum of the individual values.

Table 4.1-2 provides the changes in area of various ELC classes in the LSA as a result of the Project disturbance. The calculations were made without consideration of any mitigation. Mitigation measures will include recontouring, coversoil replacement, revegetation and reforestation activities that are discussed in Section 4.1.5 and in the Application, Section F – Reclamation Plan, (Benga 2015), including previous mining areas in the Project Footprint.

4.1.3 Planned Development Case

In addition to the disturbances present at Baseline, the PDC includes the Assessment Case, forest harvesting (planned and predicted to 2056), Teck Coal Limited Coal Mountain Phase 2 Project, and the Alberta Transportation Highway 3 Re-alignment (Table 2.4-1). Throughout the lifetime of the Project an additional 624 ha of sustainable forest harvest is expected within the LSA while an additional 13,530.7 ha of forest harvesting is expected within the RSA. Approximately 158 ha of the planned forest harvest is scheduled to occur within the Project Footprint. Additional area disturbed by Tech Coal Limited is approximately 80.8 ha and the Highway 3 re-alignment will add 91.5 ha of additional disturbance.

Forest harvesting is the only PDC activity within the LSA. Forest harvesting is a highly regulated activity that requires protection of the soil resource, prompt reforestation, balance of stand age distribution within the forest management unit, and avoidance of sensitive areas and species (Government of Alberta 2010b). Sustainable forest harvesting thus does not result in a change of ecosite classification for harvest areas outside the Project Footprint.

Within the LSA, only two small mapped, but not surveyed ecosite phases (Subalpine Natural Subregion e2 and d1) will be completely removed due to the Project. These ecosite phases were identified from aerial imagery during the mapping process and are not uncommon in the region (Appendix C) with ecosite e being the modal ecosite for the subalpine region. With mitigation a variety of ecosite phases will be established (Application, Section F, Reclamation Plan) including Subalpine d and e ecosites. Establishing whitebark pine where practicable (*i.e.*, ecosite phase e2) is also included in the planned Project reclamation.

Because ecosite phase is an ageless classification system, the PDC assessment also utilizes the ELC classification. This allows for assessment of Project effects over time. Planned and predicted forest harvest areas are first placed into regenerating ELC class then aged as appropriate back toward the pre disturbance condition (overwhelmingly closed conifer ELC class). With the PDC, no ELC class of limited distribution is removed from the LSA or RSA during the project lifetime. When assessed at time 41 years cumulative changes in ELC class attributable to the project are insignificant. The greatest change over time in the RSA is due to forest harvesting (forest harvest blocks are categorized as Open Regeneration - Forest) followed by an increase in closed mature conifer forest (Table 4.1-3). Changes in ELC area and other characteristics for all time steps assessed (year 14, year 22, and year 41) are provided in Appendix H and included along with other assessed parameters in the biodiversity assessment (Tables 4.8-5, 4.8-7, 4.8-8).

Table 4.1-3 Planned Development Case Effects on Ecological Land Classes in the Regional Study Area

Ecological Land Class[1]	Baseline Case T41 (Area ha[2])	PDC T41 with Project with Mitigation (Area ha[2])	Baseline T41 – PDC T41 (Area ha[2])
Barren Land	18,650.5	1,8675	-24.5
Open Regeneration - Herbaceous	98	82.9	15.1
Open Regeneration – Shrub	0.5	0.5	0.0
Closed Regeneration - Forest	0.0	16,585.9	-16,585.9
Open Deciduous Young Forest	62.2	62.1	0.1
Open Deciduous Mature Forest	430.1	426.8	3.3
Open Deciduous Old Forest	1,922.9	1,839.0	83.9
Open Mixed Young Forest	0.0	0.0	0.0
Open Mixed Mature Forest	460.2	458.8	1.4

Table 4.1-3 Planned Development Case Effects on Ecological Land Classes in the Regional Study Area

Ecological Land Class[1]	Baseline Case T41 (Area ha[2])	PDC T41 with Project with Mitigation (Area ha[2])	Baseline T41 – PDC T41 (Area ha[2])
Open Mixed Old Forest	1,728.5	1,651.1	77.4
Open Conifer Young Forest	198.8	198.8	0.0
Open Conifer Mature Forest	2,0236.6	19,038.2	1,198.4
Open Conifer Old Forest	14,732.5	1,3074.2	1,658.3
Moderate Deciduous Young Forest	1.8	1.8	0.0
Moderate Deciduous Mature Forest	469.5	466.9	2.6
Moderate Deciduous Old Forest	3,616.2	3,558.6	57.6
Moderate Mixed Young Forest	0.0	139.8	-139.8
Moderate Mixed Mature Forest	172.1	169.8	2.3
Moderate Mixed Old Forest	3,794.5	3,701.4	93.1
Moderate Conifer Young Forest	149.9	129.4	20.5
Moderate Conifer Mature Forest	15,981.1	14,305.5	1,675.6
Moderate Conifer Old Forest	12,638.5	10,891.7	1,746.8
Closed Deciduous Young Forest	113.4	107.7	5.7
Closed Deciduous Mature Forest	986.7	901.7	85
Closed Deciduous Old Forest	5,208.3	5,169.5	38.8
Closed Mixed Young Forest	23,598.2	22,951.8	646.4
Closed Mixed Mature Forest	529.8	526.5	3.3
Closed Mixed Old Forest	950	882.1	67.9
Closed Conifer Young Forest	11,189.2	11,400.6	-211.4
Closed Conifer Mature Forest	31,526.8	26,795.2	4,731.6
Closed Conifer Old Forest	9,962.9	8,457.1	1,505.8
Dense Deciduous Mature Forest	79.2	79.2	0.0
Dense Deciduous Old Forest	1,151.2	1,147.6	3.6

Table 4.1-3 Planned Development Case Effects on Ecological Land Classes in the Regional Study Area

Ecological Land Class[1]	Baseline Case T41 (Area ha[2])	PDC T41 with Project with Mitigation (Area ha[2])	Baseline T41 – PDC T41 (Area ha[2])
Dense Mixed Mature Forest	3.7	0.6	3.1
Dense Mixed Old Forest	101.4	101.4	0.0
Dense Conifer Young Forest	0.0	0.0	0.0
Dense Conifer Mature Forest	14,164.4	11,200.3	2,964.1
Natural Shrub	7,555.5	7,547.8	7.7
Natural Upland Herbaceous	38,513.7	38,656.5	-142.8
Natural Graminoid Wetland	158.5	151.9	6.6
Natural Shrub Wetland	762.7	760.9	1.8
Treed Wetland	126.5	108.1	18.4
Industrial (Mining)	3,183.6	3,036.5	147.1
Settlement	595.5	585.9	9.6
Open Water	1,544	1,591.8	-47.8
Linear Disturbance	7,626.0	7,503.0	123
Agriculture	27,010.7	27,010.7	0.0
Dense Conifer Old Forest	1,686.4	1,540.5	145.9
Dense Deciduous Young Forest	0.0	0.0	0.0
Lush Herb	352.0	352.0	0.0

[1] Age classes are derived from the AVI stand origin data as follows:

- young deciduous and mixed = 30-60 years;
- mature deciduous and mixed = 61 – 100;
- young conifer stands = 30-70;
- mature pine dominated conifer = 71-119;
- mature non-pine conifer = 71-139
- old deciduous and mixed stands >100;
- old pine stands >120; and
- old non-pine conifer stands >140.
- Crown closure classes are AVI codes of canopy closure (measured in %) as follows: Dense = 71-100, Closed = 51-70, Moderate = 31-50, and open = 6-30.
- Cover types are based on the proportion of conifer or Deciduous species in the canopy. Deciduous = >80% Deciduous, mixed = 30-79% conifer / deciduous, conifer ≥80% conifer (ASRD 2005).

[2] Due to rounding of numbers, total values may not equal the sum of the individual values.

4.1.4 Sensitivity of Communities of Limited Distribution to Disturbance

Communities of limited distribution are more vulnerable to disturbance impacts and could drive overall diversity losses, even when the area disturbed is relatively small. Small habitats are known to support small populations (Soulé 1991, Scott *et al.* 1993) making them more vulnerable to undesirable change. Changes could occur due to a decline in the spatial extent of a given vegetation community (*e.g.*, ecosite phases) or a change in composition, structure, and function of the community (Noss 1990), even when surrounded by undisturbed plant communities.

Natural vegetation communities occurring in intensively disturbed landscapes are especially vulnerable to biodiversity losses driven by changes in species composition; *e.g.*, an increased abundance of early regeneration species in forested areas after fire or harvesting. These losses are especially important if the ecosites are of limited distribution, both locally and regionally, or if they constitute unique vegetation communities and habitats within a larger landscape. Biodiversity losses at the ecosite phase or plant community level are not always as obvious as those that occur at larger scales (*e.g.*, regional), therefore, small habitat types should be managed sustainably and at broader spatial scales (*i.e.*, landscape and regional scales in order to protect habitat for wildlife and other ecological services).

Within the RSA, terrain is the primary driver of plant community distributions. Many of the ELC classes identified as being of limited distribution may be naturally less abundant as they may occur as small bands of vegetation along a slope gradient. They also may be more abundant than indicated because small bands of vegetation along a topographic gradient would not be captured at the scale the RSA was mapped. The band of wetland and richer plant communities that occupy lower and toe slope positions provide some of the most critical ecological functions (*e.g.*, biodiversity, water attenuation and water quality) in the landscape (Government of Alberta 2013b). Higher elevation forested communities also provide critical ecological function by stabilizing slopes, trapping snow and providing critical habitat for sensitive species (Winkler *et al.* 2012).

Mitigation and monitoring strategies described in Section 4.1.5, including all reclamation plans, will aim at returning disturbed areas to meet equivalent land capability and to restore habitat connectivity and function.

4.1.5 Mitigation and Monitoring

Potential effects to vegetation and wetlands due to the Project would be mitigated through reclamation and re-vegetation activities. This includes the 288.7 ha of previous mining operations, roads and oil and gas developments in the Project Footprint; in particular the 165.3 ha of previous mining operations that have been left unreclaimed for approximately 55 years and have only partially revegetated. These reclamation and re-vegetation activities are discussed in the detail in the

Application, Section F, Reclamation Plan. Re-vegetation activities would aim for long-term establishment of vegetation communities of equivalent capability that existed within the area prior to the Project. Vegetation communities are determined by a combination of site conditions (slope, aspect, moisture and nutrient regimes), regional climate, surficial geologic conditions, and dominant vegetation species. Target future vegetation communities would be based on pre-existing (baseline) environmental conditions, and reclaimed landscape features such as slope position, soil type, moisture regime, nutrient regime, hydrology, aspect.

4.1.5.1 Mitigation

Once operations cease, final site grading/re-contouring, coversoil replacement and re-vegetation activities will take place. Reclaimed slopes that have a moderate to high potential for erosion, will have short-lived native graminoid species quickly established to provide cover and soil stability to prevent soil erosion. Eventually a mosaic of closed conifer forests, patches of moderate mixed forest and natural upland herbaceous grasslands will be established on the reclaimed lands. These will be placed in suitable areas and will resemble the pre-disturbance conditions. These are described further in the Application, Section F, Reclamation Plan (Benga 2015).

In approximately 65+ years, re-vegetated areas are expected to resemble targeted early succession vegetation communities. Species used for revegetation of disturbed Project sites, including tree seedlings, shrubs, and graminoids, are expected to exert an influence on the understory conditions (Halpern and Franklin 1990). Long term (>65 years) expectations are that as a canopy closes and understory conditions change, the composition of native species will increase, the structure will become more complex, and re-vegetated areas will increasingly resemble pre-disturbance landscapes (Willscher *et al.* 2010).

An adaptive management approach, including non-native invasive species control and monitoring, and re-vegetation establishment assessments will be used to ensure that sites have been re-vegetated to meet target vegetation communities.

Terrestrial vegetation mitigation measures will include:

- implementation of a re-vegetation program which aims at the establishment of target vegetation with equivalent capability;
  - seed steeper slopes to stabilize soil;
  - use natural recovery on areas with low erosion potential;
  - collect seed for trees and shrubs locally and store to use later;
  - use wildling transplants from adjacent undisturbed areas.

- develop a reclamation plan that includes the establishment of communities that are locally and regionally limited in distribution where conditions allow;
- preservation of adjacent vegetation communities by limiting disturbance to areas required for development of the Project;
- use of an appropriate soil substrate where re-vegetated areas can establish;
- seed coversoil stockpiles with suitable vegetation species mix to ensure long term stability of the soil piles, which reduces erosion and the potential for weed establishment;
- the use of coarse woody debris and direct soil placement techniques;
- the use of direct placement of soil for provision of propagules to enhance opportunity for re-establishment of native species composition and enhanced species richness;
- implement a weed management and control program;
- incorporate traditional use plants into the reclamation program; and
- establish multiple layers of native vegetation (*e.g.*, trees, shrubs and graminoids) to provide initial structure for wildlife habitat and to enhance biodiversity.

4.1.5.2 Monitoring

Re-vegetation monitoring should include:

- routine inspections of reclaim areas to identify erosion problems early so corrective actions can be taken including the establishment of vegetation;
- implement annual weed monitoring program;
- periodic assessment of the composition, structure, ecological succession and biodiversity of reclaimed vegetation through the establishment of long term monitoring plots (with a monitoring frequency of five – ten years); and
- periodic assessments of survival, growth and health assessments of re-vegetated areas to monitor the effectiveness of reclamation efforts relative to re-vegetation targets.

Monitoring should provide the information required for adaptive management. Information from early phases of reclamation to determine survival and growth should be used to revise and provide direction for reclamation and future closure monitoring.

4.1.6 Impact Rating

Potential effects of the Project on ecosite phases and ELC classes are related to clearing of vegetation and physical alteration of the landscape by the Project. The following assessment of the vegetation community classification VC has been completed with consideration of effective mitigation being applied.

- Geographic Extent: Project effects on plant communities are local in extent. Effects of the Project on vegetation communities is limited to direct removal. Conditions that would extend disturbance beyond the Footprint are limited due to the terrain and to the mitigation proposed for the Project. The final project contours, slopes and aspects are expected to provide for a range of ecosite communities similar to those in the region.
- Duration: The duration of the effects are extended. Reclaimed land will require time to develop mature forests and grasslands and for the return of the natural processes of disturbance and succession.
- Frequency: Effects will continue throughout the operational phase of the project and cease only after reclamation is completed.
- Ability for Recovery: Effects are reversible in the long term with the planned mitigation. Reclaimed terrain and soils will support establishment of native communities including previously disturbed areas, such as from previous mining operations, within the Project Footprint.
- Magnitude: The project effect will be of high magnitude due to the removal of vegetation and altering of the landscape. Project effects will exceed large scale natural disturbances such as fire and insect infestation and more closely resemble smaller scale disturbances such as landslide or other mass wasting events.
- Project Contribution: The project will have a neutral contribution with respect to vegetation communities. The reclaimed land will support a range of communities with equivalent capabilities to those of the surrounding lands and that existed prior to development. In addition, historical disturbances and other anthropogenic features will also be reclaimed.
- Confidence Rating: The confidence rating is high. The effect of the project is well understood as are the techniques used for revegetation. Use of proven techniques for revegetation will be supported by adaptive management and monitoring.
- Probability of Occurrence – Ecological Context: The probability of occurrence is high given the type of project and method of coal extraction.
- Significance: With mitigation the project effects are insignificant. No irreversible effects to sustainability of the resource are expected.

4.2 Rare Plants and Rare Plant Communities

4.2.1 Application Case

Construction and operation of the Project would result in the removal of all rare plants observed within the Project Footprint (Figure 3.2-1, Table 4.2-1). Of the 41 rare species (with 94 occurrences) identified in the LSA, 27 species (with 53 occurrences) were observed in the Footprint (Table 4.2-1). These species included 11 vascular plant species (32 occurrences), nine mosses and liverworts (11 occurrences) and seven lichen species (nine occurrences). All field observations of whitebark pine occurred within the mine portion and north disposal area of the Footprint. Three of the four occurrences of limber pine are within the Project Footprint with one occurrence in the north disposal area and two in the mine. Whitebark pine and limber were present as scattered individuals or groups of individuals growing in mixed stands.

Table 4.2-1 Application Case – Location and Effects on Rare Plants in the Proposed Project Footprint

Scientific Name	Common Name	[1]Easting	[1]Northing	Ecosite Phase	[2]SRANK	[3]GRANK	Footprint Component	Mitigation Proposed
Montane								
Vascular plants (5 species, 5 occurrences)								
Berberis repens	creeping mahonia	684906	5504171	c4	SS3	G5	Coal Handling and Process Plant	No species - specific mitigation
Carex petasata	pasture sedge	684008	5501787	c4	S1S2	G5	Overland Conveyor	No species - specific mitigation
Crepis atribarba	slender hawk's-beard	683910	5500890	AIH	S2	G5	Overland Conveyor	No species - specific mitigation
Pinus flexilis	limber pine	685311	5504575	c3	S2	G4	Coal Handling and Process Plant	No species - specific mitigation
Streptopus roseus	rose mandarin	684425	5502680	c1	S1	G5	Overland Conveyor	No species - specific mitigation
Mosses and Liverworts (1 species, single occurrence)								
Dicranum tauricum	broken-leaf moss	685404	5504169	c4	S1S2	G4	Ultimate Rock Disposal Area & Pit Extents	No species - specific mitigation
Lichens (3 species, 4 occurrences)								
Caloplaca sinapisperma	firedot licken	684008	5501787	c4	S2S3	GNR	Overland Conveyor	No species - specific mitigation
Hypogymnia rugose	wrinkled tube lichen	685404	5504169	c4	S1S2	G4G5	Ultimate Rock Disposal Area & Pit Extents	No species - specific mitigation
	wrinkled tube lichen	686162	5504314	c2	S1S2	G4G5	Ultimate Rock Disposal Area Extent	No species - specific mitigation
Nodobryoria abbreviate	tufted foxtail lichen	685404	5504169	c4	S1	G4?	Ultimate Rock Disposal Area & Pit Extents	No species - specific mitigation

Table 4.2-1 Application Case – Location and Effects on Rare Plants in the Proposed Project Footprint

Scientific Name	Common Name	[1]Easting	[1]Northing	Ecosite Phase	[2]SRANK	[3]GRANK	Footprint Component	Mitigation Proposed
Subalpine								
Vascular plants (8 species, 27 occurrences)								
Angelica dawsonii	yellow angelica	685345	5507690	e1	S3	G4	Ultimate Rock Disposal Area & Pit Extents	No species - specific mitigation
		685504	5506912	e1	S3	G4	Ultimate Rock Disposal Area & Pit Extents	No species - specific mitigation
		686339	5508418	e1	S3	G4	Ultimate Rock Disposal Area & Pit Extents	No species - specific mitigation
Carex petasata	pasture sedge	686495	5507364	a1	S1S2	G5	Ultimate Rock Disposal Area & Pit Extents	No species - specific mitigation
		685249	5509604	a1	S1S2	G5	Ultimate Rock Disposal Area Extent	No species - specific mitigation
Eriogonum cernuum	nodding umbrella-plant	684804	5509896	e1	S2	G5	Ultimate Rock Disposal Area Extent	No species - specific mitigation
Eucephalus engelmannii	elegant aster	685345	5507690	e1	S3S4	G4G5	Ultimate Rock Disposal Area & Pit Extents	No species - specific mitigation

Table 4.2-1 Application Case – Location and Effects on Rare Plants in the Proposed Project Footprint

Scientific Name	Common Name	[1]Easting	[1]Northing	Ecosite Phase	[2]SRANK	[3]GRANK	Footprint Component	Mitigation Proposed
Phacelia hastate	silver-leaved scorpionweed	686133	5506510	AIM	S3	G5	Ultimate Rock Disposal Area & Pit Extents	No species - specific mitigation
		684804	5509896	e1	S3	G5	Ultimate Rock Disposal Area Extent	No species - specific mitigation
		684804	5509896	e1	S3	G5	Ultimate Rock Disposal Area Extent	No species - specific mitigation
		686404	5506049	AIM	S3	G5	Ultimate Rock Disposal Area Extent	No species - specific mitigation
		685249	5509604	a1	S3	G5	Ultimate Rock Disposal Area Extent	No species - specific mitigation
Pinus albicaulis	whitebark pine	686309	5508184	e1	S2	G3G4	Ultimate Rock Disposal Area & Pit Extents	Cone collection and reintroduction by planting
		686315	5506607	e2	S2	G3G4	Ultimate Rock Disposal Area & Pit Extents	Cone collection and reintroduction by planting
		686315	5506607	e2	S2	G3G4	Ultimate Rock Disposal Area & Pit Extents	Cone collection and reintroduction by planting
		686495	5507364	a1	S2	G3G4	Ultimate Rock Disposal Area & Pit Extents	Cone collection and reintroduction by planting
		686495	5507364	a1	S2	G3G4	Ultimate Rock Disposal Area & Pit Extents	Cone collection and reintroduction by planting
		686304	5508161	e4	S2	G3G4	Ultimate Rock Disposal Area & Pit Extents	Cone collection and reintroduction by planting
		685249	5509604	a1	S2	G3G4	Ultimate Rock Disposal Area Extent	Cone collection and reintroduction by planting

Table 4.2-1 Application Case – Location and Effects on Rare Plants in the Proposed Project Footprint

Scientific Name	Common Name	[1]Easting	[1]Northing	Ecosite Phase	[2]SRANK	[3]GRANK	Footprint Component	Mitigation Proposed
		685249	5509604	a1	S2	G3G4	Ultimate Rock Disposal Area Extent	Cone collection and reintroduction by planting
		685249	5509604	a1	S2	G3G4	Ultimate Rock Disposal Area Extent	Cone collection and reintroduction by planting
		686097	5509115	e1	S2	G3G4	Ultimate Pit Extent	Cone collection and reintroduction by planting
Pinus flexilis	limber pine	685885	5507039	e1	S2	G4	Ultimate Rock Disposal Area & Pit Extents	Cone collection and reintroduction by planting
		686304	5508161	e4	S2	G4	Ultimate Rock Disposal Area & Pit Extents	Cone collection and reintroduction by planting
		685249	5509604	a1	S2	G4	Ultimate Rock Disposal Area Extent	Cone collection and reintroduction by planting
Piperia unalascensis	Alaska bog orchid	685345	5507690	e1	S2?	G5	Ultimate Rock Disposal Area & Pit Extents	No species - specific mitigation
		686808	5505278	c3	S2?	G5	Ultimate Rock Disposal Area Extent	No species - specific mitigation

Table 4.2-1 Application Case – Location and Effects on Rare Plants in the Proposed Project Footprint

Scientific Name	Common Name	[1]Easting	[1]Northing	Ecosite Phase	[2]SRANK	[3]GRANK	Footprint Component	Mitigation Proposed
Mosses and Liverworts (9 Species, 10 occurrences)								
Chiloscyphus polyanthus	liverwort	685956	5508648	e1	S1	G5	Ultimate Rock Disposal Area & Pit Extents	No species - specific mitigation
Dicranella crispa	curl-leaved fork moss	685380	5508200	e1	S2	G3G5	Ultimate Rock Disposal Area & Pit Extents	No species - specific mitigation
Dicranum tauricum	broken-leaf moss	687058	5509102	f1	S1S2	G4	Ultimate Pit Extent	No species - specific mitigation
Lophozia ascendens	liverwort	686155	5509115	e1	S1	G4	Ultimate Pit Extent	No species - specific mitigation
Lophozia longidens	liverwort	686339	5508418	e1	S1	G5	Ultimate Rock Disposal Area & Pit Extents	No species - specific mitigation
Lophozia wenzelii	liverwort	686339	5508418	e1	S1	G4G5	Ultimate Rock Disposal Area & Pit Extents	No species - specific mitigation
Pellia neesiana	liverwort	685956	5508648	e1	S2	G5	Ultimate Rock Disposal Area & Pit Extents	No species - specific mitigation
		685997	5508606	e1	S2	G5	Ultimate Rock Disposal Area & Pit Extents	No species - specific mitigation
Rhytidiopsis robusta	pipecleaner moss	685380	5508200	e1	S3	G4	Ultimate Rock Disposal Area & Pit Extents	No species - specific mitigation
Schistidium tenerum	thread bloom moss	686309	5508184	e1	S2	G5?	Ultimate Rock Disposal Area & Pit Extents	No species - specific mitigation

Table 4.2-1 Application Case – Location and Effects on Rare Plants in the Proposed Project Footprint

Scientific Name	Common Name	[1]Easting	[1]Northing	Ecosite Phase	[2]SRANK	[3]GRANK	Footprint Component	Mitigation Proposed
Lichens (4 species, 5 occurrences)								
Cladonia symphycarpia	split-peg lichen	685473	5506349	e1	S2	G5	Ultimate Rock Disposal Area & Pit Extents	No species - specific mitigation
Umbilicaria Americana	american rock trip lichen	686309	5508184	e1	S2S3	G5?	Ultimate Rock Disposal Area & Pit Extents	No species - specific mitigation
Vulpicida Canadensis	brown-eyed sunshine lichen	686339	5508418	e1	S2	G3G5	Ultimate Rock Disposal Area & Pit Extents	No species - specific mitigation
		686155	5509115	e1	S2	G3G5	Ultimate Pit Extent	No species - specific mitigation
Xylographa parallela	black woodscript lichen	687058	5509102	f1	S2S4	G5	Ultimate Pit Extent	No species - specific mitigation

[1]UTM coordinates NAD83

[2]SRANK refers to subnational (Alberta) conservation rank. Refer to Section 1.4.2 for definitions of rankings

[3]G RANK refers to global conservation rank. Refer to Section 1.4.2 for definitions of rankings

4.2.2 Application Case Effects on Rare Plant Potential

Project construction and development would reduce the area of the LSA with high potential to support rare plants by 13.1% (36.8 ha) in the Montane Natural Subregion and 40.5% (482.9 ha) in the Subalpine Natural Subregion from the Baseline Case (Table 4.2.2). Areas with moderate potential for rare plant species would decrease by 30.7% and 23.2%, in the Montane and Subalpine Subregions, respectively, with low potential areas being reduced by 21.7% and 37.0%, respectively.

Table 4.2-2 Application Case Effects on Rare Plant Potential in the Local Study Area

Rare Plant Potential	Ecosite Phase / Land Class[1]	Area (ha)[2]		Change from Baseline (Without Mitigation)	
		Baseline	Application Case	Area (ha)[2]	Percent Change (%)
Montane					
High	b1, f1, g1	281.3	244.5	-36.8	-13.1
Moderate	a1, c1, c2, c4, d2 d3, e1, e2, e3, g2, HG, SC	1,770.0	1,226.0	-544.0	-30.7
Low	b2, b3, c3, d1, SO	174.5	136.7	-37.8	-21.7
Total Montane	**-**	**2,225.8**	**1,607.2**	**-618.6**	**-27.8**
Subalpine					
High	e1, h1, HG	1,191.7	708.8	-482.9	-40.5
Moderate	a1, d1, e2, e3, f1, f2	367.6	271.4	-96.2	-26.2
Low	b1, c4	1,83.3	115.5	-67.9	-37.0
Total Subalpine	**-**	**1,742.6**	**1,095.7**	**-646.9**	**-37.1**
Total LSA	**-**	**3,968.4**	**2,702.9**	**-1,265.5**	**-31.9**

[1]Ecosite phases / land class descriptions are as provided in Table 4.1-1.

[2]Baseline and application case areas and rare plant potential for each ecosite / land class are provided in Table 4.1-1. Due to rounding of numbers, total values may not equal the sum of the individual values.

4.2.3 Application Case Effects on Rare Plant Community Potential

Project construction and development will reduce the area of the LSA with high / very high potential to support rare plant communities by 27.3% (56.6 ha) in the Montane and 63.8% (107.7 ha) in the Subalpine Natural Subregion (Table 4.2.3). Areas with moderate potential for rare plant communities will decrease by 25.7% and 20.4%, in the Montane and Subalpine Natural Subregions, respectively; low potential areas will be reduce by 28.6% and 38.6% from baseline.

Table 4.2-3 Application Case Effects on Rare Plant Community Potential in the Local Study Area

Rare Plant Community Potential	Ecosite Phase / Land Class Description[1]	Area (ha)[2]		Change from Baseline (Without Mitigation)	
		Baseline	Application Case	Area (ha)[2]	Percent Change (%)
Montane					
High / Very high	a1, HG	207.7	151.0	-56.6	-27.3
Moderate	b3, c4, d3, e2, e3, g1, g2, NMR, SC	471.9	350.6	-121.3	-25.7
Low / Very low	b1, b2, c1, c3, d1, d2, e1, f1, SO	1,549.1	1,105.6	-443.6	-28.6
Total Montane	**-**	**2,228.6**	**1,607.2**	**-621.5**	**-27.9**
Subalpine					
High	e2, HG	168.9	61.2	-107.7	-63.8
Moderate	a1, d1, e3, e4, f2, NMR	322.4	256.6	-65.8	-20.4
Low	b1, e1, f1, h1, SO	1290.9	792.3	-498.5	-38.6
Total Subalpine	**-**	**1,782.1**	**1,110.1**	**-672.0**	**-37.7**
Total LSA	**-**	**4,010.8**	**2,717.3**	**-1293.5**	**-32.3**

[1] Ecosite phases / land class are from Archibald *et.al.* 1996 and ASRD 2005.

[2] Baseline and Application Case areas and rare plant potential community for each ecosite / land class are provided in Table 4.1-1. Due to rounding of numbers, total values may not equal the sum of the individual values.

4.2.4 Planned Development Case

Inclusion of the projects identified for the PDC (with only a single mine expansion and logging activities) and their effects with respect to rare plants and rare plant potential does not materially differ from the Application case; therefore, a PDC assessment was not required. One exception is whitebark pine and limber pine, which are subject to a regional recovery plan and are discussed separately in Section 4.2.6 of this assessment. Rare species are considered and discussed within the biodiversity regional assessment (Section 4.8).

4.2.5 Sensitivity of Rare Plants to Disturbance

Rare vegetation species are frequently composed of peripheral populations located at the edge of the species' range. These populations commonly have ecological value (Lesica and Allendorf 1995; Leppig and White 2006), and unique genetic and morphological lineages that influence divergence along novel evolutionary pathways (Lesica and Allendorf 1995). Maintenance of genetic variation by rare plants increases the probability of overall species sustainability (Lesica and Allendorf 1995). Areas with peripheral populations often act as refugia during catastrophic range contractions (Channell and Lomolino 2000). Peripheral plant populations also provide the flexibility required for responding to stochastic environmental events such as global climate change (Leppig and White 2006, Thuiller *et al.* 2008). Rare vegetation species can be threatened by changes to land usage.

4.2.6 Mitigation and Monitoring

Vegetation species ranking in Alberta is largely determined by the number of times an observation is reported in the province. Based on this system, low profile, difficulty to locate, and hard to identify species are more likely to be listed as rare (ABMI 2007). It is difficult to determine if some species are rare or at the edge of their natural range. Taxonomic uncertainty and misidentification may also result in the rare status of certain species.

Two vascular plant species (whitebark pine), one moss species (curl-leaved fork moss), and one lichen species (brown-eyed sunshine lichen) with provincial rankings of S1 to S3 and global rankings of potentially less than G4, indicating potential rarity were documented during field sampling for this assessment (Table 3.2-1). The global ranks for these three species are currently G3, but may be G4 or G5 after all historical data and likely habitats have been checked. As a result, their status as rare plant species is uncertain. Whitebark pine is subject to a regional recovery plan as is limber pine though its global status is G4 (secure under present conditions).

Avoidance of rare plant species ranked between S1 and S3 is usually the more preferred option; however, where avoidance is not an option; site and species-specific mitigation planning is required. Transplanting rare plants from one location to another is a mitigation strategy. This has been shown to have a low rate of success for rare vascular vegetation (Allen 1994, Howald 1996). It is even more difficult for non-vascular lichen and bryophyte species, as they often have specific microclimate requirements and/or symbiotic relationships that must remain intact for survival, which makes transplanting not a viable option.

A key mitigation strategy for mining projects is completion of reclamation. During the reclamation process new landforms are created which should have a wide range of site conditions that will resemble pre-disturbance conditions. This will facilitate the establishment of diverse communities and provide niche habitats for rare species. In time, re-vegetated landscapes should begin to function like natural communities.

4.2.6.1 Mitigation

4.2.6.1.1 Whitebark Pine

Whitebark pine is designated as an endangered species in the Alberta Wild Species General Status Listing - 2010 (AESRD 2010a) and is a *SARA* listed Schedule 1 species in the provinces of Alberta and British Columbia. Based on its provincial and federal rare plant status an Alberta whitebark pine recovery plan (WBP Recovery Plan) was established by the Alberta Whitebark and Limber Pine Recovery Team (2014a). The goal of this plan is "*to conserve existing populations and habitat while restoring populations across its current and historical provincial range in sufficient numbers to continue functioning in its ecological role*." (Alberta Whitebark and Limber Pine Recovery Team 2014a).

To support this goal, the recovery team established four objectives and nine strategic approaches within the plan. The four goals are:

- reduce the direct mortality of whitebark pine;
- develop and introduce white pine blister rust-resistant strains;
- conserve genetic diversity; and
- manage habitat and natural regeneration.

The nine strategic approaches are:

- population monitoring;
- tree and stand protection;
- conservation of genetic resources;
- habitat management;
- education and outreach;
- research that will elucidate or facilitate recovery actions;
- plan management and administration;

- resource acquisition; and
- collaboration among agencies, jurisdictions, and stakeholders.

Mitigation measures have been developed around the objectives and approaches outlined in the Alberta WBP Recovery Plan.

4.2.6.1.1.1 Reduction of the Direct Mortality of Whitebark Pine

The mine plan has been developed to keep the disturbance to a minimum. The external rock disposal areas were kept to a minimum with only two being proposed. Most of the rock material will be disposed of within the mined out pit areas, which helps to keep the disturbance Footprint considerably smaller than if additional external disposal areas were proposed. This effort to keep the disturbed area to a minimum has successfully avoided the known historical populations of whitebark pine in the LSA.

4.2.6.1.1.2 Develop and Introduce White Pine Blister Rust-Resistant Strains

The Alberta WBP Recovery Plan states that habitat loss or alteration from commercial, industrial and/or recreational activities are threats to whitebark pine habitats; however, these threats are considered low to moderate in severity and local in effect (Alberta Whitebark and Limber Pine Recovery Team 2014). The Alberta WBP Recovery Plan identifies that the highest severity threats to whitebark pine throughout its range are white pine blister rust (*Cronartium ribicola*) and mountain pine beetle (*Dendroctonus ponderosae*) infestation. Based on this, a mitigation measure for the Project will include the introduction of white pine blister rust resistant strains during reclamation phases. The provincial recovery plan for this species includes criteria for identifying disease resistant trees and establishing greenhouses to propagate resistant seedlings for future reintroduction. Mitigation will include participation in this provincial recovery program.

Robin *et al.* (2008) describe whitebark pine as a shade-intolerant species that can thrive in poor soils and harsh, relatively dry conditions unsuitable for other tree species. Whitebark pine is an early colonizer of disturbed sites such as burned areas, landslides, and avalanche slopes (Tomback *et al.* 2001). These characteristics make whitebark pine a suitable species for planting during mine reclamation. In particular, where steep terrain and the lack of deep topsoil limit the establishment of other tree species, whitebark pine may be re-established.

4.2.6.1.1.3 Conserve Genetic Diversity

To conserve genetic diversity, clusters of whitebark pine within the Project Footprint will be investigated for their suitability for cone/seed collection prior to disturbance (Mahalovich and Dickerson 2004). Whitebark pine trees within the disturbance Footprint that are healthy and free of disease will have the cones collected after harvesting is completed. The cones will be provided to greenhouse and seed will be extracted and stored until needed for the reclamation program. Seed will also be made available to support the Alberta WBP Recovery Plan.

4.2.6.1.1.4 Manage Habitat and Natural Regeneration

Where practicable, whitebark pine will be planted on specific areas of the mine during reclamation phases. Robin *et al.* (2008) and Waring *et al.* (2012) outline conditions and strategies required for establishing whitebark pine, which include:

- identification of high light, low competition sites;
- planting in pure stands or patches to avoid competition from other trees;
- avoidance of potential swales and frost pockets;
- creation of microsites for seedling establishment (rocks, stumps or other coarse woody debris);
- use of recommended spacing to avoid interspecies competition; and
- preferentially planting seedlings in the fall to avoid hot dry summer conditions.

4.2.6.1.2 Limber Pine

Limber pine is designated as an endangered species in the Alberta Wild Species General Status Listing and is a SARA listed Schedule 1 species in the provinces of Alberta. Based on its provincial and federal rare plant status an Alberta limber pine recovery plan was established by the Alberta Whitebark and Limber Pine Recovery Team (2014b). The recovery plan includes the same four goals and nine strategies as described above (Section 4.2.6.1.1) for whitebark pine.

Like whitebark pine, limber pine is threatened by white pine blister rust and mountain pine beetle infestation. Also like whitebark pine, limber pine can establish and grow on shallow soils, exposed, rocky and dry sites not suitable for the establishment of other tree species. This makes limber pine an appropriate species for use in reclamation.

Mitigation measures have been developed around the objectives and approaches outlined in the Alberta WBP Recovery Plan.

4.2.6.1.2.1 Reduction of the Direct Mortality of limber Pine

No historical populations of limber pine have been reported within the Project Footprint (Figure 3.2-2). No large stands of limber pine were observed during mapping of the LSA; however three occurrences of limber pine within the Project Footprint and one outside the Footprint were found during field investigations in 2014. Efforts were made to keep the Project disturbance area to a minimum. The external rock disposal areas were kept to a minimum with only two being proposed. Most of the rock material will be disposed of within the mined out pit areas, which helps to keep the disturbance Footprint considerably smaller than if additional external disposal areas were proposed. This effort to keep the disturbed area to a minimum has successfully avoided the known population of limber pine outside the Footprint.

4.2.6.1.2.2 Develop and Introduce White Pine Blister Rust-Resistant Strains

The Alberta Limber Pine Recovery Plan (Alberta Whitebark and Limber Pine Recovery Team 2014b) states that habitat loss or alteration from commercial, industrial and/or recreational activities are threats to limber pine locally. The most significant threats across the limber pine range are white pine blister rust and mountain pine beetle infestation. Based on this, a mitigation measure for the Project should include the introduction of white pine blister rust resistant strains during reclamation phases. At this time the methodology for identifying resistant trees is not fully developed. Development of selection criteria for identifying resistant trees is prioritised in the recovery plan and may be available in a few years. When made available the criteria should be used to identify trees and determine if cone/seed collection should be done as described for whitebark pine.

4.2.6.1.2.3 Conserve Genetic Diversity

To conserve genetic diversity, clusters of limber pine within the Project Footprint will be investigated for their suitability for cone/seed collection prior to disturbance. The cones will be provided to greenhouse and seed will be extracted and stored until needed for the reclamation program. Seed will also be made available to support the Alberta Limber Pine Recovery Plan.

4.2.6.1.2.4 Manage Habitat and Natural Regeneration

Where practicable, limber pine will be planted on specific areas of the mine during reclamation phases. Suitable post mine habitat for planting of limber pine will in most cases also be suitable for whitebark pine. Whitebark pine, due to its greater vulnerability and limited range, should be preferred over limber pine for reclamation. No specific recommendations for planting of limber pine are available at this time; trails are underway. Recommendations described above for planting of whitebark pine should also be used when planting limber pine until specific guidance is available.

4.2.6.1.3 Other Rare Plants

Species specific mitigation is not recommended for species other than whitebark pine and limber pine. General mitigation for rare plants include:

- provide a heterogeneous soil surface with a variety of microsites to promote diversity and increased opportunity for natural revegetation;
- preserving adjacent vegetation communities by minimizing the area required for construction and operation of the Project; and

- where practical use adjacent forest floor (LFH) for provision of propagules to enhance opportunities for re-establishment of native species.

4.2.6.2 Monitoring

The following are the monitoring plans for whitebark pine and limber pine:

- identify all limber pine and whitebark pine in advance of tree clearing in the Footprint;
- assess which whitebark pine trees are free of disease in the Footprint and mark these individual trees so the cones can be collected before any clearing starts;
- careful control of the collected seed and seedling growth when preparing for reclamation; and
- monitor the success of all limber and whitebark pine planted seedlings on reclaimed or offset areas.

4.2.7 Impact Rating

The Potential effects of the Project on rare plants and rare plant potential are related to clearing of vegetation and physical alteration of the landscape of the Project. The following assessment of this VC has been completed with consideration of effective mitigation being applied.

- Geographic Extent: Project impacts on rare plants and rare plant communities are local in extent and limited to the Project Footprint. Project effects on whitebark and limber pine is regional in extent due to the requirement for preservation of genetic diversity and potential disease resistant seed.
- Duration: The duration of the effects are extended. Reclaimed land will require time to develop mature forests and grasslands and for the return of the natural processes of disturbance and succession. Until natural processes of disturbance and succession return to the landscape the opportunity for rare plant community development will be limited. The variety of open niches may promote establishment of individual rare species soon after reclamation but this will diminish over time as the plant communities establish equilibrium with site conditions. Both whitebark pine and limber pine are slow maturing species and will not produce seed for several decades after establishment. Duration for these species is also extended.
- Frequency: Effects will continue throughout the operational phase of the project and cease only after no more land is cleared.
- Ability for Recovery: Effects are reversible in the long term with the planned mitigation. Reclaimed terrain and soils will support establishment of native communities and the eventual return of natural process. Inclusion of disease resistant pine with the reclamation will mitigate for the limited losses of trees during operations.

- Magnitude: Effects will initially be of high magnitude with clearing of vegetation and mining operations exceeding that of large natural disturbances including fire and insect infestations.
- Project Contribution: The project will have a negative contribution for some rare plants removed during clearing and mining as there is no assurance that they will return after reclamation. The project will have a positive contribution for whitebark pine with the establishment of disease resistant trees on the reclaimed landscape. Where reclaimed terrain may support whitebark pine and limber pine, whitebark pine will be preferentially planted. Project effects on limber pine will be neutral with preservation of genetic diversity but limited reestablishment.
- Confidence Rating: The confidence rating is high. Although the rare species rankings (S and G ranks) for many of the species found is uncertain the effect of the project is well understood.
- Probability of Occurrence – Ecological Context: The probability of occurrence is high given the type of project.
- Significance: With mitigation the project effects are insignificant. The project reclamation includes establishing terrain and species that may support diverse communities and will also assist in preservation of whitebark pine and limber pine in the region.

4.3 Rangeland Resources

4.3.1 Application Case

The areas of native grasslands, including description of the specific native communities, in the LSA potentially impacted by the proposed Project are presented in Table 4.3-1. The Project would remove 56.3 ha (36.3%) of native montane grassland and 104.3 ha (63.0%) of native subalpine grassland in the LSA. Approximately 50% of the native grasslands within the LSA would be removed.

Table 4.3-1 Application Case - Effects on Native Grasslands in the Local Study Area

Range Type Community	Area (ha)		Change from Baseline	
	Baseline	Application	Area (ha)	% Change
Montane: b1 ecosite phase[1] Rough Fescue-Idaho Fescue-Parry Oatgrass	155.2	56.3	98.9	36.3
SASMA2[2] Rough Fescue-Sedge	165.5	104.3	61.2	63.0
Total	**320.7**	**174.9**	**145.8**	**45.5**

[1] Willoughby *et al.* 2005.
[2] Willoughby and Alexander 2006.

The exact time required to restore soils disturbed by industrial development and for native grassland communities to regenerate to pre-disturbance conditions has not been documented, however estimates of more than 30 years have been suggested (AESRD 2011).

Reclamation success of rough fescue communities has been limited to date due to the lack of tools and knowledge to reliably restore rough fescue communities (ESRD 2010). While it is unlikely in the short-term (within five - ten years) the Montane and Subalpine locations can be returned to pre-disturbance baseline conditions, it is anticipated that the affected area(s) will be returned at the conclusion of the Project to an equivalent land capability community type similar to the climax and successional grassland communities described in Willoughby *et al.* 2005 and Willoughby and Alexander 2006.

4.3.2 Planned Development Case

In addition to the disturbances present at Baseline, the PDC includes the Project, forest harvesting (planned and predicted to 2056), Teck Coal Limited Coal Mountain Phase 2 Project, and the Alberta Transportation Highway 3 Re-alignment (Table 2.4-1). The majority of the rangeland resources within the LSA and RSA are located on steeper slopes that are not subject to forest harvest or other types of disturbances identified for the PDC. Inclusion of the projects identified for the PDC and their effects on rangeland resources along with the Project, does not differ from the Application case; subsequently, a PDC assessment was not completed.

4.3.3 Sensitivity of Range Health and Fescue Grasslands to Disturbance

Long-term restoration success of native rough fescue communities has yet to be demonstrated and documented on industrial sites subjected to a full range of production and operational disturbance related activities (AESRD 2010b). Fescue plant communities have failed to be restored through natural recovery as they cannot compete with invasive non-native plants. Additionally, the seeding of disturbed sites with native plant cultivars has resulted in limited success in reducing non-native species invasion (AESRD 2010b).

It was reported in a study of reclaimed pipeline right-of-ways (ROWs) in the Foothills Fescue, Foothills Parkland, and Montane Natural Subregions that reclamation at 80% of the sites was unlikely to result in rough fescue restoration, thereby affecting the health and function of these areas (Desserud 2006). At approximately 20% of the sites, elements of reclamation success were present, based on vegetation cover, but the sites had less topsoil, higher clay content, more bare soil, less plant litter, and reduced range health scores when compared to adjacent undisturbed controls (Desserud 2006). The factors attributed to the lack of success were construction outside of the dormant period for rough fescue of August 1 to March 31 and full ROW stripping techniques. Areas where reclamation success was achieved were on hillcrests and south facing slopes, where aridity was considered to be a contributing factor to the success (Desserud 2006).

4.3.4 Mitigation and Monitoring

4.3.4.1 Mitigation

The preferred primary mitigation strategy for native rough fescue communities is avoidance (Graminae 2009) by siting developments adjacent to existing transportation corridors, trails, cultivated lands or improved pastures (Desserud 2006, AESRD 2010b). Plot GM401BE is located within the LSA and will not be impacted by the proposed Project Footprint. This particular rangeland feature will be avoided. Avoidance is not feasible for the other areas of native rough fescue grasslands, as they are within the proposed mine pit and rock disposal areas.

In addition to avoidance, (where possible) the following mitigation strategies will be implemented during Project activities:

- minimize overall project disturbance;
- prior to any soil disturbance, native seeds will be collected to be used for future phased reclamation if the opportunity arises for their use in areas that are representative of pre-disturbance habitats; and
- identify potential areas on hill crests and southern aspects where native seed collected could be planted to establish native fescue grasslands.

As the growth of native fescue grasslands may require a long period of time, the majority of early stage reclamation will use a certified, weed-free native seed mix that is representative of the range type communities identified in Table 4.3-1 for the reclamation of natural upland herbaceous grasslands. Specifically, the *C5 Forest Management Plan 2006-2026 (*Government of Alberta 2010b) recommends that for reclamation work to adhere to the *Native Plant Revegetation Guidelines for Alberta – February 2001* (Native Plant Working Group 2000). These guidelines state that seed mixes and the accompanying seed certificates of analysis be submitted to the appropriate AEP staff for approval prior seed application.

4.3.4.2 Monitoring

Well-designed monitoring programs are very important during the first five years following construction and reclamation, and long term monitoring programs are recommended for disturbance and reclamation of rough fescue grasslands (AESRD 2011). Range health assessment of natural upland herbaceous grasslands would be conducted at Year five and Year ten once each reclamation phase has been completed. Additional annual range health assessments would be conducted after

Year ten should the results of the range health assessments indicate that the range health functions of the community are not being restored.

4.3.5 Impact Rating

Potential effects of the Project on Rangeland Resources are related to clearing of vegetation and physical alteration of the landscape of the Project. The following assessment of this VC has been completed with consideration of effective mitigation being applied.

- Geographic Extent: The geographical impact will be of a local geographic extent, limited to the mine, disposal area dumps, access roads, and associated infrastructure.
- Duration: The duration of the impacts will be extended as the Project disturbance continues over the operational phase of the mine. The impacts will be extended during the early stages of the reclamation stage of the Project while natural succession processes develop, but the impacts will diminish with time.
- Frequency: Effects will continue throughout the operational phase of the project and cease only after reclamation is completed.
- Ability for Recovery: Reclaimed terrain and soils will support establishment of native communities and include slope and aspect conditions suitable for rough fescue. Present reclamation techniques for native rough fescue grassland communities have met with limited success; however, the Project has an expected reclamation period of approximately 12 years and will include adaptive management (Application, Section F, Conservation and Reclamation Plan) which may allow for improved reclamation techniques to be developed. Based on this, the impacts to the rough fescue grasslands communities are anticipated to be reversible in the long term with the planned mitigation.
- Magnitude: The Project will have a high magnitude during the operational phase of the Project due to the removal of the rangeland resource. It is expected over time that the magnitude to the range health of the rangeland resource will diminish to moderate during the reclamation phase of the Project as the natural upland herbaceous grasslands establish and associated natural processes commence.
- Project Contribution: The project will have a neutral contribution. The initial contribution will be negative due to the removal of the rangeland resource during the operational phase. However, the reclaimed land will support a range of communities with equivalent capabilities to those of the surrounding lands and that existed prior to development.
- Confidence Rating: The confidence rating is high. The effect of the project is well understood as are the techniques used for revegetation.
- Probability of Occurrence – Ecological Context. The probability of occurrence is high given the type of project and method of coal extraction.

- Significance: The final impact of the Project to the range health of the natural upland herbaceous grasslands is expected to be insignificant with implementation of the mitigation measures described in Section 4.3.4.1.

4.4 Forestry Resources

4.4.1 Application Case

Within the LSA, Project development will result in the removal of 56.8 ha (21.9%) of forest with a good timber productivity rating, 778 ha (28.8%) with a medium rating, 366.4 ha (30.7%) with a fair rating and 34.2 ha (94.3%) of unproductive forest rating (Table 4.4-1). This results in a total removal of 157,989.7 m^3 or 27% of the total timber volume from the LSA. The total volume of timber that would be removed following Project operations includes 9,210.5 m^3 from areas with a good timber productivity rating, 116,659 m^3 from areas with a medium rating, and 30,000.6 m^3 from areas with a fair productivity rating.

Table 4.4-1 Application Case Effects on Timber Productivity Rating in the Local Study Area

Cover Class	TPR	Volume		Change in Baseline		Area (ha) [1]		Change in baseline	
		Baseline[1]	Application Case[1]	Volume[1]	% Change[1]	Baseline[1]	Application Case[1]	Area (ha)[1]	% Change[1]
Coniferous	Good	58,776.2	49,565.7	-9,210.5	-15.7	259.0	202.2	-56.8	-21.9
Coniferous	Medium	406,553.9	295,848.1	-110,705.8	-27.2	2,696.8	1,918.8	-778.0	-28.8
Coniferous Leading		765.5	268.1	-497.4	-65.0				
Deciduous Leading		1,2039.8	6,584.0	-5,455.8	-45.3				
Deciduous		8,390.9	8,390.9	0.0	0.0				
Coniferous	Fair	85,432.5	61,152.5	-24,280.0	-28.4	1,194.3	827.9	-366.4	-30.7
Deciduous Leading		6,620.2	1,487.7	-5,132.5	-77.5				
Deciduous		3,961.8	3,373.7	-588.1	-14.8				
Coniferous	Unproductive	2,234.8	115.2	-2119.6	-94.8	36.3	2.1	-34.2	-94.3
Total LSA		**584,775.5**	**426,785.8**	**-157,989.7**	**-27.0**	**41,86.4**	**2,951.0**	**-1,235.4**	**-29.5**

[1]Area occupied by non-forested lands was not rated for timber productivity and is not included in the TPR area summaries. Due to rounding of numbers, total values may not equal the sum of the individual values.

The majority of timber that would be removed would include Lodgepole pine (113,273.8m^3) representing -29.3% change from volume at Baseline followed by Douglas fir (17,004.2 m^3) with a 23.1% decrease in timber volume (Table 4.4-2). The 786 m^3 of whitebark pine are outside the Footprint and are not removed by the project.

Table 4.4-2 Application Case Effects of Timber Volume by Leading Species in the Local Study Area

Species Name	Volume (m^3)		Change in Baseline	
	Baseline[1]	Application Case[1]	Volume (m^3)[1]	% Change[1]
Aspen – *Populus tremuloides* (Aw)	29,612.3	19,413.3	-10,199.0	-34.4
Subalpine fir – *Abies lasiocarpa* (Fa)	2,503.9	21,66.8	-337.2	-13.5
Balsam fir – *Abies basamea* (Fb)	353.7	112.6	-241.1	-68.2
Douglas fir – *Pseudostuga menziensii* (Fd)	73,737.4	56,733.2	-17,004.2	-23.1
Whitebark pine – *Pinus albicaulis* (Pa)	786.6	786.6	0.0	0.0
Balsam poplar – *Populus balsamifera* (Pb)	31,23.1	30,77.5	-45.6	-1.5
Lodgepole pine – *Pinus contorta* (Pl)	38,0926.8	26,7654.2	-113,273.8	-29.3
Engelmann spruce – *Picea engelmannii* (Se)	4,139.8	2,559.1	-1,580.6	-38.2
White spruce – *Picea glauca* (Sw)	89,592.0	74,282.5	-15,309.5	-17.1
Total LSA	**584,775.5**	**426,785.8**	**-157,989.7**	**-27.0**

[1] Due to rounding of numbers, total values may not equal the sum of the individual values.

Project effects on Annual Allowable Cut (AAC) will be minimal as all merchantable timber salvaged from the Project will be made available to local timber rights holders and approximately 62.8% of the Project Footprint will be reclaimed to closed conifer forests with another 4.3% reclaimed to moderate mixed forest, including historically disturbed barren land from previous mining operations, oil and gas developments, and roads.

4.4.2 Planned Development Case

Under the PDC, 624 ha of future forest harvest is expected within the LSA and 13,530.7 ha of future forest harvest is expected in the RSA, within Alberta, during the lifetime of the Project (future forest harvesting data for the BC portion of the RSA was not available). Of the 624 ha of harvest planned within the LSA, 158 ha is inside the Project Footprint (Figure 4.4-1). The limited amount of planned future timber harvest within the Project Footprint is due to the steepness of the terrain, which limits harvesting access. In addition, there is a substantial amount of non-forested land in the Footprint as result of historical mining activities and other anthropogenic disturbances. Inclusion of the forest harvesting noted above, along with the effects of the other projects identified for the PDC and their effects on forest resources, does not differ from the Application case; subsequently, a PDC assessment was not required.

4.4.3 Sensitivity of Forestry Resources to Disturbance

Forest resources are directly impacted by removal and indirectly by loss of site/soil productivity. A great deal is known about establishing forest following mining in the mountain and foothill regions of Alberta. Successful reforestation following mining is supported by historical studies (see summary by Ziemkiewicz 1985) and ongoing monitoring of forest reclamation on mountain mines in Alberta. The baseline soil survey and impact assessment (Benga 2015) found no significant barrier to forest establishment with reclamation. Learnings from historical and ongoing reclamation of mountain mines are included in the Project C&R Plan (Application, Section F, Benga 2015).

4.4.4 Mitigation and Monitoring

4.4.4.1 Mitigation

Mitigation for potential Project impacts on forest resources include:

- salvage of merchantable timber, both coniferous and deciduous;
- collection of locally available cones and seed for future reforestation programs, and
- plant seedlings on areas where reclamation and revegetation have been completed.

Aboriginal Groups Recommendations:

During the Aboriginal Consultation process and as indicated in provided Treaty 7 First Nations Traditional Use (TU) reports (*i.e.*, Piikani and Kainai First Nations), Benga are committed to providing opportunities to First Nations groups to collect important TU forestry resources. More specifically, Lodgepole pine to construct teepees as indicated by the Piikani and Tsuut'ina First Nations.

"I noticed what looked like some tipi poles. If you are going to disturb them (lodgepole pines), I believe the old people will want new tipi poles. Cut them down, peel them and offer them to the old people. Sok-ka-pii (it's all good). It will go a long ways." ~ Piikani Elder (Workshop, September 2014): Piikani Traditional Use Report: Application Appendix 7 (Benga 2015).

"There is lumber in there that is about this big. There is lumber to make log homes with. To use the material to build anything, infrastructure, around the reserves. There is going to be millans of dollars of trees that come out of there." ~ Piikani Technician (Workshop, September 2014): Piikani Traditional Use Report: Application Appendix 7 (Benga 2015).

"When (Riversdale [Benga]) enters areas of lodgepole pine, they need to notify us so that we can take them. We would like to know at least one calendar year before." Tsuu'tina Traditional Use Report: Application Appendix 7 (Benga 2015).

In addition, where applicable, Benga are committed to providing opportunities to collect suitable evergreen trees as requested by Kainai First Nation (Kainai Traditional Use Report: Application Appendix 7 (Benga 2015).

"One Kainai Elder suggested replantation effort for trees in areas of proposed development: 'Perhaps it could be a community enhancement project, where Riversdale (Benga) transports trees slated for removal at the mine site and transfers them to homes on the Blood reserve in Standoff. We are interested in evergreens. There are about 1600 to 2000 homes on reserve. The trees could be planted around houses or added to riparian areas along the river. It would give trees that would have been clear cut a second life and enhance the community.'"~ Kainai Elder (Workshop, December 2, 2014): Kainai Traditional Use Report Application Appendix 7 (Benga 2015).

4.4.4.2 Monitoring

- ensure all timber is harvested in operable areas prior to mining operations occurring;
- collect all cones and seed as harvesting is completed; and
- monitor reforested areas for seedling survival.

4.4.5 Impact Rating

Potential effects of the Project on forestry resources are related to clearing of vegetation and physical alteration of the landscape of the Project. The following assessment of the forest resource VC has been completed with consideration of effective mitigation being applied.

- Geographic Extent: Project impacts on forest resources are local in extent. Effects on forest timber productivity occur from the removal of timber, salvage of soil and subsequent reclamation of the land. Factors that may impact the timber productivity of adjacent stands (*e.g.*, disruption of soil water regimes, air quality) are not expected and limited by the terrain.

- Duration: The duration of the impacts is extended, diminishing as reclaimed forests mature. Reforested land will require time to develop mature forests.
- Frequency. Effects will continue throughout the operational phase of the project and cease only after no more land is cleared and reclamation has been implemented.
- Ability for Recovery: Effects are reversible in the long term with the planned mitigation. Reclaimed terrain and soils will support establishment of native forest communities. The seed and seedlings used in reclamation will be of local origin helping preserve local genetic diversity.
- Magnitude: The magnitude of the impact is low relative to natural disturbances in the region including fire. Progressive reclamation of the Project is planned ensuring reforestation in a timely manner.
- Project Contribution: Overall project contribution is neutral due to the inclusion of historically disturbed unproductive lands with Project reclamation. One project operations cease, the more subdued terrain will allow for an increase in the area of forest compared to pre-disturbance conditions.
- Confidence Rating: The confidence rating is high. The effect of the project on timber resources is well understood as is the ability to establish forest on reclaimed mines in Alberta.
- Probability of Occurrence – Ecological Context: The Project effect on timber resources is certain to occur.
- Significance: Project effect on timber productivity is insignificant.

4.5 Old Growth Forests

4.5.1 Application Case Effects on Old Growth Forest

Of the 168.8 ha of old growth forest in the LSA, only 8.3 ha (4.9% of old growth) are located within the proposed Project Footprint (located along the proposed conveyor route, and a small portion within the CHPP) (Figure 3.5-1). Mixed old growth stands with a closed canopy closure (51-70% closure) would primarily be impacted, with 5.9 ha (67.1%) of these old growth stands being removed. Two other old growth classes that would be affected by the Project include 1.2 ha (6.8%) of moderate deciduous stands and 1.2 ha (3.9%) of moderate mixed stands. Open coniferous and moderate deciduous old growth stands do not occur in the Footprint; subsequently, they would not be directly impacted. A summary of old growth forest occurring in the Project Footprint as part of the Application Case are provided in Table 4.5-1.

Table 4.5-1 Application Case Effects on Old Growth Forest in the LSA

ELC Class[1]	Area (ha)[1]		Change in Baseline	
	Baseline	Application Case	Area (ha)[2]	Percent Change (%)
Open Deciduous Forest	32.3	32.3	0.0	0.0
Open Coniferous Forest	<0.1	<0.1	0.0	0.0
Moderate Deciduous Forest	18.4	17.2	-1.2	-6.8
Moderate Mixed Forest	30.5	29.3	-1.2	-3.9
Moderate Coniferous Forest	78.8	78.8	0.0	0.0
Closed Mixed Forest	8.7	2.9	-5.9	-67.1
Total Old Growth Area	**168.8**	**160.5**	**-8.3**	**-4.9**

[1] Crown closure classes are AVI codes of canopy closure (measured in %) as follows: Closed = 51-70, Moderate = 31-50, and open = 6-30. Cover types are based on the proportion of conifer or deciduous species in the canopy. Deciduous = >80% deciduous, mixed = 30-79% conifer / deciduous, coniferous = >80% coniferous (ASRD 2015). Age cut off for old growth is as follows: deciduous and mixed stands ≥100, pine stands ≥120, and coniferous (non-pine) stands ≥140.

[1,2] Due to rounding of numbers, total values may not equal the sum of the individual values.

4.5.2 Application Case Effects on Old Growth Forest Potential

The Project would reduce the area with potential to support old growth forests by 30.2% (1,100.4 ha, Table 4.5-2). This includes approximately 121.5 ha (22.9% decrease from Baseline) and 45.7 ha (14.8 decrease from Baseline) of ecosite phases of moderate old growth potential in the Montane and Subalpine Natural Subregions, respectively. None of the ecosite phases mapped in the LSA have high potential to support old growth forest. It is anticipated that the mitigation measures outlined for forest resources (Section 4.4.3) would support the return of old growth forests that may be removed during Project activities.

Table 4.5-2 Application Case Effects on Old Growth Potential in the Local Study Area

Rare Plant Potential	Ecosite Phase[1]	Area (ha)[2]		Change from Baseline (Without Mitigation)	
		Baseline	Application Case	Area (ha)[2]	Percent Change (%)
Montane					
Moderate	b2, b3, c3, c4, d3, e2, e3, f1, g1, g2	530.9	409.3	-121.5	-22.9
Low	a1, b1, c1, c2, d1, d2, e1	1,533.2	1,097.0	-436.4	-28.5
Total Montane	**-**	**2,064.1**	**1,506.3**	**-557.9**	**-27.0**
Subalpine					
Moderate	d1, e3, e4, f2	309.1	263.3	-45.7	-14.8
Low	a1, b1, e1, e2, f1	1,268.1	7,71.2	-496.8	-39.2
Total Subalpine	**-**	**1577.2**	**1034.5**	**-542.5**	**-34.4**
Grand Total	**-**	**3641.3**	**2540.8**	**-1100.4**	**-30.2**

[1]Ecosite phases from Archibald *et al.* 1996.

[2]Baseline and application case areas and old growth potential for each ecosite / land class are provided in Table 4.1-1. Due to rounding of numbers, total values may not equal the sum of the individual values.

4.5.3 Planned Development Case

At a regional scale, harvesting activities not associated with Project will have the greatest impact on old growth forests. The PDC anticipates an additional 624 ha of forest harvesting within the LSA, and 13,530.7 ha within the RSA in Alberta, during the lifetime of the Project (future forest harvesting data for the BC portion of the RSA was not available). PDC harvest within the Project Footprint during this time period is only 158 ha (Figure 4.4-1). Within the RSA approximately 13,461.0 ha (4.7% of RSA) of old growth forest was identified. Harvesting within the Project RSA in Alberta is subject to regional sustainable forest management plan. This forest management plan (*C5 Forest Management Plan 2006-2026,* Government of Alberta 2010b) for the region includes specific criteria for maintaining forest age distribution, including old growth forest. At closure approximately 993.2 ha (62.8% of the Project Footprint) will be reclaimed to closed conifer forest and an additional 68.2 ha (4.3% of the Footprint) to moderate mixed forest. The ecosite phases represented by closed conifer forests and moderate mixed forests are rated high to moderate for old growth potential.

Inclusion of the forest harvesting noted above, along with the effects of the projects identified for the PDC and their effects on old growth forests does not materially differ from the Application case, and therefore a PDC assessment was not required. Predicted changes in area of old, mature and young forest for the three times steps assessed (T14, T22, and T41) are provided in the Biodiversity and Fragmentation Section 4.8.

4.5.4 Mitigation and Monitoring

Old growth forest mitigation measures will include but not be limited to the following:

- reclamation using tree species capable of achieving of old growth conditions with equivalent capabilities prior to development; and
- preserving adjacent vegetation communities by minimizing the area required for construction and operation of the Project.

Old growth forest monitoring will include, but not be limited to the following:

- periodically assesses the composition, structure, ecological succession and biodiversity of reclaimed forested stands.

4.5.5 Impact Rating

Only 8.3 ha of old growth forest currently occurs within the Project Footprint; consequently, the direct effect of the Project on old growth forest is not significant. In addition to direct removal, potential effects of the Project on old growth forest are related to removal of areas with high old growth potential. Forests with high old growth potential will be established with reclamation. In addition, the reclamation will occur in a progressive manner and not be delayed until the end of Project operations. The following assessment of the old growth resource VC has been completed with consideration of effective mitigation being applied.

- Geographic Extent: Project effects on old growth forests is local in extent.
- Duration: The duration of the effects are extended, diminishing as reclaimed forests mature. Reforested land will require time to develop mature forests.
- Frequency: Effects will continue throughout the operational phase of the project and cease only after no more land is cleared and reclamation has been implemented.
- Ability for Recovery: Effects are reversible in the long term with the planned mitigation. Reclaimed terrain and soils will support establishment of native forest communities including communities with high old growth potential.
- Magnitude: Removal of only 8.3 ha old growth forest by the Project is low in magnitude as is the removal of 167.2 ha of forest with moderate old growth potential.

- Project Contribution: The Project will have a positive contribution over the long term by establishing forest with high old growth potential and by increasing the overall area of forest by reclaiming historically disturbed and unproductive lands present within the planned development area.
- Confidence Rating: The confidence rating is high. The effect of the project on old growth forest is well understood as is the ability to establish forest on reclaimed mines in Alberta.
- Probability of Occurrence – Ecological Context: The Project effect on old growth forest is certain to occur.
- Significance: Project effect on old growth forest is insignificant

4.6 Traditional Ecological Knowledge

4.6.1 Application Case

Ecosite phase potential for identified TEK VC vegetation species within the LSA is summarized in Section 3.6. The Project would remove 1,100.4 ha (30.2%) of ecosite phases that support TEK vegetation potential (Table 4.6-1). These include 101.3 ha (27.6% decrease from Baseline) of very high or high TEK potential areas in the Montane and 0.8 ha (100%) Subalpine Natural Subregions.

Table 4.6-1 Application Case – Effects on TEK Plant Potential in the Local Study Area

TEK Plant Potential	Ecosite Phase / Land Class Description[1]	Area (ha)[2]		Change from Baseline (Without Mitigation)	
		Baseline	Application Case	Area (ha)[2]	Percent Change (%)
Montane					
High	c1, c4, g1	367.2	265.9	-101.3	-27.6
Moderate	b1, b2, c2, c3, d1, d2, d3, e1, e2, e3, f1	1,608.9	1,155.9	-453.2	-28.2
Low	a1, g2	88.0	84.5	-3.4	-3.9
Total Montane	-	**2,064.1**	**1,506.3**	**-557.9**	**-27.0**
Subalpine					
Very high	d1	0.8	0.0	-0.8	-100.0
Moderate	a1, b1, e3, e4, f2, h1	483.2	381.5	-101.5	-21.0
Low / Very low	e1, e2, f1	1,093.2	653.0	-440.2	-40.3
Total Subalpine	-	**1,577.2**	**1,034.5**	**-542.5**	**-34.4**

Table 4.6-1 Application Case – Effects on TEK Plant Potential in the Local Study Area					
TEK Plant Potential	Ecosite Phase / Land Class Description[1]	Area (ha)[2]		Change from Baseline (Without Mitigation)	
		Baseline	Application Case	Area (ha)[2]	Percent Change (%)
Total LSA	-	**3,641.3**	**2,540.8**	**-1,100.4**	**-30.2**

[1] Ecosite phases are from Archibald *et al.* 1996.

[2] Baseline and application case areas and TEK potential for each ecosite / land class are provided in Table 4.1-1. Due to rounding of numbers, total values may not equal the sum of the individual values.

- not applicable.

Note: For individual species or groups of species identified during the consultation process many are common and occur within a range of ecosites. For example pine, poplar, rose, raspberry, fireweed are common species with wide distributions. Other TEK species or groups of species identified, such as tree lichens and fungus, are common but occur primarily in late succession within mature and old forests. For these species, removal by the project will have an extended effect similar to that described for the assessment of the old growth forest VC (Section 4.5).

4.6.2 Planned Development Case

The occurrence and distribution of TEK vegetation in the RSA was not assessed. It is assumed that ecosite phases and ELCs within the LSA are similar in composition and distribution as those in the RSA, given the broad scale of the RSA, and therefore the distribution of TEK species in the RSA is comparable to what was observed in the LSA. As described for the vegetation community VC (Section 4.1), other than sustainable forest harvesting the projects included in the PDC have an insignificant effect on plant communities thus any impacts to TEK vegetation would be higher when assessed locally in the Application Case than in the PDC.

4.6.3 Sensitivity of TEK Vegetation Resources to Disturbance

Disturbance due to planned development can remove ecosite phases that support TEK species in the LSA. Additionally, removing areas of valued components, such as old growth forests and wetlands areas, which are important for TEK species, can diminish the sustainability of these species on the landscape (Lantz and Antos 2002). The best means of sustaining TEK vegetation is to ensure that plant populations continue to grow and evolve, in their intact native habitat (WHO 1986). The deliberate maintenance, by First Nations, of the diversity of native plants and animals within their environment supports systematic in-situ sustainability of genetic resources (Warren 1992).

While all plant species are valuable for biodiversity, TEK species are also valued for use by the First Nations Peoples for medicine, food, and other uses. Managing vegetation resources valued by First Nations is, therefore, not as simplistic as identifying TEK vegetation species on the landscape and providing mitigation measures for their protection and/or conservation. Both the persistence of TEK vegetation species on the landscapes, and the health and integrity of the habitats that supports these species are important to the groups of peoples who depend on them. Article 29 of the *United Nations Declaration on the Rights of Indigenous Peoples* (U.N. 2008) states: "*Indigenous peoples have the right to the conservation and protection of the environment and the productive capacity of their lands or territories and resources.*"

For instance, important habitats for TEK vegetation species (*i.e.,* berries, nuts, tubers, forbs used for food and medicines) should not be polluted with contaminants that pose risk to human or wildlife health (World Health Organization [WHO] 2003). The efficacy of active compounds found in in medicinal plants or plants used for food depends on the health and integrity of habitats in which these plants occur, can be altered by contaminants. The efficacy of these active compounds is also dependent upon, for example, the stage of plant development, and the season and time of day, the vegetation is gathered.

4.6.4 Mitigation and Monitoring

4.6.4.1 Mitigation

Mitigation measures for TEK vegetation will include:

- the continuation of on-going consultation with Aboriginal Groups in designing mitigation measures for sustainable management of TEK vegetation;
- the implementation of a re-vegetation program which will aim at the re-establishment of vegetation communities, such as closed conifer forests, mature mixed forests, native upland herbaceous grasslands and treed swamps, common to the pre-disturbed landscape that will support TEK vegetation;
- the implementation of a re-vegetation program that utilizes native vegetation species and does not include agronomic invasive species;
- the provision of opportunities to identify and collect suitable lodgepole pine for TU ceremonies, and
- where practicable, utilize locally collected seed to preserve the legacy of species and of place.

4.6.4.2 Monitoring

- engage local Aboriginal groups to participate in the establishment of TEK vegetation on reclaimed lands and the follow-up monitoring.

4.6.5 Impact Rating

Removal of ecosite phases and ELCs that are important for TEK vegetation species in the Project LSA will have a local impact as these habitats are expected to remain intact within the remainder of the LSA and in the RSA and provide similar services to Aboriginal Groups.

Potential effects of the Project on TEK vegetation are related to clearing and physical alteration of the landscape of the Project. The following assessment of the TEK vegetation VC has been completed with consideration of effective mitigation being applied.

- Geographic Extent: Project effects on TEK plant community potential is local in extent as is the effect on individual species. Effects of the Project on vegetation communities is limited to direct removal and conditions that would extend disturbance beyond the Footprint are limited due to the terrain and to the mitigation proposed for the Project. No community altering air pollutants are expected with the project (section 4.10 Acid Input and Nitrogen Deposition). The final project contours, slopes and aspects are expected to provide for a range of ecosite communities similar to those in the region.
- Duration: The duration of the effects are extended, diminishing as reclaimed forests mature. Reforested land will require time to develop mature forests and TEK species that require old mature communities and or growth forest will be slow to return to the land.
- Frequency: Effects will continue throughout the operational phase of the project and cease only after reclamation is completed.
- Ability for Recover: Effects are reversible in the long term with the planned mitigation. Reclaimed terrain and soils will support establishment of a range of native communities that will support TEK species. However, in addition to simple presence, the place where species grow may be important for some TEK species and this may not return.
- Magnitude: The project effect will be of high magnitude due to the removal of TEK vegetation and altering of the landscape. Project effects will exceed large scale natural disturbances such as fire and insect infestation due to the disturbance of the soil.
- Project Contribution: The project will have a neutral contribution with respect to TEK species and communities. The reclaimed land will support a range of communities with equivalent capabilities to those of the surrounding lands and that existed prior to development. The project will not result in the loss of the resource to the communities, the region or the province.
- Confidence Rating: The confidence rating is high. The effect of the project is well understood as are the techniques used for revegetation. Use of proven techniques for revegetation will be supported by adaptive management and monitoring.

- Probability of Occurrence – Ecological Context: The probability of occurrence is high given the type of project and method of coal extraction.
- Significance: With mitigation the project effects are insignificant. No irreversible effects to sustainability of the resource are expected.

4.7 Wetlands

4.7.1 Application Case

The area of wetlands that would potentially be impacted by the Project in the Baseline Case and Application Case in the LSA are presented in Table 4.7-1 and Figure 3.7-1. Of the four AWIS wetland types identified in the LSA, all of which have limited distribution due to the topography and terrain, three occur in the Project Footprint with a total of 7.9 ha (46.7% of LSA wetlands). Shrubby open fens (FONS) would be the most impacted by the Project with 7.8 ha (69.6%) being removed compared to Baseline. Less than 0.1 ha of open graminoid dominated marsh (MONG) (7.9%) would be removed by the proposed Project rail connection in the south of the study area. Approximately 0.1 ha (13.9%) of open water (WONN) would also be removed. None of the AWIS wetland types would be completely removed from the LSA.

Table 4.7-1 Application Case Effects on Wetlands in the Local Study Area

Wetland Class	Area (ha)		Change from Baseline (Without Mitigation)	
	Baseline	Application	Area (ha)[1]	% Change
FONS – Shrubby open fen	11.2	3.4	-7.8	-69.6
STNN – Treed swamp	4.8	4.8	0	0
WONN – Open water (<2 m deep)	0.5	0.4	-0.1	-13.9
MONG – Open graminoid dominated marsh	0.4	0.4	<0.1	-7.9
Total LSA	**16.9**	**9.0**	**-7.9**	**-46.7**

[1] Due to rounding of numbers, total values may not equal the sum of the individual values.

With reclamation 10.3 ha of treed wetland (STNN) will be added and an unknown area of shallow open water and marsh will also be created around the margins of the pit lake as described in the Application, Conservation and Reclamation Plan, Section F (Benga 2015).

4.7.2 Planned Development Case

The overall project effects on wetlands for the Application Case within the LSA are low, and there will be a net increase in wetland area. However, based on the assessment it is suspected a change in wetlands may have regional implications, therefore an assessment was completed using both the Application case and the PDC (cumulative effects) in the RSA.

The total area occupied by wetlands is expected to increase by 21 ha (Table 4.7-2). This is due to the net increase of area occupied by open water as a result of an end pit lake included in the project Reclamation Plan Section F of the Application. Although Project Application case showed a positive change in the area of treed wetlands (STNN), with 10.3 ha being added at reclamation, there is a net loss (18.4 ha) of treed wetlands in the RSA. This decrease is due to planned activities in the RSA including forest harvests, Teck Coal Limited Coal Mountain Phase 2 Project, and the Alberta Transportation Highway 3 Re-alignment.

Table 4.7-2 Planned Development Case - Effects on Wetlands in the Regional Study Area

Land Cover Class	Ecosite Phase / AVI Equivalent	AWIS Wetland Class Equivalent	Baseline Case (T0)[1]	PDC T41 (With Project with Mitigation)[1]	Baseline T0 - PDC T41[1]
Graminoid Wetland	-	FONG / MONG	158.5	151.9	6.6
Shrubby Wetland	Subalpine: g1, h2	FONS	762.7	760.9	1.8
Open Water	NWF	WONN	1,544.0	1,591.8	-47.8
Treed Wetland	Subalpine: h1	FTNN / STNN	126.5	108.1	18.4
Total Wetlands	-	-	**2,591.7**	**2,612.8**	**-21.0**

[1] Due to rounding of numbers, total values may not equal the sum of the individual values.
- not applicable.

To ensure conservativeness in the assessment the 41-year time step included the three remaining ponds for the Selenium water management program as open water and not reclaimed to wetlands. Final reclamation of these ponds will increase the area of wetlands reclaimed (Application, Conservation and Reclamation Plan, Section F (Benga 2015)).

Changes in ELC area and other characteristics for all time steps assessed (year 14, year 22, and year 41) are provided in Appendix H and included along with other assessed parameters in the biodiversity assessment (Tables 4.8-5, 4.8-7, 4.8-8).

4.7.3 Sensitivity of Wetlands to Disturbance

Wetlands are sensitive to changes in water quality, and timing and amount of water inputs and withdrawals thus wetlands are sensitive to conditions throughout the catchment area not just direct disturbance. At present, much of the literature reports that wetland reclamation, in particular organic wetland (bogs and fens) reclamation, is difficult (Ballentine and Schneider 2009; Mitsch & Gosselink 2007), and that restoring equivalent hydrological function may take decades (Moreno-Mateos *et al.* 2012). Wetlands represent an important part of the landscape by providing hydrologic connectivity, habitat for unique plants and animals, and recreational opportunities. Wetlands can occur as discrete units on the landscape, but are most often connected to other wetlands or water bodies as a complex with other types of wetlands. Wetlands serve important hydrological functions including absorbing snowmelt and large runoff events, and allowing the water to release slowly, and filter into rivers and streams throughout the year. In this regard, a wetland complex serves much the same function as a tributary. Wetlands are also critical for supporting plant species with food and medicinal value (TEK vegetation). Loss of wetlands as a result of the Project, for example, could result in a loss of hydrological functions *e.g.,* loss in efficacy for absorbing freshet events (minimization of excessive water quantities draining into rivers and streams) throughout the year or water quality filtering capability.

4.7.4 Mitigation and Monitoring

4.7.4.1 Mitigation

Based on topography, mineral soil treed swamps (STNNs) (treed wetlands in the reclamation plan) will be established in depression areas formerly used as surface water management and retention ponds during Project operation. Vegetation typical of these mineral soil wetland plant communities are expected to establish on the subsoil and mineral topsoil placed in these formerly open water ponds. Admiraal *et al.* (1997) notes that *"because the topography of most wetland projects is level to gently sloping, a contour interval of 0.3 m is recommended for grading plans."* Due to the slopes in the Project Footprint, areas of open water ≤1 m deep may be present in the treed swamps, which will be planted with emergent vegetation species. Areas classified as open water remaining after reclamation may be surrounded by littoral zone ranging from 0.1 to 3.5 m deep and may be planted with emergent vegetation.

The wetland mitigation measures will include:

- the use of wetland construction best practices to maintain the hydrologic regime of mineral soil wetlands;
- the creation of transition areas between re-vegetated ELCs to the treed swamps;
- revegetation of appropriate depression wetland areas to mineral soil wetlands, where possible;
- re-vegetation of mineral soil wetlands with wetland riparian, emergent and submergent vegetation species;

- during construction, wetland soil and propagule materials from existing (baseline) wetlands within the Footprint would be salvaged and stored for replacement during wetland reclamation/reconstruction activities;
- constructed wetlands will use submergent vegetation species as indicators of wetland health and integrity to be measured in subsequent monitoring programs;
- opportunities to direct place wetland soil materials (soils and propagules) from adjacent wetlands, to provide a soil substrate with a propagule source for wetlands will occur; and
- where applicable, culverts will be placed within wetlands that may be divided by roads to ensure that water flow between wetlands will not be affected.

4.7.4.2 Monitoring

Wetland monitoring will include the following:

- monitoring and maintenance of drainage control structures to be conducted regularly to ensure water flow and flow patterns are maintained in wetlands adjacent to the during the construction, operation, and closure phases of the Project;
- at project closure, the monitoring of road removal ,which may have had an impact on adjacent wetlands to ensure restoration of the hydrologic regime; and
- monitoring of reclaimed wetlands would continue for a minimum of ten years to ensure the composition and structure, and key wetland functions are consistent with those in wetlands in the LSA prior to the Project disturbance.

4.7.5 Impact Rating

The wetland VC includes consideration of obligate and facultative wetland vegetation not just wetland area. The Project will have a positive contribution to wetlands following planned reclamation in the LSA. Mitigation included establishing wetland vegetation and monitoring return of wetland function. Planned reclamation for wetlands increases the total area of treed swamps (STNN) from 4.8 ha to 15.5 ha (an increase of 10.7 ha or 223.2%). Open water (not classified as wetlands) also increases due to ponds and the pit lake as does an unknown area of shallow open water wetland and marsh created around the margins of the pit lake (Application, Conservation and Reclamation Plan, Section F (Benga 2015)).

Potential effects of the Project on wetlands are related to removal or disturbance by the Project. The following assessment of the wetland VC has been completed with consideration of effective mitigation being applied.

- Geographic Extent: Project effects on wetlands are local in extent. Conditions that would extend disturbance beyond the Footprint are limited due to the terrain and to the mitigation proposed for surface water management during the operational phase of the project and reclamation following end of operations.
- Duration: The duration of the effects are extended. Reclaimed land will require time to develop mature forests and grasslands and for the return of the natural processes of disturbance and succession.
- Frequency: Effects will continue throughout the operational phase of the project and cease only after reclamation is completed.
- Ability for Recovery: No residual water quality issues impacting wetland function have been identified for the Project. Effects are reversible in the long term with the planned mitigation. Reclaimed terrain and soils will support establishment of functional wetlands including obligate and facultative wetland vegetation.
- Magnitude: The disturbance is moderate in magnitude and is predicted to cause a detectable change by increasing the amount of wetlands.
- Project Contribution: The project will have a positive contribution toward wetlands. Wetlands are naturally of low abundance in the region. Establishing additional self-sustaining functional wetlands will benefit wildlife and plant diversity.
- Confidence Rating: Confidence rating is high and based on good understanding of cause-effect relationships and data pertinent to study. Wetlands have been successfully created on other mountain mines in Alberta and mitigation will be supported by adaptive management and monitoring.
- Probability of Occurrence – Ecological Context: The probability of occurrence is high given the type of project and method of coal extraction.
- Significance: Project effects on wetlands are insignificant with mitigation.

4.8 Biodiversity and Fragmentation

4.8.1 Application Case

Construction of the Project will effect 1,582.4 ha (33.1% of the LSA) of plant communities and other patches, through the clearing and use of land for Project operations. This includes approximately 288.7 ha of previously disturbed land.

4.8.1.1 Application Case Effects on Species Diversity in the LSA

Construction and operation of the Project will result in the removal of all vegetation from the Project Footprint and a temporary reduction of native species diversity in the LSA. This includes areas of high species richness identified in the LSA, *e.g.*, ecosite phases d1, c3, g1 and g2 in the Montane Natural Subregion and the f1 ecosite phase in the Subalpine Natural Subregion. Subalpine ecosite phases generally exhibited lower species diversity than in the Montane Subregion. The trend in species richness generally follows the gradient of moisture and of nutrients and is therefore higher for ecosite phases that typically occupy lower slope positions.

After closure and reclamation, native species richness is expected to be lower than intact naturally developed vegetation in the LSA, except on previously disturbed areas, where species richness will increase with mitigation. Over time, species richness will increase as late successional species establish within reclaimed lands, in conjunction with remaining early successional species.

The Reclamation Plan Section F of the Application calls for the establishment of conifer forest, mixed forests and open forest with grassland patches. Ecosite phases roughly corresponding to these classifications include a mix of high biodiversity potential (*e.g.*, Montane c4, Subalpine e1, f1 and herb-graminoid (HG)), moderate biodiversity potential (*e.g.*, Montane e2, d1, d2) and low biodiversity potential (*e.g.*, Montane e1, a1, b1).

4.8.1.2 Application Case Effects on Community and Landscape Diversity in the LSA

Construction and operation of the Project will result in the removal of 1,093 ha of ecosite phases with moderate to high biodiversity potential (Table 4.8-1) in both the Montane and Subalpine Subregions. Within the Project Footprint, ecosite phases of limited distribution in the LSA (<1% area) and identified with high biodiversity potential include the Subalpine e1, f1 and f2 ecosite phases, and Montane c3, c4, f1, g1 and g2 ecosite phases. These ecosites are typically found at mid or lower slope positions, are generally mixed tree species ecosites of balsam poplar, Engelmann spruce, white spruce and aspen.

Table 4.8-1 Application Case - Effects on Biodiversity Potential in the LSA

Biodiversity Ranking	Ecosite Phase / Land Description Class[1]	Area (ha)[2]		Change from Baseline (Without Mitigation)	
		Baseline	Application Case	Area (ha)[2]	Percent Change (%)
Montane					
High	c3, c4, f1, g1, g2	291.7	233.7	-58.0	-19.9
Moderate	b2, b3, c1, d1, d2, d3, e2, e3, a1	1,083.9	738.2	-345.7	-31.9
Low	a1, b1, c2, e1	700.0	539.2	-160.8	-23.0

Table 4.8-1 Application Case - Effects on Biodiversity Potential in the LSA

Biodiversity Ranking	Ecosite Phase / Land Description Class[1]	Area (ha)[2]		Change from Baseline (Without Mitigation)	
		Baseline	Application Case	Area (ha)[2]	Percent Change (%)
Montane Total		**2,075.6**	**1,511.1**	**-564.5**	**-27.2**
Subalpine					
High	e1, f1, f2	1,137.1	695.5	-441.6	-38.8
Moderate	d1, e2, e3, e4	231.1	198.6	-32.5	-14.1
Low	h1	34.1	22.3	-11.8	-34.6
Subalpine Total		**1,402.3**	**916.4**	**-485.9**	**-34.7**
Natural Vegetated and Non-Vegetated Land					
High	HG	320.7	160.1	-160.6	-50.1
Moderate	SC, SO	10.2	5.8	-4.4	-43.1
Low	NMR, NWF, NWL, NWR	39.9	11.7	-28.2	-70.7
Natural Vegetated and Non-Vegetated Land Total		**370.8**	**177.6**	**-193.2**	-52.1
Total LSA		**3,848.7**	**2,605.1**	**-1,243.6**	**-32.3**

[1] Ecosite phases / land class are from Archibald *et al*. 1996 and ASRD 2005.

[2] Baseline and application case areas for each ecosite / land class are provided in Table 4.1-1. Due to rounding of numbers, total values may not equal the sum of the individual values.

4.8.1.3 Application Case Effects on Fragmentation in the LSA

Biodiversity decreases with increased fragmentation (Forman 1995; Webb & Vermaat 1990; Peterken & Game 1984; Simberloff & Gotelli 1984; Weaver & Kellman 1981), thus landscape fragmentation was considered in the assessment of community and landscape level biodiversity.

The Application Case presented here assumes no progressive reclamation or mitigation of any kind for the loss of natural plant community patches in the LSA, and is thus a worst-case scenario. The Application Case also considers the entire 1,582.4 ha Project Footprint a single anthropogenic disturbance comprised of very few small anthropogenic patches, as defined in Section 4.1. Table 4.8-2 provides the Application Case results for biodiversity and fragmentation measures for each ecosite phase / land class mapped in the LSA; Table 4.8-3 summarizes the results of Baseline – Application Case values for each ecosite phase / land class, which constitutes the Application Case effects on Biodiversity and fragmentation in the LSA.

As expected the most abundant ecosite phases and ELCs in the Footprint at Baseline will experience the greatest loss in total area, core area, and perimeter area with the Project (Application Case). This decrease in natural mean patch area is due to increased fragmentation from the Project, while the decrease in total perimeter length is a reflection of the smaller patches that will be cleared for the Project. The level of fragmentation will increase the most for Montane c1, d1, d2, e1, and e2 ecosite phases, Subalpine e1 ecosite phase; and the HG land class in both the Montane and Subalpine Subregions. Within the Footprint, several ecosite and ELC patches will increase in number as they are bisected by Project infrastructure and/or disturbances.

Table 4.8-2 Application Case – Fragmentation in the Local Study Area (Without Mitigation)

Ecosite Phase / Land Description	# Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)[1]	Core Area (ha)	Patch Density (#/100 km^2)	% of LSA	Perimeter Length (m)	Mean Perimeter : Area (m/ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
Montane Natural Subregion										
a1	11	4.8	52.8	37.1	23.0	1.1	16,676.0	315.7	70.3	507.0
b1	43	4.4	191.1	147.8	90.0	4.0	46,293.9	242.2	77.4	285.4
b2	4	3.0	12.1	8.9	8.4	0.3	3,358.5	277.3	73.9	1031.3
b3	12	2.7	32.5	22.6	25.1	0.7	10,828.4	333.6	69.9	634.4
c1	22	4.4	96.4	77.6	46.1	2.0	21,020.6	218.1	80.5	392.0
c2	29	4.7	137.5	108.7	60.7	2.9	30,972.0	225.2	79.2	263.9
c3	10	1.8	18.3	13.4	20.9	0.4	5,582.5	305.2	73.5	218.4
c4	44	3.7	160.6	120.8	92.1	3.4	43,946.1	273.6	75.4	191.3
d1	17	4.2	71.4	56.2	35.6	1.5	16,339.4	228.8	78.8	227.8
d2	69	6.1	422.8	340.6	144.5	8.9	88,931.4	210.3	80.7	233.7
d3	5	2.2	10.8	6.8	10.5	0.2	4,369.9	405.7	62.9	334.5
e1	28	5.5	154.4	124.1	58.6	3.2	32,204.6	208.5	80.4	462.1
e2	15	1.8	27.3	18.9	31.4	0.6	9,863.2	361.7	69.5	515.7
e3	12	7.4	88.3	64.1	25.1	1.8	25,551.9	289.4	72.6	749.8
f1	5	4.9	24.5	18.3	10.5	0.5	6,998.1	285.5	74.9	544.8
g1	9	3.2	29.2	21.6	18.8	0.6	8,117.6	277.9	74.3	494.5
g2	8	2.7	22.0	13.7	16.7	0.5	9,390.3	427.7	63.1	196.4
NMR	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NWF	4	0.2	0.8	<0.1	8.4	<0.1	1,360.6	1,730.8	3.5	66.9
NWL	5	0.04	0.2	0.0	10.5	<0.1	603.8	3,053.2	2.5	24.1

Table 4.8-2 Application Case – Fragmentation in the Local Study Area (Without Mitigation)

Ecosite Phase / Land Description	# Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)[1]	Core Area (ha)	Patch Density (#/100 km²)	% of LSA	Perimeter Length (m)	Mean Perimeter : Area (m/ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
NWR	1	0.02	0.02	<0.1	2.1	<0.1	69.4	3,007.5	<0.1	<0.1
HG	27	1.7	46.8	31.0	56.5	1.0	17,859.4	381.7	66.5	181.9
SC	1	0.2	0.2	<0.1	2.1	<0.1	625.7	4,123.7	0.0	0.0
SO	1	0.3	0.3	0.1	2.1	<0.1	244.8	823.4	32.8	0.0
Subalpine Natural Subregion										
a1	1	9.7	9.7	6.7	2.1	0.2	3,046.0	315.0	69.1	0.0
b1	25	4.1	102.5	82.3	52.3	2.1	21,764.2	212.3	80.3	289.4
e1	116	6.1	707.7	558.3	242.9	14.8	161,530.8	228.3	79.0	188.9
e3	56	3.5	196.2	145.2	117.2	4.1	56,742.1	289.2	74.3	152.6
e4	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
f1	8	0.5	4.0	2.2	16.7	0.1	2,179.3	549.6	56.9	363.6
f2	13	1.8	22.8	14.8	27.2	0.5	9,004.7	394.2	65.0	213.9
h1	2	4.7	9.3	5.9	4.2	0.2	4,018.4	431.6	63.2	79.1
HG	15	3.1	46.7	29.0	31.4	1.0	20,423.6	436.9	62.0	531.7
NMR	5	2.7	13.5	9.6	10.5	0.3	4,379.5	324.9	70.9	1,452.1
Natural Total	623	-	2,712.7	2,086.1	-	56.8	684,296.6	-	-	-
Montane Natural Subregion Anthropogenic Patches										
AIH	43	2.1	91.7	42.9	90.0	1.9	57,603.0	628.1	47.8	26.0
AIM	1	1,517.4	1,517.4	1,483.3	2.1	31.8	34,156.5	22.5	97.7	0.0
ASC	13	4.2	55.0	44.3	27.2	1.2	12,982.8	235.9	81.2	220.9
CC	94	0.2	18.8	35.6	196.8	0.4	79,179.9	4,220.4	74.3	223.7

Table 4.8-2 Application Case – Fragmentation in the Local Study Area (Without Mitigation)

Ecosite Phase / Land Description	# Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)[1]	Core Area (ha)	Patch Density (#/100 km²)	% of LSA	Perimeter Length (m)	Mean Perimeter : Area (m/ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
CIP	14	1.3	17.5	24.2	29.3	0.4	7,155.5	408.4	66.6	555.4
CIW	7	5.0	34.9	6.0	14.7	0.7	11,047.6	316.8	71.6	185.6
CL	17	2.8	47.5	1.6	35.6	1.0	13,367.7	281.5	75.2	348.7
CO	11	4.2	45.8	11.5	23.0	1.0	22,210.5	484.5	52.8	710.7
CP	4	2.0	7.9	25.0	8.4	0.2	2,119.3	267.6	75.1	2,632.9
Subalpine Natural Region Anthropogenic Patches										
AIH	8	2.6	20.8	4.9	16.7	0.4	18,391.9	885.1	27.9	493.3
AII	1	0.21	0.21	0.05	2.09	<0.1	213.18	1,017.55	25.69	0.0
AIM	5	1.8	9.1	6.5	10.5	0.2	2,980.2	328.4	71.7	373.9
CC	22	7.6	168.0	132.5	46.1	3.5	38,024.2	226.3	79.0	369.8
CIP	3	1.7	5.1	0.8	6.3	0.1	4,526.1	894.1	15.2	567.5
CIW	8	0.7	5.3	3.3	16.7	0.1	2,402.7	456.9	62.4	570.2
CL	71	0.3	18.5		148.7	0.4	63,866.1	3,451.3		207.7
Anthropogenic Total	322	-	2,063.5	1,822.1	-	43.2	370,227.4	-	-	-
Total LSA	**945**	-	**4,776.2**	**3,908.3**	-	**100.0**	**1,054,523.9**	-	-	-

[1]Areas (ha) may be different from baseline ecosite phase areas presented in Table 4.1.1 because biodiversity assessment was based on the dominant ecosites phase assigned to each polygon on the LSA map (Refer to Section 2.3.1.2 for details on ecosite phase mapping). Due to rounding of numbers, total values may not equal the sum of the individual values.

\- not applicable.

Table 4.8-3 Application Case - Effects (Baseline Case – Application Case) on Fragmentation in the LSA (Without Mitigation)

Ecosite Phase / Land Description	# Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)[1]	Core Area (ha)	Patch Density (#/100 km²)	% of LSA	Perimeter Length (m)	Mean Perimeter :Area (m/ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
Montane Natural Subregion										
a1	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
b1	-5	1.4	27.6	22.9	-10.4	0.6	5,198.4	-6.7	0.7	26.0
b2	0	0.5	2.0	2.1	<0.1	<0.1	-37.4	-41.8	3.9	12.4
b3	0	0.0	0.0	0.1	0.0	0.0	4.3	-0.2	-0.1	-8.7
c1	0	2.4	54.1	50.3	<0.1	1.2	3,706.6	-53.8	4.5	33.2
c2	-3	0.9	8.8	7.8	-6.3	0.2	664.4	-8.9	0.4	34.8
c3	-1	0.4	1.2	0.6	-2.1	<0.1	442.1	3.3	-1.6	275.8
c4	-1	0.9	36.8	28.6	-2.1	0.7	7,897.4	-11.0	0.3	59.7
d1	-1	2.7	39.3	32.6	-2.1	0.8	6,609.8	-21.5	1.4	251.4
d2	21	1.0	220.4	174.3	43.9	4.6	48,865.2	3.9	-0.7	5.5
d3	-3	3.6	0.8	0.7	-6.3	0.0	-167.4	-42.5	1.9	1,545.4
e1	-5	6.1	112.4	103.6	-10.4	2.4	8,541.6	-55.8	4.9	104.5
e2	6	1.6	43.3	32.6	12.6	0.9	11,626.6	-57.3	3.4	-94.8
e3	-1	1.2	5.8	4.9	-2.1	0.2	933.4	-8.1	0.7	280.0
f1	0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-0.2	5.2
g1	-1	2.2	14.2	12.0	-2.1	0.3	2,221.4	-39.8	3.0	279.4
g2	0	0.5	3.4	2.8	0.0	0.0	602.7	-34.5	1.9	-20.7
NMR	2	0.7	1.4	0.8	4.2	0.0	688.1	489.3	57.8	50.9
NWF	-2	0.2	0.0	0.0	-4.2	0.0	82.4	-10.0	-0.9	66.4
NWL	-2	0.1	0.1	0.0	-4.2	0.0	192.3	-74.8	-0.3	27.0

Table 4.8-3 Application Case - Effects (Baseline Case – Application Case) on Fragmentation in the LSA (Without Mitigation)

Ecosite Phase / Land Description	# Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)[1]	Core Area (ha)	Patch Density (#/100 km²)	% of LSA	Perimeter Length (m)	Mean Perimeter :Area (m/ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
NWR	0	0	0	0	0	0	0	0	0	0
HG	9	0.6	36.1	26.5	18.9	0.7	10,089.5	-44.5	2.9	51.3
SC	0	0	0	0	0	0	0	0	0	0
SO	0	0	0	0	0	0	0	0	0	0
Subalpine Natural Subregion										
a1	2	-2.9	10.6	8.5	4.2	0.2	2,298.1	-52.4	5.5	1,899.0
b1	3	0.4	23.5	17.8	6.3	0.5	5,943.0	7.7	-0.8	-8.2
e1	17	2.2	402.7	332.4	35.6	8.4	73,953.6	-16.2	1.2	13.4
e3	-2	0.3	11.3	10.3	-4.1	0.2	974.3	-11.1	0.6	10.3
e4	1	27.7	27.7	23.4	2.1	0.6	4,390.5	158.3	84.5	0
f1	2	3.2	32.9	24.9	4.2	0.7	8,849.2	-250.5	16.6	-116.3
f2	-6	2.5	7.1	5.9	-12.5	0.1	990.2	-60.2	4.3	338.3
h1	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HG	23	1.4	124.1	92.9	48.2	2.6	32,951.1	-124.4	9.4	-273.7
NMR	7	1.1	31.8	24.3	14.6	0.6	7,852.9	-54.8	3.9	-871.8
Natural Total	60	-	1,279.43	1,043.8	-	26.6	246,364.4	-	-	-
Montane Natural Subregion Anthropogenic Patches										
AIH	-20	1.1	-18.4	-18.0	-41.8	-0.4	-2,180.1	127.9	-13.8	430.6
AIM	1	-1,499.4	-1,481.5	-1,452.9	2.1	-31.0	-28,447.2	136.5	-12.9	876.5
ASC	-4	4.8	26.3	27.0	-8.4	0.5	-2,053.5	-101.5	6.5	10.1
CC	-77	3.4	42.1	9.9	-161.2	0.9	-62,394.0	-3944.8	0.5	158.1

Table 4.8-3 Application Case - Effects (Baseline Case – Application Case) on Fragmentation in the LSA (Without Mitigation)										
Ecosite Phase / Land Description	# Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)[1]	Core Area (ha)	Patch Density (#/100 km²)	% of LSA	Perimeter Length (m)	Mean Perimeter :Area (m/ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
CIP	-5	2.5	16.5	-7.6	-10.5	0.3	10,734.9	117.7	-17.7	478.0
CIW	-3	-3.0	-27.0	0.0	-6.3	-0.5	-8,928.3	-49.2	3.5	1,266.6
CL	79	-2.6	-24.9	-1.6	165.4	-0.5	91,198.9	4,340.5	-75.2	-102.0
CO	13	-1.8	12.9	27.7	27.2	0.2	-427.3	-113.5	14.0	-280.6
CP	-1	10.4	29.4	2.8	-2.1	0.6	8109.3	6.5	-0.5	-2,242.4
Subalpine Natural Region Anthropogenic Patches										
AIH	3	-0.3	4.0	0.6	6.3	0.1	11,872.5	332.9	-5.8	-33.4
AII	0	0	0	0	0	0	0	0	0	0
AIM	4	12.6	120.2	103.8	8.3	2.5	17,229.1	-172.1	13.6	-30.7
CC	-4	2.2	8.4	7.8	-8.4	0.2	520.7	-7.8	0.5	-35.0
CIP	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	110.1
CIW	1	0.3	4.0	3.1	2.1	0.1	1,028.4	-89.6	5.6	-311.4
CL	30	<0.1	8.3	<0.1	62.8	0.2	40,491.0	438.7	<0.1	-22.5
Anthropogenic Total	17	-	-1,279.68	-1,297.0	-	-26.6	76,754.2	-	-	-
Total LSA	**77**	-	**-0.3**	**-253.2**	-	**0.0**	**323,118.7**	-	-	-

[1] Due to rounding of numbers, total values may not equal the sum of the individual values.

- not applicable.

A summary of the overall (totals of each biodiversity and fragmentation indicator assessed) Application Case effects on biodiversity and fragmentation in the LSA is provided in Table 4.8-4. In this Application Case, the Project will result in a decrease in the total number of natural patches from 683 to 623 (Table 4.8-4). Likewise, the mean natural patch area will decrease from 5.8 ha to 4.4 ha (Table 4.8-4). The total core area of natural patches (non-anthropogenic patches) decreases by 1,043.8 ha and their perimeter length decreases by 246,364 m (Table 4.8-4). This decrease in the number of natural patches in the Application Case is attributed to the Project's broad-level disturbance into anthropogenic patches.

Overall, landscape level fragmentation metrics demonstrate a reduction in the total number of patches (natural and anthropogenic), which is indicative of removing many smaller undisturbed natural patches that existed at Baseline Case, and replacing them with a few anthropogenic disturbed patches in the Application Case. The large amount of historical disturbance within the Project Footprint at Baseline also means that the total number of anthropogenic patches decreases in the Application Case from 339 to 322 (Table 4.8-4). This is despite the fact that the total area occupied by anthropogenic patches in the LSA increases by 1,279.7 ha (Table 4.8-4).

The overall mean patch area increases from 4.7 ha to 5.1 ha in the Application Case for the same reasons as the ones highlighted above for reduced total number of patches. The total core area also increases by 253.3 ha, due to an increase in anthropogenic patch size (Table 4.8-4), while total perimeter length is reduced by 323,119 m (Table 4.8-4).

Without mitigation the LSA assessment indicates that biodiversity may be reduced at the landscape level because of fragmentation, thus an assessment of potential cumulative effects is required. Cumulative effects are assessed in the PDC (Section 4.8.2), including temporal changes (*e.g.*, progressive mine reclamation, other projects occurring during this Project's timeframe), mitigation and reclamation.

Table 4.8-4 Application Case - Effects on Fragmentation Statistics for Local Study Area (Without mitigation)

Land Cover Type	# of Patches	Mean Patch Area (ha)	Total Patch Area (ha)[1]	Core Area (ha)	Patch Density (#/100 km^2)	Perimeter Length (m)	Mean Perimeter : Area (m/ha)	Core Area Index (%)
Baseline Case								
Natural	683	5.8	3,992.1	3,129.9	143	930,661	233.1	78.4
Anthropogenic	339	2.3	783.8	525.1	71	446,982	570.3	67
Combined	1,022	4.7	4,776.0	3,655	214	1,377,643	288.5	76.5
Application Case (Without Mitigation)								
Natural	623	4.4	2,712.7	2,086.1	130	684,296.6	252.3	76.9
Anthropogenic	322	6.4	2,063.5	1,822.1	67	370,227.4	179.4	88.3
Combined	945	5.1	4,776.2	3,908.3	198	1,054,523.9	220.8	81.8
Difference (Baseline Case – Application Case)								
Natural	60	1.4	1,279.4	1,043.8	13	246,364.4	-19.2	1.5
Anthropogenic	17	-4.1	-1,279.7	-1,297	4	76,754.2	390.9	-21.3
Combined	77	-0.4	-0.3	-253.2	16	323,118.7	67.7	-5.3

[1] Due to rounding of numbers, total values may not equal the sum of the individual values.

4.8.2 Planned Development Case

The PDC assessment in the RSA utilizes the ELC Map Unit cover classes. The advantage of the ELC map units is that they incorporate age and canopy structure for forested units, and thus are not static. The ELC map units also align with the planned reclamation for the Project allowing for improved confidence in change assessment over time.

To assess potential cumulative and residual effects, the Project Footprint and other planned developments (Section 2.4.1) were mapped. Two time periods were selected for the assessment; 14 years after project start (maximum extent of area cleared or mined, with minimal area of the Footprint progressively reclaimed), and 41 years after project start (approximately 15 years after final reclamation with associated aging structural changes of the ELC map units). In addition to the disturbances present at Baseline, the PDC includes forest harvesting (planned and predicted to 2056), Teck Coal Limited Coal Mountain Phase 2 Project, and the Alberta Transportation Highway 3 Re-alignment. The Project Reclamation Plan Section F of the Application (Application, Section F, Benga 2015) was used to map the Project progressive reclamation (minimal at 14 years) and final reclamation (complete and aged at 41 years). Because these comparisons take into account the Project mitigation and reclamation plan, they are not worst-case scenarios. This is in contrast to the assessment of the Application Case in the LSA, which does not include any mitigation or reclamation plan and is therefore a worst-case scenario.

Four comparisons are used to assess biodiversity and fragmentation for the PDC in the RSA:

- Baseline Case and Application Case at T14;
- Application Case and PDC with Project at T14;
- Baseline Case and PDC with Project at T41; and
- PDC with Project and without Project at T41.

Cumulative and incremental effects of the project were assessed using comparisons one to three above, while Project residual effects were assessed based on comparison four. Biodiversity and fragmentation statistics differences for each of the four PDC assessment comparisons are provided in Tables 4.8-5 to 4.8-8. A summary of fragmentation statistics for the four comparisons are provided in Table 4.8-9. Fragmentation statistical data for each of the Cases (Baseline Case, Application Case, PDC with Project and PDC without Project) and for each of the time periods used in the four PDC comparisons (T14 and T41) are provided in Appendix H. This Appendix also includes the comparison for assessing Project residual effects at the end of Project life (Baseline Case at T27 and PDC at T27 comparisons) but is not discussed in this report.

4.8.2.1 PDC Fragmentation in the RSA - Baseline Case and Application Case at T14

The fragmentation statistics from this comparison (Baseline Case (T14) and Application Case (T14) assess the maximum amount of fragmentation cumulative effects associated with the Project in the RSA, and with mitigation included. The disturbance within the Footprint is at its maximum extent, however, in the Application Case, progressive reclamation has started. This is in contrast to the worst-case scenario comparison of the Baseline Case to the Application Case in the LSA, where no progressive reclamation (mitigation) had started. The results indicate the cumulative effects of the Project itself are minimal with mitigation, as the total number of patches only decreases by 31, associated with a decrease of 228,875.5 m in patch perimeter length. The overall difference in patch mean perimeter: total patch area ratio actually increases by 0.8 m/ha further indicating a small change in fragmentation cumulative effects with the Project.

As the total number and total area of smaller natural patches decrease and the total area of larger patches directly correlated with the Project increase, patch core area only increases by 171.8 ha. However, the total number of anthropogenic disturbance patches, primarily the Industrial (Mining)

ELC Map Unit, actually decrease in total, as previous mining disturbance patches in the Project Footprint are included within new larger Industrial (Mining) ELC Map Unit Project patches. The largest numbers of natural patches lost to Project disturbance are from the Closed Regeneration - Forest (present at Baseline Case from previous harvesting in the Project Footprint) (11 patches eliminated), the Moderate Conifer Mature Forest (14), the Natural Upland Herbaceous (13), and the Natural Shrub Wetland (14) map units. The largest increase in natural patches (23) is for the Closed Conifer Mature Forest map unit as forest harvesting within the Project Footprint changes compared to Baseline.

Table 4.8-5 Fragmentation Statistics for a Comparison Scenario in the RSA – Baseline Case and Application Case at T14

ELC Classes[1]	Difference Between Baseline and Application at T14[2]									
	# of Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)	Core Area (ha)	Patch Density (#/100 km²)	% of RSA	Perimeter Length (m)	Mean Perimeter : Area (m / ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
Open Regeneration - Herbaceous	-2	0.2	13.2	12.3	-1	<0.01	781.9	-62.3	5.0	14.8
Open Regeneration - Shrub	0	<0.01	<0.01	54.3	0	<0.01	16,437.5	0.3	<0.01	1.6
Closed Regeneration - Forest	11	<0.01	65.9	51.3	1	<0.01	16,121.7	0.3	<0.01	0.4
Open Deciduous Young Forest	0	0	0	0	0	0	0	0	0	0
Open Deciduous Mature Forest	0	<0.01	<0.01	<0.01	0	<0.01	<0.01	<0.01	<0.01	<0.01
Open Deciduous Old Forest	2	<0.01	8.1	5.9	0	<0.01	2,399.3	0.3	<0.01	-11.7
Open Mixed Young Forest	0	<0.01	<0.01	<0.01	0	<0.01	<0.01	<0.01	<0.01	0.0
Open Mixed Mature Forest	-5	0.3	2.1	1.8	0	<0.01	<0.01	-0.3	<0.01	27.2
Open Mixed Old Forest	0	<0.01	<0.01	<0.01	0	<0.01	<0.01	<0.01	<0.01	<0.01
Open Conifer Young Forest	0	<0.01	<0.01	<0.01	0	<0.01	38.6	<0.01	<0.01	<0.01
Open Conifer Mature Forest	-2	0.1	154.5	127.2	0	0.1	26,595.4	-0.2	<0.01	1.2
Open Conifer Old Forest	8	-0.1	13.3	10.8	1	<0.01	2,691.4	<0.01	<0.01	-2.8
Moderate Deciduous Young Forest	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
Moderate Deciduous Mature Forest	0	<0.01	<0.01	<0.01	0	<0.01	-3.1	<0.01	<0.01	<0.01

Table 4.8-5 Fragmentation Statistics for a Comparison Scenario in the RSA – Baseline Case and Application Case at T14

ELC Classes[1]	Difference Between Baseline and Application at T14[2]									
	# of Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)	Core Area (ha)	Patch Density (#/100 km^2)	% of RSA	Perimeter Length (m)	Mean Perimeter : Area (m / ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
Moderate Deciduous Old Forest	0	<0.01	<0.01	<0.01	0	<0.01	-11.2	<0.01	<0.01	<0.01
Moderate Mixed Young Forest	-9	3.8	-26.1	-21.0	0	<0.01	-6,671.2	-16.6	0.6	508.4
Moderate Mixed Mature Forest	0	<0.01	<0.01	<0.01	0	<0.01	-7.2	<0.01	<0.01	0.0
Moderate Mixed Old Forest	4	<0.01	34.7	27.8	0	<0.01	7,071.5	-1.6	0.1	-2.4
Moderate Conifer Young Forest	1	<0.01	11.7	9.8	0	<0.01	1,798.6	-0.3	<0.01	1.4
Moderate Conifer Mature Forest	14	<0.01	214.8	175.0	1	0.1	41,789.9	-0.3	<0.01	0.4
Moderate Conifer Old Forest	-9	0.2	48.6	45.3	0	<0.01	2,577.8	-1.1	0.1	7.1
Closed Deciduous Young Forest	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
Closed Deciduous Mature Forest	0	<0.01	<0.01	<0.01	0	<0.01	-114.5	<0.01	<0.01	<0.01
Closed Deciduous Old Forest	0	<0.01	<0.01	<0.01	0	<0.01	12.5	<0.01	<0.01	<0.01
Closed Mixed Young Forest	0	<0.01	<0.01	<0.01	0	<0.01	-4.1	<0.01	<0.01	<0.01
Closed Mixed Mature Forest	0	<0.01	<0.01	<0.01	0	<0.01	<0.01	<0.01	<0.01	<0.01
Closed Mixed Old Forest	2	0.2	22.6	17.4	0	<0.01	5,340.2	-2.2	0.2	-24.4

Table 4.8-5 Fragmentation Statistics for a Comparison Scenario in the RSA – Baseline Case and Application Case at T14

ELC Classes[1]	Difference Between Baseline and Application at T14[2]									
	# of Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)	Core Area (ha)	Patch Density (#/100 km²)	% of RSA	Perimeter Length (m)	Mean Perimeter : Area (m / ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
Closed Conifer Young Forest	-9	-1.0	-324.8	-299.9	0	-0.1	-26,271.6	17.2	-1.6	18.6
Closed Conifer Mature Forest	-23	0.2	257.3	224.4	-1	0.1	31,701.7	-0.5	<0.01	2.7
Closed Conifer Old Forest	10	-0.1	52.5	40.6	0	<0.01	12,720.1	0.6	-0.1	-17.7
Dense Deciduous Mature Forest	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
Dense Deciduous Old Forest	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
Dense Mixed Mature Forest	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
Dense Mixed Old Forest	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
Dense Conifer Young Forest	0	<0.01	<0.01	<0.01	0	<0.01	-16.3	-0.1	<0.01	<0.01
Dense Conifer Mature Forest	-3	0.2	198.1	176.6	0	0.1	21,325.5	-0.9	0.1	2.5
Barren Land	1	<0.01	3.1	2.0	0	<0.01	1,059.3	<0.01	<0.01	-0.6
Natural Shrub	-2	<0.01	0.3	0.3	0	<0.01	-168.6	<0.01	<0.01	1.4
Natural Upland Herbaceous	13	-0.1	27.9	18.3	1	<0.01	10,619.6	0.2	<0.01	-0.1
Natural Graminoid Wetland	0	<0.01	<0.01	<0.01	0	<0.01	<0.01	<0.01	<0.01	<0.01
Natural Shrub Wetland	14	-1.1	<0.01	<0.01	0	<0.01	429.9	0.6	<0.01	-166.1
Treed Wetland	0	0.2	10.7	9.1	0	<0.01	1,716.3	-2<0.01	1.8	3.8
Industrial (Mining)	11	-1.4	-863.4	-850.8	0	-0.3	-9,927.2	38.1	-3.3	-3.2
Settlement	-4	<0.01	9.4	8.3	0	<0.01	958.5	-5.8	0.4	1.8

Table 4.8-5 Fragmentation Statistics for a Comparison Scenario in the RSA – Baseline Case and Application Case at T14

ELC Classes[1]	Difference Between Baseline and Application at T14[2]									
	# of Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)	Core Area (ha)	Patch Density (#/100 km²)	% of RSA	Perimeter Length (m)	Mean Perimeter : Area (m / ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
Open Water	2	<0.01	1.4	0.5	0	<0.01	964.3	0.3	<0.01	-2.3
Linear Disturbance	0	<0.01	-9.5	-21.0	0	<0.01	65,040.3	1<0.01	-0.2	0.1
Agriculture	1	<0.01	<0.01	-0.1	0	<0.01	-3<0.01	<0.01	<0.01	-0.5
Dense Conifer Old Forest	5	-1.0	3.7	2.1	0	<0.01	1,753.9	1.4	-0.1	-73.2
Dense Deciduous Young Forest	0	0	0	0	0	0	0	0	0	0
Lush Herb	0	<0.01	<0.01	<0.01	0	<0.01	-4.8	<0.01	<0.01	<0.01

[1] Age classes are derived from the AVI stand origin data as follows:

- young deciduous and mixed = 30-60 years;
- mature deciduous and mixed = 61 – 100;
- young conifer stands = 30-70;
- mature pine dominated conifer = 71-119;
- mature non-pine conifer = 71-139
- old deciduous and mixed stands >100;
- old pine stands >120; and
- old non-pine conifer stands >140.
- Crown closure classes are AVI codes of canopy closure (measured in %) as follows: Dense = 71-100, Closed = 51-70, Moderate = 31-50, and open = 6-30.
- Cover types are based on the proportion of conifer or Deciduous species in the canopy. Deciduous = >80% Deciduous, mixed = 30-79% conifer / deciduous, conifer ≥80% conifer (ASRD 2005).

[2] Due to rounding of numbers, total values may not equal the sum of the individual values.

4.8.2.2 PDC Fragmentation in the RSA – Application Case and PDC with Project at T14

The fragmentation statistics from this comparison (Application Case [aged 14 years] and PDC [aged 14 years]) assesses the fragmentation cumulative effects from the other planned projects in the PDC but not the Project as the project is already included in both scenarios. The fragmentation cumulative effects from other planned projects in the RSA are greater than the fragmentation cumulative effects associated with the Project as the total number of patches increases by 16,409, correlated with an increase of 2,564,904.2 m in total in patch perimeter length and a decrease in patch core area by 988.0 ha (Table 4.8-6). Average patch size decreased by 1.2 ha and patch density decreased by 11.5 patches per 100 km^2.

This is in contrast to a decrease of only 31 patches for the Project itself, and as noted previously, an increase in the total number of patches, average patch size, and a decrease in core patch area, is associated with increased fragmentation and decreased biodiversity. Landscape fragmentation is also associated with increasing distance between patches of the same map unit, which increase by an average of 117.5 m in this scenario (Table 4.8-6). The overall difference in patch mean perimeter to total patch area ratio also decreased by 8.7 m/ha further indicating increasing fragmentation cumulative effects. The greatest change is in the Conifer Forest map units indicating forest harvesting is the primary anthropogenic disturbance within RSA. Coupled with the Alberta Transportation Highway 3 Re-alignment is an increase in Linear Disturbance map unit patches.

Table 4.8-6 Fragmentation Statistics for a Comparison Scenario in the RSA – Application Case and PDC with Project at T14

ELC Classes[1]	Difference Between Application and PDC with Project at T14[2]									
	# of Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)	Core Area (ha)	Patch Density (#/100 km²)	% of RSA	Perimeter Length (m)	Mean Perimeter : Area (m / ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
Barren Land	-4	0.1	4.5	3.2	0	<0.01	879.4	<0.01	<0.01	4.2
Open Regeneration - Herbaceous	-2,813	-4.8	-16,597.7	-13,308.3	-99	-5.8	-3,600,622.4	304.1	-23.9	273.1
Open Regeneration - Shrub	-520	4.0	1,194.9	1,066.8	-18	0.4	63,129.0	-6.7	0.2	78.2
Closed Regeneration - Forest	-137	1.3	352.4	335.4	-5	0.1	1,891.7	-3.1	0.2	31.6
Open Deciduous Young Forest	1	0.3	12.6	9.2	1	<0.01	3,403.5	-1.1	-0.3	66.4
Open Deciduous Mature Forest	-5	0.4	59.7	46.0	0	<0.01	11,026.9	-2.9	<0.01	28.3
Open Deciduous Old Forest	-7	0.4	6.8	5.5	0	<0.01	900.4	-1.2	0.1	64.8
Open Mixed Young Forest	0	0.2	4.1	3.4	0	<0.01	634.8	-7.4	0.5	67.7
Open Mixed Mature Forest	4	0.2	52.1	35.5	0	<0.01	17,718.0	6.3	-0.6	-11.4
Open Mixed Old Forest	-11	0.8	11.8	8.2	0	<0.01	2,189.0	-0.8	-0.1	171.7
Open Conifer Young Forest	-9	0.2	10.4	10.4	0	<0.01	-1,265.3	-1.6	0.1	11.7
Open Conifer Mature Forest	-630	2.3	1,874.5	1,600.1	-22	0.7	192,937.0	-7.7	0.4	72.8
Open Conifer Old Forest	-759	4.1	781.4	656.1	-27	0.3	42,575.6	-22.5	0.6	217.1
Moderate Deciduous Young Forest	-1	0.2	1.9	1.4	0	<0.01	415.2	-2.7	0.1	260.5
Moderate Deciduous Mature Forest	-16	0.1	46.7	34.3	-1	<0.01	10,346.2	-1.7	<0.01	15.8

Table 4.8-6 Fragmentation Statistics for a Comparison Scenario in the RSA – Application Case and PDC with Project at T14										
ELC Classes[1]	Difference Between Application and PDC with Project at T14[2]									
	# of Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)	Core Area (ha)	Patch Density (#/100 km²)	% of RSA	Perimeter Length (m)	Mean Perimeter : Area (m / ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
Moderate Deciduous Old Forest	-7	0.2	11.6	8.9	-1	<0.01	2,523.3	-0.6	<0.01	39.4
Moderate Mixed Young Forest	-1	0.5	2.3	1.9	0	<0.01	222.2	-1.6	<0.01	437.0
Moderate Mixed Mature Forest	-9	0.5	13.4	10.9	0	<0.01	1,261.7	-5.9	0.3	145.7
Moderate Mixed Old Forest	-39	0.2	44.9	35.4	-2	<0.01	6,586.9	-2.9	0.2	18.6
Moderate Conifer Young Forest	-25	0.5	22.5	21.3	-1	<0.01	-2,270.2	-2.9	0.1	34.8
Moderate Conifer Mature Forest	-2,353	4.3	2,440.2	1952.7	-83	0.9	245,211.3	-18.0	0.2	179.5
Moderate Conifer Old Forest	-627	5.0	610.4	508.2	-22	0.2	33,166.5	-15.1	0.2	237.9
Closed Deciduous Young Forest	0	<0.01	<0.01	<0.01	0	<0.01	-0.1	<0.01	<0.01	<0.01
Closed Deciduous Mature Forest	-14	0.3	12.0	9.1	0	<0.01	1,294.3	-0.5	<0.01	31.4
Closed Deciduous Old Forest	-9	0.2	19.7	18.7	0	<0.01	-425.8	-2.1	0.1	17.8
Closed Mixed Young Forest	9	-0.2	13.8	8.7	0	<0.01	6,358.6	1.6	-0.1	-10.1
Closed Mixed Mature Forest	-15	0.9	10.8	6.4	0	<0.01	2,657.1	-0.6	-0.3	230.9
Closed Mixed Old Forest	-33	2.1	16.2	11.8	-1	<0.01	1,497.1	-8.6	-0.1	401.0

Table 4.8-6 Fragmentation Statistics for a Comparison Scenario in the RSA – Application Case and PDC with Project at T14

ELC Classes[1]	Difference Between Application and PDC with Project at T14[2]									
	# of Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)	Core Area (ha)	Patch Density (#/100 km²)	% of RSA	Perimeter Length (m)	Mean Perimeter : Area (m / ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
Closed Conifer Young Forest	-30	1.1	26.0	24.5	-1	<0.01	-2,185.8	-3.2	0.1	71.1
Closed Conifer Mature Forest	-4,498	7.9	5,272.7	4,734.5	-159	1.9	51,050.4	-33.6	1.4	192.5
Closed Conifer Old Forest	-550	6.7	564.1	510.3	-19	0.2	-9,010.6	-31.6	1.3	312.2
Dense Deciduous Mature Forest	0	<0.01	3.6	2.7	0	<0.01	845.9	<0.01	<0.01	19.4
Dense Deciduous Old Forest	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
Dense Mixed Mature Forest	-6.0	2.3	3.1	1.8	0	<0.01	701.3	-0.7	-0.6	79.6
Dense Mixed Old Forest	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
Dense Conifer Young Forest	-2	0.6	0.1	<0.01	0	<0.01	27.7	0.1	<0.01	55.1
Dense Conifer Mature Forest	-2,497	8.3	2,834.1	2,472.3	-88	1.0	93,549.6	-34.5	1.0	206.1
Natural Shrub	-1	<0.01	0.7	0.7	0	<0.01	-55.4	<0.01	<0.01	1.5
Natural Upland Herbaceous	-21	0.2	14.8	9.0	-1	<0.01	4,502.4	0.1	<0.01	3.4
Natural Graminoid Wetland	-11	0.9	6.6	5.7	0	<0.01	-164.0	-13.6	0.6	535.1
Natural Shrub Wetland	-2	0.2	1.4	1.0	0	<0.01	184.6	-0.2	<0.01	47.2
Treed Wetland	-12	0.7	13.6	8.7	-1	<0.01	2,234.8	-30.8	<0.01	695.8
Industrial (Mining)	1	<0.01	11.3	8.3	0	<0.01	3,019.7	0.3	<0.01	5.3
Settlement	0	<0.01	<0.01	<0.01	0	<0.01	<0.01	<0.01	<0.01	<0.01
Open Water	-1	<0.01	2.1	1.4	0	<0.01	272.4	-0.3	<0.01	3.3

Table 4.8-6 Fragmentation Statistics for a Comparison Scenario in the RSA – Application Case and PDC with Project at T14

ELC Classes[1]	Difference Between Application and PDC with Project at T14[2]									
	# of Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)	Core Area (ha)	Patch Density (#/100 km²)	% of RSA	Perimeter Length (m)	Mean Perimeter : Area (m / ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
Linear Disturbance	-686	0.2	148.9	51.1	-25	0.1	243,346.5	9.3	<0.01	27.9
Agriculture	0	<0.01	<0.01	<0.01	0	<0.01	-0.9	<0.01	<0.01	<0.01
Dense Conifer Old Forest	-63	7.6	63.1	54.4	-2	<0.01	2,535.0	-12.5	0.3	505.0
Dense Deciduous Young Forest	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
Lush Herb	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0

[1] Age classes are derived from the AVI stand origin data as follows:

- young deciduous and mixed = 30-60 years;
- mature deciduous and mixed = 61 – 100;
- young conifer stands = 30-70;
- mature pine dominated conifer = 71-119;
- mature non-pine conifer = 71-139
- old deciduous and mixed stands >100;
- old pine stands >120; and
- old non-pine conifer stands >140.
- Crown closure classes are AVI codes of canopy closure (measured in %) as follows: Dense = 71-100, Closed = 51-70, Moderate = 31-50, and open = 6-30.
- Cover types are based on the proportion of conifer or Deciduous species in the canopy. Deciduous = >80% Deciduous, mixed = 30-79% conifer / deciduous, conifer ≥80% conifer (ASRD 2005).

[2] Due to rounding of numbers, total values may not equal the sum of the individual values.

4.8.2.3 PDC Fragmentation in the RSA – Baseline Case and PDC with Project at T41

The fragmentation statistics from this comparison (Baseline Case T41 and PDC T41) assesses the fragmentation cumulative effects from 1) the Project itself and 2) the other planned projects in the PDC, when the Project disturbance is mitigated (fully reclaimed) and aged to T14 and structural changes to the ELC map units.

Fragmentation cumulative effects increase with time due to the Project and other projects in the PDC, when compared to the results from the time 14 year scenario discussed in section 4.8.2.1, but do not differ considerably from the fragmentation cumulative effects that considers only other planned projects in the RSA. The total number of patches increases by 17,552, correlated with increasing total in patch perimeter length by 2,466,562.0 m and decreasing patch core area by 853.5 ha (Table 4.8-7). The distance between patches of the same map unit, increased by an average of 143.2 m, average patch size decreased by 1.6 ha and patch density decreased by 12.2 patches per 100 km^2.

Similar to the results above for time 14 comparison, the largest increases are in Conifer Forest map units indicating forest harvesting is the primary anthropogenic disturbance within RSA. Associated with 41 years of aging and structural changes to ELC map units the amount of Closed Regeneration - Forest map units also increase. Coupled with the Alberta Transportation Highway 3 Re-alignment is an increase in Linear Disturbance map unit patches.

Table 4.8-7 Fragmentation Statistics for a Comparison Scenario in the RSA – Baseline Case and PDC with Project at T41

ELC Classes[1]	Difference Between Baseline and PDC with Project at T41[2]									
	# of Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)	Core Area (ha)	Patch Density (#/100 km²)	% of RSA	Perimeter Length (m)	Mean Perimeter : Area (m / ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
Barren Land	-13	0.2	-24.5	-22.8	0	<0.01	-3,095.1	<0.01	<0.01	8.1
Open Regeneration - Herbaceous	-2	0.2	15.1	13.4	-1	<0.01	1,522.3	-65.2	5.1	14.8
Open Regeneration - Shrub	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
Closed Regeneration - Forest	-2,809	-5.9	-16,585.9	-13,298.9	-98	-5.8	-3,597,686.1	-216.9	-80.2	-240.0
Open Deciduous Young Forest	0	<0.01	0.2	0.2	0	<0.01	-144.7	-2.9	0.1	-3.2
Open Deciduous Mature Forest	-1	0.1	3.3	2.2	0	<0.01	1,008.3	0.2	-0.1	9.8
Open Deciduous Old Forest	-10	0.5	83.9	65.8	-1	<0.01	14,938.8	-3.5	0.1	26.7
Open Mixed Young Forest	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
Open Mixed Mature Forest	-1	0.3	1.4	1.2	0	<0.01	12.0	-0.5	<0.01	41.3
Open Mixed Old Forest	-10	0.7	77.4	56.2	-1	<0.01	20,804.0	0.7	-0.2	60.8
Open Conifer Young Forest	0	<0.01	<0.01	0.1	0	<0.01	-100.6	-0.5	0.1	-2.3
Open Conifer Mature Forest	-302	1.5	1,198.4	1,032.8	-11	0.4	127,879.7	-6.1	0.3	48.1
Open Conifer Old Forest	-1,179	4.3	1,658.3	1,406.0	-41	0.6	114,002.5	-18.6	0.6	159.8
Moderate Deciduous Young Forest	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
Moderate Deciduous Mature Forest	-1	0.1	2.6	1.9	0	<0.01	<0.01	-0.4	<0.01	47.0

Table 4.8-7 Fragmentation Statistics for a Comparison Scenario in the RSA – Baseline Case and PDC with Project at T41

ELC Classes[1]	Difference Between Baseline and PDC with Project at T41[2]									
	# of Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)	Core Area (ha)	Patch Density (#/100 km^2)	% of RSA	Perimeter Length (m)	Mean Perimeter : Area (m / ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
Moderate Deciduous Old Forest	-23	0.1	57.6	42.7	-1	<0.01	12,740.4	-1.4	<0.01	16.1
Moderate Mixed Young Forest	-352	-0.4	-139.8	-114.0	-12	<0.01	-35,758.3	-255.8	-81.6	-30.1
Moderate Mixed Mature Forest	-1	0.9	2.3	1.9	0	<0.01	221.3	-1.4	<0.01	566.2
Moderate Mixed Old Forest	-44	0.2	93.1	74.1	-1	<0.01	148,44.3	-4.9	0.3	14.6
Moderate Conifer Young Forest	-17	3.3	20.6	16.6	-1	<0.01	2,259.8	-23.0	0.7	825.8
Moderate Conifer Mature Forest	-1,191	3.2	1,675.6	1,371.6	-42	0.6	179,176.2	-13.2	0.3	141.1
Moderate Conifer Old Forest	-1,859	6.0	1,746.9	1,456.7	-65	0.6	85,467.8	-26.3	0.6	248.5
Closed Deciduous Young Forest	-7	0.9	5.7	4.1	0	<0.01	905.7	-6.9	<0.01	149.1
Closed Deciduous Mature Forest	0	0.7	85.1	73.2	0	<0.01	11,907.5	-8.6	0.8	55.6
Closed Deciduous Old Forest	-24	0.3	38.9	35.9	-1	<0.01	-450.8	-1.9	0.1	23.3
Closed Mixed Young Forest	-233	2.2	646.4	580.2	-8	0.2	38,909.2	-2.2	0.1	36.6
Closed Mixed Mature Forest	6	-0.5	3.3	1.9	0	<0.01	2,257.1	3.1	-0.2	-80.2
Closed Mixed Old Forest	-38	1.4	67.9	49.8	-2	<0.01	15,175.7	-4.2	<0.01	127.9
Closed Conifer Young Forest	-780	6.9	-211.4	-234.2	-28	-0.1	-77,346.5	-3.7	-0.5	186.8

Table 4.8-7 Fragmentation Statistics for a Comparison Scenario in the RSA – Baseline Case and PDC with Project at T41

ELC Classes[1]	Difference Between Baseline and PDC with Project at T41[2]									
	# of Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)	Core Area (ha)	Patch Density (#/100 km²)	% of RSA	Perimeter Length (m)	Mean Perimeter : Area (m / ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
Closed Conifer Mature Forest	-3,982	7.7	4,731.7	4,243.8	-140	1.7	66,965.9	-29.6	1.2	189.6
Closed Conifer Old Forest	-1,291	6.9	1,505.7	1,308.5	-46	0.5	50,387.7	-28.9	1.0	266.3
Dense Deciduous Mature Forest	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
Dense Deciduous Old Forest	0	<0.01	3.6	2.7	0	<0.01	845.9	<0.01	<0.01	4.4
Dense Mixed Mature Forest	-6	0.9	3.1	1.8	0	<0.01	701.3	-1,655.5	36.0	46.2
Dense Mixed Old Forest	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
Dense Conifer Young Forest	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
Dense Conifer Mature Forest	-2,446	8.8	2,964.1	2,586.7	-86	1.0	113,108.0	-36.3	1.0	212.2
Natural Shrub	-3	<0.01	7.7	7.1	0	<0.01	850.2	-0.2	<0.01	2.3
Natural Upland Herbaceous	-127	1.0	-142.8	-142.1	-4	-0.1	-4,897.5	0.4	<0.01	21.0
Natural Graminoid Wetland	-11	0.9	6.6	5.7	0	<0.01	-164.0	-13.6	0.6	535.1
Natural Shrub Wetland	12	-0.9	1.7	1.3	0	<0.01	642.9	0.3	<0.01	-118.9
Treed Wetland	-15	0.9	18.4	13.5	-1	<0.01	<0.01	-43.7	1.3	806.4
Industrial (Mining)	17	0.1	147.1	112.6	0	0.1	37,660.1	3.2	-0.3	0.7
Settlement	-4	<0.01	9.6	8.4	0	<0.01	1,065.8	-5.8	0.4	1.8
Open Water	-3	-0.1	-47.8	-43.9	0	<0.01	-4,770.3	7.6	-0.7	-8.2
Linear Disturbance	-662	0.2	123.1	7.1	-24	<0.01	327,289.6	24.3	-0.5	27.9
Agriculture	1	<0.01	<0.01	-0.1	0	<0.01	-30.9	<0.01	<0.01	-0.5
Dense Conifer Old Forest	-141	4.6	145.9	121.3	-5	0.1	11,657.3	-10.4	0.1	287.1

Table 4.8-7 Fragmentation Statistics for a Comparison Scenario in the RSA – Baseline Case and PDC with Project at T41

ELC Classes[1]	Difference Between Baseline and PDC with Project at T41[2]									
	# of Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)	Core Area (ha)	Patch Density (#/100 km^2)	% of RSA	Perimeter Length (m)	Mean Perimeter : Area (m / ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
Dense Deciduous Young Forest	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
Lush Herb	0	<0.01	<0.01	<0.01	0	<0.01	-4.8	<0.01	<0.01	<0.01

[1] Age classes are derived from the AVI stand origin data as follows:

- young deciduous and mixed = 30-60 years;
- mature deciduous and mixed = 61 – 100;
- young conifer stands = 30-70;
- mature pine dominated conifer = 71-119;
- mature non-pine conifer = 71-139
- old deciduous and mixed stands >100;
- old pine stands >120; and
- old non-pine conifer stands >140.
- Crown closure classes are AVI codes of canopy closure (measured in %) as follows: Dense = 71-100, Closed = 51-70, Moderate = 31-50, and open = 6-30.
- Cover types are based on the proportion of conifer or Deciduous species in the canopy. Deciduous = >80% Deciduous, mixed = 30-79% conifer / deciduous, conifer ≥80% conifer (ASRD 2005).

[2] Due to rounding of numbers, total values may not equal the sum of the individual values.

4.8.2.4 PDC Fragmentation in the RSA – PDC with Project and PDC without Project at T41

The fragmentation statistics from this comparison (PDC with Project [aged 41 years] and PDC without Project [aged 41 years]) assesses the fragmentation residual effects from the Project after mitigation and aging and structural changes to the landscape at 41 years. The residual fragmentation effects from the Project itself are relatively minimal compared to effects from forest harvesting and relative to the total number of patches in the RSA. The residual fragmentation effects result in 458 less patches, but are contrasted with an increase of 2,564,904.2 m in total in patch perimeter length and a decrease in patch core area of 235.9 ha (Table 4.8-8). This is despite the fact that the project reduces the perimeter length and increases core area with reclamation. The distance between patches of the same map unit increase by an average of 102.9 m.

The largest increase is in patches of the Open Regeneration – Herbaceous resulting from regenerating forest cover after forest harvesting and reclamation. This increase is associated with a decrease in Conifer Forest map unit patches lost to Project operations (and some forest harvesting within the Project Footprint). The number of Industrial – Mining map unit patches also increases due mining disturbances from other included mine projects in the RSA are not assumed to be reclaimed.

Table 4.8-8 Fragmentation Statistics for a Comparison Scenario in the RSA – PDC with Project and PDC Without Project at T41

ELC Classes[1]	Difference Between PDC with Project – PDC without Project at T41[2]									
	# of Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)	Core Area (ha)	Patch Density (#/100 km²)	% of RSA	Perimeter Length (m)	Mean Perimeter : Area (m / ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
Barren Land	9	-0.1	29.5	26.6	0	<0.01	3,762.9	<0.01	<0.01	-3.4
Open Regeneration - Herbaceous	-1,044	-1.1	-2,295.1	-1,747.1	-36	-0.8	-65,4450.2	232.0	-19.4	296.5
Open Regeneration - Shrub	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
Closed Regeneration - Forest	-13	<0.01	-180.1	-153.3	-1	-0.1	-28,316.0	0.6	-0.1	-0.1
Open Deciduous Young Forest	0	<0.01	<0.01	<0.01	0	<0.01	<0.01	<0.01	<0.01	<0.01
Open Deciduous Mature Forest	0	<0.01	<0.01	<0.01	0	<0.01	<0.01	<0.01	<0.01	<0.01
Open Deciduous Old Forest	1	<0.01	3.1	2.1	0	<0.01	995.2	0.1	<0.01	-3.2
Open Mixed Young Forest	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
Open Mixed Mature Forest	2	-0.5	0.2	<0.01	0	<0.01	501.6	1.0	<0.01	-34.1
Open Mixed Old Forest	2	-0.1	-8.6	-6.3	0	<0.01	-2,448.5	-0.2	<0.01	7.2
Open Conifer Young Forest	0	<0.01	<0.01	<0.01	0	<0.01	<0.01	<0.01	<0.01	<0.01
Open Conifer Mature Forest	48	<0.01	348.7	284.9	2	0.1	68,843.3	-0.2	<0.01	-1.3
Open Conifer Old Forest	127	-0.1	347.8	264.6	4	0.1	99,820.5	1.5	-0.1	-5.6
Moderate Deciduous Young Forest	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
Moderate Deciduous Mature Forest	0	<0.01	<0.01	<0.01	0	<0.01	<0.01	<0.01	<0.01	<0.01

Table 4.8-8 Fragmentation Statistics for a Comparison Scenario in the RSA – PDC with Project and PDC Without Project at T41										
ELC Classes[1]	Difference Between PDC with Project – PDC without Project at T41[2]									
	# of Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)	Core Area (ha)	Patch Density (#/100 km²)	% of RSA	Perimeter Length (m)	Mean Perimeter : Area (m / ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
Moderate Deciduous Old Forest	11	<0.01	10.9	7.0	0	<0.01	4,756.0	0.4	<0.01	-3.2
Moderate Mixed Young Forest	352	0.4	139.8	114.0	12	<0.01	35,758.3	255.8	81.6	30.1
Moderate Mixed Mature Forest	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
Moderate Mixed Old Forest	4	<0.01	-20.6	-18.2	0	<0.01	-2,011.7	1.4	-0.1	2.7
Moderate Conifer Young Forest	-4	0.2	-5.5	-3.7	0	<0.01	-2,915.4	-10.3	0.3	69.2
Moderate Conifer Mature Forest	107	-0.1	175.4	138.4	4	0.1	44,794.4	0.3	<0.01	-4.7
Moderate Conifer Old Forest	40	<0.01	78.3	54.1	1	<0.01	26,614.9	0.7	-0.1	-1.2
Closed Deciduous Young Forest	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
Closed Deciduous Mature Forest	1	<0.01	12.9	10.1	0	<0.01	2,761.7	-0.4	<0.01	-14.0
Closed Deciduous Old Forest	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
Closed Mixed Young Forest	6	-0.1	-118.1	-95.2	1	<0.01	-23,546.1	-0.3	<0.01	-2.4
Closed Mixed Mature Forest	0	<0.01	<0.01	<0.01	0	<0.01	<0.01	<0.01	<0.01	<0.01
Closed Mixed Old Forest	1	<0.01	-0.6	0.1	0	<0.01	-721.6	-0.6	0.1	13.4

Table 4.8-8 Fragmentation Statistics for a Comparison Scenario in the RSA – PDC with Project and PDC Without Project at T41										
ELC Classes[1]	Difference Between PDC with Project – PDC without Project at T41[2]									
	# of Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)	Core Area (ha)	Patch Density (#/100 km²)	% of RSA	Perimeter Length (m)	Mean Perimeter : Area (m / ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
Closed Conifer Young Forest	353	-1.2	1,128.4	1,051.2	13	0.4	124,439.1	-6.3	0.9	-48.0
Closed Conifer Mature Forest	269	-0.1	285.5	227.6	9	0.1	84,929.0	0.9	<0.01	-3.2
Closed Conifer Old Forest	16	<0.01	65.7	49.3	1	<0.01	17,282.7	0.3	<0.01	-1.2
Dense Deciduous Mature Forest	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
Dense Deciduous Old Forest	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
Dense Mixed Mature Forest	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
Dense Mixed Old Forest	8	-2.7	75.8	59.6	0	<0.01	17,511.4	13.5	-0.3	5436.3
Dense Conifer Young Forest	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
Dense Conifer Mature Forest	78	-0.1	-21.2	-36.1	3	<0.01	19,776.7	2.2	-0.2	-1.0
Natural Shrub	2	<0.01	-0.3	-0.3	0	<0.01	211.1	<0.01	<0.01	-0.3
Natural Upland Herbaceous	98	-0.7	176.5	169.9	3	0.1	8,624.2	-0.4	<0.01	-15.6
Natural Graminoid Wetland	0	<0.01	<0.01	<0.01	0	<0.01	<0.01	<0.01	<0.01	<0.01
Natural Shrub Wetland	0	<0.01	<0.01	<0.01	0	<0.01	<0.01	<0.01	<0.01	<0.01
Treed Wetland	3	-0.2	-4.7	-4.8	0	<0.01	84.7	18.3	-1.5	-109.9

Table 4.8-8 Fragmentation Statistics for a Comparison Scenario in the RSA – PDC with Project and PDC Without Project at T41

ELC Classes[1]	Difference Between PDC with Project – PDC without Project at T41[2]									
	# of Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)	Core Area (ha)	Patch Density (#/100 km²)	% of RSA	Perimeter Length (m)	Mean Perimeter : Area (m / ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
Industrial (Mining)	-16	-0.2	-215.9	-179.9	0	-0.1	-39,099.5	0.4	<0.01	4.6
Settlement	5	<0.01	-9.4	-8.3	0	<0.01	-955.3	5.8	-0.4	-2.2
Open Water	2	0.1	51.8	46.8	0	<0.01	5,228.9	-8.2	0.8	11.2
Linear Disturbance	-33	<0.01	-53.5	-19.7	-1	<0.01	-94,328.9	-4.3	<0.01	0.6
Agriculture	0	<0.01	<0.01	<0.01	0	<0.01	<0.01	<0.01	<0.01	<0.01
Dense Conifer Old Forest	23	-0.4	3.3	2.4	1	<0.01	3,048.7	1.6	<0.01	-24.1
Dense Deciduous Young Forest	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
Lush Herb	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0

[1] Age classes are derived from the AVI stand origin data as follows:

- young deciduous and mixed = 30-60 years;
- mature deciduous and mixed = 61 – 100;
- young conifer stands = 30-70;
- mature pine dominated conifer = 71-119;
- mature non-pine conifer = 71-139
- old deciduous and mixed stands >100;
- old pine stands >120; and
- old non-pine conifer stands >140.
- Crown closure classes are AVI codes of canopy closure (measured in %) as follows: Dense = 71-100, Closed = 51-70, Moderate = 31-50, and open = 6-30.
- Cover types are based on the proportion of conifer or Deciduous species in the canopy. Deciduous = >80% Deciduous, mixed = 30-79% conifer / deciduous, conifer ≥80% conifer (ASRD 2005).

[2] Due to rounding of numbers, total values may not equal the sum of the individual values.

4.8.2.5 Summary of Planned Development Case Scenario Results

Fragmentation summary statistics for all four PDC comparison scenarios are provided in Table 4.8-9. The fragmentation cumulative effects on most habitats are expected to slightly increase because of the Project itself at time 14 years and decrease with reclamation. The Project, in combination with other projects in the PDC for the RSA is predicted to contribute to an increase in fragmentation cumulative effects, especially an increase in the number of patches, a decrease in patch perimeter length (m) and a decrease in patch core area. However, due to the already highly fragmented condition of the Project development area, including from approximately 55 year old previous mining activities, roads and oil and gas developments, the Project contribution to the increase in fragmentation cumulative effects is minimal and positive compared to other projects included in the PDC, especially compared to forest harvesting in the RSA. Establishing large contiguous forest patches, during reclamation, on the landscape will somewhat offset the unnaturally small patches created by harvesting.

It is anticipated that populations and communities of most native vegetation will recover, given time, to near-Baseline levels after reclamation, and that reclaimed habitat will be structurally and compositionally similar to that existing at Baseline, including previous disturbed areas in the Project Footprint.

Table 4.8-9 Fragmentation Summary Statistics for the Four PDC Comparison Scenarios in the RSA Landscape

# of Patches	Average Patch Size (ha)	Total Area of Patches (ha)	Average Patch Density (#/100 km²)	% of RSA	Patch Perimeter Length (m)	Average of Patch Mean Perimeter : Area (m/ha)	Patch Core Area (ha)	Average Core Area Index of Patches (%)	Average Distance to Nearest Neighbour of Patches of Same Type (m)	Overall Core Area Index of Patches (%)	Overall Patch Mean Perimeter : Area of Total Patches (m/ha)
Difference between Baseline Case and Application Case at T14 (Baseline Case – Application Case)											
31	<0.01	<0.01	<0.01	0.0	228,875.5	-0.9	-171.8	0.1	5.8	-0.1	0.8
Difference between Application Case and PDC with Project at T14 (Application – PDC)											
-16,409	1.2	<0.01	-11.5	0.0	-2,564,904.2	0.9	988.0	-0.4	117.5	0.3	-9.0
Difference between Baseline Case and PDC with Project at T41 (Baseline – PDC)											
-17,552	1.6	<0.01	-12.2	0.0	-2,466,562.0	-39.7	853.5	0.7	143.2	0.3	-8.7
Difference between PDC with Project and PDC without Project at T41 (PDC with Project – PDC without Project)											
458	-0.3	<0.01	-0.4	<0.01	-279,047.9	3.8	235.9	-0.3	102.9	0.1	-1.0

4.8.3 Sensitivity of Plant Community Biodiversity to Disturbance

The removal of vegetation within the Project Footprint will initially reduce species richness, habitat richness and diversity (some ecosite phases and ELC classes will be reduced in extent), and increase habitat fragmentation. If one or more plant species depends on the affected ecosite phase or ELC class, the effects will also lead to a decline in those niche species as well. Other potential effects of the Project that may affect biodiversity include an increase in noxious weed and invasive species.

Having a distribution of patch sizes is beneficial with respect to maintaining diversity. This has been identified as a forest harvest management goal and is reflected in the planned (future) spatial harvest sequence for the Project RSA. However, social constraints limit the active creation of large forest patches with forest harvesting (*C5 Forest Management Plan 2006-2026*). With reclamation, the Project will contribute large patches of forest to the landscape providing an improved patch size distribution by offsetting the numerous small patches caused by historical and ongoing human disturbance, including forest harvesting.

Responses of vegetation species populations to changes in habitat area and fragmentation are species-specific, habitat-specific, and disturbance-specific. Despite this variability in responses, studies that have examined correlations between vegetation species richness and patch size have consistently concluded that larger patches support greater diversity of native vegetation and wildlife species than smaller patches (*e.g.*, Weaver and Kellman 1981, Peterken & Game 1984, Simberloff & Gotelli 1984, Webb and Vermaat 1990, Forman 1995).

4.8.4 Mitigation and Monitoring

4.8.4.1 Mitigation

Measures taken to mitigate the reduction in areas of terrestrial vegetation, wetlands, old growth forests, and to attenuate the spread of non-native and invasive species due to the Project will be effective for the Project effects on loss of biodiversity. Project effects related to fragmentation will decrease, following the implementation of mitigation measures, primarily reclamation. The Project will reduce the amount of historical fragmentation present from existing disturbances (primarily previous mining operations), as well. Mitigation measures for biodiversity will include:

- direct placement of soil salvaged (with propagules) from new mining areas as much as is practicable;
- re-establishing native species by planting native trees, native shrub species and native graminoids to provide structural diversity, wildlife habitat and wildlife browse; and

- an adaptive re-vegetation strategy to take advantage of opportunities present on the re-contoured lands for establishment of a variety target vegetation communities and wetlands as outlined in the reclamation plan (closed conifer forests, moderate mixed forests, native herbaceous grasslands and treed wetlands); or other vegetation communities that may become more appropriate with knowledge gained from adaptive management.

4.8.4.2 Monitoring

The re-vegetation monitoring program will include:

- re-generation survival surveys to monitor for health and survival of planted trees, shrubs and graminoids; and
- complete surveys early in the life of the re-vegetation program, to assess the level of biodiversity success and allow for adaptive management of subsequent stages of re-vegetation.

4.8.5 Impact Rating

Residual effects are defined as the remaining effects, or those predicted to remain, after mitigation measures for a Project are implemented. Cumulative effects are the environmental effects that are likely to result from a project in combination with the environmental effects of other past, existing and future projects or activities (CEAA 2014). The Project will reclaim existing anthropogenic disturbances, primarily from previous mining activities, and therefore reduce the existing fragmentation within the Project Footprint. However, residual effects on vegetation and plant communities will occur with the removal of vegetation and alteration of the landscape due to the Project even after reclamation is completed. These residual effects will diminish over time following mitigation as reclaimed plant communities will become more complex and natural processes, such as fire, return to the landscape, and these processes will bring ever-increasing complexity and structure to the reclaimed landscape.

Reclamation of the Project will use a progressive approach; as portions of the Project are abandoned, they will be re-vegetated with native species as part of the reclamation plan to establish self-sustaining communities. Only two small mapped, but not surveyed ecosite phases (Subalpine Natural Subregion e2 and d1) will be permanently removed from the Project Footprint. Plant communities to be established with reclamation include species rich patches of moderate mixed forest and natural upland herbaceous grassland, and areas of closed canopy conifer forests. Wetland mitigation includes an increase in treed wetland (STNN) as well as unknown area of shallow open water and marsh will also be created around the margins of the pit lake (Application, Conservation and Reclamation Plan, Section F (Benga 2015)). All but three rare species found in the study area are globally secure. In addition, specific mitigation for whitebark pine and limber pine (SARA listed species) includes contributing to the regional recovery plan for each (Alberta Whitebark and Limber Pine Recovery Team 2014a, 2014b) by identifying and preserving the genetics of disease resistant trees, if present, and establishing whitebark and or limber pine in appropriate habitats during reclamation.

A great deal of the RSA is fragmented and the amount of fragmentation is expected to increase over time with forest harvesting being the largest contributor. The project will have a positive effect on landscape level fragmentation due to the already highly fragmented condition of the Project development area that will be reclaimed. Having a distribution of patch sizes is beneficial and has been identified as a forest management goal for the region. However, social constraints limit the active creation of large forest patches with forest harvesting (C5 Forest Management Plan 2006-2026). With reclamation, the Project will contribute large patches of closed conifer forest to the landscape providing an improved patch size distribution by offsetting the numerous small patches and linear disturbances caused by historical and ongoing human activities.

Potential effects of the Project on biodiversity and fragmentation are related to clearing of vegetation and physical alteration of the landscape of the Project. The following assessment of this VC has been completed with consideration of effective mitigation being applied.

4.8.5.1 Species Level

- Geographic Extent: Project effects on species level biodiversity are local in extent. Effects of the Project on species is limited to direct removal. Conditions that would extend disturbance beyond the Footprint are limited due to the terrain and to the mitigation proposed for the Project.
- Duration: The duration of the effects are extended. Reclaimed land will require time to develop mature forests and grasslands and for the return of the natural processes of disturbance and succession. Effective control of weeds and invasive species will also be implemented by the project.
- Frequency: Effects will continue throughout the operational phase of the project and cease only after reclamation is completed.
- Ability for Recovery: Effects are reversible in the long term with the planned mitigation. Reclaimed terrain and soils will support establishment of native communities.
- Magnitude: The project effect on plant species will be of moderate magnitude. A variety of habitats will be created providing opportunity for invasion and establishment of native species. However, Project effects will be well above large scale natural disturbances such as fire and insect infestation due to the alteration of the terrain and soil resources.

- Project Contribution: The project will have a negative contribution toward species level biodiversity. The establishment of a variety of landscapes and communities (*e.g.*, coniferous and mixed canopies) during reclamation will mitigate for the removal of three rare plant species that are not globally secure from the Project Footprint, as this will facilitate the establishment of diverse communities and provide niche habitats for other species. The reclaimed land will support a range of communities with equivalent capabilities to those of the surrounding lands and that existed prior to development. In addition, historical disturbances and other anthropogenic features will also be reclaimed. For whitebark pine and limber pine, mitigation will include planting.
- Confidence Rating: The confidence rating is moderate due to the uncertainties in individual rare species designations and regional distributions. The effect of the Project is well understood as are the techniques used for revegetation. Use of proven techniques for revegetation will be supported by adaptive management and monitoring.
- Probability of Occurrence – Ecological Context: The probability of occurrence is high given the type of project and method of coal extraction.
- Significance: With mitigation the project effects are insignificant. No irreversible effects to sustainability of the resource are expected.

4.8.5.2 Community Level

Project effects on community level biodiversity are local in extent, extended in duration, continuous in frequency and reversible in the long term. The confidence rating of the assessment is high and the probability of effect occurrence is high. Project contribution to the effect is negative but low in magnitude. The establishment of a variety of landscapes during reclamation will mitigate the effects to plant community diversity due to the Project. Therefore, the overall impact rating is low following the implementation of mitigation measures.

- Geographic Extent: Project effects on biodiversity and fragmentation is local in extent. Effects of the Project on communities is limited to direct removal. Conditions that would extend disturbance beyond the Footprint are limited due to the terrain and to the mitigation proposed for the Project. The final project contours, slopes and aspects are expected to provide for a range of ecosite communities similar to those in the region.
- Duration: The duration of the effects are extended. Reclaimed land will require time to develop mature forests and grasslands and for the return of the natural processes of disturbance and succession.
- Frequency: Effects will continue throughout the operational phase of the project and cease only after reclamation is completed.

- Ability for Recovery: Effects are reversible in the long term with the planned mitigation. Reclaimed terrain and soils will support establishment of native communities.
- Magnitude: The project effect will be of high magnitude due to the removal of vegetation and altering of the landscape. Project effects will exceed large scale natural disturbances such as fire and insect infestation.
- Project Contribution: The project will have a neutral contribution with respect to biodiversity of communities. The reclaimed land will support a range of communities with equivalent capabilities to those of the surrounding lands and that existed prior to development. In addition, historical disturbances and other anthropogenic features will also be reclaimed.
- Confidence Rating: The confidence rating is high. The effect of the Project is well understood as are the techniques used for revegetation. Use of proven techniques for revegetation will be supported by adaptive management and monitoring.
- Probability of Occurrence – Ecological Context: The probability of occurrence is high given the type of project and method of coal extraction.
- Significance: With mitigation the project effects are insignificant. No irreversible effects to sustainability of the resource are expected.

4.8.5.3 Landscape level

- Geographic Extent: Project effects on landscape biodiversity and fragmentation are regional in extent. Effects of the Project on landscape level biodiversity extend outside the Project boundary to regional surroundings. The size, shape and distribution of patches will be different following reclamation and additional open water and wetland will be created.
- Duration: The duration of the effects are residual. The addition of open water and larger forest patches on the more subdued post reclamation landscape will be permanent.
- Frequency: Effects will continue throughout the operational phase of the project and cease only after reclamation is completed.
- Ability for Recovery: Effects are irreversible with permanent changes to the landscape. Reclaimed terrain and soils will support establishment of native communities.
- Magnitude: The project effect will be of moderate magnitude due to the altering of the landscape and addition of more wetland patches.
- Project Contribution: The project will have a positive contribution by reducing fragmentation and establishing larger patches of forest with respect to vegetation communities. The reclaimed land will support a range of communities with equivalent capabilities to those of the surrounding lands and that existed prior to development. In addition, historical disturbances and other anthropogenic features will also be reclaimed.
- Confidence Rating: The confidence rating is high. The effect of the Project is well understood.

- Probability of Occurrence – Ecological Context: The probability of occurrence is high given the type of project and method of coal extraction.
- Significance: With mitigation the project effects are insignificant. No irreversible negative effects to landscape level biodiversity are expected.

4.9 Noxious and Invasive Species

Noxious and invasive species were not identified as a VC for the Project but are included where applicable with other VC assessments. Assessment of noxious and invasive species was included in the AER TOR and CEAA guidelines for the Project (Appendix 1 and 2, respectively). Project effects and mitigation for noxious and invasive weeds are described below in the same manner as Project VC's for consistency and to identify specific mitigation or monitoring recommendations. The *Weed Control Act and Regulations* (Government of Alberta 2010b) is provincial legislation that requires and enforces the control of noxious weeds and the eradication of prohibited noxious weeds.

4.9.1 Application Case

Eight (15 occurrences) out of the nine noxious weed species identified in the LSA also occur in the Project Footprint. These species include *Bromus tectorum, Chrysanthemum leucanthemum, Cirsium arvense*, *Echium vulgare, Linaria dalmatica, Linaria vulgaris, Ranunculus acris,* and *Verbascum Thapsus* (Table 4.9-1, Figure 3.9-1). Invasive species (Table 4.9-2) were found throughout the LSA and noxious species were observed primarily along existing disturbances.

Table 4.9-1 Occurrences of Noxious Weeds in the Local Study Area and Project Footprint

Scientific Name	Common Name	Number of Occurrences	
		LSA	Footprint
Bromus tectorum	downy brome	1	1
Chrysanthemum leucanthemum	ox-eye daisy	7	2
Cirsium arvense	creeping thistle	4	2
Cynoglossum officinale	hound's-tongue	1	0
Echium vulgare	blueweed	1	1
Linaria dalmatica	dalmatian toadflax	3	1
Linaria vulgaris	common toadflax	1	2
Ranunculus acris	tall buttercup	11	3
Verbascum thapsus	common mullein	3	3

Table 4.9-2 Invasive Species Identified in the Local Study Area

Scientific Name	Common Name
Invasive Species	
Agropyron repens	quack grass
Bromus inermis	smooth brome
Cerastium arvense	field chickweed
Cirsium vulgare	bull thistle
Dactylis glomerata	orchard grass
Glyceria grandis	great manna grass
Medicago lupulina	black medick
Phleum pratense	timothy
Plantago major	common plantain
Poa pratensis	Kentucky bluegrass
Potentilla argentea	silvery cinquefoil
Rumex crispus	curled dock
Senecio vulgaris	common groundsel
Taraxacum officinale	dandelion
Thlaspi arvense	stinkweed
Tragopogon dubius	common goat's-beard
Trifolium aureum	yellow clover
Trifolium hybridum	Alsike clover
Trifolium pratense	red clover
Trifolium repens	white clover

4.9.2 Planned Development Case

Noxious and invasive vegetation species were not assessed for the RSA. It is assumed that ecosite phases, ELCs and disturbed areas within the LSA are similar in composition and distribution as those in the RSA. In addition, existing and planned development areas in the RSA are subject to provincial control under the *Weed Control Act and Regulations* (Government of Alberta 2010a). Thus, the PDC effects for non-native and invasive species was not required. Competition from noxious and invasive species is considered in the assessment of biodiversity (Section 4.8).

4.9.3 Disturbance Effects on Noxious and Invasive Species

Although noxious and invasive species are already present within the Project area, construction and operations activities may enhance the spread and establishment of these species into areas adjacent to disturbed sites. Noxious and invasive plants can reduce or displace native species and may alter some ecosystem functions (Hobbs and Huenneke 1992). The removal of vegetation and organic matter will increase the surface area of bare ground, which increases the propensity for the establishment and proliferation of noxious and invasive vegetation species (Hayes and Holl 2003).

4.9.4 Mitigation and Monitoring

As the Project Footprint is land subject to direct disturbance, it will be particularly important to control or eliminate noxious and prohibited noxious weed populations and invasive species in this area prior to mine disturbance to prevent the spread and re-establishment of these species throughout and adjacent to the Project Footprint.

4.9.4.1 Mitigation

As required by the Weed Control Act and Regulations, noxious weed populations identified during baseline field sampling will be controlled prior to site disturbance and mine operation to prevent the further spread of weeds. Noxious weed management will occur in compliance with R&R/03-4 *Weeds on Industrial Development Sites* (Alberta Environment 2003b).

Potential methods for controlling noxious weed populations may singly or in combination include hand-pulling, cultivation, and/or spot-spraying of herbicide. Application of residual herbicides to control weeds, although effective, will be avoided to prevent damage to native and planted species. Regardless of weed species, the application of control treatments will be site-specific and will vary based on the weed species and its biology, the extent of weed infestation, and the proximity to sensitive environmental features including water-bodies, wetlands, and sites prone to erosion. Licensed herbicide applicators will be responsible for the use and application of herbicides to treat weed infestations.

Throughout the lifetime of the Project, ongoing inspections will be conducted during each growing season to identify the presence of prohibited noxious and noxious weeds listed under the *Weed Control Act* and *Regulation* (Government of Alberta 2010b). Should any prohibited noxious or noxious weeds be found, timely measures will be taken to control or eliminate the population. Records must be kept specific to the species of concern, population extent, UTM location and the methods employed to achieve control. Recommended precautions to mitigate weed establishment may include steam-cleaning equipment and construction materials before their arrival on site, use of first class and certified seed for re-vegetation, use of weed-free soil amendments, and prompt re-vegetation with suitable species at the time of reclamation. Additionally, stockpiled soils should be seeded with suitable species to prevent weed establishment and proliferation.

Invasive species are productive, quick to establish, and have the potential to become invasive in areas where the existing vegetation and soil has been disturbed. For example, aggressive agronomic grasses colonize rapidly under conditions of limited interspecific competition; however, the control of these species is not required by law. Other species, such as dandelion (*Taraxacum officianale*) and common plantain (*Plantago major*), pose more of a minor nuisance than an invasive threat. The best approach to limit or prevent dominance of these undesirable plants is to ensure timely reclamation and re-vegetation with suitable species that have the ability to establish cover and provide sufficient competition. The planting of an annual or biennial cover crop in association with perennial re-vegetation species may prevent or minimize the colonization of aggressive agronomic species by providing immediate cover and competition.

Noxious and invasive species mitigation measures will include those measures outlined above and will also include:

- minimize areas of bare ground during Project construction and operation;
- prompt reclamation and re-vegetation of bare ground upon completion of mining;
- use a non-invasive certified seed-mix for erosion control, and use approved re-vegetation species that are compatible with the target vegetation communities;
- implement a noxious and invasive species control program prior to, during construction and operation of the Project and reclamation programs;
- clean equipment arriving from offsite to remove soil and vegetative material before accessing the study area; and
- use recommended re-vegetation techniques and species that will limit the establishment and spread of noxious and invasive species during reclamation.

4.9.4.2 Monitoring

The non-native and invasive species monitoring program will include:

- ensure regular annual site inspections during the life of the Project (construction and operation to closure) to identify noxious and invasive species distribution, spread and establishment;
- control noxious vegetation species occurrences that are identified during inspections (monitoring); and
- assess and report on the success of weed control activities.

4.9.5 Impact Rating

Following the implementation of mitigation measures (including a weed management and monitoring program), the Project is not expected to have lasting local or regional effects on the establishment and spread of noxious and invasive species.

Potential effects of the Project on noxious and invasive species are related to clearing of vegetation and physical alteration of the landscape of the Project. The following assessment of this VC has been completed with consideration of effective mitigation being applied.

- Geographic Extent: Project effects on noxious and invasive species is local in extent and limited to the Project Footprint.
- Duration: The duration of the effects are extended. Reclaimed land will require time to develop self-sustaining native vegetation cover and for the return of the natural processes of disturbance and succession. Until natural processes of disturbance and succession return to the landscape, the opportunity for noxious and invasive species development will remain.
- Frequency: Effects will occur periodically (intermittently but repeatedly) and require routine maintenance activities to control noxious and invasive species continue throughout the operational phase of the project and cease only after reclamation has been successful.
- Ability for Recovery: Effects of noxious and invasive species are reversible in the long term with the planned mitigation.
- Magnitude: Effects will be of low magnitude with clearing of vegetation and mining operations exceeding that of natural disturbances and providing openings for noxious and invasive species to establish.
- Project Contribution: The project will have a neutral contribution with no net increase in noxious and invasive species after mitigation is complete.
- Confidence Rating: The confidence rating is high. The presence of noxious and invasive species in the planned development area will result in an increase without mitigation.
- Probability of Occurrence – Ecological Context: The probability of occurrence is high given the type of project.
- Significance: With mitigation, the project effects are insignificant.

4.10 Potential Acid Input and Nitrogen Deposition

Potential acid input and nitrogen deposition were not identified as VCs for the Project. Assessment of potential acid input and nitrogen deposition was included with the AER TOR (Appendix 1). Project effects and mitigation are described below in the same manner as Project VCs for consistency of reporting and to identify specific mitigation or monitoring recommendations.

4.10.1 Application Case

The range of PAI increased slightly from the Baseline range of 0.17 to 0.40 keq H^+/ha/yr, to 0.17 to 0.41 keq H^+/ha/yr, when the Application Case model isopleths were overlain on the LSA and RSA maps. The affected land area also increased from the Baseline Case to the Application Case. Due to the limited extent of plant communities with highly sensitive soils, the indirect impacts to plants, with respect to potential soil acidification, are considered negligible at the local and regional scale across all application assessment cases. PAI is not likely to affect vegetation within the LSA or RSA. Refer to CR 7 – Soils Report of the Project Application (Benga 2015) for more details on the impacts of the Application Case.

There was no change in range of nitrogen deposition values for either the LSA or RSA for the Application Case. The area affected by nitrogen deposition increased from the Baseline Case to the Application Case and included additional area of conifer forest communities within the LSA. However, the extent of area was limited and was not expected to have a discernable impact on the plant communities at either a local or a regional scale.

4.10.2 Planned Development Case

No projects were found for the PDC other than those already included in the Application Case for the CR 1 – Air Quality Assessment of the Project Application (Benga 2015)). Therefore, the results for the PDC are the same as for the Application Case (Section 4.10.1) and PDC assessment was not required for PAI and Nitrogen Deposition.

4.10.3 Mitigation and Monitoring

No mitigation measures are necessary for PAI and nitrogen deposition.

4.10.4 Impact Rating

Potential effects of the Project on acid input and nitrogen deposition are related to Project contribution to emissions. No mitigation is required.

- Geographic Extent: Project effects for PAI and nitrogen deposition are regional in extent. Effects of the Project on for PAI and nitrogen deposition extend outside the Project boundary to regional surroundings.
- Duration: The duration of the effects are extended and will continue until project operations cease.
- Frequency: Effects will continue throughout the operational phase of the project and cease only after reclamation is completed.

- Ability for Recovery: No effects are expected but would be reversible in the long term after emissions cease and the impacted sites return to equilibrium.
- Magnitude: The project effect will be of low and within established protective guidelines.
- Project Contribution: Though small Project emissions will have a negative contribution to PAI and nitrogen deposition though emissions are expected to be below guidelines in the Project Footprint and project emissions are not expected to contribute to PAI and nitrogen deposition in other areas of the LSA.
- Confidence Rating: The confidence rating is moderate and based on a good understanding of modeled emission sources and threshold levels for vegetation.
- Probability of Occurrence – Ecological Context: The probability of occurrence is high given the type of project.
- Significance: The project effects are insignificant.

5.0 IMPACT ASSESSMENT AND MITIGATION SUMMARY

5.1 Impact Assessment

A summary of the Project impact on the Valued Environmental Components (VCs) assessed is provided in Table 5.1.1. With mitigation and monitoring, overall Project impacts are characterised as being insignificant for all VCs assessed.

Cumulative impacts, using the PDC, were assessed for terrestrial vegetation, wetlands, and biodiversity and fragmentation. With mitigation, cumulative impacts to all three VCs were assessed as being insignificant.

Table 5.1-1 Summary of Impacts on Vegetation Components

VC Potential Impact or Effect	Mitigation / Protection Plan	Type of Impact	Geographical Extent of Impact[1]	Duration of Impact[2]	Frequency of Impact[3]	Ability for Recovery[4]	Magnitude[5]	Project Contribution[6]	Confidence Rating[7]	Probability Occurrence – Ecological Context[8]	Significance
1. Terrestrial Vegetation/Plant Communities or Ecosite Phases											
Reduction in Plant Community Types & Area	Yes	Application	Local	Extended	Continuous	Reversible Long Term	High	Neutral	High	High	Insignificant
		Cumulative	Local	Extended	Continuous	Reversible Long Term	High	Neutral	High	High	Insignificant
2. Rare Plants, Rare Plant Communities and Rare Plant Potential											
Removal of rare plants and potential	Yes	Application	Local	Extended	Continuous	Reversible Long Term	High	Negative	High	High	Insignificant
Removal of whitebark (and limber pine)	Yes	Application	Local	Extended	Continuous	Reversible Long Term	High	Positive (Neutral)	High	High	Insignificant
3. Rangeland Resources											
Removal of Rangelands	Yes	Application	Local	Extended	Continuous	Reversible Long Term	High	Neutral	High	High	Insignificant
4. Forest Resources											
Removal of Forested stands	Yes	Application	Local	Extended	Continuous	Reversible Long Term	Low	Neutral	High	High	Insignificant
5. Old Growth Forests											
Removal of Old Growth Forests	Yes	Application	Local	Extended	Continuous	Reversible Long Term	Low	Positive	High	High	Insignificant

Table 5.1-1 Summary of Impacts on Vegetation Components

VC Potential Impact or Effect	Mitigation / Protection Plan	Type of Impact	Geographical Extent of Impact[1]	Duration of Impact[2]	Frequency of Impact[3]	Ability for Recovery[4]	Magnitude[5]	Project Contribution[6]	Confidence Rating[7]	Probability Occurrence – Ecological Context[8]	Significance
6. Traditionally Used Plants											
Removal of TEK species	Yes	Application	Local	Extended	Continuous	Reversible	High	Neutral	High	High	Insignificant
7. Wetlands											
Reduction in Types & Area	Yes	Application	Local	Extended	Continuous	Reversible Long Term	Moderate	Positive	High	High	Insignificant
		Cumulative	Local	Extended	Continuous	Reversible Long Term	Moderate	Positive	High	High	Insignificant
8. Biodiversity											
Reduction in Species Diversity	Yes	Application	Local	Extended	Continuous	Reversible Long Term	Moderate	Negative	Moderate	High	Insignificant
		Cumulative	Local	Extended	Continuous	Reversible Long Term	Moderate	Negative	Moderate	High	Insignificant
Reduction of Community Diversity	Yes	Application	Local	Extended	Continuous	Reversible Long Term	High	Neutral	High	High	Insignificant
		Cumulative	Local	Extended	Continuous	Reversible Long Term	High	Neutral	High	High	Insignificant
Reduction of Landscape Diversity	Yes	Application	Regional	Residual	Continuous	Irreversible	Moderate	Positive	High	High	Insignificant
		Cumulative	Regional	Residual	Continuous	Irreversible	Moderate	Positive	High	High	Insignificant
9. Noxious Vegetation Species											
Spread of Invasive & Noxious Species	Yes	Application	Local	Extended	Periodic	Reversible Long Term	Low	Neutral	High	High	Insignificant

Table 5.1-1 Summary of Impacts on Vegetation Components

VC Potential Impact or Effect	Mitigation / Protection Plan	Type of Impact	Geographical Extent of Impact[1]	Duration of Impact[2]	Frequency of Impact[3]	Ability for Recovery[4]	Magnitude[5]	Project Contribution[6]	Confidence Rating[7]	Probability Occurrence – Ecological Context[8]	Significance
10. Potential Acid Input and Nitrogen Deposition											
Potential Acid Input and Nitrogen deposition	Yes	Application	Local	Extended	Continuous	Reversible Long Term	Low	Neutral	Moderate	High	Insignificant

[1] Local, Regional, Provincial, National, Global

[2] Short, Long, Extended, Residual

[3] Continuous, Isolated, Periodic, Occasional, Accidental, Seasonal

[4] Reversible in short term, Reversible in long term, Irreversible – rare

[5] No Impact, Low Impact, Moderate Impact, High Impact

[6] Neutral, Positive, Negative

[7] Low, Moderate, High

[8] Low, Medium, High

[9] Significant, In-significant

5.2 Summary of Mitigation and Monitoring Measures

Progressive reclamation of the Project Footprint to equivalent land capability provides the primary measure required to mitigate the impacts on vegetation and wetland VCs. It is important to note 165.3 ha of the Project Footprint (10.4% of the Project Footprint and 3.4% of the LSA) were disturbed by previous mining activities, and total previous anthropogenic disturbances (previous mining operations, and roads and oil and gas developments) in the Project Footprint are 288.7 ha (18.2% of the Project Footprint and 6.0% of the LSA). Project mitigation will aim to reclaim not only these previously disturbed areas to equivalent land capability, but all areas disturbed by mine operations. The reclamation of the 288.7 ha of the Project Footprint left un-reclaimed, is an additional positive outcome of the Project from a vegetation standpoint, especially as the previous mining operations are approximately 55 years old and have only partially revegetated by natural processes. Reclamation of previously disturbed areas could also positively impact other environmental components, such as improving wildlife habitat, limiting soil erosion, and controlling stream sedimentation. Mitigation measures will include, but are not limited to, the following:

- a re-vegetation program which aims to establish diverse native vegetation communities (closed conifer forests, moderate mixed forests, natural upland herbaceous grasslands, and treed wetlands) with equivalent pre-disturbance capability;
- a C&R Plan which aims to establish communities that are locally and regionally limited in distribution where conditions allow;
- preservation of adjacent vegetation communities by minimizing the area required for construction and operation of the Project;
- provision of appropriate soil substrate where re-vegetated areas can establish;
- seeding of stockpiled topsoil with suitable vegetation species mix to ensure long term stability of the soil piles, which reduces erosion and the potential for weed establishment;
- use of coarse woody debris and direct soil placement techniques to augment mycorrhizal and microbial inoculums;
- use direct placement of soil for provision of propagules to enhance opportunity for re-establishment of native species composition and enhanced species richness; and
- planting of multiple layers of native vegetation (*e.g.*, trees, shrubs and graminoids) to provide initial structure for wildlife habitat and to enhance biodiversity.

Re-vegetation monitoring will include but not be limited to the following:

- periodic assessment of the composition, structure, ecological succession and biodiversity of reclaimed vegetation; and
- survival, growth and health assessments of re-vegetated areas to monitor the effectiveness of reclamation efforts relative to re-vegetation targets (including noxious and invasive species and effectiveness of control methods).

In addition to the strategies noted above, the preferred primary mitigation strategy for native rough fescue grasslands is avoidance. Until disturbance is unavoidable, the following mitigation strategies will be implemented to preserve the resource:

- construct, or undertake assessments and surveys, during the dormant period for rough fescue (August to March); and
- avoid soil disturbance (Desserud 2006; AESRD 2010b) by:
  - minimizing topsoil stripping and grading;
  - utilizing existing trails;
  - using geotextiles to minimize the amount of topsoil stripping during construction where grading is required; and
  - using interlocking rig mats over the grassland on temporary access roads (AESRD 2010b).

Where disturbance is unavoidable, mitigation strategies will include collection of native seed or native sod from areas with rough fescue that will be disturbed, where feasible, and use of certified, weed-free native seed mixes in re-vegetation plan.

For old growth forests, additional mitigation measures should include reclamation with tree species capable of achieving of old growth conditions. As a rare tree species with a specific conservation plan, whitebark pine mitigation will focus on the goals of introducing white pine blister rust resistant strains and conserving genetic diversity during reclamation. To preserve genetic diversity, clusters of whitebark pine will be investigated for suitability for cone/seed collection prior to disturbance and seed collection would include selection of trees showing evidence of white pine blister rust resistance. Conditions and strategies for establishing whitebark pine during reclamation include:

- identification of high light, low competition sites;
- planting in pure stands or patches to avoid competition from other trees;
- avoiding planting in swales and frost pockets;
- creation of microsites for seedling establishment (rocks, stumps or other coarse woody debris);

- use of recommended spacing to avoid interspecies competition; and
- planting seedlings in the fall to avoid hot dry summer conditions.

Given that various wetland classes are rare in the Project Footprint and in the region, added mitigation measures for wetland impacts should include the following:

- use of best practices to maintain the hydrologic regime of mineral soil wetlands;
- creation of transition areas between re-vegetated ELCs as outlined in the reclamation plan to the treed swamps, where it is possible and/or appropriate to do so; and
- placement of culverts within wetlands that will be divided by roads to ensure that water flow between wetlands will not be affected.

Wetland monitoring will include but not be limited to the following:

- monitoring and maintenance of drainage control structures should be conducted regularly to ensure water flow and flow patterns are maintained in wetlands adjacent to the Project Footprint;
- monitoring road removal at Project closure which may have had an effect on adjacent wetlands to ensure restoration of the hydrologic regime; and
- monitoring of reclaimed wetlands should continue for a minimum of ten years to ensure the composition and structure, and key wetland functions are consistent with those in wetlands in the LSA prior to the Project disturbance; and
- monitoring of reclaimed wetlands should include the use of sub-emergent vegetation species as indicators of wetland health and integrity in the monitoring program.

Vegetation species that have current or historical uses and importance to First Nations groups are considered Traditional Ecological Knowledge (TEK) resources. Supplementary mitigation measures for TEK vegetation impacts include the following:

- consult with and involve First Nations Peoples in designing mitigation measures for sustainable management of TEK vegetation;
- implement a re-vegetation program which aims at the re-establishment of vegetation communities, such as those previously mentioned (closed conifer forests, mature mixed forests, native upland herbaceous grasslands and treed swamps) that are common to the pre-disturbed landscape and that will support TEK vegetation; and,
- where practicable utilize locally collected seed to preserve the legacy of species and of place.

Measures taken to mitigate the reduction in area of terrestrial vegetation, wetlands, old growth forests, and to attenuate the spread of non-native and invasive species due to the Project will mitigate the Project impacts on overall loss of biodiversity. Project impacts related to fragmentation will decrease, following the implementation of mitigation measures, primarily reclamation. The Project will reduce the amount of historical fragmentation present from existing disturbances (primarily previous mining operations), as well, through tree planting programs on previously disturbed areas.

Ongoing reclamation and re-vegetation of disturbed areas no longer required for Project-related activities will be maintained throughout the life of the project. Reclaimed plant communities, wetlands, aquatic ,and riparian environments will be designed to support wildlife habitats, forest resources, TEK vegetation, old growth forests, rare plants, and rare plant communities. Detailed reclamation and re-vegetation strategies and goals are provided in the proposed Section F – C&R Plan of the Application for the Project [Benga 2015]).

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7.0 GLOSSARY OF TERMS

ACIMS: Alberta Conservation Information Management System. As part of the International Natural Heritage Network, ACIMS provides biodiversity information for the purpose of natural resource management, development planning, and conservation. Specifically, ACIMS tracks and watches population size and condition, global and sub-national status, and geographic range of several species of flora and fauna within the province.

Alberta Ground Cover Classification (AGCC): an ecological land classification system wherein the classification and mapping of ground cover within Alberta makes use of medium resolution satellite data. Categories of ground cover include anthropomorphic features or human-related disturbances, vegetated areas of forests, shrub-lands, grasslands, wetlands or water, and barren lands covered by rock or snow.

Application: describes the expected environmental effects of the Project.

Climate change interval: a range of time where a certain type of climate conditions occurs.

Critical load: in the study of air pollution, a critical load is a quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge.

Baseline: describes existing environmental conditions prior to Project development.

Biodiversity: the degree of variation in flora or/and fauna in a given ecosite, ecosystem or environment. Biodiversity is a measure of ecological health and function, and plays a role in economic, aesthetic, and recreational value.

Bryophyte: terrestrial plants lacking true vascular tissue and reproducing via spores, which includes mosses, liverworts, and hornworts.

Climax vegetation community: a self-perpetuating vegetation community where species composition is expected to be relatively stable and long lasting.

Ecological land classification: a system that classifies natural environments based on numerous environmental factors including geology, topography, soils, vegetation, water, climate, fauna and human activity.

Ecosite: an ecological unit defined by moisture and nutrient regimes. Ecosites contain one or more ecosite phases characterised by specific plant species.

Ecosite phase: a subdivision of ecosite based primarily on the dominant plant species in the canopy, but may also consider lower-strata plant species abundance and pedogenic processes. Ecosite phases are subdivided into one or more plant community types that vary in species composition and abundance.

Ecosystem: a biological environment consisting of living organisms interacting with all abiotic and physical components of the environment including climate, landform, topography, air, water, and soils. Ecosystem function relies on the integrity and maintenance of several complex relationships between organisms and their environment.

Epiphytic: a vegetation species growing on another vegetation species (*e.g.*, lichen growing on a tree).

Ericaceous: a group of low woody plants, often termed shrubs, belonging to the *Ericaceae* family.

Forb: Any non-graminoid herbaceous species.

Fragmentation: the disruption of the natural continuity of a tract of land due to human-induced disturbances within native landscapes.

Graminoid: herbaceous plants with narrow leaves and parallel leaf venation, which include grasses, sedges and rushes.

Habitat fragmentation: the act of creating discontinuities or disruptions within an organism's preferred or required environment. Habitat fragmentation is caused by human induced disturbances to native landscapes.

Herbaceous: non-woody vascular plants which includes forbs and graminoids.

Hydric: a soil moisture regime where water is removed so slowly that the water table is at or above the soil surface all year.

Hygric: a soil moisture regime where water is removed slowly enough to keep soil wet for most of the growing season; permanent seepage and mottling usually below 30 cm in depth.

Land capability equivalent: as it is applied to land reclamation has two main components which are soils and landscape. Each component is evaluated separately, following which the overall rating is determined by the most limiting of the two. The rating system has five classes, with Class 1 lands having the highest capability for forest ecosystems. The accepted (by Alberta Environment) system used in Alberta is *Land Capability Classification System for Forest Ecosystems in the Oil Sands, 3rd Edition.* Volume 1: Field Manual for Land Capability Determination (CEMA 2006).

Landscape level: is a mosaic where the mix of local ecosystems is repeated in similar form over a kilometres-wide area. Conversely, where portions of a region are ecologically dissimilar; a landscape manifests ecological unity throughout its area (Forman 1995).

Lawns: are large wetland microhabitats with little microtopography that are generally 40 – 60 cm lower than the surrounding wooded bog. Lawns can be dominated by a ground cover of *Sphagnum* spp and lichens, or they can be wet and dominated by *Sphagnum spp.* and Carex spp.

Lichen: Fungi and certain species of algae that live in a symbiotic relationship whereby the fungus provides structural support, nutrients absorbed from the substrate, and a relatively stable microenvironment. In turn the algae provides carbohydrates through a process of photosynthesis (*e.g., Cladina spp*.).

Limited in distribution: a plant community, ecosite phase, or wetland which is limited in distribution is one that covers less than 1% of the study area.

Mesic: a soil moisture regime with medium soil moisture regime that has neither excess soil moisture nor a moisture deficit.

Modal: a modal site or modal ecosystem refers to a more or less mesic soil moisture regime and a more or less medium soil nutrient regime. Thus, modal can be referred to as the reference site for each respective region.

Natural region: the broadest category of ecological land classification within Alberta based on biophysical attributes including climate, landform, soil, topography and vegetation. There are five natural regions within Alberta, which are further subdivided into natural sub-regions.

Peatland: a tract of land characterised by the accumulation of peat (*i.e.*, non-decayed or partially decayed organic matter originating from plant material.) Peatlands within Alberta include bogs and fens.

Planned Case: describes the expected environmental effects following the development of the Project combined with other projects in the regional study area that are existing and expected to occur.

Plant community: A plant community is a collection of vegetation species within a designated geographical unit, which forms a relatively uniform patch, distinguishable from neighbouring patches of different vegetation types. The components of each plant community are influenced by soil type, topography, climate and human disturbance. In Alberta, a plant community is defined as a subdivision of ecosite phase based on vegetation species composition and abundance. Plant community type is the most specific and detailed unit within the ecological land cover classification system.

Rare plant: a plant species that is very uncommon or scarce within a certain geographical range. Specifically within Alberta, rare plants are considered to be those given an S1, S2, or S3 rank within the ACIMS tracked elements list.

Saline: the presence of soluble salts in the soil parent material at concentration that influence or affect vegetation growth.

Shrub: perennial woody plant occupying the stratum in a plant community from ground level to 5 m in height.

Sub-hydric: a soil moisture regime where water is removed slowly enough to keep the water table at or near the surface for most of the year; permanent seepage 0-30 cm below surface.

Sub-hygric: a soil moisture regime where water is removed slowly enough to keep the soil wet for a significant period of the growing season; some temporary seepage and possibly mottling below 20 cm.

Succession: replacement of one vegetation (plant) community by another, which often progresses to a stable end community referred to as a climax community.

Timber Productivity Rating (TPR): a measure of the potential timber productivity of a forested stand based on tree height and age. TPR reflects tree growth response to environmental factors including soil, topography, climate, elevation and moisture. Forested stands can be rated as good, medium, fair or unproductive.

Trees: perennial woody plant occupying the stratum in a plant community that is greater than (>) 5 m in height.

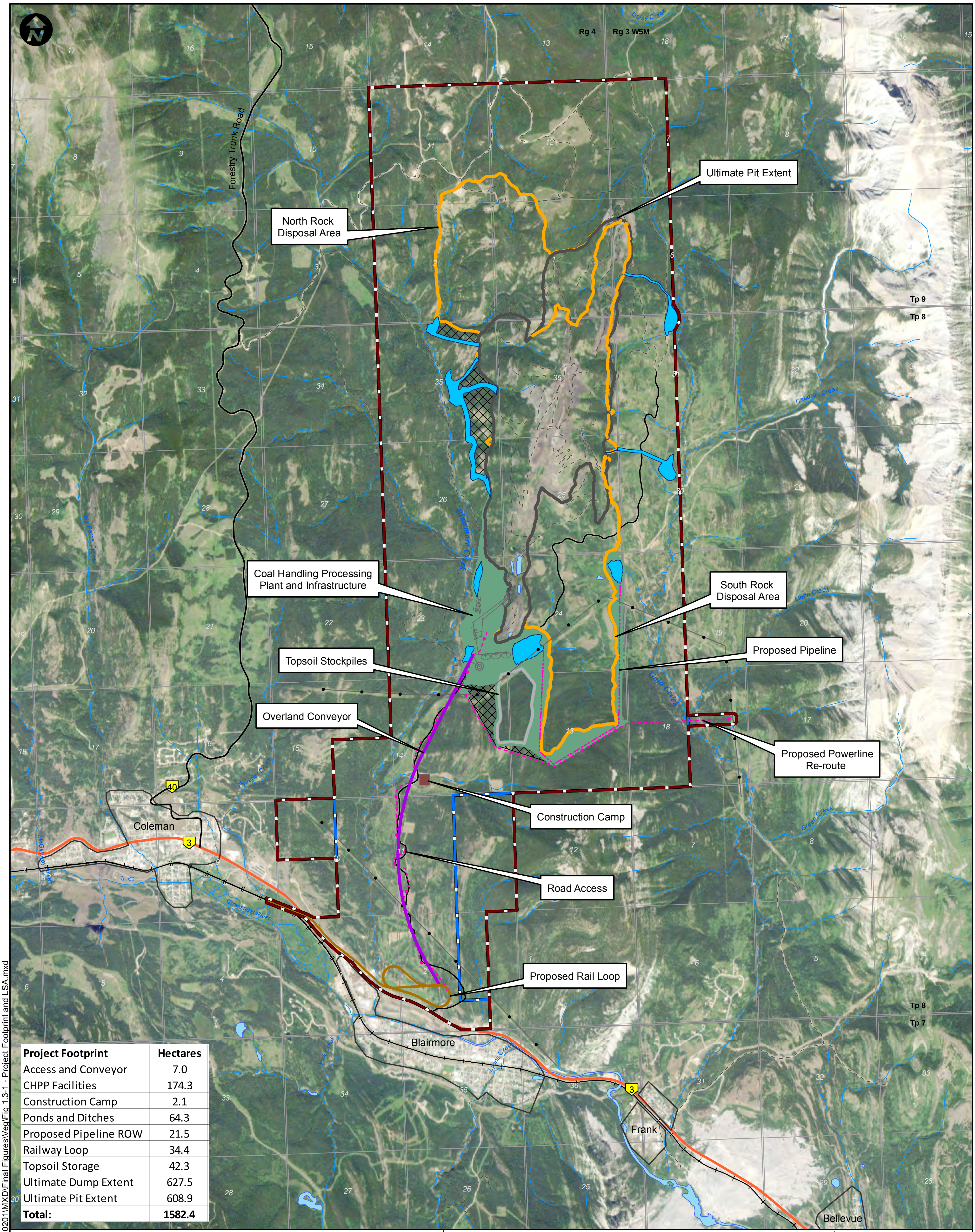
Unique species: a biotic species where its presence is considered unusual and/or of special interest due to its extremities or limits of range (distribution), specific requirement for nutrient or moisture regime or habitat, or requirement for an unusual association with other species (e.g., ectomycorrhizal fungi). For the purpose of this survey, unique species refers to those vegetation species that were observed only in one ecosite phase.

Valued (ecosystem) components: a resource or environmental feature that is economically, ecologically, socially, or aesthetically important for the purpose of evaluating environmental impacts of anthropogenic developments.

Vascular: of pertaining to conductive vegetation tissue (*i.e.,*xylem and phloem).

Wetland: Sites dominated by hydrophytic vegetation where soils are water saturated for a sufficient length of time such that excess water and resulting low soil oxygen levels are principal determinants of vegetation and soil development. Major wetlands types within Alberta include bogs, fens, marshes, and swamps. Bogs and fens typically have organic soil depths greater than 40 cm (although not always) and marsh and swamp soils are comprised largely of mineral soil, although both may have a component of organic soil.

FIGURES



Project Footprint	Hectares
Access and Conveyor	7.0
CHPP Facilities	174.3
Construction Camp	2.1
Ponds and Ditches	64.3
Proposed Pipeline ROW	21.5
Railway Loop	34.4
Topsoil Storage	42.3
Ultimate Dump Extent	627.5
Ultimate Pit Extent	608.9
Total:	**1582.4**

LEGEND

- Primary Highway
- Secondary Highway
- Existing Trails
- Existing Railway
- Road Access
- CHPP Facilities
- Existing Powerline
- Overland Conveyor
- Proposed Pipeline
- Proposed Powerline
- Railway Loop
- Surface Water Drainage
- Waterbody
- Vegetation Local Study Area
- Proposed Mine Permit Boundary
- Coal Handling Processing Plant and Infrastructure
- Ultimate Pit Extent
- Ultimate Dump Extent
- Topsoil Storage
- Construction Camp
- Ponds and Ditches
- Undisturbed Area

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PROJECT FOOTPRINT AND LSA

NOTES

AltaLIS, 2015; Geobase, 2015; Golder, 2015; RapidEye, 2015 (Image Date: Jul 26/13); Riversdale, 2015
Datum/Projection: UTM NAD 83 Zone 11

0 1 2 4
Kilometres

PROJECT: 14-00201-01
DRAWN BY: SL
CHECKED BY: EK
DATE: AUGUST 12, 2015

FIGURE

1.3-1

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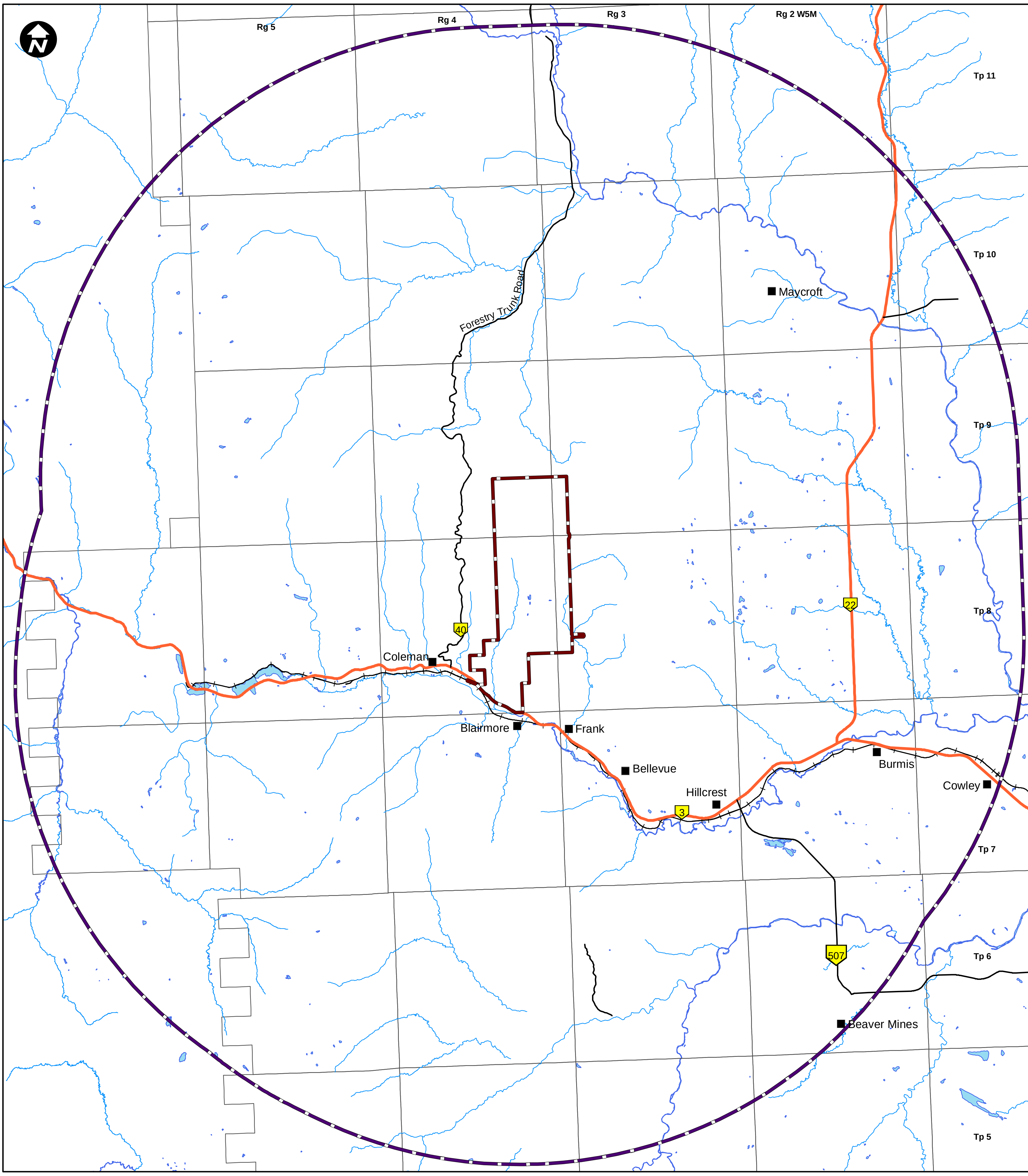

LEGEND

- Primary Highway
- Secondary Highway
- Existing Railway
- Surface Water Drainage
- Waterbody
- Vegetation Regional Study Area
- Vegetation Local Study Area

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

VEGETATION STUDY AREAS

NOTES

AltaLIS, 2015; Geobase, 2015; MEMS, 2015; Riversdale, 2015
Datum/Projection: UTM NAD 83 Zone 11

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Kilometres

PROJECT: 14-00201-01
DRAWN BY: SL/JDC
CHECKED BY: EK
DATE: SEPTEMBER 25, 2015

FIGURE

1.3-1

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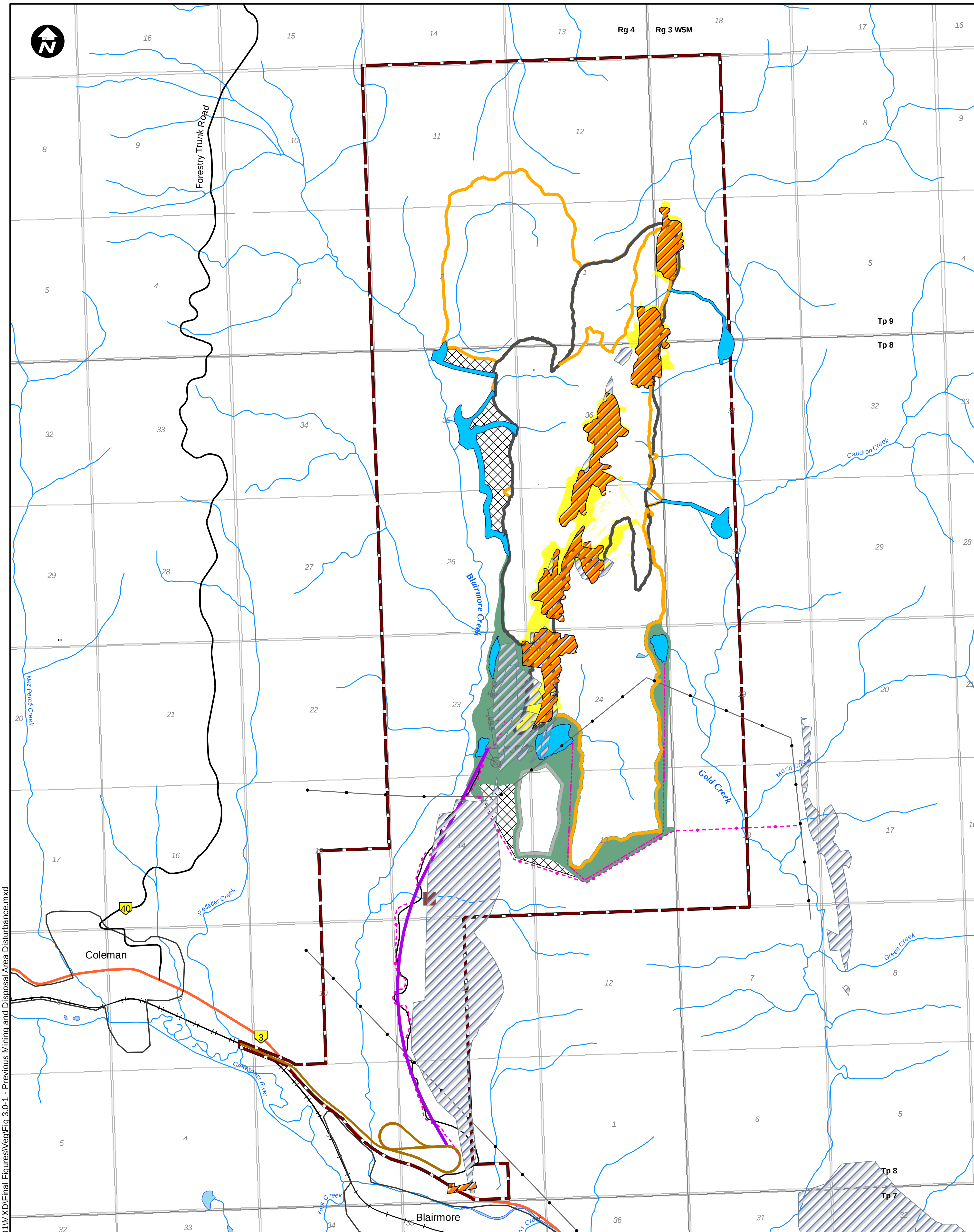

LEGEND

- Surface Water Drainage
- Primary Highway
- Secondary Highway
- Existing Railway
- Road Access
- CHPP Facilities
- Existing Powerline
- Overland Conveyor
- Proposed Pipeline
- Proposed Powerline
- Railway Loop
- Vegetation Local Study Area
- Coal Handling Processing Plant and Infrastructure
- Ultimate Pit Extent
- Ultimate Dump Extent
- Topsoil Storage
- Construction Camp
- Ponds and Ditches
- Undisturbed Area
- Surface Mine
- Underground Mine
- Previously Disturbed Land

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREVIOUS MINING AND DISPOSAL AREA DISTURBANCE

NOTES

AltaLIS, 2015; Golder, 2015; MEMS, 2015; Riversdale, 2015.
Datum/Projection: UTM NAD 83 Zone 11

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PROJECT: 14-00201-01
DRAWN BY: SL/JDC
CHECKED BY: EK
DATE: SEPTEMBER 25, 2015

FIGURE

3.0-1

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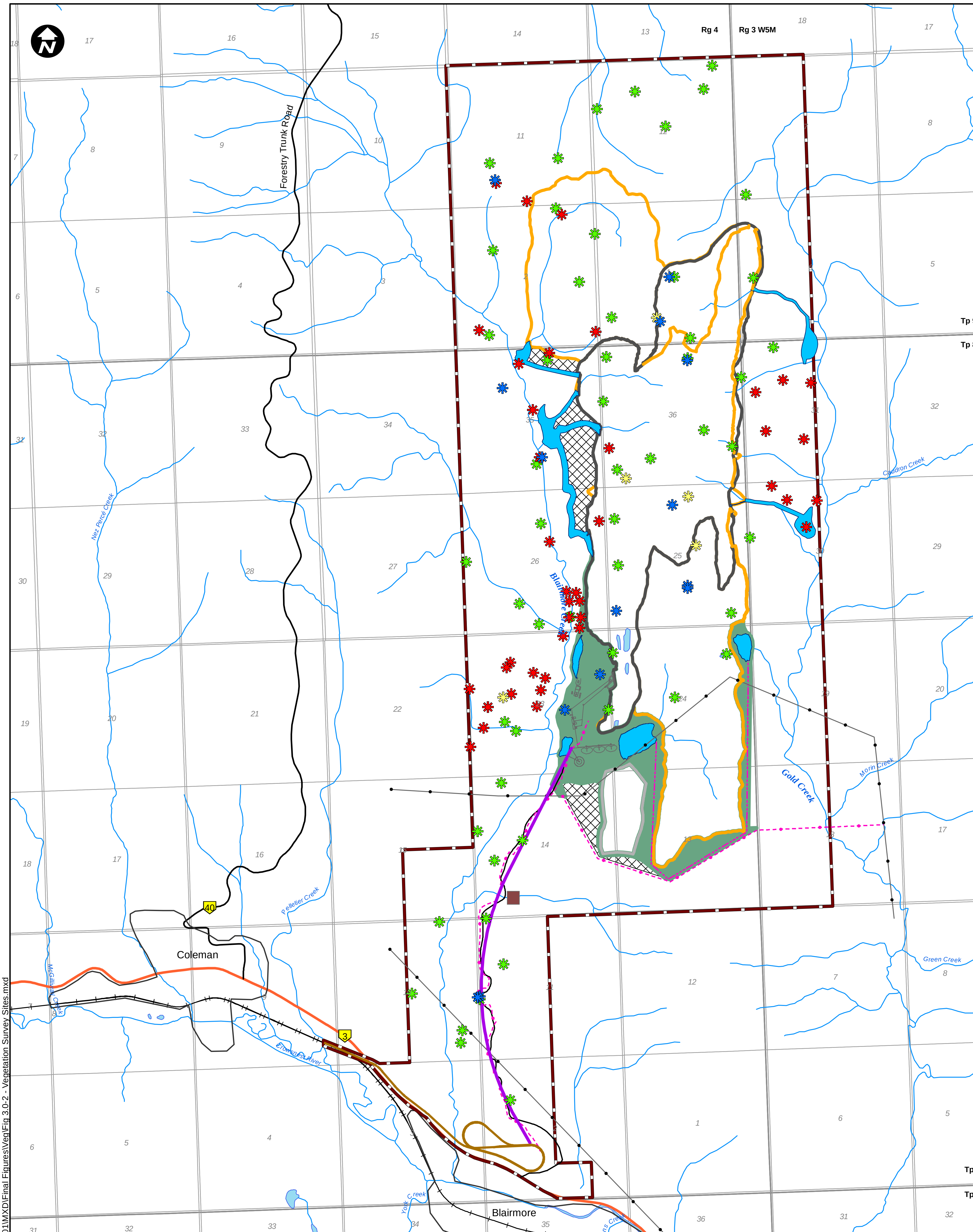

LEGEND

- Vegetation Inventory Plots (Diversity, ecosite verification, invasive and rare plants survey)
- Festuca spp. Survey Plots
- Range Health Assessment Plots
- Rare Survey Plots
- Surface Water Drainage
- Primary Highway
- Secondary Highway
- Existing Railway
- Road Access
- CHPP Facilities
- Existing Powerline
- Overland Conveyor
- Proposed Pipeline
- Proposed Powerline
- Railway Loop
- Vegetation Local Study Area
- Coal Handling Processing Plant and Infrastructure
- Ultimate Pit Extent
- Ultimate Dump Extent
- Topsoil Storage
- Construction Camp
- Ponds and Ditches
- Undisturbed Area

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

VEGETATION SURVEY SITES

NOTES

AltaLIS, 2015; Golder, 2015; MEMS, 2015; Riversdale, 2015.
Datum/Projection: UTM NAD 83 Zone 11

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Kilometres

PROJECT: 14-00201-01
DRAWN BY: SL/JDC
CHECKED BY: EK
DATE: SEPTEMBER 25, 2015

FIGURE

3.0-2

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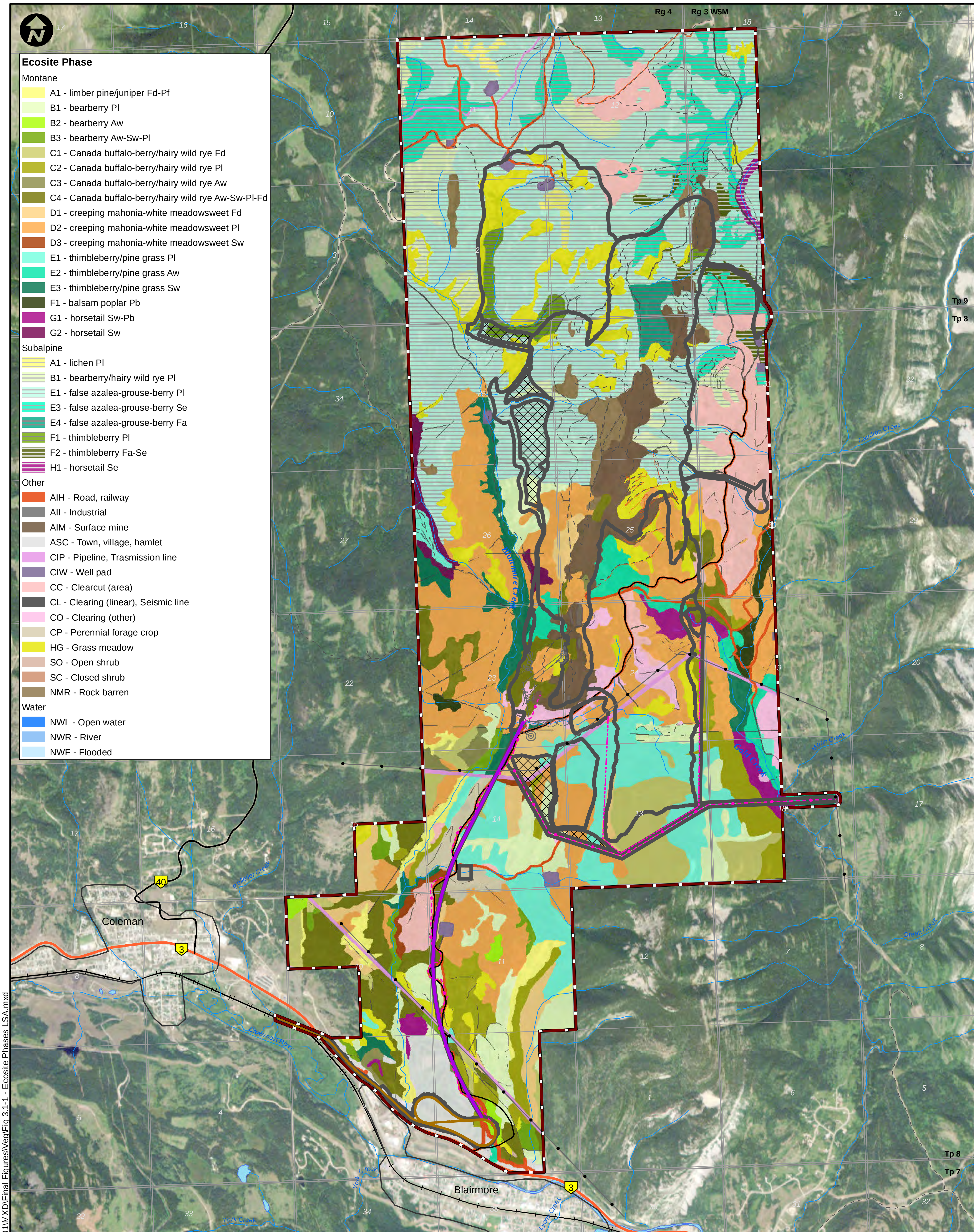

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LEGEND

- Primary Highway
- Secondary Highway
- Existing Railway
- Existing Trails
- Road Access
- CHPP Facilities
- Existing Powerline
- Overland Conveyor
- Proposed Pipeline
- Proposed Powerline
- Railway Loop
- Surface Water Drainage
- Waterbody
- Vegetation Local Study Area
- Project Footprint
- Undisturbed Area

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

ECOSITE PHASES IN THE LSA AND FOOTPRINT

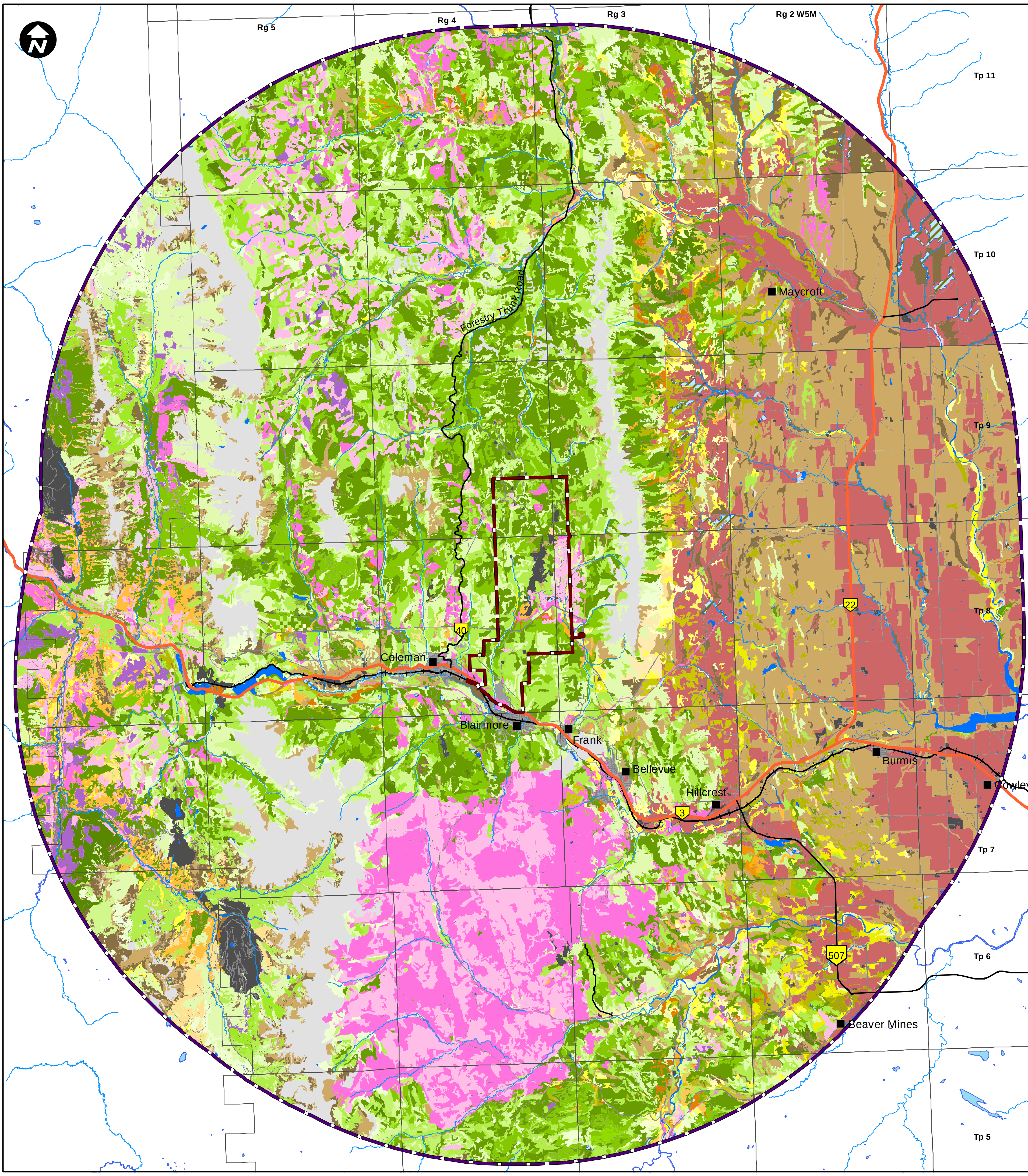
NOTES

AltaLIS, 2015; Geobase, 2015; Golder, 2015; MEMS, 2015; RapidEye, 2015
(Image Date: Jul 26/13); Riversdale, 2015
Datum/Projection: UTM NAD 83 Zone 11

0 0.75 1.5 3
Kilometres

PROJECT: 14-00201-01
DRAWN BY: SL
CHECKED BY: EK
DATE: AUGUST 13, 2015

FIGURE
3.1-1



Ecological Land Cover Class

- Open Broadleaf Young Forest
- Open Broadleaf Mature Forest
- Open Broadleaf Old Forest
- Moderate Broadleaf Young Forest
- Moderate Broadleaf Mature Forest
- Moderate Broadleaf Old Forest
- Dense Broadleaf Young Forest
- Dense Broadleaf Mature Forest
- Dense Broadleaf Old Forest
- Closed Broadleaf Young Forest
- Closed Broadleaf Mature Forest
- Closed Broadleaf Old Forest
- Open Conifer Young Forest
- Open Conifer Mature Forest
- Open Conifer Old Forest
- Moderate Conifer Young Forest
- Moderate Conifer Mature Forest
- Moderate Conifer Old Forest
- Dense Conifer Young Forest
- Dense Conifer Mature Forest
- Dense Conifer Old Forest
- Closed Conifer Young Forest
- Closed Conifer Mature Forest
- Closed Conifer Old Forest
- Open Mixed Young Forest
- Open Mixed Mature Forest
- Open Mixed Old Forest
- Moderate Mixed Young Forest
- Moderate Mixed Mature Forest
- Moderate Mixed Old Forest
- Dense Mixed Young Forest
- Dense Mixed Mature Forest
- Closed Mixed Young Forest
- Closed Mixed Mature Forest
- Closed Mixed Old Forest
- Natural Graminoid Wetland
- Natural Shrubby Wetland
- Treed Wetland
- Open Water
- Agriculture
- Natural Shrubby
- Natural Upland Herb
- Lush Herb
- Closed Regenerating Treed
- Open Regenerating Herb
- Open Regenerating Shrub
- Barren Land
- Settlement
- Linear Anthropogenic Disturbance
- Industrial (e.g. Mining)

LEGEND

- Primary Highway
- Secondary Highway
- Existing Railway
- Surface Water Drainage
- Waterbody
- Vegetation Regional Study Area
- Vegetation Local Study Area

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

ECOLOGICAL LAND COVER CLASSES IN THE RSA

NOTES

AltaLIS, 2015; Geobase, 2015; MEMS, 2015; Riversdale, 2015
Datum/Projection: UTM NAD 83 Zone 11

0 4 8 16
Kilometres

PROJECT: 14-00201-01
DRAWN BY: SL
CHECKED BY: EK
DATE: AUGUST 13, 2015

FIGURE

3.1-2

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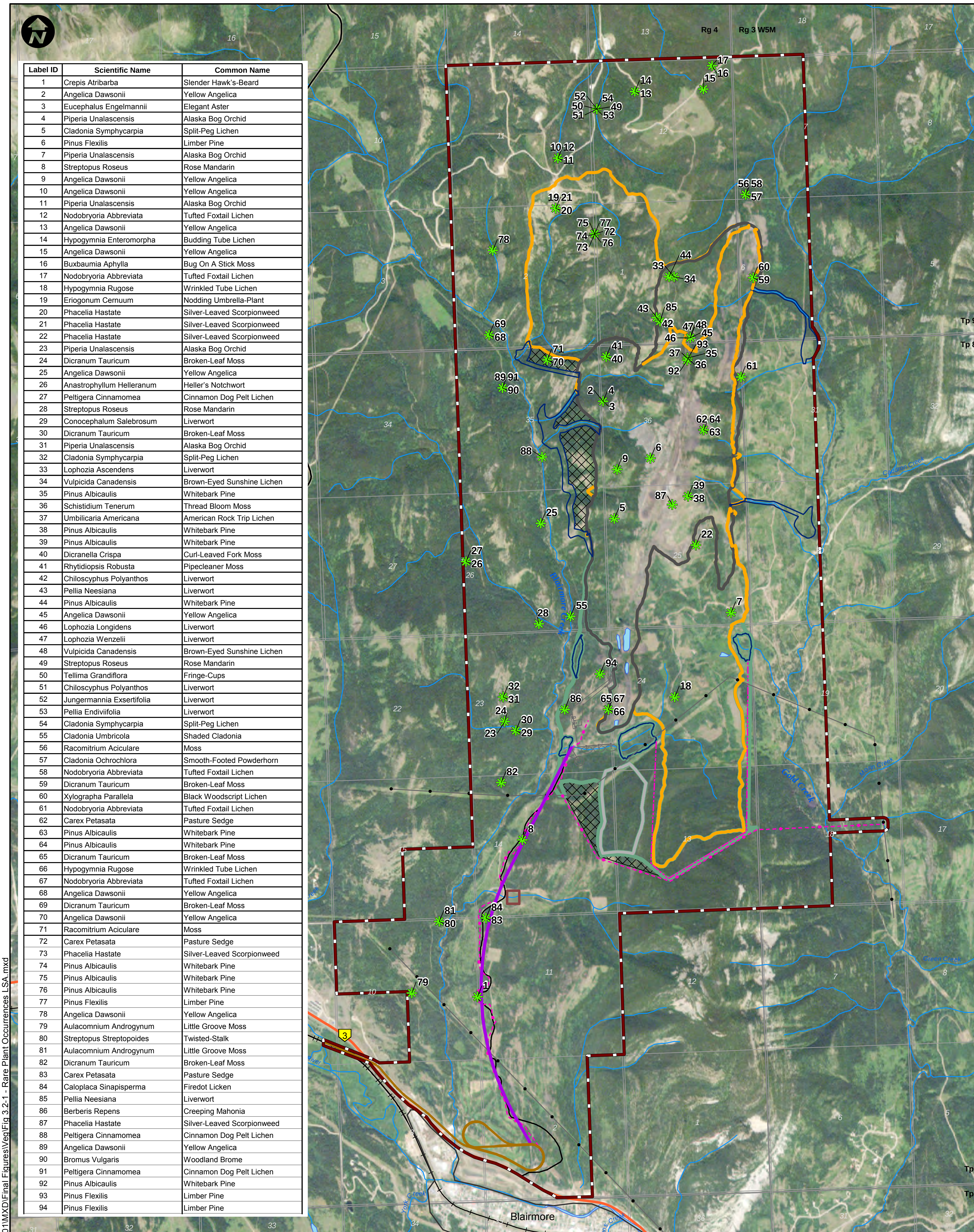


Label ID	Scientific Name	Common Name
1	Crepis Atribarba	Slender Hawk's-Beard
2	Angelica Dawsonii	Yellow Angelica
3	Eucephalus Engelmannii	Elegant Aster
4	Piperia Unalascensis	Alaska Bog Orchid
5	Cladonia Symphycarpia	Split-Peg Lichen
6	Pinus Flexilis	Limber Pine
7	Piperia Unalascensis	Alaska Bog Orchid
8	Streptopus Roseus	Rose Mandarin
9	Angelica Dawsonii	Yellow Angelica
10	Angelica Dawsonii	Yellow Angelica
11	Piperia Unalascensis	Alaska Bog Orchid
12	Nodobryoria Abbreviata	Tufted Foxtail Lichen
13	Angelica Dawsonii	Yellow Angelica
14	Hypogymnia Enteromorpha	Budding Tube Lichen
15	Angelica Dawsonii	Yellow Angelica
16	Buxbaumia Aphylla	Bug On A Stick Moss
17	Nodobryoria Abbreviata	Tufted Foxtail Lichen
18	Hypogymnia Rugose	Wrinkled Tube Lichen
19	Eriogonum Cernuum	Nodding Umbrella-Plant
20	Phacelia Hastate	Silver-Leaved Scorpionweed
21	Phacelia Hastate	Silver-Leaved Scorpionweed
22	Phacelia Hastate	Silver-Leaved Scorpionweed
23	Piperia Unalascensis	Alaska Bog Orchid
24	Dicranum Tauricum	Broken-Leaf Moss
25	Angelica Dawsonii	Yellow Angelica
26	Anastrophyllum Helleranum	Heller's Notchwort
27	Peltigera Cinnamomea	Cinnamon Dog Pelt Lichen
28	Streptopus Roseus	Rose Mandarin
29	Conocephalum Salebrosum	Liverwort
30	Dicranum Tauricum	Broken-Leaf Moss
31	Piperia Unalascensis	Alaska Bog Orchid
32	Cladonia Symphycarpia	Split-Peg Lichen
33	Lophozia Ascendens	Liverwort
34	Vulpicida Canadensis	Brown-Eyed Sunshine Lichen
35	Pinus Albicaulis	Whitebark Pine
36	Schistidium Tenerum	Thread Bloom Moss
37	Umbilicaria Americana	American Rock Trip Lichen
38	Pinus Albicaulis	Whitebark Pine
39	Pinus Albicaulis	Whitebark Pine
40	Dicranella Crispa	Curl-Leaved Fork Moss
41	Rhytidiopsis Robusta	Pipecleaner Moss
42	Chiloscyphus Polyanthos	Liverwort
43	Pellia Neesiana	Liverwort
44	Pinus Albicaulis	Whitebark Pine
45	Angelica Dawsonii	Yellow Angelica
46	Lophozia Longidens	Liverwort
47	Lophozia Wenzelii	Liverwort
48	Vulpicida Canadensis	Brown-Eyed Sunshine Lichen
49	Streptopus Roseus	Rose Mandarin
50	Tellima Grandiflora	Fringe-Cups
51	Chiloscyphus Polyanthos	Liverwort
52	Jungermannia Exsertifolia	Liverwort
53	Pellia Endiviifolia	Liverwort
54	Cladonia Symphycarpia	Split-Peg Lichen
55	Cladonia Umbricola	Shaded Cladonia
56	Racomitrium Aciculare	Moss
57	Cladonia Ochrochlora	Smooth-Footed Powderhorn
58	Nodobryoria Abbreviata	Tufted Foxtail Lichen
59	Dicranum Tauricum	Broken-Leaf Moss
60	Xylographa Parallela	Black Woodscript Lichen
61	Nodobryoria Abbreviata	Tufted Foxtail Lichen
62	Carex Petasata	Pasture Sedge
63	Pinus Albicaulis	Whitebark Pine
64	Pinus Albicaulis	Whitebark Pine
65	Dicranum Tauricum	Broken-Leaf Moss
66	Hypogymnia Rugose	Wrinkled Tube Lichen
67	Nodobryoria Abbreviata	Tufted Foxtail Lichen
68	Angelica Dawsonii	Yellow Angelica
69	Dicranum Tauricum	Broken-Leaf Moss
70	Angelica Dawsonii	Yellow Angelica
71	Racomitrium Aciculare	Moss
72	Carex Petasata	Pasture Sedge
73	Phacelia Hastate	Silver-Leaved Scorpionweed
74	Pinus Albicaulis	Whitebark Pine
75	Pinus Albicaulis	Whitebark Pine
76	Pinus Albicaulis	Whitebark Pine
77	Pinus Flexilis	Limber Pine
78	Angelica Dawsonii	Yellow Angelica
79	Aulacomnium Androgynum	Little Groove Moss
80	Streptopus Streptopoides	Twisted-Stalk
81	Aulacomnium Androgynum	Little Groove Moss
82	Dicranum Tauricum	Broken-Leaf Moss
83	Carex Petasata	Pasture Sedge
84	Caloplaca Sinapisperma	Firedot Licken
85	Pellia Neesiana	Liverwort
86	Berberis Repens	Creeping Mahonia
87	Phacelia Hastate	Silver-Leaved Scorpionweed
88	Peltigera Cinnamomea	Cinnamon Dog Pelt Lichen
89	Angelica Dawsonii	Yellow Angelica
90	Bromus Vulgaris	Woodland Brome
91	Peltigera Cinnamomea	Cinnamon Dog Pelt Lichen
92	Pinus Albicaulis	Whitebark Pine
93	Pinus Flexilis	Limber Pine
94	Pinus Flexilis	Limber Pine

LEGEND

- Location of Rare Species
- Primary Highway
- Secondary Highway
- Existing Railway
- Road Access
- CHPP Facilities
- Existing Powerline
- Overland Conveyor
- Proposed Pipeline
- Proposed Powerline
- Railway Loop
- Surface Water Drainage
- Waterbody
- Vegetation Local Study Area
- Coal Handling Processing Plant and Infrastructure
- Ultimate Pit Extent
- Ultimate Dump Extent
- Topsoil Storage
- Construction Camp
- Ponds and Ditches
- Undisturbed Area

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

RARE PLANT OCCURRENCES IN THE LSA AND FOOTPRINT

NOTES

AltaLIS, 2015; Geobase, 2015; Golder, 2015; MEMS, 2015; RapidEye, 2015
(Image Date: Jul 26/13); Riversdale, 2015
Datum/Projection: UTM NAD 83 Zone 11

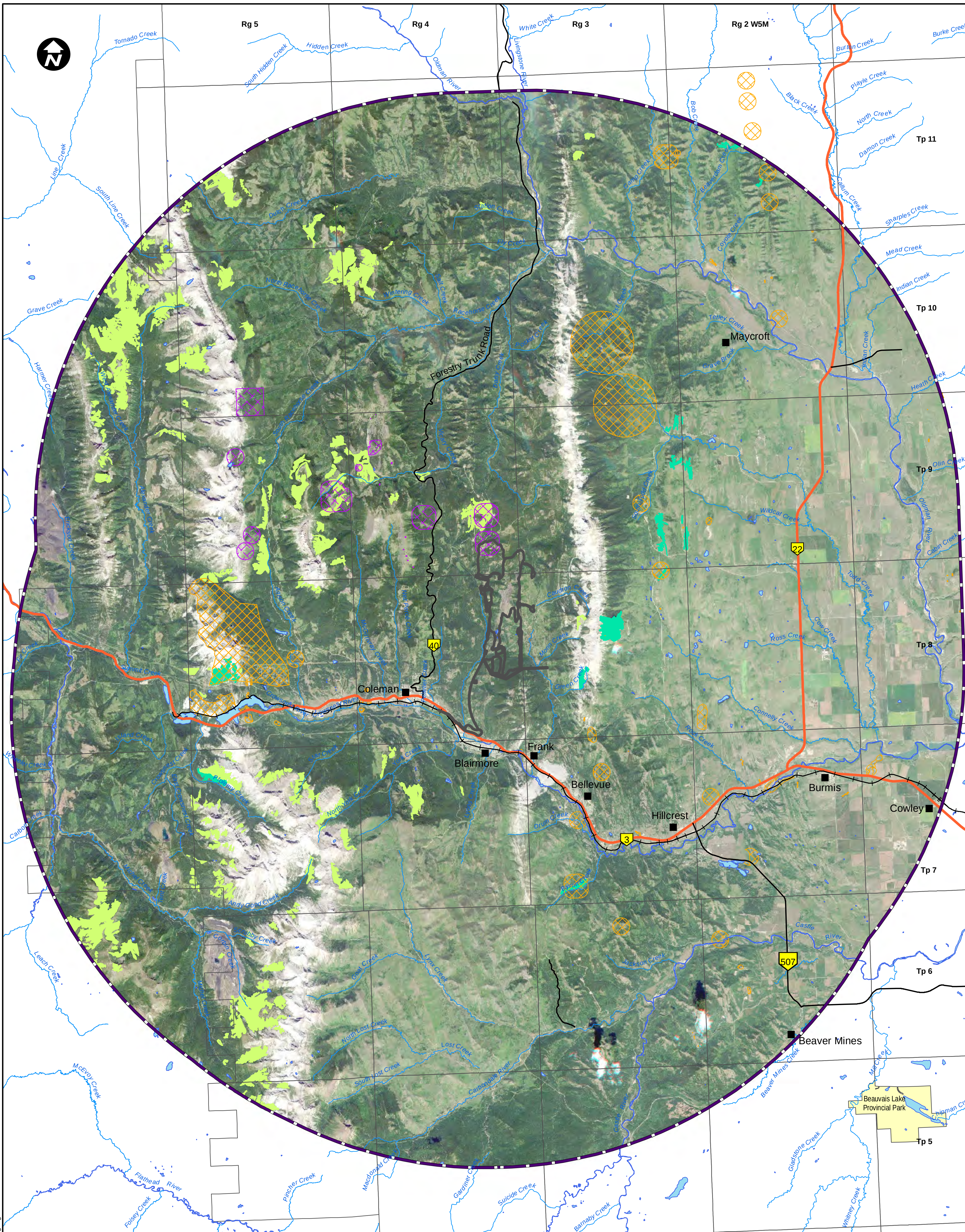
0 0.75 1.5 3
Kilometres

PROJECT: 14-00201-01
DRAWN BY: JDC/SL
CHECKED BY: EK
DATE: AUGUST 13, 2015

FIGURE

3.2-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Veg\Fig 3.2-1 - Rare Plant Occurrences LSA.mxd



LEGEND

- Primary Highway
- Secondary Highway
- Existing Railway
- Surface Water Drainage
- Waterbody
- Provincial Park
- Project Footprint
- Vegetation Regional Study Area
- Historical Whitebark Pine Population
- Whitebark Pine (AVI/VRI)
- Historical Limber Pine Population
- Limber Pine (AVI/VRI)

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

WHITEBARK AND LIMBER PINE OCCURRENCE IN THE RSA

NOTES

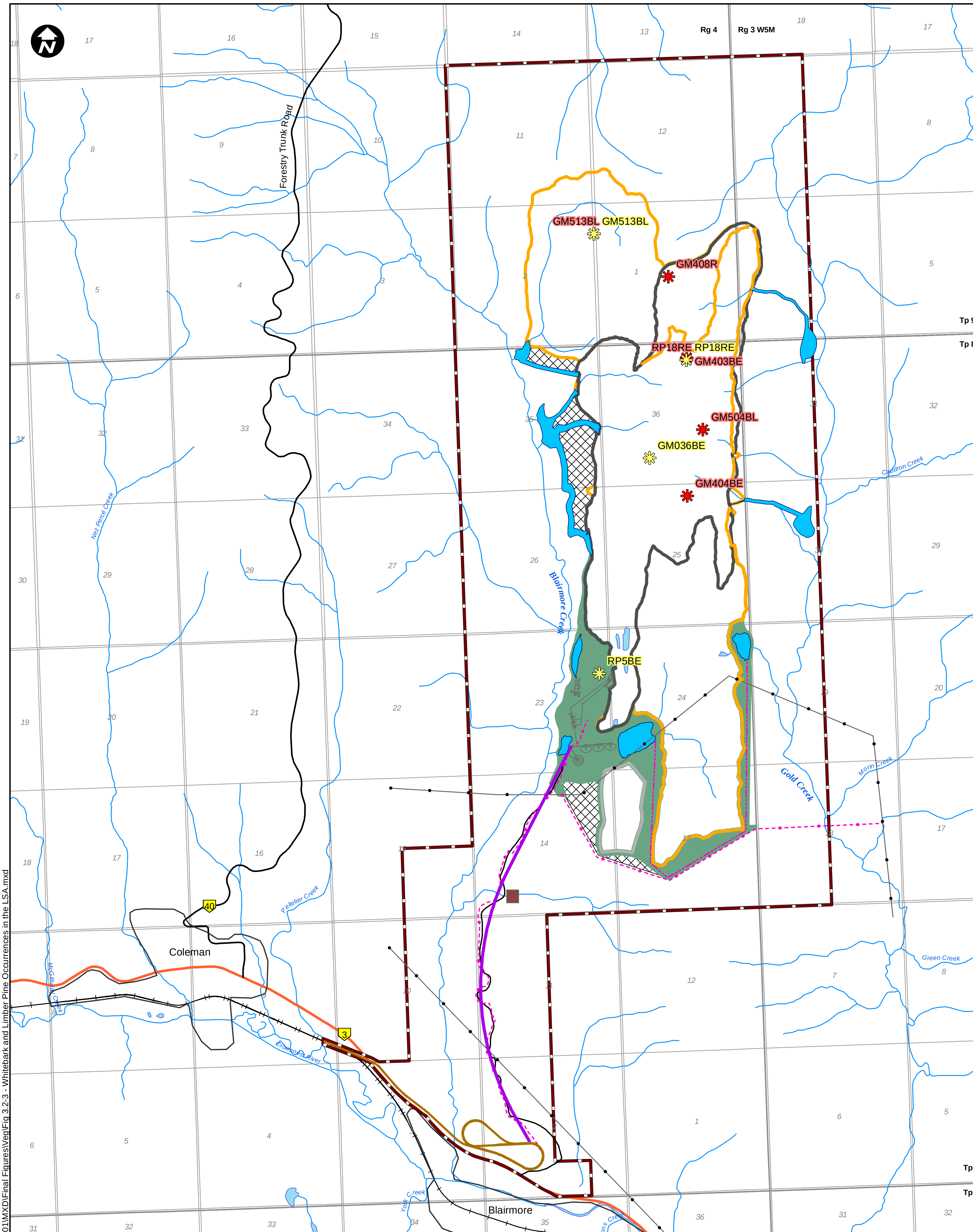
AltaLIS, 2015; Geobase, 2015; Golder, 2015; MEMS, 2015; RapidEye, 2015 (Image Date: Jul 26/14); Riversdale, 2015
Datum/Projection: UTM NAD 83 Zone 11

0 4 8 16
Kilometres

PROJECT: 14-00201-01
DRAWN BY: JDC/SL
CHECKED BY: EK
DATE: OCTOBER 14, 2015

FIGURE
3.2-2

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Veg\Fig 3.2-2 - Whitebark and Limber Pine occurrence in the RSA.mxd



LEGEND

- Limber Pine Location
- Whitebark Pine Location
- Surface Water Drainage
- Primary Highway
- Secondary Highway
- Existing Railway
- Road Access
- CHPP Facilities
- Existing Powerline
- Overland Conveyor
- Proposed Pipeline
- Proposed Powerline
- Railway Loop
- Vegetation Local Study Area
- Coal Handling Processing Plant and Infrastructure
- Ultimate Pit Extent
- Ultimate Dump Extent
- Topsoil Storage
- Construction Camp
- Ponds and Ditches
- Undisturbed Area

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

WHITEBARK AND LIMBER PINE OCCURRENCES IN THE LSA

NOTES

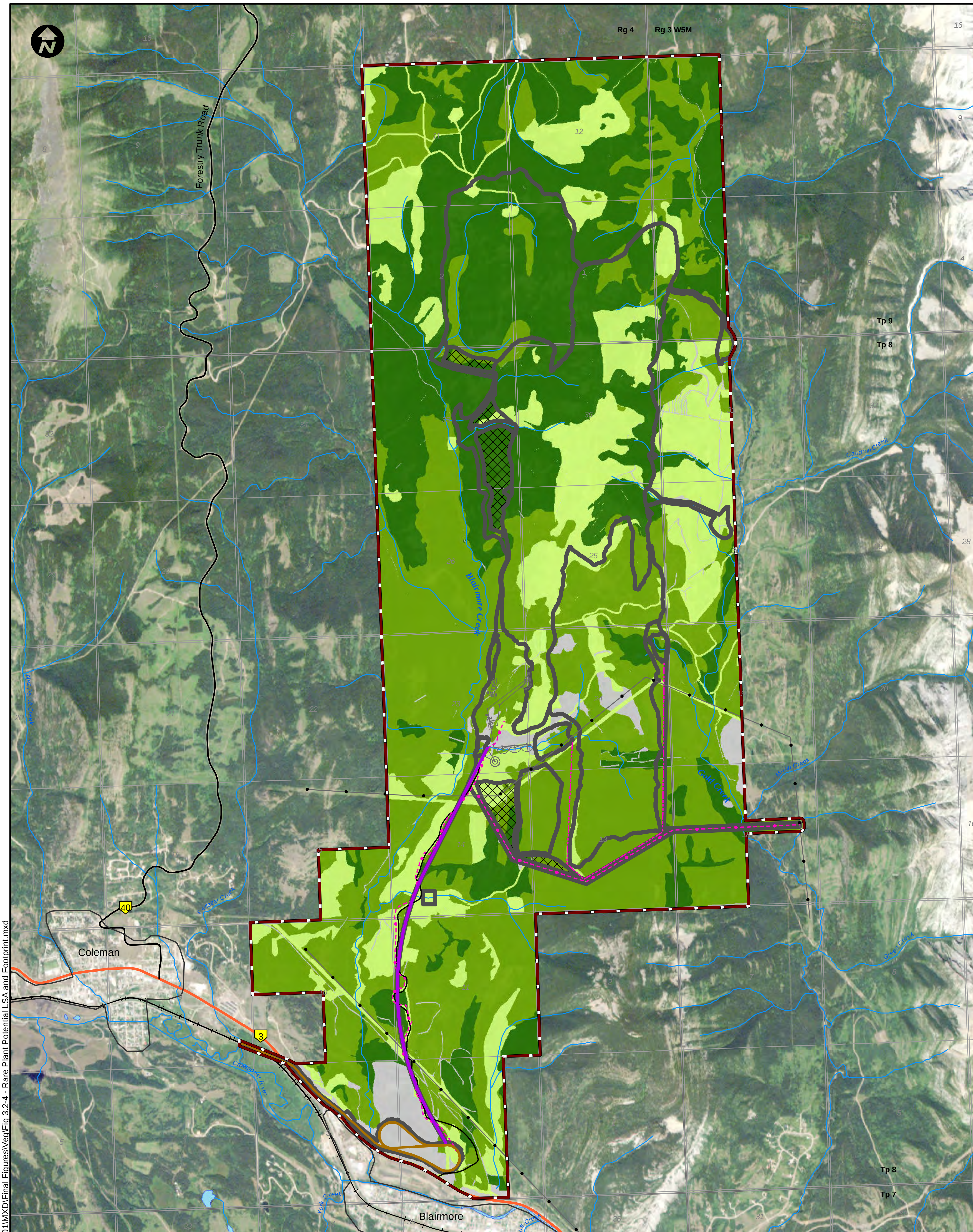
AltaLIS, 2015; Golder, 2015; MEMS, 2015; Riversdale, 2015.
Datum/Projection: UTM NAD 83 Zone 11

0 0.75 1.5 3
Kilometres

PROJECT: 14-00201-01
DRAWN BY: JDC
CHECKED BY: EK
DATE: SEPTEMBER 25, 2015

FIGURE
3.2-3

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Veg\Fig 3.2-3 - Whitebark and Limber Pine Occurrences in the LSA.mxd



LEGEND

- Primary Highway
- Secondary Highway
- Existing Railway
- Road Access
- CHPP Facilities
- Existing Powerline
- Overland Conveyor
- Proposed Pipeline
- Proposed Powerline
- Railway Loop
- Surface Water Drainage
- Waterbody
- Vegetation Local Study Area
- Project Footprint
- Undisturbed Area

Rare Plant Potential

- High
- Moderate
- Low
- Non-vegetated

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

RARE PLANT POTENTIAL IN THE LSA AND FOOTPRINT

NOTES

AltaLIS, 2015; Geobase, 2015; Golder, 2015; MEMS, 2015; RapidEye, 2015
(Image Date: Jul 26/13); Riversdale, 2015
Datum/Projection: UTM NAD 83 Zone 11

0 0.75 1.5 3
Kilometres

PROJECT: 14-00201-01
DRAWN BY: SL/JDC
CHECKED BY: EK
DATE: SEPTEMBER 25, 2015

FIGURE

3.2-4

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Veg\Fig 3.2-4 - Rare Plant Potential LSA and Footprint.mxd

LEGEND

- Primary Highway
- Secondary Highway
- Existing Railway
- Road Access
- CHPP Facilities
- Existing Powerline
- Overland Conveyor
- Proposed Pipeline
- Proposed Powerline
- Railway Loop
- Surface Water Drainage
- Waterbody
- Vegetation Local Study Area
- Project Footprint
- Undisturbed Area

Rare Plant Community Potential

- Very High
- High
- Moderate
- Low
- Very Low
- Anthropogenic
- Water

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

RARE PLANT COMMUNITY POTENTIAL IN THE LSA AND FOOTPRINT

NOTES

AltaLIS, 2015; Geobase, 2015; Golder, 2015; MEMS, 2015; RapidEye, 2015
(Image Date: Jul 26/13); Riversdale, 2015
Datum/Projection: UTM NAD 83 Zone 11

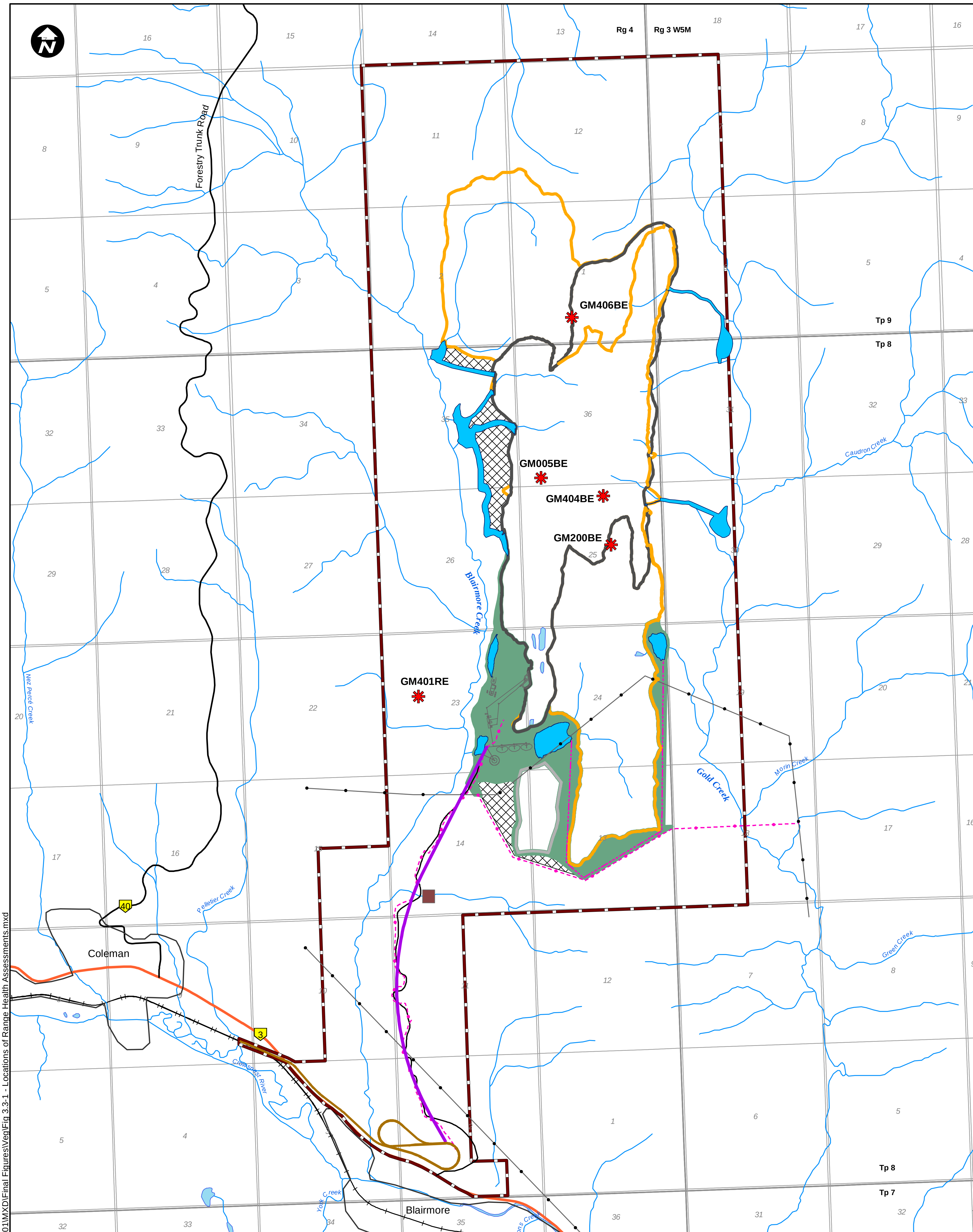
0 0.75 1.5 3
Kilometres

PROJECT: 14-00201-01
DRAWN BY: SL/JDC
CHECKED BY: EK
DATE: SEPTEMBER 25, 2015

FIGURE

3.2-5

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Veg\Fig 3.2-5 - Rare Plant Community Potential LSA and Footprint.mxd



LEGEND

- Range Health Assessment Location
- Surface Water Drainage
- Primary Highway
- Secondary Highway
- Existing Railway
- Road Access
- CHPP Facilities
- Existing Powerline
- Overland Conveyor
- Proposed Pipeline
- Proposed Powerline
- Railway Loop
- Vegetation Local Study Area
- Coal Handling Processing Plant and Infrastructure
- Ultimate Pit Extent
- Ultimate Dump Extent
- Topsoil Storage
- Construction Camp
- Ponds and Ditches
- Undisturbed Area

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

LOCATIONS OF RANGE HEALTH ASSESSMENTS

NOTES

AltaLIS, 2015; Golder, 2015; MEMS, 2015; Riversdale, 2015.
Datum/Projection: UTM NAD 83 Zone 11

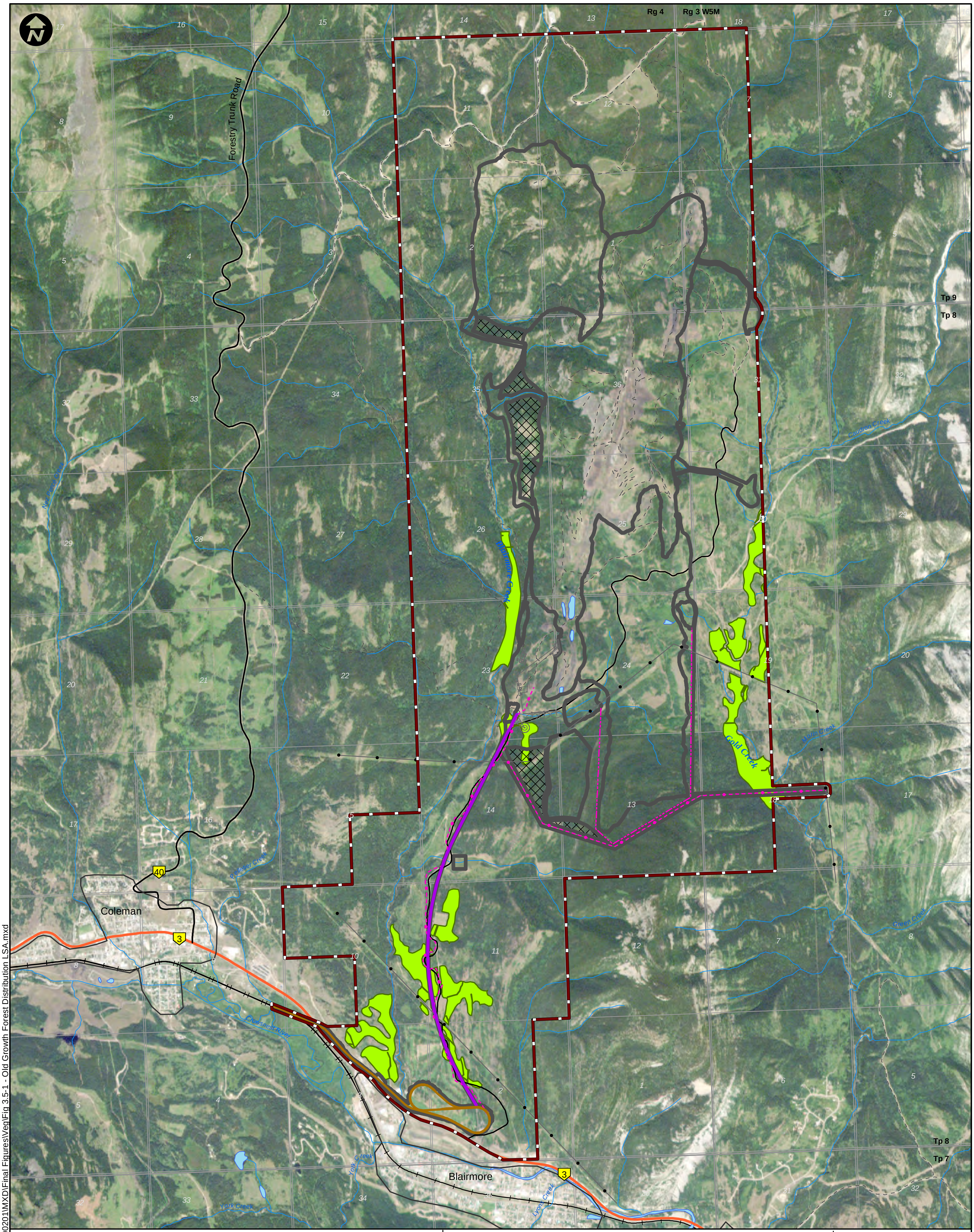
0 0.75 1.5 3
Kilometres

PROJECT: 14-00201-01
DRAWN BY: SL/JDC
CHECKED BY: EK
DATE: SEPTEMBER 25, 2015

FIGURE

3.3-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Veg\Fig 3.3-1 - Locations of Range Health Assessments.mxd



LEGEND

- Primary Highway
- Secondary Highway
- Existing Trails
- Existing Railway
- Road Access
- CHPP Facilities
- Existing Powerline
- Overland Conveyor
- Proposed Pipeline
- Proposed Powerline
- Railway Loop
- Surface Water Drainage
- Waterbody
- Vegetation Local Study Area
- Project Footprint
- Undisturbed Area
- Old Growth Forest

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

OLD GROWTH FOREST DISTRIBUTION IN THE LSA AND FOOTPRINT

NOTES

AltaLIS, 2015; Geobase, 2015; Golder, 2015; MEMS, 2015; RapidEye, 2015 (Image Date: Jul 26/13); Riversdale, 2015
Datum/Projection: UTM NAD 83 Zone 11

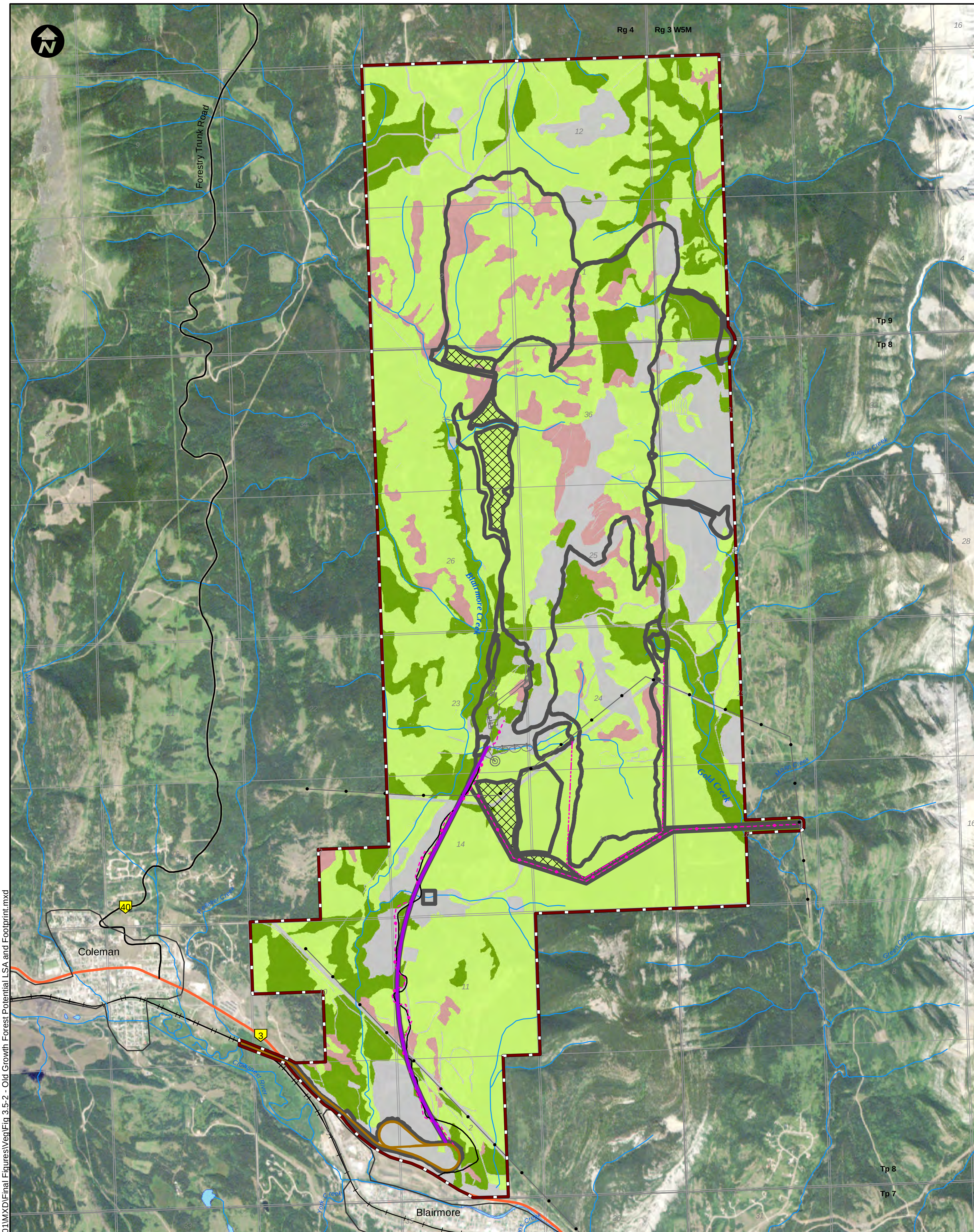
0 0.75 1.5 3
Kilometres

PROJECT: 14-00201-01
DRAWN BY: SL
CHECKED BY: EK
DATE: AUGUST 13, 2015

FIGURE

3.5-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Veg\Fig 3.5-1 - Old Growth Forest Distribution LSA.mxd



LEGEND

- Primary Highway
- Secondary Highway
- Existing Railway
- Road Access
- CHPP Facilities
- Existing Powerline
- Overland Conveyor
- Proposed Pipeline
- Proposed Powerline
- Railway Loop
- Surface Water Drainage
- Waterbody
- Vegetation Local Study Area
- Project Footprint
- Undisturbed Area

Old Growth Forest Potential

- Moderate
- Low
- Non-Forested
- Anthropogenic

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

OLD GROWTH FOREST POTENTIAL IN THE LSA AND FOOTPRINT

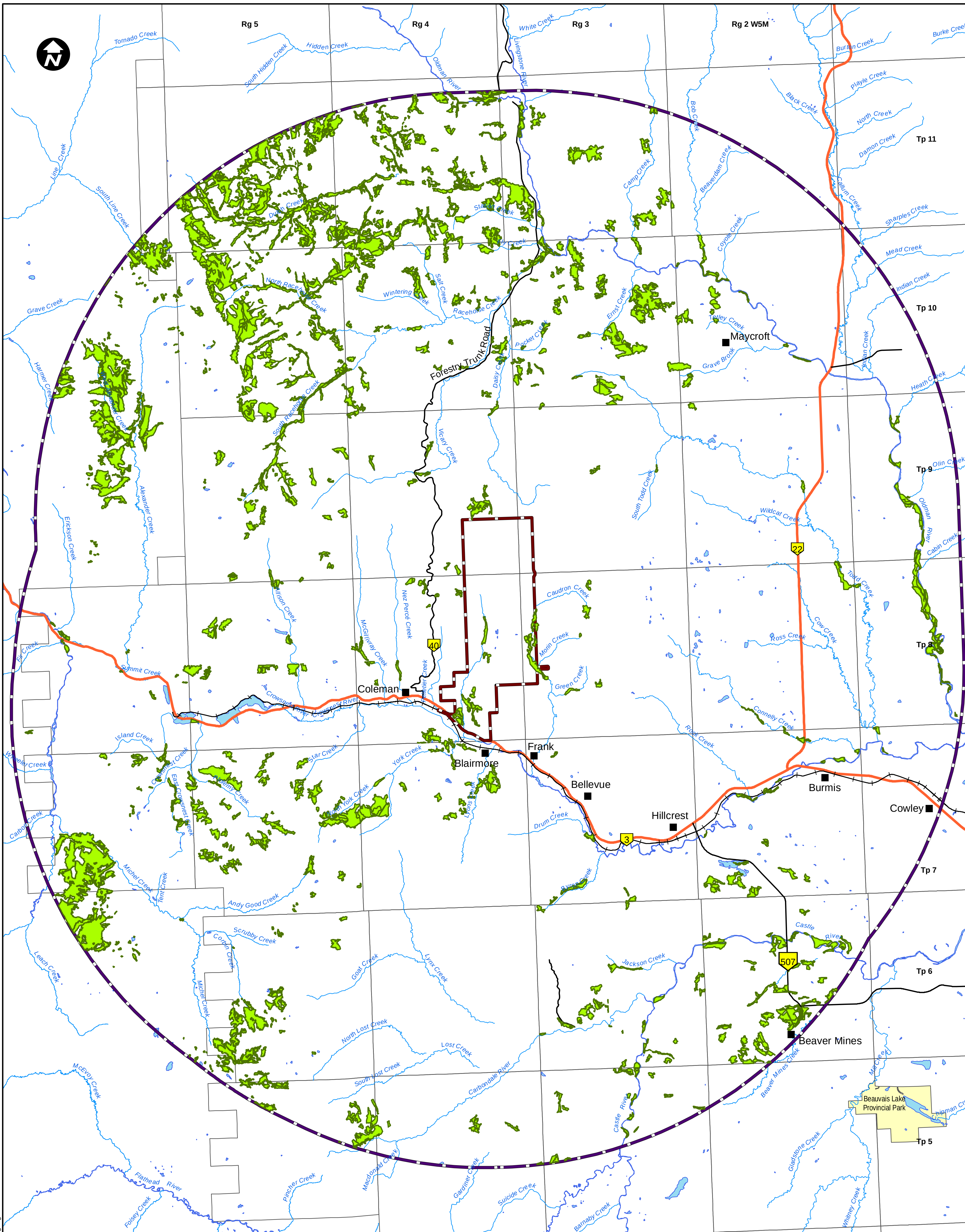
NOTES

AltaLIS, 2015; Geobase, 2015; Golder, 2015; MEMS, 2015; RapidEye, 2015 (Image Date: Jul 26/13); Riversdale, 2015
Datum/Projection: UTM NAD 83 Zone 11

0 0.75 1.5 3
Kilometres

PROJECT: 14-00201-01
DRAWN BY: SL
CHECKED BY: EK
DATE: AUGUST 17, 2015

FIGURE
3.5-2



LEGEND

- Primary Highway
- Secondary Highway
- Existing Railway
- Surface Water Drainage
- Waterbody
- Provincial Park
- Vegetation Regional Study Area
- Vegetation Local Study Area
- Old Growth Forest

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

OLD GROWTH FOREST DISTRIBUTION IN THE RSA

NOTES

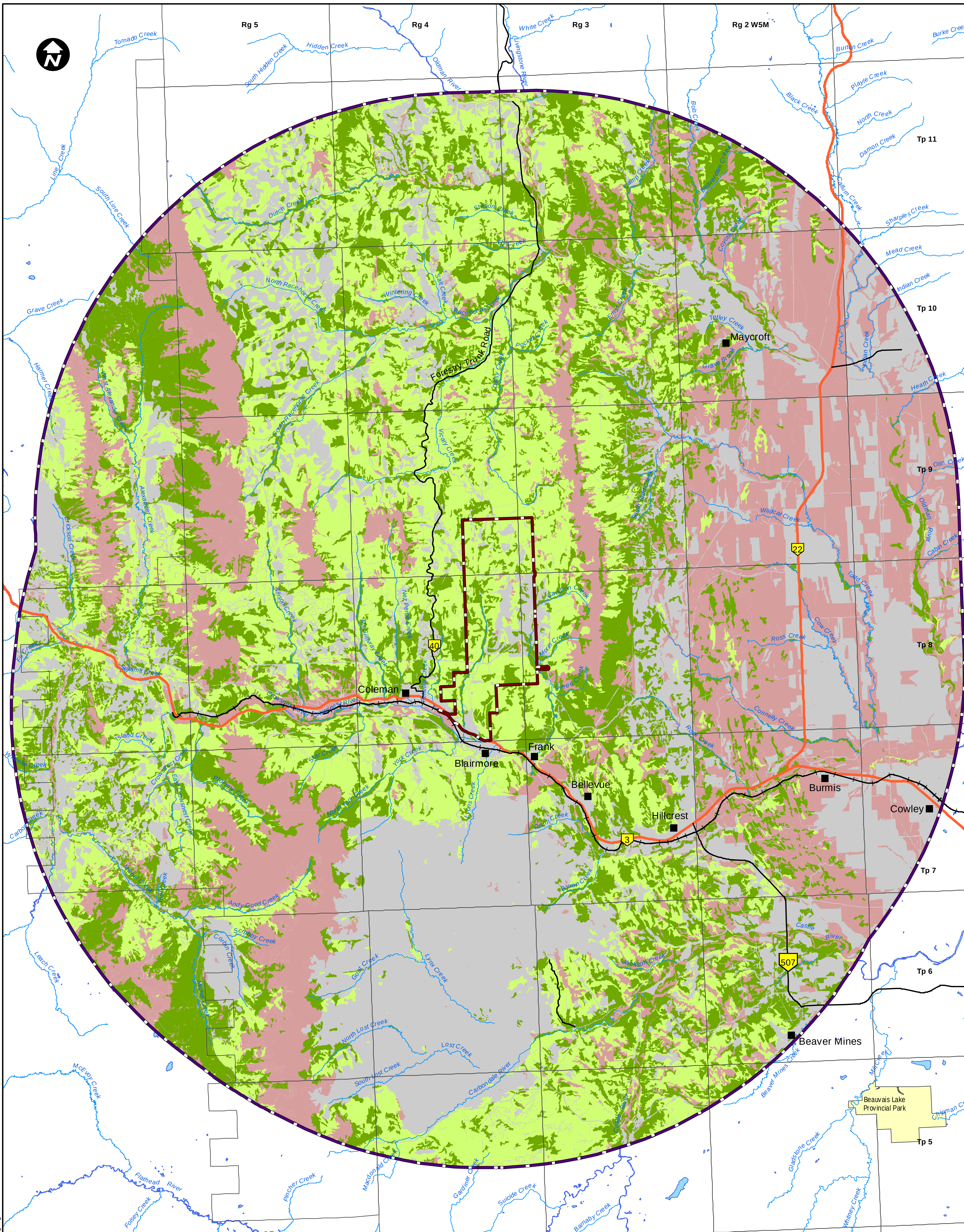
AltaLIS, 2015; Geobase, 2015; MEMS, 2015; Riversdale, 2015
Datum/Projection: UTM NAD 83 Zone 11

0 4 8 16
Kilometres

PROJECT: 14-00201-01
DRAWN BY: SL
CHECKED BY: EK
DATE: AUGUST 13, 2015

FIGURE
3.5-3

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Veg\Fig 3.5-3 - Old Growth Forest Distribution RSA.mxd



LEGEND

- Primary Highway
- Secondary Highway
- Existing Railway
- Surface Water Drainage
- Waterbody
- Provincial Park
- Vegetation Regional Study Area
- Vegetation Local Study Area

Old Growth Forest Potential

- Moderate
- Low
- Non-Forested
- Anthropogenic

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

OLD GROWTH FOREST POTENTIAL IN THE RSA

NOTES

AltaLIS, 2015; Geobase, 2015; MEMS, 2015; Riversdale, 2015
Datum/Projection: UTM NAD 83 Zone 11

0 4 8 16
Kilometres

PROJECT: 14-00201-01
DRAWN BY: SL
CHECKED BY: EK
DATE: AUGUST 13, 2015

FIGURE

3.5-4

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Veg\Fig 3.5-4 - Old Growth Forest Potential RSA.mxd

LEGEND

- Primary Highway
- Secondary Highway
- Existing Railway
- Road Access
- CHPP Facilities
- Existing Powerline
- Overland Conveyor
- Proposed Pipeline
- Proposed Powerline
- Railway Loop
- Surface Water Drainage
- Waterbody
- Vegetation Local Study Area
- Project Footprint
- Undisturbed Area

TEK Vegetation Potential

- Very High
- High
- Moderate
- Low
- Very Low
- Anthropogenic
- Rock
- Water

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

TEK VEGETATION POTENTIAL IN THE LSA AND FOOTPRINT

NOTES

AltaLIS, 2015; Geobase, 2015; Golder, 2015; MEMS, 2015; RapidEye, 2015 (Image Date: Jul 26/13); Riversdale, 2015
Datum/Projection: UTM NAD 83 Zone 11

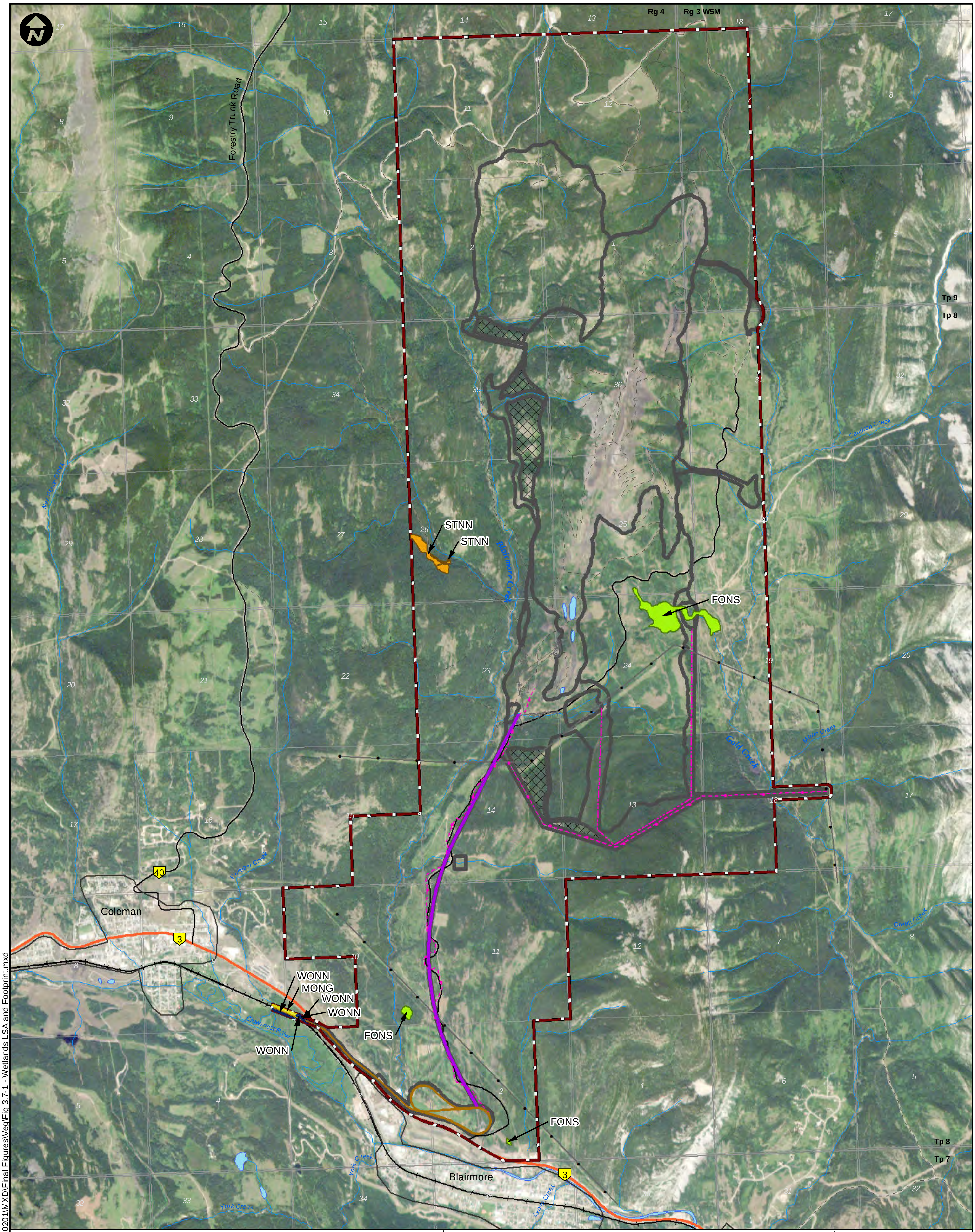
0 0.75 1.5 3
Kilometres

PROJECT: 14-00201-01
DRAWN BY: SL
CHECKED BY: EK
DATE: AUGUST 17, 2015

FIGURE

3.6-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Veg\Fig 3.6-1 - TEK Vegetation Potential LSA and Footprint.mxd



LEGEND

- Primary Highway
- Secondary Highway
- Existing Trails
- Existing Railway
- Road Access
- CHPP Facilities
- Existing Powerline
- Overland Conveyor
- Proposed Pipeline
- Proposed Powerline
- Railway Loop
- Surface Water Drainage
- Waterbody
- Vegetation Local Study Area
- Project Footprint
- Undisturbed Area

Wetland

- FONS - Shrubby open fen
- STNN - Wooded open canopy (6-70% cover) swamp
- MONG - Marsh
- WONN - Open water (<2 m deep)

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

WETLANDS IN THE LSA AND FOOTPRINT

NOTES

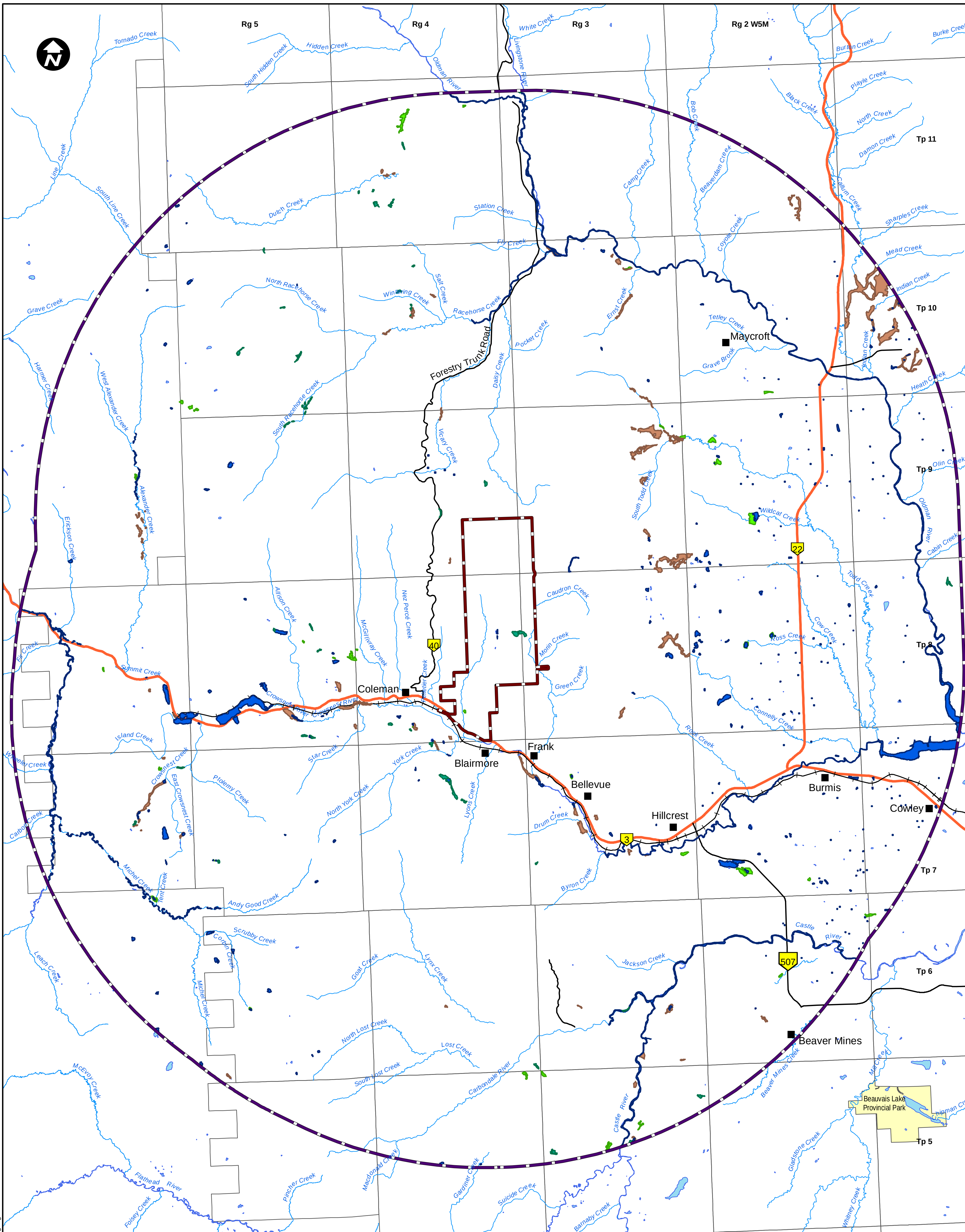
AltaLIS, 2015; Geobase, 2015; Golder, 2015; MEMS, 2015; RapidEye, 2015 (Image Date: Jul 26/13); Riversdale, 2015
Datum/Projection: UTM NAD 83 Zone 11

0 0.75 1.5 3
Kilometres

PROJECT: 14-00201-01
DRAWN BY: SL/JDC
CHECKED BY: EK
DATE: SETEMBER 25, 2015

FIGURE
3.7-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Veg\Fig 3.7-1 - Wetlands LSA and Footprint.mxd



LEGEND

- Primary Highway
- Secondary Highway
- Existing Railway
- Surface Water Drainage
- Waterbody
- Provincial Park
- Vegetation Regional Study Area
- Vegetation Local Study Area

Wetland

- Natural Graminoid Wetland
- Natural Shrubby Wetland
- Treed Wetland
- Open Water

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

WETLANDS IN THE RSA

NOTES

AltaLIS, 2015; Geobase, 2015; MEMS, 2015; Riversdale, 2015
Datum/Projection: UTM NAD 83 Zone 11

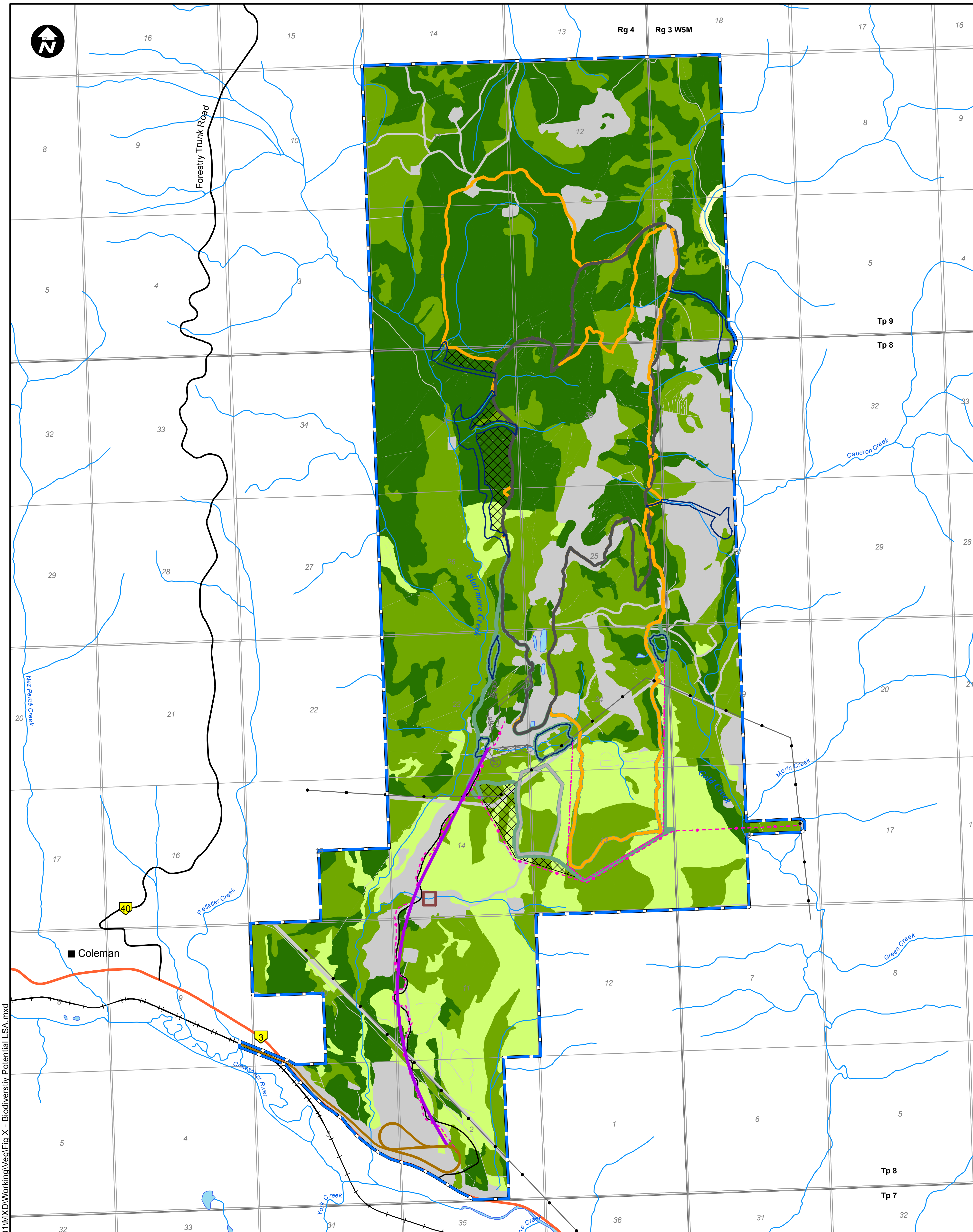
0 4 8 16
Kilometres

PROJECT: 14-00201-01
DRAWN BY: SL
CHECKED BY: EK
DATE: AUGUST 13, 2015

FIGURE

3.7-2

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Veg\Fig 3.7-2 - Wetlands in the RSA.mxd



LEGEND

- Surface Water Drainage
- Primary Highway
- Secondary Highway
- Existing Railway
- Road Access
- CHPP Facilities
- Existing Powerline
- Overland Conveyor
- Proposed Pipeline
- Proposed Powerline
- Railway Loop
- Vegetation Local Study Area
- Coal Handling Processing Plant and Infrastructure
- Ultimate Pit Extent
- Ultimate Dump Extent
- Topsoil Storage
- Construction Camp
- Ponds and Ditches
- Non-Disturbed Area

Biodiversity Potential

- High
- Moderate
- Low
- Very Low
- Anthropogenic

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

BIODIVERSITY POTENTIAL BY MAP UNIT IN THE LSA

NOTES

AltaLIS, 2015; Golder, 2015; MEMS, 2015; Riversdale, 2015.
Datum/Projection: UTM NAD 83 Zone 11

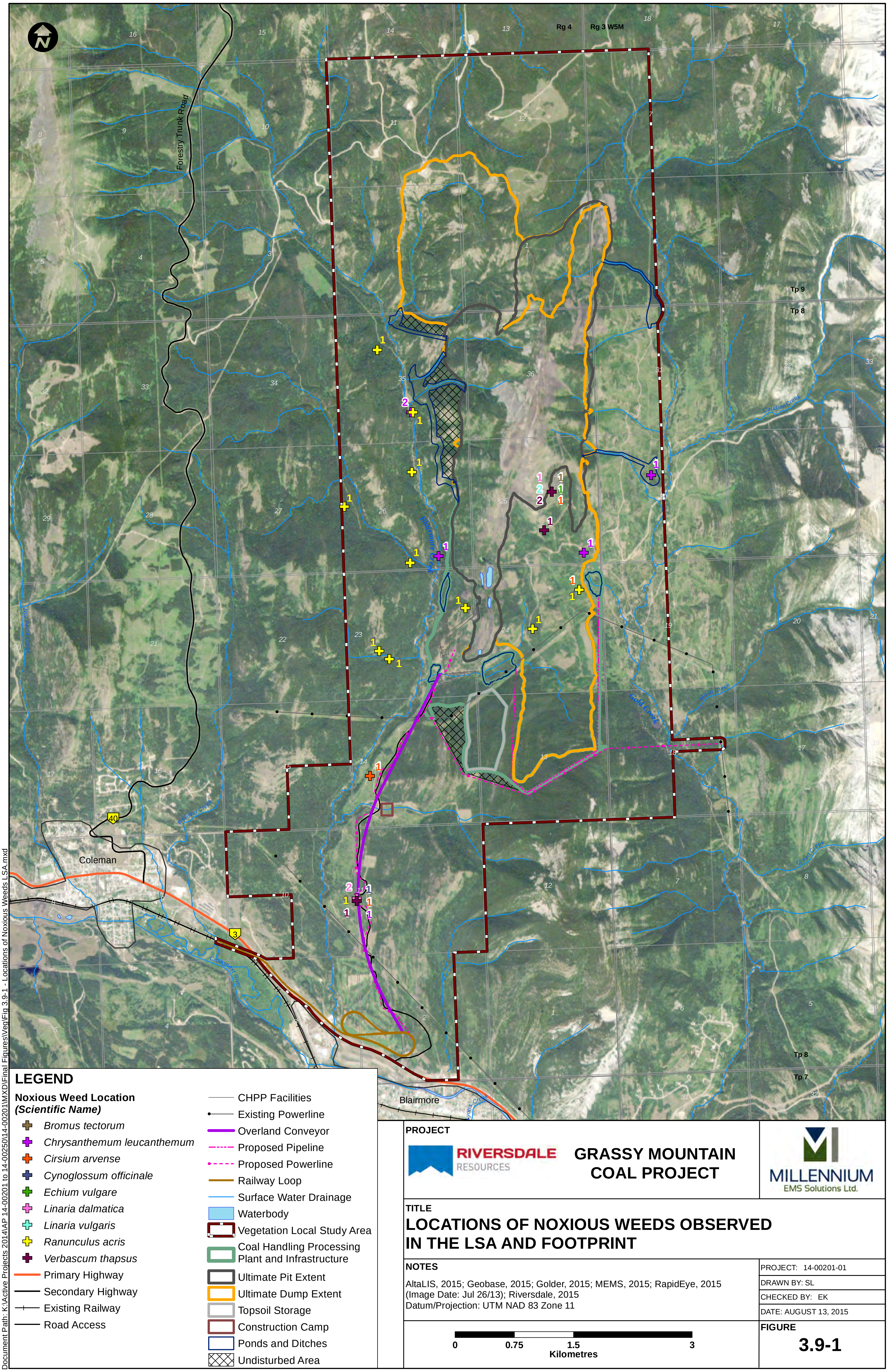
0 0.75 1.5 3
Kilometres

PROJECT: 14-00201-01
DRAWN BY: SL
CHECKED BY: KK
DATE: AUGUST 10, 2015

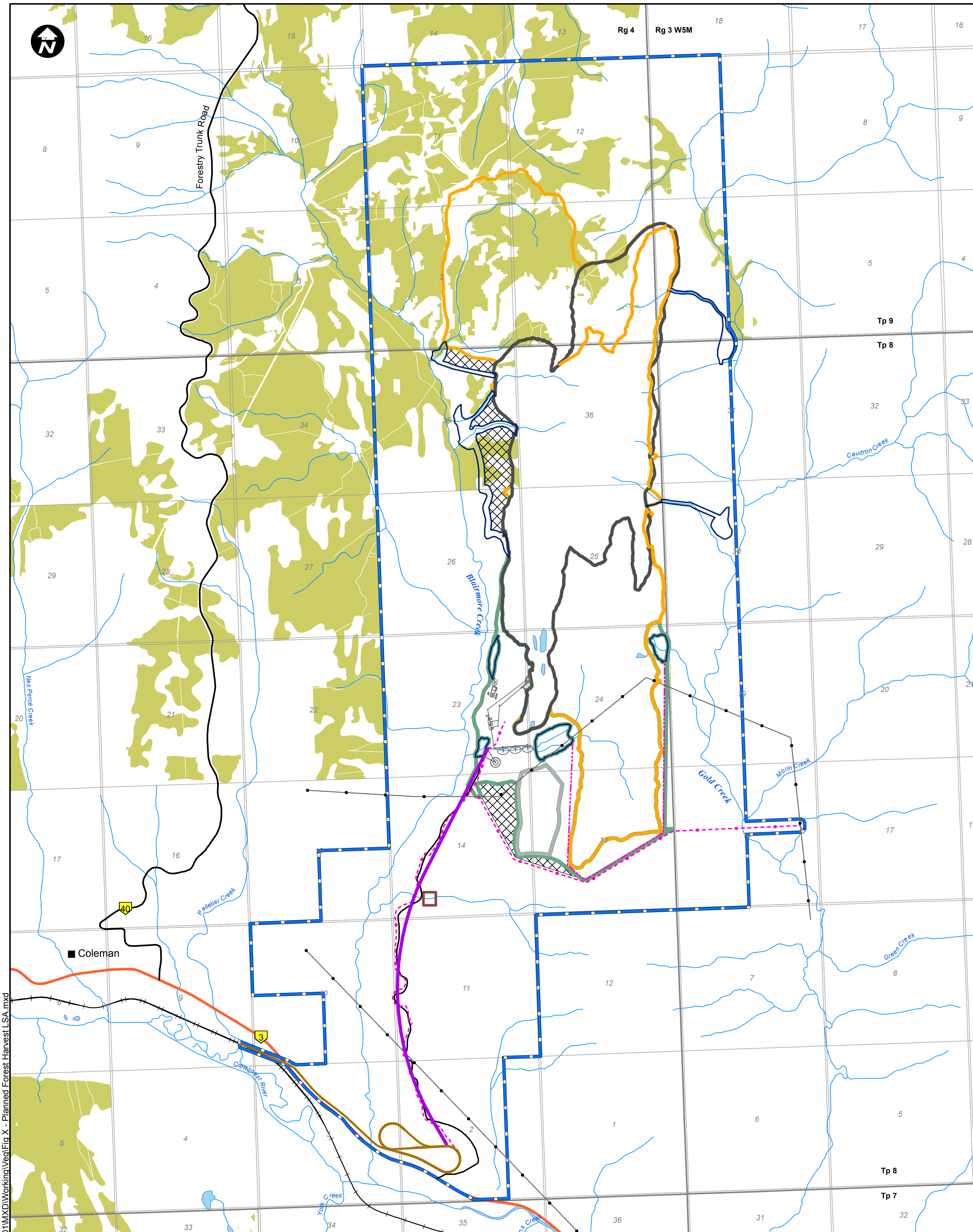
FIGURE

3.8-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Working\Veg\Fig X - Biodiversity Potential LSA.mxd



Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Veg\Fig 3.9-1 - Locations of Noxious Weeds LSA.mxd



LEGEND

- Surface Water Drainage
- Primary Highway
- Secondary Highway
- Existing Railway
- Road Access
- CHPP Facilities
- Existing Powerline
- Overland Conveyor
- Proposed Pipeline
- Proposed Powerline
- Railway Loop
- Vegetation Local Study Area
- Coal Handling Processing Plant and Infrastructure
- Ultimate Pit Extent
- Ultimate Dump Extent
- Topsoil Storage
- Construction Camp
- Ponds and Ditches
- Non-Disturbed Area
- Planned Forest Harvest

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PLANNED FOREST HARVEST MAP FOR THE LSA

NOTES

AESRD, 2015; AltaLIS, 2015; Golder, 2015; MEMS, 2015; Riversdale, 2015.
Datum/Projection: UTM NAD 83 Zone 11

0 0.75 1.5 3
Kilometres

PROJECT: 14-00201-01
DRAWN BY: SL
CHECKED BY: KK
DATE: AUGUST 10, 2015

FIGURE
4.4-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Working\Veg\Fig X - Planned Forest Harvest LSA.mxd

APPENDIX A: AER VEGETATION AND WETLANDS CONCORDANCE TABLE

4.6 VEGETATION			
4.6.1 Baseline Information			
	[A] Describe and map vegetation communities. Identify the occurrence, relative abundance and distribution and identify any species that are:	Section E.8.2.1	CR #8 Section 2.3, 3.1, 3.2
	a) listed as "at Risk, May be at Risk and Sensitive" in The Status of Alberta Species (ESRD);	Section E.8.2.2.1	CR #8 Section 2.3.2, 3.2
	b) listed in Schedule 1 of the federal Species at Risk Act;	Section E.8.2.2.1	CR #8 Section 2.3.2, 3.2
	c) listed as "at risk" by COSEWIC; and	Section E.8.2.2.1	CR #8 Section 2.3.2, 3.2
	d) traditional and currently used species.	Section E.8.2.6, H.2.1, H.3.1.3, H.3.2.3, H.3.3.3, H.3.4.3, H.3.5.3	CR #8 Section 2.3.6, 3.6
	[B] Describe and quantify the current extent of habitat fragmentation.	E.8.2.8.3 (LSA) E.8.2.8.4 (RSA)	CR #8 Section 2.3.8, 3.8
	[C] Discuss the potential of each ecosite phase to support rare plant species, plants for traditional, medicinal and cultural purposes, old growth forests and communities of limited distribution. Consider their importance for local and regional habitat, sustained forest growth, rare plant habitat and the hydrologic regime.	Section E.8.2.2, E.8.2.5, E.8.2.6	CR #8 Section 3.1, 3.2, 3.5, 3.6, 3.7
	[D] Describe the regional relevance of landscape units that are identified as rare.	N/A	CR #8 Section 3.1.2, Table 3.1-1
	[E] Provide Timber Productivity Ratings for both the Project Area and the Local Study Area, including identification of productive forested, non-productive forested and non-forested lands.	Section E.8.2.4.1, E.8.3.4	CR #8 Section 2.3.4, 3.4

4.6 VEGETATION			
4.6.2 Impact Assessment			
[A] Describe and assess the potential impacts of the Project on vegetation communities;		E.8.3	CR #8 Section 4.1
[B] Discuss any potential impacts the Project may have on rare plants or endangered species.		Section E.8.3.2, H.2.2, H.3.1.4.2, H.3.1.4.1.2, H.3.2.4.2, H.3.2.4.1.2, H.3.3.4.2, H.3.3.4.1.2, H.3.4.4.2, H.3.4.1.2, H.3.5.4.2, H.3.5.4.1.2	CR #8 Section 4.2
[C] Identify key vegetation indicators used to assess the Project impacts. Discuss the rationale for the indicator's selection.		N/A	CR #8 Section 2.4, Table 2.4-2, 2.4.1-2.4.4
[D] Discuss temporary (include timeframe) and permanent changes to vegetation and wetland communities and comment on:		Section E.8.3.1, E.8.3.7, E.8.4.1, E.8.4.2	CR #8 Section 2.4.1, 4.0
	a) the impacts and their implications for other environmental resources (*e.g.*, habitat diversity and quantity, water quality and quantity, erosion potential);	N/A	CR #8 Section 4.8
	b) the impacts on recreation, aboriginal and other uses; and	Section E.8.3.6	CR #8 Section 4.6
	c) the sensitivity to disturbance (including acid deposition), as well as the techniques used to estimate sensitivity to disturbance and reclamation, of each vegetation community.	Section E.8.2, E.8.5	CR #8 Section 4.1.4, 4.2.5, 4.3.3, 4.4.3, 4.5.4, 4.6.3, 4.7.3, 4.8.3, 4.9.3, 4.10 Sections 2.3.10 and 3.10 (CR # 6 - Soils and Terrain)

4.6 VEGETATION			
	[E] Describe the regional impact of any ecosite phase to be removed.	Section E.8.4.1	CR #8 Section 3.1.2, 4.1.4, 4.7.3
	[F] Discuss from an ecological perspective, the expected timelines for establishment and recovery of vegetative communities and the expected differences in the resulting vegetative community structures.	Section E.8.4.3	CR #8 Section, 4.1.5, 4.8.1.1, 4.8.3,
	[G] Provide a predicted Ecological Land Classification map that shows the reclaimed vegetation. Comment on the importance of the size, distribution and variety of the reclaimed landscape units from both a local and regional perspective.	See C&R Plan (Section F of the EIA Application)	See Conservation and Reclamation Plan (Section F of the EIA Application)
	[H] Discuss the impact of any loss of wetlands, including how the loss will affect land use.	Section E.8.3.7, E.8.4.2	CR #8 Section 4.7.1-4.7.3
	[I] Discuss weeds and non-native invasive species and describe how these species will be assessed and controlled prior to and during operation and reclamation.	Section E.8.2.9, E.8.5	CR #8 Section 2.3.9, 3.9, 5.2
	[J] Discuss the predicted changes to upland, riparian and wetland habitats resulting from increased fragmentation.	Section E.8.3.7, E.8.4.2	CR #8 Section 4.7.1-4.7.3

APPENDIX B: VEGETATION SPECIES IDENTIFIED WITHIN THE LSA

Table B-1 Vegetation Species Identified in the LSA

Scientific Name	Common Name	SRANK	GRANK	Tracked
Vascular plants (298 species)				
Abies balsamea	Balsam fir	S5	G5	N
Abies lasiocarpa	Subalpine fir	SNA	GNRQ	N
Acer glabrum	Mountain maple	S4	G5	N
Achillea millefolium	Common yarrow	S5	G5	N
Actaea rubra	Red and white baneberry	S5	G5	N
Agoseris aurantiaca	Orange false dandelion	S4	G5	N
Agoseris glauca	Yellow false dandelion	S5	G5	N
Agropyron albicans	Awned northern wheat grass	S3	G5	N
Agrostis scabra	Rough hair grass	S5	G5	N
Allium cernuum	Nodding onion	S5	G5	N
Allium schoenoprasum	Wild chives	S4	G5	N
Alnus incana	Alder	S5	G5	N
Alnus incana ssp. *tenuifolia*	River alder	S5	G5T5	N
Alnus viridis	Green alder	S5	G5	N
Alnus viridis ssp. *crispa*	Alder	S4S5	G5TNR	N
Alnus viridis ssp. *sinuata*	Alder	S4S5	G5T5	N
Alopecurus aequalis	Short-awned foxtail	S5	G5	N
Amelanchier alnifolia	Saskatoon	S5	G5	N
Anaphalis margaritacea	Pearly everlasting	S4	G5	N
Androsace septentrionalis	Northern fairy candelabra	S5	G5	N
Anemone multifida	Cut-leaved anemone	S5	G5	N
Anemone occidentalis	Western anemone	S4	G5	N
Anemone patens	Prairie crocus	S5	G5	N
Angelica dawsonii	Yellow angelica	S3	G4	W
Antennaria alpina	Alpine everlasting	S4	G5	N
Antennaria anaphaloides	Tall everlasting	S3	G5	N
Antennaria microphylla	Littleleaf pussytoes	SNR	G5	N

Table B-1 Vegetation Species Identified in the LSA

Scientific Name	Common Name	SRANK	GRANK	Tracked
Antennaria neglecta	Broad-leaved everlasting	S5	G5	N
Antennaria parvifolia	Small-leaved everlasting	S5	G5	N
Antennaria pulcherrima	Showy everlasting	S4	G5	N
Antennaria racemosa	Racemose everlasting	S4	G5	N
Antennaria rosea	Rosy everlasting	S5	G5	N
Antennaria umbrinella	Brown-bracted mountain everlasting	S3	G5	N
Aquilegia brevistyla	Blue columbine	S5	G5	N
Aquilegia flavescens	Yellow columbine	S5	G5	N
Arctostaphylos rubra	Alpine bearberry	S5	G5	N
Arctostaphylos uva-ursi	Common bearberry	S5	G5	N
Arenaria capillaris	Linear-leaved sandwort	S4	G5	N
Arnica cordifolia	Heart-leaved arnica	S5	G5	N
Arnica fulgens	Shining arnica	S5	G5	N
Arnica gracilis	Graceful arnica	S3	G5	N
Arnica latifolia	Broad-leaved arnica	S4	G5	N
Artemisia frigida	Pasture sagewort	S5	G5	N
Astragalus americanus	American milk vetch	S5	G5	N
Astragalus canadensis	Canadian milk vetch	S4	G5	N
Astragalus miser	Timber milk vetch	S3	G5	N
Balsamorhiza sagittata	Balsamroot	S4	G4G5	N
Berberis repens	Creeping mahonia	S3	G5	W
Bromus carinatus	Keeled brome	SNA	G5	N
Bromus ciliatus	Fringed brome	S5	G5	N
Bromus pumpellianus	Pumpelly brome	S5	G5T5	N
Bromus tectorum	Downy chess	SNA	GNR	N
Bromus vulgaris	Woodland brome	S3	G5	W
Calamagrostis canadensis	Bluejoint	S5	G5	N
Calamagrostis inexpansa	Northern reed grass	S5	G5T5	N

Table B-1 Vegetation Species Identified in the LSA

Scientific Name	Common Name	SRANK	GRANK	Tracked
Calamagrostis rubescens	Pine reed grass	S4	G5	N
Caltha palustris	Marsh-marigold	S5	G5	N
Calypso bulbosa	Venus'-slipper	S5	G5	N
Campanula rotundifolia	Harebell	S5	G5	N
Carex aquatilis	Water sedge	S5	G5	N
Carex bebbii	Bebb's sedge	S4	G5	N
Carex concinna	Beautiful sedge	S5	G5	N
Carex disperma	Two-seeded sedge	S5	G5	N
Carex petasata	Pasture sedge	S1S2	G5	Y
Carex phaeocephala	Head-like sedge	S3	G5	N
Carex utriculata	Small bottle sedge	S5	G5	N
Castilleja miniata	Common red paintbrush	S5	G5	N
Cerastium arvense	Field mouse-ear chickweed	S5	G5	N
Chimaphila umbellata	Prince's-pine	S4	G5	N
Chrysanthemum leucanthemum	Ox-eye daisy	SNA	GNR	N
Cicuta bulbifera	Bulb-bearing water-hemlock	S4	G5	N
Cirsium arvense	Creeping thistle	SNA	GNR	N
Cirsium vulgare	Bull thistle	SNA	GNR	N
Clematis occidentalis	Purple clematis	S5	G5	N
Collinsia parviflora	Blue-eyed Mary	S3	G5	N
Collomia linearis	Narrow-leaved collomia	S5	G5	N
Comandra umbellata	Bastard toadflax	S5	G5	N
Corallorhiza maculata	Spotted coralroot	S3	G5	N
Corallorhiza striata	Striped coralroot	S3	G5	N
Corallorhiza trifida	Pale coralroot	S5	G5	N
Cornus canadensis	Bunchberry	S5	G5	N
Cornus stolonifera	Red-osier dogwood	S5	G5	N
Crepis atribarba	Slender hawk's-beard	S2	G5	Y

Table B-1 Vegetation Species Identified in the LSA

Scientific Name	Common Name	SRANK	GRANK	Tracked
Cynoglossum officinale	Hound's-tongue	SNA	GNR	N
Cystopteris fragilis	Fragile bladder fern	S5	G5	N
Dactylis glomerata	Orchard grass	SNA	GNR	N
Danthonia intermedia	Intermediate oat grass	S4S5	G5	N
Danthonia unispicata	One-spike oat grass	S3	G5	N
Delphinium glaucum	Tall larkspur	S5	G5	N
Delphinium nuttallianum	Nuttall's larkspur	S3	G5	N
Deschampsia cespitosa	Tufted hair grass	S5	G5	N
Diphasiastrum complanatum	Ground-cedar	S5	G5	N
Disporum trachycarpum	Fairybells	S5	G5	N
Dodecatheon pulchellum	Saline shooting star	S5	G5	N
Elymus elymoides	Squirreltail	S3	G5	N
Elymus glaucus	Smooth wild rye	S3	G5	N
Elymus trachycaulus	Slender wheatgrass	S5	G5	N
Elymus trachycaulus ssp. *trachycaulus*	Slender wheat grass	S5	G5T5	N
Elytrigia repens var. *repens*	Quack grass	SNA	GNRTNR	N
Epilobium angustifolium	Common fireweed	S5	G5	N
Epilobium ciliatum	Northern willowherb	S5	G5	N
Equisetum arvense	Common horsetail	S5	G5	N
Equisetum fluviatile	Swamp horsetail	S5	G5	N
Equisetum hyemale	Common scouring-rush	S5	G5	N
Equisetum scirpoides	Dwarf scouring-rush	S5	G5	N
Erigeron caespitosus	Tufted fleabane	S5	G5	N
Erigeron compositus	Compound-leaved fleabane	S5	G5	N
Erigeron peregrinus	Wandering daisy	S4	G5	N
Erigeron philadelphicus	Philadelphia fleabane	S5	G5	N
Erigeron speciosus	Showy fleabane	S3	G5	N
Eriogonum cernuum	Nodding umbrella-plant	S2	G5	Y

Table B-1 Vegetation Species Identified in the LSA

Scientific Name	Common Name	SRANK	GRANK	Tracked
Eriogonum umbellatum	Subalpine umbrellaplant	S3	G5	N
Erythronium grandiflorum	Glacier lily	S4	G5	N
Eucephalus engelmannii	Elegant aster	S3S4	G4G5	W
Eurybia conspicua	Showy aster	S5	G5	N
Festuca campestris	Mountain rough fescue	S5	G5	N
Festuca idahoensis	Bluebunch fescue	S4	G5	N
Festuca saximontana	Rocky Mountain fescue	S5	G5	N
Fragaria vesca	Woodland strawberry	S4	G5	N
Fragaria virginiana	Wild strawberry	S5	G5	N
Gaillardia aristata	Gaillardia	S5	G5	N
Galium boreale	Northern bedstraw	S5	G5	N
Galium triflorum	Sweet-scented bedstraw	S5	G5	N
Gentianella amarella	Felwort	S5	G5	N
Geranium richardsonii	Wild white geranium	S5	G5	N
Geranium viscosissimum	Sticky purple geranium	S4	G5	N
Geum aleppicum	Yellow avens	S5	G5	N
Geum macrophyllum	Large-leaved yellow avens	S5	G5	N
Geum rivale	Purple avens	S5	G5	N
Geum triflorum	Three-flowered avens	S5	G5	N
Glyceria grandis	Common tall manna grass	S5	G5	N
Glyceria striata	Fowl manna grass	S4	G5	N
Goodyera oblongifolia	Rattlesnake plantain	S3	G5	N
Hackelia jessicae	Jessica's stickseed	S3	G5	N
Hedysarum sulphurescens	Yellow hedysarum	S4	G5	N
Heracleum lanatum	Cow parsnip	S5	G5	N
Heterotheca villosa	Golden aster	S5	G5	N
Heuchera cylindrica	Sticky alumroot	S3	G5	N
Hieracium albiflorum	White hawkweed	S3	G4G5	N

Table B-1 Vegetation Species Identified in the LSA

Scientific Name	Common Name	SRANK	GRANK	Tracked
Hierochloe hirta	Sweet grass	SNR	G5	N
Juncus drummondii	Drummond's rush	S4	G5	N
Juniperus communis	Ground juniper	S5	G5	N
Juniperus scopulorum	Rocky Mountain juniper	S3	G5	N
Koeleria macrantha	June grass	S5	G5	N
Lathyrus ochroleucus	Cream-colored vetchling	S5	G5	N
Lepidium densiflorum	Common pepper-grass	S5	G5	N
Leymus innovatus	Hairy wild rye	S5	G5	N
Lilium philadelphicum	Western wood lily	S5	G5	N
Linaria dalmatica	Dalmatian toadflax	SNA	G5	N
Linaria vulgaris	Common toadflax	SNA	GNR	N
Linnaea borealis	Twinflower	S5	G5	N
Listera cordata	Heart-leaved twayblade	S4	G5	N
Lithospermum ruderale	Woolly gromwell	S4	G5	N
Lomatium macrocarpum	Long-fruited wild parsley	S3	G5	N
Lomatium triternatum	Western wild parsley	S3	G5	N
Lonicera involucrata	Bracted honeysuckle	S5	G5T4T5	N
Lonicera utahensis	Red twinberry	S4	G5	N
Lupinus arcticus	Arctic lupine	SU	G5	N
Lupinus argenteus	Silvery perennial lupine	S3	G5	N
Lupinus sericeus	Silky perennial lupine	S4	G5	N
Lupinus sulphureus	Sulphur lupine	SU	G5	N
Lycopodium annotinum	Stiff club-moss	S5	G5	N
Maianthemum canadense	Wild lily-of-the-valley	S5	G5	N
Medicago lupulina	Black medick	SNA	GNR	N
Melica subulata	Alaska onion grass	S3	G5	N
Menziesia ferruginea	False azalea	S5	G5	N
Mitella nuda	Bishop's-cap	S5	G5	N

Table B-1 Vegetation Species Identified in the LSA

Scientific Name	Common Name	SRANK	GRANK	Tracked
Moehringia lateriflora	Blunt-leaved sandwort	S5	G5	N
Moneses uniflora	One-flowered wintergreen	S5	G5	N
Oenothera villosa	Hairy evening-primrose	S3	G5	N
Orthilia secunda	One-sided wintergreen	S5	G5	N
Oryzopsis asperifolia	White-grained mountain rice grass	S4	G5	N
Oryzopsis pungens	Northern rice grass	S4	G5	N
Osmorhiza chilensis	Blunt-fruited sweet cicely	S4	G5	N
Osmorhiza depauperata	Spreading sweet cicely	S5	G5	N
Oxytropis campestris	Northern locoweed	S2	G5	N
Oxytropis sericea	Early yellow locoweed	S4	G5	N
Parnassia palustris	Northern grass-of-parnassus	S5	G5	N
Pedicularis bracteosa	Western lousewort	S4	G5	N
Penstemon confertus	Yellow beardtongue	S4	G4	N
Penstemon fruticosus	Shrubby beardtongue	S2	G5	N
Penstemon procerus	Slender blue beardtongue	S5	G5	N
Petasites frigidus	Coltsfoot	S5	G5	N
Petasites frigidus var. *sagittatus*	Arrow-leaved coltsfoot	S5	G5	N
Phacelia hastata	Silver-leaved scorpionweed	S3	G5	W
Phacelia sericea	Silky scorpionweed	S4	G5	N
Phleum commutatum	Mountain timothy	S5	G5	N
Phleum pratense	Timothy	SNA	GNR	N
Picea engelmannii	Engelmann spruce	S5	G5	N
Picea glauca	White spruce	S5	G5	N
Picea mariana	Black spruce	S5	G5	N
Pinus albicaulis	Whitebark pine	S2	G3G4	Y
Pinus contorta	Lodgepole pine	S5	G5	N
Pinus flexilis	Limber pine	S2	G4	Y
Piperia unalascensis	Alaska bog orchid	S2	G5	Y

Table B-1 Vegetation Species Identified in the LSA				
Scientific Name	**Common Name**	**SRANK**	**GRANK**	**Tracked**
Plantago major	Common plantain	SNA	G5	N
Platanthera obtusata	Blunt-leaved bog orchid	S5	G5	N
Poa cusickii	Early bluegrass	S4	G5	N
Poa glauca	Timberline bluegrass	S5	G5	N
Poa juncifolia	Alkali bluegrass	S3	GNR	N
Poa nemoralis	Wood bluegrass	SNA	G5	N
Poa palustris	Fowl bluegrass	S5	G5	N
Poa pratensis	Kentucky bluegrass	S5	G5	N
Poa wheeleri	Wheeler's bluegrass	S3	G5	N
Polemonium pulcherrimum	Showy Jacob's-ladder	S3	G5	N
Populus balsamifera	Balsam poplar	S5	G5	N
Populus tremuloides	Aspen	S5	G5	N
Potentilla anserina	Silverweed	S5	G5	N
Potentilla argentea	Silvery cinquefoil	SNA	GNR	N
Potentilla arguta	White cinquefoil	S5	G5	N
Potentilla diversifolia	Mountain cinquefoil	S5	G5	N
Potentilla fruticosa	Shrubby cinquefoil	S5	G5T5	N
Potentilla gracilis	Graceful cinquefoil	S5	G5	N
Prunus virginiana	Choke cherry	S5	G5	N
Pseudoroegneria spicata	Bluebunch wheatgrass	S3	G5	N
Pseudotsuga menziesii	Douglas-fir	S4	G5	N
Pyrola asarifolia	Common pink wintergreen	S5	G5	N
Pyrola chlorantha	Greenish-flowered wintergreen	S5	G5	N
Ranunculus acris	Tall buttercup	SNA	G5	N
Ranunculus gmelinii	Yellow water crowfoot	S5	G5	N
Rhinanthus minor	Yellow rattle	S4	G5	N
Rhododendron albiflorum	White-flowered rhododendron	S4	G5	N
Ribes glandulosum	Skunk currant	S5	G5	N

Table B-1 Vegetation Species Identified in the LSA

Scientific Name	Common Name	SRANK	GRANK	Tracked
Ribes lacustre	Bristly black currant	S5	G5	N
Ribes oxyacanthoides	Northern gooseberry	S5	G5	N
Ribes triste	Wild red currant	S5	G5	N
Rosa acicularis	Prickly rose	S5	G5	N
Rosa woodsii	Common wild rose	S5	G5	N
Rubus idaeus	Wild red raspberry	S5	G5	N
Rubus parviflorus	Thimbleberry	S3S4	G5	N
Rubus pubescens	Dewberry	S5	G5	N
Rumex crispus	Curled dock	SNA	GNR	N
Rumex occidentalis	Western dock	S5	G5T5	N
Salix bebbiana	Beaked willow	S5	G5	N
Salix scouleriana	Scouler's willow	S4	G5	N
Sambucus racemosa	Red elderberry	S4	G5	N
Sanicula marilandica	Snakeroot	S4	G5	N
Saxifraga bronchialis	Spotted saxifrage	S4	G5	N
Schizachne purpurascens	Purple oat grass	S5	G5	N
Scutellaria galericulata	Marsh skullcap	S5	G5	N
Sedum lanceolatum	Lance-leaved stonecrop	S4	G5	N
Selaginella densa	Prairie selaginella	S5	G5	N
Senecio canus	Prairie groundsel	S5	G5	N
Senecio pauperculus	Balsam groundsel	S5	G5	N
Senecio pseudaureus	Thin-leaved ragwort	S3	G5	N
Senecio triangularis	Brook ragwort	S4	G5	N
Senecio vulgaris	Common groundsel	SNA	GNR	N
Shepherdia canadensis	Canada buffaloberry	S5	G5	N
Silene parryi	Parry's campion	S3	G5	N
Smilacina racemosa	False Solomon's-seal	S5	G5	N
Smilacina stellata	Star-flowered Solomon's-seal	S5	G5	N

Table B-1 Vegetation Species Identified in the LSA

Scientific Name	Common Name	SRANK	GRANK	Tracked
Solidago canadensis	Canada goldenrod	S5	G5	N
Solidago multiradiata	Alpine goldenrod	S5	G5	N
Solidago nemoralis	Showy goldenrod	S4	G5	N
Solidago simplex ssp. *simplex*	Mountain goldenrod	S5	G5T5	N
Spiraea betulifolia	White meadowsweet	S5	G5	N
Spiranthes romanzoffiana	Hooded ladies'-tresses	S5	G5	N
Stellaria longifolia	Long-leaved chickweed	S5	G5	N
Stenanthium occidentale	Bronzebells	S4	G4	N
Stipa nelsonii	Nelson's needlegrass	SNR	G5	N
Stipa richardsonii	Richardson needle grass	S3	G5	N
Streptopus amplexifolius	Clasping-leaved twisted-stalk	S5	G5	N
Streptopus roseus	Rose mandarin	S1	G5	Y
Streptopus streptopoides	Twisted-stalk	S1	G5	Y
Symphoricarpos albus	Snowberry	S5	G5	N
Symphyotrichum ciliolatum	Lindley's aster	S5	G5	N
Symphyotrichum foliaceum	Leafy-bracted aster	SNR	G5	N
Symphyotrichum puniceum	Purple-stemmed aster	S4	G5	N
Taraxacum officinale	Common dandelion	SNA	G5	N
Tellima grandiflora	Fringe-cups	S1	G5	Y
Thalictrum venulosum	Veiny meadow rue	S5	G5	N
Thlaspi arvense	Stinkweed	SNA	GNR	N
Tragopogon dubius	Common goat's-beard	SNA	GNR	N
Trifolium aureum	Yellow clover	SNA	GNR	N
Trifolium hybridum	Alsike clover	SNA	GNR	N
Trifolium pratense	Red clover	SNA	GNR	N
Trifolium repens	White clover	SNA	GNR	N
Trisetum spicatum	Spike trisetum	S5	G5	N
Urtica dioica	Common nettle	S5	G5	N

Table B-1 Vegetation Species Identified in the LSA

Scientific Name	Common Name	SRANK	GRANK	Tracked
Vaccinium caespitosum	Dwarf bilberry	S5	G5	N
Vaccinium membranaceum	Tall bilberry	S4	G5	N
Vaccinium myrtilloides	Common blueberry	S5	G5	N
Vaccinium myrtillus	Low bilberry	S4	G5	N
Vaccinium scoparium	Grouseberry	S5	G5	N
Valeriana sitchensis	Mountain valerian	S4	G5	N
Veratrum viride	Green false hellebore	S4	G5	N
Verbascum thapsus	Common mullein	SNA	GNR	N
Veronica americana	American brooklime	S5	G5	N
Viburnum edule	Low-bush cranberry	S5	G5	N
Vicia americana	Wild vetch	S5	G5	N
Viola adunca	Early blue violet	S5	G5	N
Viola canadensis	Western Canada violet	S5	G5	N
Viola orbiculata	Evergreen violet	S4	G5	N
Viola renifolia	Kidney-leaved violet	S5	G5	N
Woodsia oregana	Oregon woodsia	S3	G5	N
Woodsia scopulina	Mountain woodsia	S3	G5	N
Zigadenus elegans	White camas	S5	G5	N
Zigadenus venenosus	Death camas	S4	G5	N
Mosses and Liverworts (77 species)				
Amblystegium varium	Moss	S3	G5	N
Amphidium lapponicum	Moss	S3	G5	N
Anastrophyllum helleranum	Heller's notchwort	S2	G5	Y
Aulacomnium androgynum	Little groove moss	S2	G5	Y
Aulacomnium palustre	Tufted moss	S5	G5	N
Barbilophozia floerkei	Liverwort	S3	G5	N
Barbilophozia hatcheri	Liverwort	S5	G5	N
Barbilophozia lycopodioides	Liverwort	S5	G5	N

Table B-1 Vegetation Species Identified in the LSA

Scientific Name	Common Name	SRANK	GRANK	Tracked
Barbula convoluta	Convolute screw moss	S3	G5	N
Barbula unguiculata	Bird's claw screw moss	S4	G5	N
Brachythecium rivulare	Moss	S3	G5	N
Brachythecium salebrosum	Moss	S5	G5	N
Brachythecium turgidum	Moss	S3	G4	N
Bryoerythrophyllum recurvirostre	Red leaf moss	S4	G5	N
Bryum argenteum	Silvery Bryum moss	S5	G5	N
Buxbaumia aphylla	Bug on a stick moss	S2	G4G5	Y
Ceratodon purpureus	Purple horn-toothed moss	S5	G5	N
Chiloscyphus pallescens	Liverwort	S3	G5	N
Chiloscyphus polyanthos	Liverwort	S1	G5	Y
Conocephalum salebrosum	Liverwort	S2	G5	Y
Dicranella crispa	Curl-leaved fork moss	S2	G3G5	Y
Dicranum fragilifolium	Cushion moss	S3S4	G4G5	N
Dicranum fuscescens	Fuscous moss	S5	G5	N
Dicranum montanum	Cushion moss	SNR	G5	N
Dicranum polysetum	Wavy dicranum moss	S5	G5	N
Dicranum scoparium	Broom moss	S5	G5	N
Dicranum tauricum	Broken-leaf moss	S1S2	G4	Y
Dicranum undulatum	Wavy dicranum moss	S5	G5	N
Distichium capillaceum	Moss	S5	G5	N
Eurhynchium pulchellum	Moss	S5	G5	N
Grimmia anodon	Toothless grimmia moss	S4	G5	N
Hylocomium splendens	Stair-step moss	S5	G5	N
Hypnum revolutum	Moss	S5	G5	N
Jungermannia exsertifolia	Liverwort	S1	G5	Y
Lepidozia reptans	Liverwort	S3	G5	N
Lophozia ascendens	Liverwort	S1	G4	Y

Table B-1 Vegetation Species Identified in the LSA

Scientific Name	Common Name	SRANK	GRANK	Tracked
Lophozia longidens	Liverwort	S1	G5	Y
Lophozia ventricosa	Liverwort	S5	G5	N
Lophozia wenzelii	Liverwort	S1	G4G5	Y
Marchantia polymorpha	Liverwort	S5	G5	N
Mnium thomsonii	Moss	S3	G5	N
Mylia anomala	Liverwort	S4	G5	N
Oncophorus wahlenbergii	Mountain curved-back moss	S4	G5	N
Orthotrichum obtusifolium	Moss	S4	G5	N
Orthotrichum speciosum	Moss	S4	G5	N
Pellia endiviifolia	Liverwort	S2	G5	Y
Pellia neesiana	Liverwort	S2	G5	Y
Philonotis fontana	Moss	S4	G5	N
Plagiomnium cuspidatum	Moss	S5	G5	N
Plagiomnium ellipticum	Moss	S4	G5	N
Pleurozium schreberi	Schreber's moss	S5	G5	N
Pohlia nutans	Copper wire moss	S5	G5	N
Polytrichum commune	Common hair-cap moss	S5	G5	N
Polytrichum juniperinum	Juniper hair-cap moss	S5	G5	N
Polytrichum piliferum	Awned hair-cap moss	S5	G5	N
Pseudoleskeella tectorum	Moss	S3	G5	N
Pterigynandrum filiforme	Moss	S3	G4G5	N
Ptilidium pulcherrimum	Liverwort	S5	G5	N
Ptilium crista-castrensis	Knight's plume moss	S5	G5	N
Pylaisiella polyantha	Moss	S5	G5	N
Racomitrium aciculare	Moss	S1	G5	Y
Racomitrium canescens	Moss	S3	G5	N
Rhizomnium pseudopunctatum	Moss	S3	G5	N
Rhytidiopsis robusta	Pipecleaner moss	S3	G4	W

Table B-1 Vegetation Species Identified in the LSA

Scientific Name	Common Name	SRANK	GRANK	Tracked
Rhytidium rugosum	Pipecleaner moss	S4	G5	N
Sanionia uncinata	Brown moss	S5	G5	N
Schistidium tenerum	Thread bloom moss	S2	G5	Y
Stegonia latifolia	Moss	S3	G4G5	N
Tetraphis pellucida	Moss	S4	G5	N
Thuidium recognitum	Moss	S5	G5	N
Timmia austriaca	Moss	S4	G4G5	N
Tortella tortuosa	Twisted moss	S5	G5	N
Tortula mucronifolia	Sharp twisted moss	S4	G5	N
Tortula norvegica	Moss	S4	G5	N
Tortula ruralis	Hairy screw moss	S5	G5	N
Tritomaria exsectiformis ssp. *exsectiformis*	Liverwort	S3	G5T5	N
Tritomaria quinquedentata var. *quinquedentata*	Liverwort	S3	G5T5	N
Lichens (105 species)				
Baeomyces rufus	Brown beret lichen	S3S5	G5	N
Bryoria capillaris	Old man's beard	S3S5	G4	N
Bryoria fremontii	Old man's beard	S4	G3G5	N
Bryoria fuscescens	Old man's beard	S3S4	G5	N
Bryoria lanestris	Old man's beard	S3	G5	N
Buellia erubescens	Button lichen	S3	G3G5	N
Caloplaca holocarpa	Firedot lichen	S5	G5	N
Caloplaca sinapisperma	Firedot lichen	S2S3	GNR	Y
Candelaria concolor	Lemon lichen	S3	G5	N
Cetraria ericetorum	Iceland lichen	S5	G5	N
Cladonia borealis	Boreal pixie-cup	S4	G5	N
Cladonia cariosa	Split-peg lichen	S4	G5	N
Cladonia carneola	Crowned pixie-cup	S4	G5	N
Cladonia cenotea	Powdered funnel lichen	S5	G5	N

Table B-1 Vegetation Species Identified in the LSA

Scientific Name	Common Name	SRANK	GRANK	Tracked
Cladonia cervicornis ssp. *verticillata*	Ladder lichen	S3S4	G5T5	N
Cladonia chlorophaea	Mealy pixie-cup lichen	S5	GU	N
Cladonia coniocraea	Common powderhorn lichen	S5	G5	N
Cladonia cornuta	Bighorn cladonia	S5	G5	N
Cladonia deformis	Lesser sulphur-cap lichen	S5	G5	N
Cladonia ecmocyna	Frosted cladonia	S4	G5	N
Cladonia fimbriata	Trumpet lichen	S5	G5	N
Cladonia gracilis	Smooth cladonia	S5	G5	N
Cladonia gracilis ssp. *turbinata*	Smooth cladonia	S5	G5T5	N
Cladonia macilenta	Cup lichen	S3S4	G5	N
Cladonia macrophyllodes	Large-leaved cladonia	S3	G4G5	N
Cladonia multiformis	Sieve lichen	S5	G5	N
Cladonia ochrochlora	Smooth-footed powderhorn	S1	G4G5	Y
Cladonia pleurota	Red-fruited pixie-cup lichen	S3S4	G5	N
Cladonia pocillum	Carpet pixie-cup lichen	S4	G5	N
Cladonia pyxidata	Pebbled pixie-cup lichen	S5	G5	N
Cladonia sulphurina	Greater sulphur-cup	S5	G5	N
Cladonia symphycarpia	Split-peg lichen	S2	G5	Y
Cladonia umbricola	Shaded cladonia	S1	G3G5	Y
Evernia mesomorpha	Boreal oakmoss lichen	S5	G5	N
Flavocetraria nivalis	Crinkled snow lichen	S5	G5	N
Hypogymnia austerodes	Varnished tube lichen	S3	G5	N
Hypogymnia bitteri	Powdered tube lichen	S3	G5	N
Hypogymnia enteromorpha	Budding tube lichen	S2	G4	Y
Hypogymnia imshaugii	Forked tube lichen	S4	G4	N
Hypogymnia occidentalis	Lattice tube lichen	S3	G3G5	N
Hypogymnia physodes	Hooded tube lichen	S5	G5	N
Hypogymnia rugosa	Wrinkled tube lichen	S1S2	G4G5	Y

Table B-1 Vegetation Species Identified in the LSA

Scientific Name	Common Name	SRANK	GRANK	Tracked
Hypogymnia tubulosa	Powder-headed tube lichen	S4	G5	N
Icmadophila ericetorum	Candy lichen	S5	G5	N
Kaernefeltia merrillii	Flattened wrinkle lichen	S4	G3G5	N
Lecanora circumborealis	Black-eyed rim-lichen	S5	G5	N
Lecanora pulicaris	Rim-lichen	S5	G5	N
Lecanora symmicta	Fused rim-lichen	S3S5	G5	N
Lecidea atrobrunnea	Brown tile lichen	S4	G4G5	N
Leptogium saturninum	Bearded jellyskin	S4	G5	N
Letharia columbiana	Brown-eyed wolf lichen	S4	G3G5	N
Letharia vulpina	Wolf lichen	S5	G5	N
Melanohalea elegantula	Elegant camouflage lichen	S5	G5	N
Melanohalea exasperatula	Lustrous camouflage lichen	S5	G5	N
Melanohalea subolivacea	Brown-eyed camouflage lichen	S4	G5	N
Nephroma parile	Powdery kidney lichen	S3	G5	N
Nodobryoria abbreviata	Tufted foxtail lichen	S1	G4	Y
Nodobryoria oregana	Pendent foxtail lichen	S3	G3G5	N
Parmelia sulcata	Hammered shield lichen	S5	G5	N
Parmeliopsis ambigua	Green starburst lichen	S5	G5	N
Parmeliopsis hyperopta	Grey starburst lichen	S5	G5	N
Peltigera aphthosa	Studded leather lichen	S5	G5	N
Peltigera canina	Dog lichen	S5	G5	N
Peltigera cinnamomea	Cinnamon dog pelt lichen	S2	GNR	Y
Peltigera elisabethae	Concentric pelt lichen	S4	G5	N
Peltigera kristinssonii	Dark-veined pelt lichen	S3	G4	N
Peltigera leucophlebia	Ruffled freckle pelt lichen	S4	G5	N
Peltigera malacea	Veinless pelt lichen	S5	G5	N
Peltigera membranacea	Membranous dog lichen	S3	G5	N
Peltigera neckeri	Black saddle lichen	S3	G5	N

Table B-1 Vegetation Species Identified in the LSA

Scientific Name	Common Name	SRANK	GRANK	Tracked
Peltigera neopolydactyla	Carpet pelt lichen	S3	G5	N
Peltigera praetextata	Scaly pelt lichen	S4	G5	N
Peltigera rufescens	Field dog lichen	S5	G5	N
Peltigera venosa	Fan lichen	S4	G5	N
Physcia adscendens	Hooded rosette lichen	S5	G5	N
Physcia aipolia	Hoary rosette lichen	S5	G5	N
Physcia caesia	Blue-gray rosette lichen	S3	G5	N
Physcia stellaris	Star rosette lichen	S4	G5	N
Platismatia glauca	Varied rag lichen	S4	G5	N
Protopannaria pezizoides	Brown-grey shingle lichen	S4	G5	N
Pseudephebe minuscula	Rockwool lichen	S3	G5	N
Rhizocarpon geographicum	Yellow map lichen	S5	G5	N
Rhizoplaca melanophthalma	Green rock-posy	S4	G4G5	N
Stereocaulon alpinum	Alpine foam lichen	S4	G5	N
Stereocaulon paschale	Common foam lichen	S3	G5	N
Stereocaulon tomentosum	Woolly foam lichen	S5	G5	N
Trapeliopsis granulosa	Granular mottled-disk lichen	S4	G5	N
Tuckermannopsis americana	Fringed wrinkle lichen	S5	G5	N
Tuckermannopsis chlorophylla	Powdered wrinkle-lichen	S4	G5	N
Tuckermannopsis platyphylla	Broad wrinkle lichen	S3S4	GNR	N
Umbilicaria americana	American rock tripe lichen	S2S3	G5	Y
Umbilicaria hyperborea	Blistered rock tripe lichen	S4	G5	N
Umbilicaria proboscidea	Netted rock tripe	S3	G5	N
Usnea filipendula	Fishbone beard lichen	S3	G5	N
Usnea glabrescens	Speckled beard lichen	S5	GNR	N
Usnea hirta	Bristly beard lichen	S5	G5	N
Usnea lapponica	Powdered beard lichen	S4	G5	N
Usnea substerilis	Beard lichen	S5	G5	N

Table B-1 Vegetation Species Identified in the LSA

Scientific Name	Common Name	SRANK	GRANK	Tracked
Vulpicida canadensis	Brown-eyed sunshine lichen	S2	G3G5	Y
Vulpicida pinastri	Wrinkle lichen	S5	G5	N
Xanthomendoza fallax	Hooded sunburst lichen	S5	G5	N
Xanthoria candelaria	Shrubby sunburst lichen	S3	G5	N
Xanthoria elegans	Elegant sunburst lichen	S5	G5	N
Xanthoria polycarpa	Pin-cushion sunburst lichen	S5	G5	N
Xylographa parallela	Black woodscript lichen	S2S4	G5	Y

APPENDIX C: ECOLOGICAL LAND CLASSIFICATION DESCRIPTIONS

Ecosite and Ecosites Phases in the LSA and Footprint

The ecosites and ecosite phases that were mapped in the LSA and Footprint are described below. These ecosites are part of the Subalpine and Montane Natural Subregions of the Rocky Mountain Natural Region. All descriptions are from Archibald *et al*. 1996.

Subalpine Natural Subregion

Ecosite a – lichen (xeric/poor)

Ecosite a, is generally found on dry, south facing slopes on nutrient poor soils. Soils are typically shallow to bedrock and the organic layers are thin with parent materials dominantly being colluvial over rock, morainal, or undifferentiated materials. Surface soil texture may be sandy loam, sandy clay loam, or loam with well to rapidly drained soils. Soil moisture regime is subxeric to xeric with a poor to very poor nutrient regime. Vegetation reflects the dry site conditions and includes lichens, bearberry, and juniper with lodgepole pine (Pl) forming an edaphic climax. Forbs are typically sparse. There is one ecosite phase associated with the a ecosite: a1 lichen lodgepole pine, and it was encountered in the LSA during the field survey (Photo 1).

Photo 1 Ecosite phase a1, n = 3, species richness = 96.

a1 ecosite phase – lichen Pl

The a1 ecosite phase is dominated by lodgepole pine. The shrub layer consists of younger lodgepole pine, twinflower, ground juniper, and low bilberry. Grasses are typically absent and forbs are sparse but may include wild strawberry and broad-leaved everlasting. Moss cover is dominated by stair-step moss and juniper hair-cap, with low proportions of copper wire moss. Reindeer lichen and trace amounts of brown-foot cladonia may also be observed. Only one plant community type is associated with this ecosite phase: a1.1 Pl/juniper/lichen. The a1 ecosite phase occupied less than (<) 1% (11.5 ha) of the total LSA.

Ecosite b – bearberry/hairy wild rye (subxeric/medium)

The ecosite is generally found on dry, south facing slopes as well, but it is not as dry as the previously described lichen ecosite and more medium nutrient soils are common. These sites are typically found on morainal, colluvial, fluvial, or morainal over rock parent materials. Surface soil texture includes loam, loamy sand, clay loam, silty loam, or sandy loam resulting in moderately well to rapidly drained soils. The moisture regime on these sites is subxeric to mesic with a poor to rich nutrient regime. Succession of the site is towards Engelmann spruce; however, a canopy of lodgepole pine is often maintained due to the dry site conditions and frequency of fire. Shrub and form layers are generally sparse but the grass layer is often well developed and indicator species for this ecosite are bearberry and hairy wild rye. There is one ecosite phase associated with the b ecosite: b1 bearberry/hairy wild rye Pl, and it was encountered in the LSA during the time of the survey (Photo 2).

Photo 2 Ecosite phase b1, n = 2, species richness = 52.

b1 ecosite phase – bearberry/hairy wild rye Pl

The b1 ecosite phase is dominated by lodgepole pine with succession towards Engelmann spruce. The shrub layer consists of younger lodgepole pine and Engelmann spruce, bearberry, ground juniper, Canada buffalo berry, twinflower, and prickly rose. Forbs are sparse and may include wild strawberry and cut-leaved anemone. A well-developed grass layer of hairy wild rye is typical of this ecosite. Moss and lichen layers are generally absent. Only one plant community type is associated with this ecosite phase: b1.1 Pl/bearberry/hairy wild rye. The b1 ecosite phase occupied approximately 3.4% (163.4 ha) of the total LSA.

Ecosite d – spruce/heather (mesic/poor)

The d ecosite represents a transition from subalpine to alpine conditions and occurs near treelines at high elevations (1,760 - 2,330m) throughout the subregion. A short growing season and high snow cover is typical. Soils are often shallow to bedrock and parent materials are typically morainal, morainal over rock, and colluvial over rock. Clay loam or sandy loam surface soil textures dominate, and soils are frequently stony, leading to generally poor nutrient conditions. These sites are found in upper slope positions that are typically mesic and well drained, although moderately well-drained, imperfectly-drained, and rapidly drained soils may also be observed. Stands are generally open and the climax vegetation consists of Engelmann spruce and subalpine fir, with heather being an important indicator species. Only one ecosite phase belongs to the d ecosite: d1 spruce/heather Se.

d1 ecosite phase – spruce/heather Se

The d1 ecosite is dominated by climax species Engelmann spruce and subalpine fir. Grasses are typically absent in this ecosite, but there is a significant shrub and moss layer. Shrubs typically consist of heather, young subalpine fir, willow, grouse-berry, white mountain heather, and young engelmann spruce. Dominant mosses include stair-step moss and Schreber's moss, but broom moss and cushion moss may also be present. Lichens may also be present, in relatively low cover, and include studded leather lichen, orange-foot cladonia, and reindeer lichen. This ecosite phase was not encountered in the field at the time of the survey. However, it was identified on aerial imagery as existing within the LSA, based on overstory species and elevation. Only one plant community type is associated with this ecosite phase: d1.1 Se/heather. The d1 ecosite phase occupied <1% (0.8 ha) of the total LSA.

Ecosite e – false azalea – grouse-berry (mesic/medium)

The e ecosite is the modal ecosite for mid to lower elevations in the Subalpine Natural subregion and spans several moisture regimes, varying from xubxeric to hygric. Parent materials typical to this ecosite are morainal, fluvial, or colluvial, and surface textures may be loam, silty loam or sandy loam. The ecosite may occur on upper, mid, or lower slope positions and soils are generally well-drained, although moderate to imperfect drainage may also occur. Grouse-berry and false azalea are common indicator species for this ecosite. Other indicator species include low bilberry, Canada buffalo-berry, green alder, thimbleberry, pinegrass and stair-step moss. Succession of the ecosite is from lodgepole pine to Engelmann spruce to subalpine fir, but lodgepole pine is the most common due to the frequency of fire in the area. There are four ecosite phases associated with the e ecosite, and are differentiated by dominant tree species: e1 false azalea – grouse-berry Pl, e2 false azalea - grouse-berry Pw, e3 false azalea – grouse-berry Se, and e4 false azalea – grouse-berry Fa. All four ecosite phases were encountered in the LSA, however plot data was only collected from e1 and e3 ecosite phases (Photos 3 and 4).

Photo 3 Ecosite phase e1, n = 19, species richness = 257.

e1 ecosite phase – false azalea – grouse-berry Pl

Lodgepole pine is the dominant species of the e1 ecosite phase. Six vegetation communities exist within this phase, differentiated by dominant understory vegetation. Tree species may include lodgepole pine, Engelmann spruce, and subalpine fir. Shrubs may include green alder, low bilberry, false azalea, grouse-berry, Canada buffalo-berry, twinflower, young Engelmann spruce, young subalpine fir, prickly rose, young lodgepole pine, dwarf bilberry, and ground juniper. Forbs are relatively sparse but may include heart-leaved arnica, bunchberry, stiff club-moss, showy aster, wild strawberry, one-sided wintergreen, and fireweed. Pine grass and hairy wild rye are usually the only grass species observed. Mosses may include Schreber's moss, stair-step moss, brown moss, and knight's plume moss. Lichens are usually absent but studded leather lichen may appear. The six vegetation communities belonging to this ecosite phase are: Pl/green alder/arnica (e1.1), Pl/grouse-berry/feather moss (e1.2), Pl/low bilberry (e1.3), Pl/false azalea/feather moss (e1.4), Pl/pine grass (e1.5) and Pl/Canada buffalo-berry (e1.6). The e1 ecosite phase occupied approximately 20.8% (992.2 ha) of the total LSA.

e2 ecosite phase – false azalea – grouse-berry Pw

Whitebark pine (Pinus albicaulis) is the dominant tree species of the e2 ecosite phase, but subalpine fir and Engelmann spruce may also be present in moderate to high cover. The shrub layer is well-developed and consists of young subalpine fir, low bilberry, false azalea, white-flowered rhodendron, grouse-berry, and young whitebark pine. Forbs are sparse but one-sided wintergreen may be observed. Mosses include liverworts and Schreber's moss. Lichens are typically absent. No plot data were collected from this ecosite phase, however it was encountered during the time of the survey and was identified on aerial imagery as existing within the LSA. Only one plant community type is associated with this ecosite phase: e2.1 Pw/false azalea. The e2 ecosite phase occupied <1% (3.4 ha) of the total LSA.

Photo 4 Ecosite phase e3, n = 1, species richness = 37.

e3 ecosite phase – false azalea – grouse-berry Se

Engelmann spruce is the dominant tree species that characterizes the e3 ecosite phase. Lodgepole pine, subalpine fir, and black spruce may also be present in varying combinations and cover. Seven vegetation communities exist within this phase, differentiated by dominant understory vegetation.

Shrubs may include green alder, false azalea, grouse-berry, low bilberry, twinflower, Canada buffalo-berry, young subalpine fir, ground juniper, dwarf bilberry, bog cranberry, bearberry, glandular Labrador tea, young Engelmann spruce, crowberry, and Labrador tea. Forbs are relatively sparse but may include heart-leaved arnica and bunchberry. Hairy wild rye is typically the only grass species observed. Bryophytes are plentiful and may include wiry fern moss, stair-step moss, Schreber's moss, knight's plume moss, brown moss, and cushion moss. Lichens are usually absent but studded leather lichen and dog lichen may appear. The seven vegetation communities belonging to this ecosite phase are: Se/grouse-berry/feather moss (e3.1), Se/low bilberry/feather moss (e3.2), Se/green alder/feather moss (e3.3), Se/false azalea/feather moss (e3.4), Se/Canada buffalo-berry/feather moss (e3.5), Se/stair-step moss (e3.6), and Se/wiry fern moss (e3.7). The e3 ecosite phase occupied approximately 4.3% (207.0 ha) of the total LSA.

e4 ecosite phase – false azalea – grouse-berry Fa

Subalpine fir is the dominant tree species that characterizes the e4 ecosite phase. Engelmann spruce and lodgepole pine may also be present. Seven vegetation communities exist within this phase, differentiated by dominant understory vegetation. Shrubs may include green alder, false azalea, grouse-berry, low bilberry, twinflower, Canada buffalo-berry, young subalpine fir, ground juniper, dwarf bilberry, bog cranberry, bearberry, glandular Labrador tea, young Engelmann spruce, crowberry, and Labrador tea. Forbs are relatively sparse but may include heart-leaved arnica and bunchberry. Hairy wild rye is typically the only grass species observed. Bryophytes are plentiful and may include wiry fern moss, stair-step moss, Schreber's moss, knight's plume moss, brown moss, and cusion moss. Lichens are usually absent but studded leather lichen and dog lichen may appear. This ecosite phase was not encountered in the field at the time of the survey. However, it was identified on aerial imagery as existing within the LSA, based on overstory species and topographic position. The seven vegetation communities belonging to this ecosite phase are: Se/grouse-berry/feather moss (e3.1), Se/low bilberry/feather moss (e3.2), Se/green alder/feather moss (e3.3), Se/false azalea/feather moss (e3.4), Se/Canada buffalo-berry/feather moss (e3.5), Se/stair-step moss (e3.6), and Se/wiry fern moss (e3.7). The e3 ecosite phase occupies <1% (19.0 ha) of the total LSA.

Ecosite f – thimbleberry (subhygric/rich)

Much like the d ecosite represents a transition between alpine and subalpine conditions, the f ecosite represents a transition between subalpine and Montane. Well-developed shrub and forb layers reflect this transition. The ecosite is generally located at lower elevations in the southern portion of the subregion, typically in seepage areas mid-slope. Morainal or colluvial parent materials dominate, and surface textures vary from loam to sandy loam to silty loam. Soils are subhygric and nutrient-rich, resulting in high species diversity. Succession of the ecosite is from lodgepole pine to Engelmann spruce and subalpine fir. Indicator species include thimbleberry, heart-leaved arnica, false hellebore, and red and white baneberry. Two ecosite phases are associated with this site: thimbleberry Pl (f1), and thimbleberry Fa-Se (f2), but only f1 was encountered and mapped in the LSA (Photo 5).

Photo 5 Ecosite phase f1, n = 4, species richness = 99.

f1 ecosite phase – thimbleberry Pl

Lodgepole pine is the dominant tree species in the f1 ecosite phase, but subalpine fir and Engelmann spruce are also present with high cover. Dominant shrub species include thimbleberry, green alder, and young subalpine fir, with less cover of white meadowsweet, prince's pine, and currant. Forbs diversity is quite large, although cover of each species is relatively small. Forb species include showy aster, heart-leaved arnica, veiny meadow rue, false hellebore, yellow angelica, one-sided wintergreen, red and white baneberry, bronze-bells, mountain heliotrope, and cow parsnip. A small amount of bryophytes may be present, consisting of ragged moss and copper wire moss. Grasses and lichens are typically absent. Only one plant community type is associated with this ecosite phase: f1.1 Pl/thimbleberry, and it occupies approximately 2.0% (97.6 ha) of the total LSA.

f2 ecosite phase – thimbleberry Fa-Se

Subalpine fir and Engelmann spruce co-dominate this ecosite, with a lesser amount of lodgepole pine. Shrubs are present in high cover and include young subalpine fir, thimbleberry, false azalea, young Engelmann spruce, and currant. Dominant forbs include western meadow rue, red and white baneberry, and heart-leaved arnica. Other forb species of less cover may include bronze bells, false hellebore, one-sided wintergreen, sugarscoop, rattlesnake plantain, cow parsnip, and sweet-scented bedstraw. Grass, moss, and lichen layers are typically absent. No plot data was collected from this ecosite phase, however it was identified on aerial imagery as existing within the LSA, based on overstory species and topographic position, and it occupies approximately 1.0% (47.3 ha) of the total LSA.

Ecosite h – horsetail (subhydric/rich)

The horsetail ecosite represents wet sites in the subregion. It is found in lower slope and valley positions on fluvial parent materials. Surface texture is predominantly loam, but may be clay, silty clay loam, silty loam, or even organic. Drainage is typically imperfect to very poor, resulting in hygric to hydric soils that are nutrient-rich. Indicator species include dwarf birch, horsetail, sedge, feather moss, peat moss, and golden moss. There are two ecosite phases associated with the h ecosite: h1 horsetail Se and h2 horsetail fen, and they are not related successionally. The fen phase remains as a shrubland because cool temperatures in the valley bottom limits tree growth, whereas the Engelmann spruce phase is successional to subalpine fir. Only the h1 ecosite phase was encountered and mapped in the LSA (Photo 6).

Photo 6 Ecosite phase h1, n = 1, species richness = 26.

h1 ecosite phase – horsetail Se

Engelmann spruce is typically the only tree species in the h1 ecosite phase. Common shrubs are young Engelmann spruce, twinflower, and prickly rose. Meadow and common horsetail dominate the forb cover, with dwarf scouring rush, fireweed, and wild strawberry also commonly present. The ecosite phase typically has a high amount of bryophytes, such as stair-step moss and Schreber's moss.

Studded leather lichen is the most common lichen species in this ecosite phase. Only one plant community type is associated with this ecosite phase: h1.1 Se/horsetail/feather moss, which occupies <1% (34.1 ha) of the total LSA.

Montane Natural Subregion

Ecosite a – limber pine/juniper (subxeric/poor)

This ecosite is typically found on ridgetops or upper slope positions exposed to westerly winds and is characterized by dry site conditions, open tree canopy, and a well-developed grass layer. Soils are often shallow to bedrock and consist of colluvial and rock parent materials; surface texture may be sandy loam or loam with rapid to well-drained soils. Soil moisture regime is usually subxeric with a poor to medium nutrient regime. Exposure and drought conditions limit the establishment and growth rate of trees and therefore open Douglas fir (Fd) and limber pine (Pf) stands with grassland vegetation form an edaphic climax. Bearberry, juniper, and rough fescue are other indicator species. There is one ecosite phase associated with the a ecosite: a1 limber pine/juniper Fd-Pf and it was encountered in the LSA during the time of the survey (Photo 7).

Photo 7 Ecosite phase a1, n = 1, species richness = 26.

a1 ecosite phase – limber pine/juniper Fd-Pf

In the a1 ecosite phase, the edaphic climax species Douglas fir and limber pine are the dominant trees. Shrubs are dominated by ground juniper, bearberry, young Douglas fir, and young limber pine. Small amounts of shrubby cinquefoil and prickly rose may also be present. Forbs are sparse and may consist of common yarrow, nodding onion, showy aster, wild strawberry, northern bedstraw, harebell, and star-flowered Solomon's-seal. Grasses are also edaphic and dominated by rough fescue and hairy wild rye. Hairy screw moss, copper wire moss and rolled-leaf pigtail moss may be present in low covers and lichens are absent. The plant community type a1.1 Fd-Pf/Juniper occupies approximately 1.1% (52.5 ha) of the total LSA.

Ecosite b – bearberry (subxeric/poor)

This ecosite is found on south-facing slopes with coarse textured soils, resulting in dry site conditions. Slope position can vary greatly, ranging from upper slope to toe and level positions. Soils are characteristically poorly developed and with thin organic layers. Parent materials may be fluvial, glaciofluvial, or morainal over rock with surface textures ranging from loamy sand to sandy loam, silty loam, or loam. Soils are moderately well to rapidly drained, resulting in a submesic moisture regime, and soils are relatively nutrient-poor. Bearberry, juniper, and hairy wild rye are indicator species for this ecosite. Shrub and forb layers are generally poorly developed due to the dry site conditions. Edaphic climaxes may occur in some of the drier sites. Pure and mixed stands of lodgepole pine (Pl), aspen (Aw), and white spruce (Sw) occur in this ecosite and succession, although slow, is generally toward white spruce. There are three ecosite phases associated with this ecosite: bearberry Pl (b1), bearberry Aw (b2), and bearberry Aw-Sw-Pl (b3). All three ecosite phases are present in the LSA, although only b1 was encountered during the time of the survey (Photo 8).

b1 ecosite phase – bearberry Pl

Lodgepole pine (and occasionally Douglas fir) is the dominant tree species of the b1 ecosite phase. Dominant shrubs include bearberry, Canada buffalo-berry, ground juniper, and twinflower, with a lesser amount of prickly rose and younger lodgepole pine. Forbs are limited and may include species such as wild strawberry and showy aster. Pine grass and hairy wild rye are common grasses, and are present with moderate cover. Mosses and lichens are typically absent. Only one vegetation community exists in this ecosite phase: b1.1 Pl/bearberry-juniper, and it occupies approximately 4.6% (221.0 ha) of the total LSA.

Photo 8 Ecosite phase b1, n = 1, species richness = 55.

b2 ecosite phase – bearberry Aw

Aspen dominates the b2 ecosite phase. Shrubs are abundant and include bearberry, prickly rose, Canada buffalo-berry, and young aspen. Alpine hedysarum, showy aster, and cream-coloured vetchling are the dominant forbs, but several others may be present in small amounts, including wild strawberry, common yarrow, cut-leaved anemone, star-flowered Solomon's-seal, northern bedstraw, harebell, and white camas. Grass cover is dominated by hairy wild rye, followed by pine grass and sedge. Moss and lichens are typically absent. Only one vegetation community exists in this ecosite phase: b2.1 Aw/bearberry, which occupies <1% (22.5 ha) of the total LSA.

b3 ecosite phase – bearberry Aw-Sw-Pl

The b3 ecosite phase is a mixture of co-dominating tree species. White spruce, lodgepole pine, and aspen are the most common, but subalpine fir may also be present. The shrub layer is well developed and typically includes bearberry, ground juniper, Canada buffalo-berry, shrubby cinquefoil, white spruce, and lesser amounts of prickly rose, and young aspen. Forbs are relatively sparse but may include fireweed, wild strawberry, cream-coloured vetchling, northern bedstraw, star-flowered Solomon's-seal, common yarrow, Lindley's aster, and early blue violet. Hairy wild rye is typically quite abundant. Sedges may be present, and Schreber's moss, knight's plume moss, and brown moss may also be found in these sites. Only one vegetation community exists in this ecosite phase: b3.1 Aw-Sw-Pl/bearberry, which occupies <1% (33.8 ha) of the total LSA.

Ecosite c – Canada buffalo-berry/hairy wild rye (submesic/medium)

The c ecosite is characterized by closed canopies with sparse understories, especially in Douglas fir (Fd) stands. Submesic moisture conditions mean that these sites are relatively dry, but not as dry as the a or b ecosites. Parent materials are usually morainal and surface textures vary between loam, sandy loam, silty loam, or clay loam. These sites are typically found on mid to upper slopes that are well to moderately well drained, with soils with a medium nutrient regime. Canada buffalo-berry and hairy wild rye are common indicator species for this ecosite. Lodgepole pine, Douglas fir, and aspen form pure and mixed stands on this ecosite and succession is toward white spruce and/or Douglas fir, although rates are slow due to the dry site conditions. There are four ecosite phases associated with this ecosite, distinguished by dominant tree species: Canada buffalo-berry/hairy wild rye Fd (c1), Canada buffalo-berry/hairy wild rye Pl (c2), Canada buffalo-berry/hairy wild rye Aw (c3), and Canada buffalo-berry/hairy wild rye Aw-Sw-Pl-Fd (c4). All four ecosite phases were encountered in the LSA during the time of the survey (Photos 9 to 12).

Photo 9 Ecosite phase c1, n = 3, species richness = 96.

c1 ecosite phase – Canada buffalo-berry/hairy wild rye Fd

The c1 ecosite phase is dominated by Douglas fir, with white spruce and lodgepole pine present in low to mid cover on some sites. Young Douglas fir and prickly rose make up the scarce shrub layer of this ecosite phase. Forbs are also limited but may include shower aster, or trace amounts of wild strawberry, northern bedstraw, or western meadow rue. Grasses, if present, include hairy wild rye and pine grass. The only moss likely found on these sites is a reduced cover of stair-step moss and lichens are typically absent. There are two-plant community types associated with the c1 ecosite phase, differentiated based on understory cover and diversity: c1.1 Fd/needle litter, and c1.2 Fd/hairy wild rye. The c1 ecosite phase represents approximately 3.2% (150.7 ha) of the total LSA.

Photo 10 Ecosite phase c2, n = 2, species richness = 92.

c2 ecosite phase – Canada buffalo-berry/hairy wild rye Pl

The c2 ecosite phase is dominated by lodgepole pine with white spruce also occurring on some sites. Shrubs are more common than the previous ecosite phase and consist of Canada buffalo-berry, twinflower, white meadowsweet, willow, bearberry, ground juniper, prickly rose, and young white spruce. Forbs are limited but may include showy aster, wild strawberry, and one-sided wintergreen. A well-developed grass layer exists, consisting of hairy wild rye and pine grass. Mosses are also more prevalent than in the b ecosite phase, and include moderate coverage of stair-step moss and Schreber’s moss. Only the one plant community type exists in this phase: c2.1 Pl/Canada buffalo-berry/hairy wild rye, which occupies approximately 2.8% (135.8 ha) of the total LSA.

Photo 11 Ecosite phase c3, n = 2, species richness = 89.

c3 ecosite phase – Canada buffalo-berry/hairy wild rye Aw

Aspen, with some balsam poplar, dominate the c3 ecosite phase. Shrubs are common and include Canada buffalo-berry, prickly rose, young aspen, and bearberry. There is an increase in forbs over the previous ecosite phase, and includes species such as cream-coloured vetchling, wild strawberry, Lindley's aster, northern bedstraw, and wild vetch. Grasses usually make up the majority of the ecosite and include hairy wild rye, silvery-flowered sedge, and rough fescue. Mosses and lichens are typically absent. Only the one plant community type exists in this phase: c3.1 Aw/hairy wild rye, which occupies <1% (22.9 ha) of the total LSA.

Photo 12 Ecosite phase c4, n = 5, species richness = 163.

c4 ecosite phase – Canada buffalo-berry/hairy wild rye Aw-Sw-Pl-Fd

A mix of co-dominant aspen, Douglas fir, white spruce, and lodgepole pine characterizes the c4 ecosite phase. Shrubs are dominated by prickly rose and young aspen, with lesser amounts of young white spruce and Canada buffalo-berry. Forbs include cream-coloured vetchling, wild strawberry, showy aster, Lindley's aster, wild vetch, and northern bedstraw. Grasses have a high cover and include hairy wild rye, pine grass, and rough fescue. Only one vegetation community is associated with this ecosite phase: Aw-Sw-Pl-Fd/hairy wild rye, which occupies 3.6% (173.9 ha) of the total LSA.

Ecosite d – creeping mahonia – white meadowsweet (mesic/medium)

The d ecosite supports a variety of plant communities throughout the subregion with its mid-range nutrient and moisture regimes. Generally located on gentle slopes and lower valley positions, this site has well to moderately-well drained soils. Parent materials may be morainal, colluvial, glaciofluvial or undifferentiated and surface textures tend to be loam, sandy loam, or silty loam. Lodgepole pine, Douglas fir, and white spruce form pure and mixed stands, with succession towards white spruce and Douglas fir. However, an extensive history of fire and disturbance has resulted in a predominance of lodgepole pine in the place of white spruce. Indicator species for this ecosite include white meadowsweet, creeping mahonia, mountain lover, green alder, pine grass, and feather moss. Three ecosite phases are associated with this ecosite, differentiated based on dominant tree species: creeping mahonia-white meadowsweet Fd (d1), creeping mahonia-white meadowsweet Pl (d2), and creeping mahonia-white meadowsweet Sw (d3). All three ecosite phases were mapped within the LSA, but only d1 and d2 were encountered in the LSA during the time of the survey (Photos 13 and 14).

Photo 13 Ecosite phase d1, n = 1, species richness = 58.

d1 ecosite phase – creeping mahonia – white meadowsweet Fd

The d1 ecosite phase is dominated by Douglas fir with some white spruce also present. This phase has two distinguishable plant communities based on the presence/absence of aspen and understory species: d1.1 Fd/feather moss and d1.2 Fd/white meadowsweet. Only the d1.2 plant community was surveyed in the LSA. Shrub species include white meadowsweet, prickly rose, and snowberry, with lesser amounts of young white spruce, purple clematis, and Saskatoon. Forbs include showy aster, wild strawberry, star-flowered Solomon's-seal, northern bedstraw, and veiny meadow rue. Grasses may include pine grass and/or hairy wild rye. Mosses are typically absent from the d1.2 ecosite phase but present in high cover in the d1.1 ecosite phase, and include species such as stair-step moss, pipecleaner moss, wiry fern moss, and Schreber's moss. Lichens are typically absent. This ecosite phase occupies 1.9% (89.0 ha) of the total LSA.

Photo 14 Ecosite phase d2, n = 1, species richness = 56.

d2 ecosite phase – creeping mahonia – white meadowsweet Pl

The d2 ecosite phase has five distinguishable plant community types based on the dominant understory species, but only one community type was surveyed in the LSA: d2.3 Pl/pine grass. Lodgepole pine is the dominant tree in this vegetation community, with lesser amounts of white spruce and Douglas fir also present. This vegetation community has little for shrubs, forbs, mosses, or lichens but has a well-developed grass layer consisting of pine grass. Shrub species that may be present include white meadowsweet, young white spruce, and twinflower. Forbs may be heart-leaved arnica and showy aster. The d2 ecosite phase occupies approximately 12.4% (593.5 ha) of the total LSA.

d3 ecosite phase – creeping mahonia – white meadowsweet Sw

The d3 ecosite phase is dominated by white spruce with Douglas fir and lodgepole pine also present. Twinflower, young white spruce, and prickly rose make up the shrub layer. Forbs consist of showy aster, heart-leaved arnica, and one-sided wintergreen. Grass, if present, consists of hairy wild rye. Stair-step moss and Schreber's moss make up the rather large bryophyte layer and dog lichens may also be present. Only one vegetation community is associated with this ecosite phase: d3.1 Sw/feather moss. It was not encountered in the LSA during the time of the survey, but it was identified on aerial imagery as existing in the LSA, based on overstory species and topographic position, and occupies <1% (25.7 ha) of the total LSA.

Ecosite e – thimbleberry/pine grass (mesic/rich)

The e ecosite has a slightly richer nutrient regime when compared to the d ecosite, as a result of seepage following the spring or heavy rain and as indicated by well-developed humus layers. Parent materials are typically morainal or fluvial, and surface textures vary from loam, to sandy loam, to clay loam. Sites are typically located in mid-slope positions with well to moderately well-drained soils. Aspen and white spruce form pure and mixed stands, with successions towards white spruce. Due to the favourable nutrient and moisture status, shrub and forb layers are well-developed and this results in high competition levels for coniferous seedlings. Common indicator species for this ecosite include snowberry, Saskatoon, thimbleberry and pine grass. Three ecosite phases are associated with the e ecosite: e1 thimbleberry/pine grass Pl, e2 thimbleberry/pine grass Aw, and e3 thimbleberry/pine grass Sw. Only e1 was encountered in the LSA at the time of the survey (Photo 15), but all three ecosite phases were mapped within the LSA.

Photo 15 Ecosite phase e1, n = 2, species richness = 97.

e1 ecosite phase – thimbleberry/pine grass Pl

In the e1 ecosite phase, lodgepole pine and white spruce are the dominant trees. Shrubs include thimbleberry, white meadowsweet, and white spruce. There is a high diversity of forbs in this ecosite, dominated by heart-leaved arnica and showy aster. Other forbs that are present, with low cover, include bunchberry, wild strawberry, cream-coloured vetchling, false hellebore, one-sided wintergreen, fireweed, northern bedstraw, false Solomon's-seal, and cow parsnip. A moderate amount of pine grass makes up the grass layer. Mosses and lichens are typically absent. Only one plant community type, e1.1 Pl/thimbleberry, is associated with this ecosite phase and it occupies 6.1% (289.8 ha) of the total LSA.

e2 ecosite phase – thimbleberry/pine grass Aw

The e2 ecosite phase has three plant community types, differentiated by dominant understory species: Aw/thimbleberry (e2.1), Aw/pinegrass (e2.2), and Aw/Saskatoon-snowberry (e2.3). Aw is the dominant tree species common to all three-plant community types, however the e2.2 type may also have white spruce, Douglas fir, and/or lodgepole pine present. Shrub species in this ecosite phase may include thimbleberry, prickly rose, young aspen, white meadowsweet, snowberry, and saskatoon. Forbs are diverse and may include showy aster, red and white baneberry, fireweed, wild strawberry, western Canada violet, veiny meadow rue, fair-bells, false hellebore, wild white geranium, twisted-stalk, cow parsnip, wild vetch, cream-coloured vetchling, and false Solomon's seal. Mosses and lichens are typically absent from this ecosite phase, but grasses such as pine grass, hairy wild rye, marsh reed grass, tufted hair grass, and slender wheatgrass are common. This ecosite phase was not encountered in the LSA during the time of the survey, but it was identified on aerial imagery and occupies 1.6% (75.4 ha) of the total LSA.

e3 ecosite phase – thimbleberry/pine grass Sw

The e3 ecosite phase has an overstory dominated by white spruce, however Douglas fir, aspen, subalpine fir, and lodgepole pine may also be present. Shrubs are few and include thimbleberry, white spruce, prickly rose, and currant. Forbs are diverse but % cover of species is relatively low and consist of heart-leaved arnica, yellow angelica, wild strawberry, red and white baneberry, one-sided wintergreen, northern bedstraw, twisted-stalk, cow parsnip, and false hellebore. Grasses, mosses and lichens are typically absent. Only one plant community is associated with this ecosite phase, e3.1 Sw/thimbleberry, and it occupies 1.7% (81.8 ha) of the total LSA.

Ecosite f – balsam poplar (subhygric/rich)

The f ecosite is located on steeper slopes in mid to lower topographic positions where seepage is common in the spring or following a heavy rainfall. It is found on a variety of parent materials, including colluvial, glacio-fluvial, morainal, morainal over rock, or fluvial deposits. Surface soil textures are typically sandy clay loam or silty clay loam and the nutrient status is rich. Due to its topographic position and frequency of seepage, this ecosite has an enhanced moisture regime that is indicated by the presence of balsam poplar. Succession of the site is towards white spruce; however, establishment is slow due to high vegetation competition. Indicator species for this ecosite include balsam poplar, snowberry, and red and white baneberry. This ecosite was not encountered in the field at the time of the survey. However, it was identified on aerial imagery as existing within the LSA, based on overstory species and elevation. There is only one phase associated with this ecosite, f1 balsam poplar Pb.

f1 ecosite phase – balsam poplar Pb

Balsam poplar is the dominant tree species of the f1 ecosite, followed by aspen and white spruce. Shrubs include white meadowsweet, snowberry, prickly rose, Canada buffalo-berry, and saskatoon, with lesser amounts of dogwood and devil's club. Forbs include red and white baneberry, wild white geranium, cream-coloured vetchling, showy aster, common pink wintergreen, western Canada violet and wild strawberry, with trace amounts of northern bedstraw, false Solomon's-seal, cow parsnip, and twisted stalk. Grasses are present in high cover and include pine grass, hairy wild rye, and marsh reed grass. Mosses and lichens are typically absent. The f1 ecosite phase has only one vegetation community associated with it, f1.1 Pb/snowberry, and it occupies <1% (16.8 ha) of the total LSA.

Ecosite g – horsetail (hygric/rich)

The g ecosite is the wettest and richest of the ecosites in the Montane natural subregion. It is found in midslope to toe or level topographic positions where water tables are high and seepage is common. Parent materials are typically fluvial or morainal, but have also been found on colluvial over fluvial materials and morainal over undifferentiated materials. Surface soil textures may be loam, clay loam, sandy loam, sandy clay loam, or silty loam and soil drainage varies from well to very poor. Shrub and forb diversity is high in these hygric and nutrient-rich sites. Dogwood and horsetails are common indicator species for the g ecosite. Like the f ecosite, balsam poplar is a pioneer species with slow succession towards white spruce. There are two phases associated with this ecosite, both of which were observed in the LSA at the time of the survey: g1 horsetail Sw-Pb and g2 horsetail Sw.

g1 ecosite phase – horsetail Sw-Pb

In the g1 ecosite phase, white spruce is the dominant tree species, followed by balsam poplar and aspen. Shrubs include high amounts of dogwood, young balsam poplar, river alder, thimbleberry, and prickly rose, with lesser amounts of bracted honeysuckle, willow, and twinflower. Forb diversity is high and dominated by meadow horsetail. Other forb species present in less cover include red and white baneberry, showy aster, dwarf scouring rush, bunchberry, one-sided wintergreen, veiny meadow rue, wild white geranium, cow parsnip, dewberry, bishop's-cap, sweet-scented bedstraw, cream-coloured vetchling, spreading sweet cicely, western Canada violet, common pink wintergreen, and wild vetch. Grasses are also quite prevalent and include marsh reed grass and sedge. There is one plant community type associated with this ecosite phase: g1.1 Sw-Pb/horsetail, and it was encountered at the time of the survey (Photo 16). The g1 ecosite phase represents <1% (42.6 ha) of the total LSA.

Photo 16 Ecosite phase g1, n = 2, species richness = 103.

g2 ecosite phase – horsetail Sw

Much like the g1 ecosite phase, white spruce is the dominant tree species in the g2 ecosite phase and balsam poplar may also be present. Shrubs are somewhat reduced compared to the g1 phase and may include moderate amounts of prickly rose, young white spruce, dogwood, and willow. Forbs are dominated by meadow horsetail. Other forb species that may be present include yellow angelica, common horsetail, fireweed, dewberry, red and white baneberry, western Canada violet, Lindley's aster, bunchberry, dwarf scouring rush, northern bedstraw, wild white geranium, and bishop's cap. Sedges make up the grass layer, and mosses and lichens appear. The moss layer is dominated by stair-step moss, but common beaked moss and ragged moss may also be present, and lichens consist mostly of dog lichen. There are two plant community types associated with the g2 ecosite phase: Sw/horsetail (g2.1) and Sw/dogwood (g2.2). Both vegetation communities are present in the LSA, although only g2 was encountered at the time of the field survey. The g2 ecosite phase represents <1% (35.5 ha) of the total LSA.

Photo 17 Ecosite phase g2, n = 1, species richness = 52.

ELC Units in the RSA and Footprint

The ELC units that were mapped in the RSA and Footprint are described below.

Barren Land

The barren land cover class represents land that has no vegetation and is composed of bare soil and rock, as well as bare rock at higher alpine elevations. There are no equivalent ecosites or ecosite phases associated with this land class. This land class represents 6.6% (18,650.5 ha) of the total RSA.

Open Regeneration - Herbaceous

This land class is often anthropogenic and in this case represents regenerating growth on previously harvested areas that have a canopy closure of between 0% – 5%, but can also include areas regenerating after fire. Managed stands are distinguished from stands having natural origins (*e.g.,* ecosite phases). This class is comprised of younger stands (zero – five years) is more open than open regenerating shrubby because they have not had enough time to establish either a shrub or tree layer. The majority of this area is comprised of newly re-planted trees following forest harvesting and tree heights are typically <.05 m. After harvesting but especially after fire typical understory species are forbs, graminoids (such as bluejoint,) and some mosses, with forbs and graminoids being dominant. Seven ecosites of the Subalpine and Montane Subregions are associated with the managed forest open regeneration – herbaceous ELC land class. Those ecosites are a, b, c, d, e, f and h. Not all ecosites were located in both Subregions (Archibald *et al.* 1996). This land class represents 6.3% (17,991.2 ha) of the total RSA.

Open Regeneration - Shrub

This land class is often anthropogenic and in this case represents regenerating growth on previously harvested areas that have a canopy closure of <6%, but also can include areas regenerating after fire. Managed stands are distinguished from stands having natural origins (*e.g.,* ecosite phases). This class is comprised of younger stands (6 – 14 years) is more open than a closed treed stand because they have not had enough time to establish a tree canopy. The majority of this area is comprised of recently re-planted trees following forest harvesting. Tree heights typically have not reached breast height (<1.3 m). After harvesting but especially after fire, the typical understory includes shrubs (such as willow species and alder species, and other native shrubs) along with forbs, graminoids and some mosses. Seven ecosites of the Subalpine and Montane Subregions are associated with the managed forest open regeneration – shrub land class. Those ecosites are a, b, c, d, e, f and h. Not all ecosites were located in both Subregions (Archibald *et al.* 1996). This land class represents 6.2% (17,631.8.2 ha) of the total RSA.

Closed Regeneration - Forest

Montane Subregion

This land class is considered anthropogenic and represents re-planted areas in the Montane that have been harvested (cut) in previous years (between 15-29 years ago) and are now considered treed with 6-29% canopy closure, and typical tree heights of between 5 and 9 metres. Managed stands are distinguished from stands having natural origins (*e.g.*, ecosite phases). The majority of areas have been replanted with pine and spruce, with some areas regenerating naturally with aspen. Five ecosites of the Montane Subregion are associated with managed forests of less than about 40 years old. Those ecosites are a, b, c, d and e (Archibald *et al.* 1996).

Subalpine Subregion

This land class is considered anthropogenic and represents re-planted areas in the Subalpine Subregion that have been harvested (cut) in previous years (between 15 - 29 years ago) and are now considered treed with 6-29% canopy closure, and typical tree heights of between 3 and 8 metres. Managed stands are distinguished from stands having natural origins (*e.g.*, ecosite phases). The majority of areas have been replanted with pine and spruce, with some areas regenerating naturally with aspen and sub-alpine fir. Four ecosites of the Subapline Subregion are associated with managed forests of less than about 40 years old. Those ecosites are d, e, f and h (Archibald *et al.* 1996).

The Closed Regeneration – Forest land class in the Montane and Subalpine Subregions combined represents <1% (2,253.7 ha) of the total RSA.

Four possible age classes were used for open, moderate, closed and dense forests. Young deciduous or mixed forests are those forest stands between 30 and 60 years of age and mature stands are those between 61 and 100 years of age. Young coniferous (without pine) forests are those forest stands between 30 and 70 years of age, while mature stands are those between 71 and 139 years old, and old coniferous forests are <140 years old. Pine of any species is considered old growth at or greater than 120 years, while it is mature from 71 to 119 years of age. All other conifers are considered old growth when 140 years old or older.

Not all forest types (deciduous, mixed or coniferous) will always have every age class; nonetheless, given certain bio-geophysical conditions, there may be limited occurrences of each.

Open Deciduous

Canopy closure for this class is between 6 and 30%, and the dominant tree species is trembling aspen, with portions of lodgepole pine (montane), limber pine (subalpine), Englemann spruce and white spruce, but with less than 20% conifer species canopy cover. In some instances, tree sized willows take the place of deciduous tree species, and due to their tall heights and the coarse resolution of the classification, are included in this class and not in the open regeneration - shrub land class. Trees are typically 18 m high or greater. The understory species can be bearberry, Buffalo-berry and hairy wild rye. Ecosite phases found within this class are b2, c3, c4, e2 and f1 in the Montane (Archibald *et al.* 1996). This land class occupies approximately <1% (2,346.7 ha) of the total RSA.

Moderate Deciduous

Tree species composition in this class is similar to the open deciduous class, and the dominant trees species are trembling aspen and balsam poplar with portions of lodgepole pine (montane) limber pine (subalpine), Englemann spruce and white spruce but with a more closed canopy (30-50%) and <20% conifer species canopy cover. Trees are typically 18 m high or greater. Bearberry, Buffalo-berry and hairy wild rye commonly appear in the understory. Ecosite phases found in this class are the same as described for the open deciduous class (Archibald *et al.* 1996). Young stands are likely to have a large shrub proportion. Old age stands are likely to have a large portion of snags and deadfall but will have coniferous species in the understory. This land class represents approximately 1.4% (4,070.2 ha) of the total RSA.

Closed Deciduous

Tree species composition in this class is similar to the other deciduous classes with no more than 20% of conifer species. The canopy is more open, with 51 to 70% coverage and heights of 18 m or more. Bearberry, Buffalo-berry and hairy wild rye commonly appear in the understory. Ecosite phases found in this class are the same as described for the open deciduous class (Archibald *et al.* 1996). Young stands are likely to have a large shrub proportion. Old age stands are likely to have a large portion of snags and deadfall but will have coniferous species in the understory. This land class represents 2.2% (6,108.3 ha) of the total RSA.

Dense Deciduous

Tree species composition in this class is similar to the other deciduous classes with a canopy of greater than 70% cover and tree heights of 18 m or taller. Some conifer species can be present in the stand, but make up no more than 20% of the total proportion of tree cover. Spruce, bearberry, Buffalo-berry and hairy wild rye are typical understory species. Ecosite phases found in this class are the same as described for the open deciduous class (Archibald *et al.* 1996). These stands generally fit into the mature and old age categories. However, dense stands that fit an old age class will be limited in occurrence. This land class represents <1% (1230.4 ha) of the total RSA.

Open Mixed

The open mixed class tree species composition includes trembling aspen, white spruce, lodgepole pine, balsam poplar and Douglas fir (depending on the ecosite phase) and with tree canopy closure between 6 and 30%. Typical tree heights are 18 m or taller and the understory is commonly composed of bearberry, Buffalo-berry, juniper, species, prickly rose, red osier dogwood and white meadowsweet. Ecosite phases found within this class are b2, b3, c3, c4, d1, d2, e2, f1, g1 and g2 in the Montane Subregion. No ecosite phases from the Subalpine Region are found in this class. This land class represents <1% (2,185.5 ha) of the total RSA.

Moderate Mixed

This land class represents mixedwood forests (31 to 50% conifer) with a canopy closure between 30 and 50% and tree heights of generally 18 m or more. Tree species include trembling aspen, balsam poplar, white spruce, lodgepole pine, and Douglas fir (depending on the ecosite phase). Common understory species and ecosite phases found in this class are the same as described for the open mixed class (Archibald *et al.* 1996). Similar to the moderate deciduous class, the young stands will likely have limited occurrence or will have a large proportion of shrubs in the understory. Mixed stands in the old age category will likely be in this cover class. This land class represents 1.4% (3,966.6 ha) of the total RSA.

Closed Mixed

This land class represents mixedwood forests (30 to 79% conifer) with a canopy closure between 51 and 70% and tree heights of generally 18 m or more. Tree species include trembling aspen, white spruce, lodgepole pine, balsam poplar and Douglas fir. Common understory species and ecosite phases found in this class are the same as described for the open mixed and moderate mixed classes (Archibald *et al.* 1996). These stands will likely be young and mature age classes. This land class represents <1% (985.3 ha) of the total RSA.

Dense Mixed

The dense mixed land class includes those forested areas that have a canopy cover of both coniferous and deciduous trees greater than 70%, with the proportion of conifers in the stand between 21 and 79%. The deciduous component is either trembling aspen or balsam poplar, and the coniferous component can be white spruce, lodgepole pine, and Douglas fir depending on the ecosite phase Trees in this class are typically ≥18 m or greater. Common understory species and ecosite phases found in this class are the same as described for the open mixed, moderate mixed and closed mixed classes (Archibald *et al.* 1996). This land class represents <1% (105.1 ha) of the total RSA.

Open Conifer

The open conifer land class applies to conifer forests with canopy coverage between 6 and 30%. Lodgepole pine, white spruce, Englemann spruce, subalpine fir and Douglas fir are the commonly found tree species, with some ecosite phases containing limber pine (a1 ecosite phase in the Montane subregion), and heights are generally 18 m or more. The understory is commonly composed of juniper species, bearberry, green alder twinflower, thimbleberry, heather species, buffalo-berry, false azalea and feather moss species. Ecosite phases found within this class are a1, b1, c1, c2, d1, d2, d3, e1, and g2 in the Montane Subregion and a1, b1, c1, d1, e1, e2, e3, e4, f1, f2, f3, and h1 in the Subalpine Subregion (Archibald *et al.* 1996). Young and mature stands could include any of the coniferous species. This land class represents 12.4% (35,167.8 ha) of the total RSA.

Moderate Conifer

Forests with 31 to 50% canopy coverage comprise the moderate conifer class. Some deciduous trees may be present, but are not more than 20% of the total proportion of trees in the stand. On average, trees are 20 m or more in height, and the understory species and ecosite phases found within this class are the same as those found in the open conifer class (Archibald *et al.* 1996). All three-age classes, young, mature and old are likely to occur in this class. This land class represents approximately 10.1% (28,759.8 ha) of the total RSA.

Closed Conifer

Forests of with 51 to 70% canopy coverage comprise the moderate conifer class. Some deciduous trees may be present, but are not more than 20% of the total proportion of trees in the stand. On average, trees are 20 m or more in height, and the understory species and ecosite phases found within this class are the same as those found in the moderate and open conifer class (Archibald *et al.* 1996). Young and mature stands will likely be the most common, as with the deciduous and mixed closed stands, old stands are less likely to occur. This land class represents about 13.8% (39,292.3 ha) of the total RSA.

Dense Conifer

Dense conifer refers to conifer forests (greater than or equal to 80% conifer composition) that have greater than 70% canopy closure with tree heights typically 20 m or more. On average, trees are 20 m or more in height, and the understory species and ecosite phases found within this class are the same as those found in the moderate, open and closed conifer classes (Archibald *et al.* 1996). This cover class will have both young and mature stands, and limited occurrences of old stands. This land class represents 5.6% (15,850.8 ha) of the total RSA.

Natural Shrub

The natural shrub land class refers to those upland areas that are dominated by shrubs and stunted trees, such as deciduous and conifer species outlined previously outlined and may encompass older re-vegetated stands limited by unsuccessful regeneration. Younger or shorter coniferous, mixedwood and deciduous stands are included in this class. Ecosite phases included in this land class are a1 and b1 from the Subalpine Subregion (Archibald *et al.* 1996). This land class represents 2.7% (7,555.5 ha) of the total RSA.

Natural Upland Herbaceous

This land class includes those upland areas that are dominated by herbs, forbs, and/or grasses, and upland treed areas with less than 6% canopy cover. The majority of this class is represented by native grassland communities Ecosite phases included in this land class are a1 and b1 from the Subalpine Subregion (Archibald *et al.* 1996). This land class represents approximately 13.6% (38,513.7 ha) of the total RSA.

Lush Herb

Lush herb class is dominantly avalanche chutes. These are usually moist productive sites providing excellent forage for grizzly bears and other wildlife. Common vegetation includes cow parsnip, monk's hood, buttercups, larkspurs, anemones, and dock. No ecosite phases are similar to this group. This land class represents less than 1% (352.0 ha) of the total RSA. Open Water

The open water land class is represented by lakes, ponds, and rivers, and includes impoundments and end pit lakes within existing development areas, including mine projects. No ecosite phases are equivalent to this land class. This land class represents <1% (1,544.0 ha) of the total RSA.

Natural Graminoid Wetland

The natural graminoid wetland land class refers to low-lying (depression) open wetlands that have <6% canopy closure and are dominated by graminoid species (sedge species and grass species). Riparian areas are also classified as open natural graminoid wetlands. This land class represents <1% 158.5 ha) of the total RSA.

Natural Shrub Wetland

The natural shrub wetland land class refers to low-lying (depression) open wetlands that have <6% canopy closure and they are dominated by shrub species (perennial woody plants). Shrub dominated riparian areas can also be classified as open natural shrub wetlands. This land class represents <1% (762.7 ha) of the total RSA.

Treed Wetland

This land class is located in low-lying areas. Principal tree species in this land class are spruce species, balsam poplar, and subalpine fir the tree canopy closure is <6%. Some treed wetlands with coniferous cover may also have shrub species in the understory. This land class represents about <1% (126.5) of the total RSA.

Settlements

Municipal areas, such as Blairemore, are treated as entire polygons. They were not mapped for forest succession. This land class represents approximately <1% (595.4 ha) of the total RSA.

Linear Disturbance

This land class is likely to include power lines, pipelines, roads (including mine roads for previous and existing operations), and seismic lines. This land class represents 2.71% (7,626.1 ha) of the total RSA.

Industrial (Mining)

This land class includes previous mining disturbance within the footprint and other mine developments within the RSA. This land class represents 1.1% (3,183.6 ha) of the total RSA.

Agriculture

Pastures, areas of crop production, and grazing were classified as agriculture. This land class represents 9.5% (27,010.6 ha) of the total RSA.

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APPENDIX D: RARE PLANT OCCURRENCES AND DESCRIPTIONS

Table D-1 Rare Plant Occurrences in the LSA

Name	Plot Card Label[1]	Easting[2]	Northing[2]	Ecosite Phase[3]	GRANK[4]	SRANK[4]
Vascular Plants (14 species, 48 occurrences)						
Angelica dawsonii (yellow angelica)*	RP17BE	684195	5507844	c1	G4	S3
	GM003BE	685345	5507690	e1		
	GM063BE	685504	5506912	e1		
	GM075BE	684829	5510469	e1		
	GM076BE	685708	5511231	e1		
	GM077BE	686489	5511258	e1		
	GM305BE	684634	5506297	e1		
	GM409BE	686339	5508418	e1		
	GM509BL	684045	5508450	e1		
	GM512BL	684707	5508163	f1		
	GM514BL	684086	5509415	f1		
Berberis repens (creeping mahonia)	RP02	684906	5504171	c4	G5	SS3
Bromus vulgaris (woodland brome)	RP17	684195	5507844	e1	G5	S3
Carex petasata (pasture sedge)	GM504BL	686495	5507364	a1	G5	S1S2
	GM513BL	685249	5509604	a1		
	GM521BL	684008	5501787	c4		
Crepis atribarba (slender hawk's-beard)	CREPATR	683910	5500890	AIH	G5	S2
Eriogonum cernuum (nodding umbrella-plant)	GM148BE	684804	5509896	e1	G5	S2
Eucephalus engelmannii (elegant aster)	GM003BE	685345	5507690	e1	G4G5	S3S4
Phacelia hastate (silver-leaved scorpionweed)	GM148BE	684804	5509896	e1	G5	S3
	RP13RE	686133	5506510	AIM		
	GM513BL	685249	5509604	a1		
	GM200BE	686404	5506049	AIM		
Pinus albicaulis (whitebark pine)	GM403BE	686309	5508184	e1	G3G4	S2
	GM408R	686097	5509115	e1		
	GM504BL	686495	5507364	a1		
	GM513BL	685249	5509604	a1		
	RP18RE	686304	5508161	e4		
	GM404BE	686315	5506607	e2		

Table D-1 Rare Plant Occurrences in the LSA

Name	Plot Card Label[1]	Easting[2]	Northing[2]	Ecosite Phase[3]	GRANK[4]	SRANK[4]
Pinus flexilis (limber pine)	RP5BE	685311	5504575	c3	G4	S2
	GM036BE	685885	5507039	e1		
	RP18RE	686304	5508161	e4		
	GM513BL	685249	5509604	a1		
Piperia unalascensis (Alaska bog orchid)	GM003BE	685345	5507690	e1	G5	S2?
	GM051BE	686808	5505278	c3		
	GM075BE	684829	5510469	e1		
	GM302BE	684221	5504032	b1		
	GM401RE	684203	5504313	c4		
Streptopus roseus (rose mandarin)	GM058BE	684425	5502680	c1	G5	S1
	GM309BE	684611	5505149	g2		
	GM412BE	685273	5511029	e1		
Streptopus streptopoides (twisted-stalk)	GM516BL	683474	5501748	c4	G5	S1
Tellima grandiflora (fringe-cups)	GM412BE	685273	5511029	e1	G5	S1
Mosses and Liverworts (16 species, 25 occurrences)						
Anastrophyllum helleranum (Heller's notchwort)	GM307BE	683781	5505860	g1	G5	S2
Aulacomnium androgynum (little groove moss)	GM515BL	683160	5500931	d1	G5	S2
	GM516BL	683474	5501748	c4		
Buxbaumia aphylla (bug on a stick moss)	GM078BE	686590	5511525	e1	G4G5	S2
Chiloscyphus polyanthos (liverwort)	GM412BE	685273	5511029	e1	G5	S1
	GM406BE	685956	5508648	e1		
Conocephalum salebrosum (liverwort)	GM400RE	684350	5503928	e1	G5	S2
Dicranella crispa (curl-leaved fork moss)	GM405BE	685380	5508200	e1	G3G5	S2

Table D-1 Rare Plant Occurrences in the LSA

Name	Plot Card Label[1]	Easting[2]	Northing[2]	Ecosite Phase[3]	GRANK[4]	SRANK[4]
Dicranum tauricum (broken-leaf moss)	GM302BE	684221	5504032	b1	G4	S1S2
	GM502BL	687058	5509102	f1		
	GM507BL	685404	5504169	c4		
	GM509BL	684045	5508450	e1		
	GM518BL	684183	5503336	c1		
	GM400RE	684350	5503928	e1		
Jungermannia exsertifolia (liverwort)	GM412BE	685273	5511029	e1	G5?	S1
Lophozia ascendens (liverwort)	GM402BE	686155	5509115	e1	G4	S1
Lophozia longidens (liverwort)	GM409BE	686339	5508418	e1	G5	S1
Lophozia wenzelii (liverwort)	GM409BE	686339	5508418	e1	G4G5	S1
Pellia endiviifolia (liverwort)	GM412BE	685273	5511029	e1	G5	S2
Pellia neesiana (liverwort)	PELLNEE	685997	5508606	e1	G5	S2
	GM406BE	685956	5508648	e1		
Racomitrium aciculare (moss)	GM501BL	686972	5510052	e1	G5	S1
	GM512BL	684707	5508163	f1		
Rhytidiopsis robusta (pipecleaner moss)	GM405BE	685380	5508200	e1	G4	S3
Schistidium tenerum (thread bloom moss)	GM403BE	686309	5508184	e1	G5?	S2
Lichens (11 species, 21 occurrences)						
Caloplaca sinapisperma (firedot licken)	GM521BL	684008	5501787	c4	GNR	S2S3
Cladonia ochrochlora (smooth-footed powderhorn)	GM501BL	686972	5510052	e1	G4G5	S1?
Cladonia symphycarpia (split-peg lichen)	GM006BE	685473	5506349	e1	G5	S2
	GM412BE	685273	5511029	e1		
	GM401RE	684203	5504313	c4		

Table D-1 Rare Plant Occurrences in the LSA

Name	Plot Card Label[1]	Easting[2]	Northing[2]	Ecosite Phase[3]	GRANK[4]	SRANK[4]
Cladonia umbricola (shaded cladonia)	GM500BE	684973	5505234	e3	G3G5	S1
Hypogymnia enteromorpha (budding tube lichen)	GM076BE	685708	5511231	e3	G4	S2
Hypogymnia rugose (wrinkled tube lichen)	GM090BE	686162	5504314	c2	G4G5	S1S2
	GM507BL	685404	5504169	c4		
Nodobryoria abbreviata (tufted foxtail lichen)	GM075BE	684829	5510469	e1	G4?	S1
	GM078BE	686590	5511525	e1		
	GM501BL	686972	5510052	e1		
	GM503BL	686919	5507970	f1		
	GM507BL	685404	5504169	c4		
Peltigera cinnamomea (cinnamon dog pelt lichen)	RP14BE	684648	5507056	g1	GNR	S2
	RP17BE	684195	5507844	c1		
	GM307BE	683781	5505860	g1		
Umbilicaria americana (American rock trip lichen)	GM403BE	686309	5508184	e1	G5?	S2S3
Vulpicida canadensis (brown-eyed sunshine lichen)	GM402BE	686155	5509115	e1	G3G5	S2
	GM409BE	686339	5508418	e1		
Xylographa parallela (black woodscript lichen)	GM502BL	687058	5509102	f1	G5	S2S4

[1]GM – Biodiversity, ecosite and rare plant survey plots surveyed in the Grassy Mountain LSA. RP and plots with a four letter code are rare plants survey plots only.

[2]UTMs are NAD 83 Zone

[3]Ecosite phases are based on the *Field Guide to Ecosites of Southwestern Alberta* (Archibald *et. al.* 1996).

[5]GRANK refers to global conservation rank and SRANK refers to subnational conservation rank (i.e., Alberta in this case). See Section 2.1.4 for definitions of rankings (Derived from ACIMS 2014, NatureServe 2015)

RARE PLANT DESCRIPTIONS

A. VASCULAR PLANTS

Angelica dawsonii – yellow angelica

Angelica dawsonii is a stout perennial herb (0.3 to 1.2 m tall) in the carrot family; stems are erect and arise from a fleshy enlargement above the taproot (Kershaw *et al.* 2001, Klinkenberg 2014). This species is identifiable by its single umbel, large whorl of pale-greenish to yellow flowers, and leafy, sharply toothed involucral bracts (Kershaw *et al.* 2001, Klinkenberg 2014). Yellow angelica is found on steep, moist, forested slopes and on riverbanks (NatureServe 2015). This species occurs in Alberta, British Columbia, Idaho, and west Montana. *A. dawsonii* is reported as S3 (vulnerable) in Alberta and S3S4 (vulnerable to apparently secure) in British Columbia, and is ranked G4 (apparently secure) globally (ACIMS 2013, NatureServe 2015). This species was found at eleven sites within the LSA, primarily in Montane Natural Subregion e1 and Subalpine Subregion e1 and f1 ecosite phases.

Berberis (Mahonia) repens – creeping mahonia

Berberis repens is a low glabrous shrub in the barberry family; stems are trailing or erect stem, 10 to 30 cm long (Moss 1983). The leaves are pinnate, three to seven in number, leathery, ovate to oblong, with spinulose-dentate leaflets; persistent into autumn; tinted with red or purple (Moss 1983). The inflorescence is a raceme that is subtended by a few small bracts; flowers yellow six petals and six sepals (Moss 1983). The two series petals have two basal glands each; six stamens opposite the petals which bend inward when touched at the base (Moss 1983). The pistil is simple with a sessile stigma (Moss 1983). Fruits are a blue berry, sour and juicy; few large seeds (Moss 1983). This species range covers British Columbia to Alberta, south through California and west to Texas and North Dakota. *B. repens* is ranked S3 (vulnerable) in Alberta and is secure (G5) globally (ACIMS 2014, NatureServe 2015). This species was observed in a single location within the LSA, in ecosite phase c4 in the Montane Subregion.

Bromus vulgaris – woodland brome

Bromus vulgaris is a slender woodland grass; lacking elongated underground rhizomes. Culms are 80 to 100 cm tall with pubescent nodes (Moss 1983). Leaves are alternate; sheaths and clades are soft-hairy; the blade is commonly 5 to 8 mm wide (Moss 1983). Ligules are prominent, 3 to 5 mm long (Moss 1983). The inflorescence is a slender panicle of flower clusters; spikelets are few that are narrow and dropping (Moss 1983). The first glume is 1-nerved while the second is 3-nerved (Moss 1983). Lemmas are 8 to 10 mm long and 2 mm wide, narrow and sparsely hairy over the back, denser towards the margins, or nearly glabrous; awns are 6 to 8 mm long (Moss 1983, Kershaw *et al*. 2001). This species occurs in British Columbia, Alberta, and in the western states. *B. vulgaris* is ranked S3 (vulnerable) in Alberta and is secure (G5) globally (ACIMS 2014, NatureServe 2015). This species was found at one location in an e1 ecosite phase in the Subalpine Subregion within the LSA.

***Carex petasata* – pasture sedge**

Carex petasata is a sedge with tufted, fibrillose, short rhizomes, and is 30 to 80 cm tall (Moss 1983). The base is brown and conspicuously clothed with dried-up leaves from the previous year (Moss 1983). The leaves are alternate, two to five per stem, clustered near the base and shorter than the stems; blades are firm, flat or nearly, usually 2 to 3 mm wide (Kershaw *et al*. 2001). Culms are smooth, 30 to 80 cm tall, slender and stiff (Kershaw *et al*. 2001). The overlapping spikes (three to six) are gynaecandrous, stalkless, and aggregated in an erect head 2 to 4 cm long (Moss 1983). The inconspicuous bracts are scale-like or occasionally short-prolonged lower (Moss 1983). Scales are ovate and tinged with reddish brown with broad and hyaline margins (Moss 1983). The perigynia are largely concealed by scales (Moss 1983). The beak (~2 mm long) is oblong-lanceolate, 6 to 8 mm long, striate and narrowly winged-margined (Moss 1983, Kershaw *et al*. 2001). This species range covers the west coast of North America, from Alaska south to California, and east to Saskatchewan south to New Mexico. (NatureServe 2015). *C. petasata* is ranked S1S2 (critically imperiled to imperiled) in Alberta and is secure (G5) globally (ACIMS 2014, NatureServe 2015). This species was found at three sites within the LSA in ecosite phase a1 (Supalpine Subregion) and c4 (Montane Subregion).

***Crepis atribarba* – slender hawk's-beard**

Crepis atribarba is a perennial herb with milky juice. Stems, one to two (15 to 70 cm), branched, woody root crowns on taproots (Kershaw *et al*. 2001). Leaves, mostly basal, alternate; lower leave (10 to 35 cm long) are pinnately cut into linear to narrowly lance-shaped segments, hairless to woolly, mostly entire; upper stems shorter, linear and entire (Kershaw *et al*. 2001). Flower heads (eight to 14 {15} mm high and 3 to 5 mm wide), yellow, ray florets (ten to 35, {40}), involucres grey-woolly, sometimes bristly, black hairs, lacking glands, two overlapping rows of bracts; five to ten outer bracts less than half as long as the eight to ten inner bracts; florets (ten to 18 mm long) have both male and female parts; almost leafless clusters, (3 to 30) branched (Kershaw *et al.* 2001). Fruits, cylindrical, ten to 20 ribbed achenes, gradually tapered to a slender point, usually greenish, tipped with a whitish pappus (Kershaw *et al.* 2001).

This species has been referred to as *Crepis exilis* Osterh. and *Crepis occidentalis* Nutt. var. *gracilis*, and misspelled *Crepis atrabarba* (Kershaw *et al.* 2001). Small flowered hawk's beard (*C. occidentalis* Nutt.), also rare in Alberta, can be distinguished from *C. atribarba* by its broader (5-10 mm wide), glandular-villose involucres, smaller plants (usually less than 35cm tall), and brownish (or yellowish) seeds (Kershaw *et al.* 2001). The lower leaves of *C. occidentalis* may have broader segments that are less deeply lobed and toothed; habitat is dry, eroding sloped in the prairies (Kershaw *et al.* 2001). Also comparable, intermediate hawk's beard (*Crepis intermedia*), is an intermediate between *C. occidentalis* and *C. atribarba*. *C. intermedia* lack gland-tipped hairs and have involucres less than 5 mm wide; habitat is dry, open areas (Kershaw *et al.* 2001). This species ranges from British Columbia to Saskatchewan; south from Nevada to Colorado (NatureServe 2015). *C. atribarba* is ranked globally secure (G5); it is however ranked S2 (imperilled) in Alberta, SNR (not ranked) in British Columbia and S1 (critically imperiled) is Saskatchewan (ACIMS 2014, NatureServe 2015). This species was observed once in a disturbed (permanent right of way) site within the Montane Subregion in the LSA.

***Eriogonum cernuum* – nodding umbrella-plant**

Eriogonum cernuum is an annual plant, 10 to 40 cm high (Moss 1983). The stems are freely branched, trichotomous at the base and dichotomous on the upper parts, slender, hairless or somewhat woolly near the base (Kershaw *et al*. 2001). The leaves are basal, petioled, round to oval, 1 to 2 cm wide, lack stipules, white-tomentose lower, and less tomentose upper (Kershaw *et al*. 2001). The flowering scapes are glabrous and have slender, spreading or recurved branches; calyx is white to pinkish, conular, approximately 2 mm long (Moss 1983). Sepals are three broad with wavy-edged lobes and petals are alternating with three narrower lobes and are notched at the tip (Kershaw *et al*. 2001). Flowers are borne on short stalks in several-flowered, flat-topped heads from hairless, 5-lobed involucres that are 1.5 to 2 mm long (Kershaw *et al*. 2001). Involucres are glabrous, borne singly on slender branches approximately 5 to 15 mm long and bend sharply downward when open (Kershaw *et al*. 2001). This species occurs in central Canada and the west United States (NatureServe 2015). *E. cernuum* is ranked S2 (imperiled) in Alberta and is secure (G5) globally (ACIMS 2014, NatureServe 2015). The species was found at one site within the LSA, in ecosite phase e1 (Subalpine Subregion).

***Eucephalus engelmannii* – elegant aster**

Eucephalus engelmannii is a bulky perennial with a caudex or thick rhizome (Moss 1983). Stems are 30 to 130 cm tall, are very leafy, nearly glabrous to slightly glandular (Moss 1983). The leaves are sessile, ovate-lanceolate to narrowly elliptic, pointed, entire 5 to 10 cm long (Moss 1983). The inflorescence is corymb-like and short (Moss 1983). Involucre is 8 to 12 mm high, the bracts imbricate, chartaceous below, somewhat keeled, the outer ones acuminate, the inner often purplish (Moss 1983). Rays, nine to 15, are widely spaced, white to pinkish and are approximately 2 cm long (Moss 1983). *Eucephalus engelmannii* is ranked S3S4 (vulnerable to apparently secure) in Alberta and is apparently secure to secure (G4G5) globally (ACIMS 2014 NatureServe 2015). The species was found at one site within the LSA, in ecosite phase e1 (Subalpine Subregion).

Phacelia hastata – silver-leaved scorpionweed

Phacelia hastata is a perennial or biennial herb with a bulky taproot and caudex. This species has a single stem or cluster of stems (Moss 1983). Stems 30 to 50 cm high, are covered with pubescence and long bristly hairs (Moss 1983). The leaves are mostly simple with lanceolate or linear lobes near the base, 4 to 8 cm long; veins conspicuous; silvery, dull grey or brownish; with dense pubescence and long appressed coarse hairs (Moss 1983). The inflorescence is compact and hispid (Moss 1983). Flowers are white, pinkish or bluish; corolla is slightly longer than the calyx-lobes. The filaments are usually bearded and long-exserted (Moss 1983). *Phacelia hastata* is ranked S3 (vulnerable) in Alberta and is secure (G5) globally (ACIMS 2014, NatureServe 2015). This species was found at four sites within the LSA, in ecosite phase a1 and e1 (Subalpine Subregion).

Pinus albicaulis – whitebark pine

Pinus albicaulis is a small alpine tree often reduced to a shrub with the branches sometimes prostrate on the ground (Moss 1983). The trunk is often crooked and the crown matted (Moss 1983). The bark is smooth, whitish, and a little broken except at the base of the trunk (Moss 1983). Twigs are yellowish and hairy (Moss 1983). The needles are 4 to 8 cm long and stiff (Moss 1983). Seed-cones are 3 to 7 cm long, purplish, thickened scales with a bulky pointed umbo, which is not prickly (Moss 1983). *Pinus albicaulis* is ranked S2 (imperiled) in Alberta and federally ranked as Schedule 1 Endangered under SARA; it is apparently secure to secure (G4G5) globally (ACIMS 2014, COSEWIC 2015, NatureServe 2015). This species was observed at six locations, including a1, e1, e2 and e4 ecosite phases in the Subalpine Natural Subregion as well as in herbaceous grassland and disturbed sites.

Pinus flexilis – limber pine

Pinus flexilis is a small tree with an irregular crown, whorls of thick limbs, and short bulky trunk (Moss 1983). The bark is light grey, getting dark brown and highly cracked with age (Moss 1983). The needles are 3 to 7 cm long, rigid, and crowded at the ends of the branches (Moss 1983). Seed-cones are 8 to 20 cm long, light brown tinged with purple and the scales are thickened at the tip (Moss 1983). *P. flexilis* is ranked S2 (imperiled) in Alberta and is apparently secure (G4) globally (ACIMS 2014, NatureServe 2015). In November 2014, this species was designated Endangered by COSEWIC (COSEWIC 2015); it was not listed under SARA at the time this assessment was submitted. *P.flexilis* grows on exposed rocky slopes and hilltops to subalpine elevations. It was observed four times within the LSA: in a1 and e4 ecosite phases (Subalpine Natural Subregion) and in c3 ecosite phase (Montane Natural Subregion).

Piperia unalascensis – Alaska bog orchid

Piperia unalascensis is a small glabrous orchid that emerges from a rounded tuberous base (Moss 1983). The slender stems are bracted above, 20 to 50 cm high (Moss 1983). The leaves, one to four, are basal, erect or spreading, oblanceolate to lanceolate, 6 to 12 cm long and wither when flowering (Moss 1983). The inflorescence is 10 to 30 cm long is slender and remotely flowered (Moss 1983). Flowers are greenish to yellowish green, often marked with purple, and have an unpleasant odor; sepal and petals are ovate to lanceolate and 1 nerved (Moss 1983). The lip is approximately 5 mm long, ovate to lanceolate and widens at the base; spur is slender of clavate and is about the same length as the lip (Moss 1983). This species occurs in Alberta, British Columbia, Newfoundland, Ontario and Quebec. *P. unalascensis* is ranked S2? (imperiled) in Alberta and is secure (G5) globally (ACIMS 2014, NatureServe 2015). This species was found at five sites within the LSA, in Montane ecosite phases e1, c4, and d2.

***Streptopus roseus* – rose mandarin**

Streptopus roseus is a perennial herb from a very slender rhizome; stems are usually unbranched, 15-30 cm tall, fringed with coarse hairs at the nodes (Parish *et al.* 1996). Leaves (3-10 cm long) are oval to elliptic, with tiny, irregularly spaced, forward-pointing hairs along the margins; sessile (Parish *et al.* 1996). Inflorescence is of single, stalked flowers nodding or drooping from the axils on a curved stalk. Flowers bell-shaped, rose-coloured with white tips to greenish-yellow streaked with reddish purple (Parish *et al.* 1996). Fruits are a globose berry, round to oblong, red, several-seeded (Moss 1983, Parish *et al.* 1996). *Splachnum sphaericum* is ranked S2 (imperiled) in Alberta and is vulnerable to secure (G3G5) globally (ACIMS 2014, NatureServe 2015). *S. sphaericum* has adapted to using flies for dispersal on animal excrement. This species was found at one location in each of three ecosite phases: c1 and g2 (Montane) and e1 (Subalpine).

***Streptopus streptopoides* – small twisted-stalk**

Streptopus streptopoides is a perennial herb, 10 to 30 cm tall. The stems are simple to twice branched and the nodes are fringed (Moss 1983). Leaves are sessile, 3 to 5 cm long, 1 to 2 cm wide, ovate to elliptic or ovate to lanceolate, with an acuminate to acute apex (Moss 1983). Margins have single celled, translucent, closely crowded teeth (Kershaw *et al*. 2001, MacKinnon *et al*. 1992). The perianth is small, rotate, saucer-shaped, with segments rose to reddish brown and yellowish green tips, oblong- lanceolate with acute to acuminate recurved tips, 2.8 to 4.2 mm long (Moss 1983, Kershaw *et al*. 2001). The stamens with filaments are 1.4 to 2.2 mm long, with anthers minutely apiculate and 1 mm long (Moss 1983). The ovary is 3 mm long; style is short, bulbous to conical; stigma is undivided but 3 faced; berry is red, rarely maroon of black, ovoid-globose, 4.5 to 6.5 mm long with few seeds (Moss 1983). Small twisted-stalk (*S. streptopoides*) is similar to rose mandarin (*S. roseus*). Both species are rare in Alberta; occur in moist coniferous woods and along streambanks (Kershaw *et al*. 2001). This species occurs in British Columbia, Alberta, Alaska, Idaho, Oregon, and Washington. *S. streptopoides* is ranked S1 (critically imperiled) in Alberta and is secure (G5) globally

(ACIMS 2014, NatureServe 2015). This species was observed once in a c4 ecosite phase (Montane Subregion).

***Tellima grandiflora* – fringe-cup**

Tellima grandiflora is a perennial herb with stiff, unbranched, flowering stems that are stiffly hairy on the lower portion (Kershaw *et al*. 2001). As described by Kershaw *et al.* (2001) the leaves are heart to kidney shaped with long, hairy, basal stalks. The fragrant flowers are greenish white, with five fringed-tipped petals, that redden with age, spreading from a greenish calyx. The flowers grow in branched clusters on a narrow, elongated, glandular spike and produce egg-shaped capsules with two spreading beaks. *T. grandiflora* grows on rich, moist soil and rocky seeps. This species is found within the western states and provinces of North America (AK, WA, OR, CA, and BC) as well as Alberta, Montana, and Idaho (NatureServe 2015). *T.grandiflora* is ranked S1 in Alberta and G5 globally (ACIMS 2014, NatureServe 2015). It was observed once in an e3 ecosite phase (Montane).

B. MOSSES AND LIVERWORTS

***Anastrophyllum helleranum* – heller's anastrophyllum (liverwort)**

Anastrophyllum helleranum is a tiny plant (shoots less than 1 mm wide and leaves less than 0.5 mm long), so small that it is unlikely to be encountered without deliberate searching (Atherton *et al.* 2010). It is detectable by its bright red or purple gemmae, which stick up from the liverwort mat on attenuated shoots like little match sticks; this is distinctive enough for field identification. Its leaves are sharply bilobed, although those on the attenuated shoots are small and often tattered; usually green to brownish shallow mats borne on erect branches. *A. minutum* is most similar species to *A. helleranum*, but usually almost twice the size of *A. helleranum* (Atherton *et al.* 2010). *A. helleranum* typically grows on logs (especially oak and pine) in open forests at higher elevations in the boreal and mountainous areas of the Northern Hemisphere. It tends to grow on the vertical or overhanging lower half of the sides of logs, but sometimes colonizes living trees, especially oaks in very humid woodlands (Atherton *et al.* 2010). The species is ranked G5 globally; it is ranked S2 (imperilled) in Alberta, S1S2 in New Brunswick, S3S4 in Ontario, and S3? in Quebec (NatureServe 2014). There was one occurrence of *A. helleranum* in the LSA, in a g1 ecosite phase of the Montane Subregion.

***Aulacomnium androgynum* – little groove moss**

Aulacomnium androgynum is a yellow-green moss that is often brown underneath (Lawton 1991). Leaves contort when dry, but are erect and spread when moist. Numerous small, stalked fusiform gemmas (brood bodies) are borne in a globular head atop a naked pseudopodium. *A. androgynum* grows on tree trunks, stumps, rotten logs, and occasionally on soil or soil covered rocks. Species distribution is incomplete or has not been reviewed for this taxon (NatureServe 2015). *A. androgynum* is ranked S2 in Alberta and G5 globally (ACIMS 2014, NatureServe 2015). This species was observed once in each of the Montane Subregion's c4 and d1 ecosite phases.

***Buxbaumia aphylla* – bug-on-a-stick**

Buxbaumia aphylla is a moss; stems white or reddish, 0.2 to 0.5 mm high; erect, simple, rhizoids at base; papillose (Ireland 1982). The warty seta, 2.5 to 12 mm, arises from a protonematal mass with a bulbous base; bracts are few, rudimentary, and inconspicuous around the base of the seta (Lawton 1991). Capsule may or may not be glossy, are reddish brown when mature and sometimes lighter colour on the upper side, three to six by 2.5 to 4 mm, usually flattened on one side when dry (Lawton, 1971). The neck is short with a few cryptopore; one-celled stomata (Lawton 1991). The capsule wall is approximately 4 layers of cells; the outer cuticle 6 to 12 μm thick and usually rolls back from the mouth (Lawton 1991). The operculum is 0.7 to 1 mm long (Lawton 1991). The outer peristome teeth are in one row about 0.4 mm long, teeth are somewhat papillose (Lawton 1991). Endostome papillose is about 0.57 mm long; spores 7 to 10 μm (Lawton 1991). This species is widely distributed throughout the Northern Hemisphere (NatureServe 2015). *B. aphylla* is ranked S2 (imperiled) in Alberta and is apparently secure to secure (G4G5) globally (ACIMS 2014, NatureServe 2015). This species was found at one site within the LSA, in an e1 ecosite phase of the Subalpine Subregion.

***Chiloscyphus polyanthos* – pale liverwort**

Chiloscyphus pallescens is a small leafy liverwort that forms yellowish to pale or bright green mats on soil, decaying wood and leaf litter (Paton 1999). As described by Paton (1999), the leaves are imbricate to distant along the stem and are unlobed to very shallowly lobed with the apex slightly narrowed to truncate. The under leaves are small and are separated into two long, thin lobes for about half of their length, with margins that often bear sparse cilia-like teeth that may become lobe-like. Species distribution is incomplete or has not been reviewed for this taxon (NatureServe 2014). *C. pallescens* is ranked S1 in Alberta and G5 globally (ACIMS 2014, NatureServe 2015). This species was observed twice in ecosite phase e1 (Subalpine).

***Conocephalum salebrosum* – liverwort**

Conocephalum salebrosum is a newly recognized species of lichen, with a wider Holarctic distribution than *Conocephallum conicum* (NatureServe 2015). As described by Szweykowski *et al*. (2005), the dorsal thallus surface is dull, with a narrow hyaline margin, and an uneven dorsal thallus surface. The epidermis of the archegoniophore air chambers are usually unistratose. *C. salebrosum* grows in moist, shaded, calcareous habitats and can be frequently found along streams, springs, and at the base of moist rocks and cliffs (NatureServe 2015). Species distribution is incomplete or has not been reviewed for this taxon (NatureServe 2014). *C. salebrosum* is ranked S2 in Alberta and G5 globally (ACIMS 2014, NatureServe 2015). This species was observed once in an e1 ecosite phase (Montane).

***Dicranella crispa* – curl-leaved forklet moss**

Dicranella crispa is a yellow-green moss, stems 2 to 5 mm high (Lawton 1971). The leaves are 0.6 to 2 mm long, upper squarrose, linear-subulate from a sheathing base, lower flexuose or spreading and lanceolate; margins are plane to incurved and usually serrulate at apex (Lawton, 1971). The midrib ends before the apex or percurrent, in cross section with 1 to 2 rows of large cells on the ventral side and one to three rows of small cells with slightly thick walls on the dorsal side; lamina is bistratose in the upper part of the least with cells long and narrow (Lawton 1991). Dioicous or autoicous; the perichaetial bracts are 2 to 3 mm long and plainly squarrose. Setae are red 5 to 15 mm long (Lawton 1991). Capsule is erect and straight or nearly, deeply ripped when dry; the urn is 0.7 to 0.9 mm long. The operculum is 0.6 to 0.8 mm long, rostrate, with the beak oblique or occasionally almost straight (Lawton 1991). The annulus, rows of two cells, is deciduous or sometimes adherent; peristome is 0.3 to 0.35 mm long; spores are minutely papillose to nearly smooth (Lawton 1991). This species range is globally-distributed across four continents (NatureServe 2014). *D. crispa* is ranked S2 (imperiled) in Alberta and is vulnerable to secure (G3G5) globally (ACIMS 2014, NatureServe 2015). This species was found at one site within the LSA, in an e1 ecosite phase of the Subalpine Subregion.

***Dicranum tauricum* – broken-leaf moss**

Dicranum tauricum is a dense tufted, light green to yellowish green moss; stems 0.5 to 3 cm high with whitish or reddish brown rhizoids below (Lawton 1991). The leaves are straight and erect-spreading when moist and nearly straight when dry (four to six by 0.2 to 0.4 mm); lanceolate, acute, points usually broken, concave below, and tubulose above (Lawton 1991). The margins are entire or serrulate at apex; lamina unistratose or with bistratose regions near the apex; costa is long to excurrent, 1/6 to ¼ the width of the leaf base and without stereid (prosenchyma) bands (Lawton 1991). Alar cells do not extend to the costa; basal cells above the alar region are long and rectangular or linear (Lawton, 1971). Leaf cells are smooth, thin-walled; there are few pits in the basal cells; the median and upper cells are without pits; median and upper cells quadrate, rounded, or short-rectangular (Lawton 1991). Inner Perichaetial bracts gradually narrow to the apex (Lawton 1991). Solitary setae are 1.5 to 2.5 cm long, yellow to light brown; capsule straight and erect, yellow to light brown; urn is 1.4 to 2.4 mm long and smooth to irregularly wrinkled when dry (Lawton 1991). The operculum is rostrate, straight, and usually shorter than the urn to 1.8 mm long (Lawton 1991). Dioicous, the male plants are the same in size as the females (Lawton, 1971). Distribution for this species in incomplete of has not been reviewed. *D. tauricum* is ranked S1S2 (critically imperiled to imperiled) in Alberta and is apparently secure (G4) globally (ACIMS 2014, NatureServe 2015). There were five occurrences of *D. tauricum* within the LSA, with the species occurring in both the Subalpine (e1, f1) and Montane Subregions (c1, c4, d2).

***Jungermannia exsertifolia* – liverwort**

Species distribution is incomplete or has not been reviewed for this taxon (NatureServe 2015). *J. exsertifolia* is ranked S1 in Alberta and G5? globally (ACIMS 2014, NatureServe 2015). This species was found at one site within the LSA, in an e1 ecosite phase of the Subalpine Subregion.

***Lophozia ascendens* – liverwort**

Lophozia ascendens is a yellowish green moss with erect shoots that grows on decaying wood (Söderström 2006). The leaves are described by Söderström (2006) as being longer than they are wide with straight margins as well as two-lobed and, horned-like. Yellowish gemmae are almost always in the shoot apex. Species distribution is incomplete or has not been reviewed for this taxon (NatureServe 2015). *L. ascendens* is ranked S1S2 in Alberta and G4 globally (ACIMS 2014, NatureServe 2015). This species was observed once in an e1 ecosite phase (Subalpine).

***Lophozia longidens* – horned flapwort**

The unusual leaf shape, with its two long, narrow points tipped by balls of redbrown gemmae, makes this *Lophozia longidens* plant easily recognizable in the field (Atherton *et al.* 2010). It forms loose mats or turfs of upright shoots, 0.5– 1.8 mm wide, rather than creeping on a substrate. Leaves are usually less than 1 mm wide and long. The characteristic leaf tips become eroded in older leaves, making the older part of stems appear like other *Lophozia* species. *L. excisa* and *L. bicrenata* are probably the most similar species in terms of size and colour of gemmae, but the leaves never have long lobes and they creep over the substrate (Atherton *et al.* 2010). The species is globally secure (G5). *L. longidens* is critically imperilled (S1) in Alberta, and it has not been ranked (SNR) in Manitoba (NatureServe 2015). The species is normally found growing on old coniferous logs (Williams 1968), but can sometimes be found on acidic boulders, particularly if there is a thin skin of peat or moss (Atherton *et al*. 2010). In northern Britain where it is relatively uncommon, it has been found on humid, rocky woodlands, ravines and steep heathery slopes, especially in mixed native pine or birch dominated forest, typically growing on the lower trunks and branches of birch trees. *L. longidens* was observed once in the LSA, in an e1 ecosite phase within the Subalpine Subregion.

***Lophozia wenzelii* – liverwort**

Lophozia wenzelii is a green moss with reddish brown leaf bases and yellowish gemmae (Söderström 2006). It is described by Söderström (2006) as having shallowly two lobed leaves with a rounded sinus. The leaves are also widely cupped that they cannot be flattened without breaking. *L. wenzelii* grows on wet to moist ground. Species distribution is incomplete or has not been reviewed for this taxon (NatureServe 2015). *L. wenzelii* is ranked S1 in Alberta and G4G5 globally (ACIMS 2014, NatureServe 2015). This species was observed once in an e1 ecosite phase (Subalpine).

***Pellia endiviifolia* – endive pellia**

Pellia endiviifolia is a thalloid liverwort that produces thin branching outgrowths from the edge of the green thallus (Belland 2011). Involucre consists of a complete, circular ring (Vitt *et al.* 1988). *P.endiviifolia* grows on stream sides or wet places associated with calcareous habitats and are the second most common liverwort species east to the Rockies. (Belland 2011, Vitt *et al*. 1988). *Pellia endiviifolia* is ranked S2 (imperiled) in Alberta and is secure (G5) globally (ACIMS 2014, NatureServe 2015). This species was observed once within the LSA, in an e1 ecosite phase within the Subalpine Subregion.

***Pellia neesiana* – ring pellia**

Pellia neesiana is a thallose liverwort (*i.e*., with no differentiation into stems and leaves – in this case, somewhat straplike and dichotomously branching). Thalli are shiny, dark green and usually with a red tinge that is most intense around the midrib; usually less than 1cm wide. Thalli edges are wavy and translucent, and no pores are visible (MacKinnon *et al.* 1992). The sporophyte generation consists of spherical capsules on short, transparent stalks. *P. neesiana* is vegetatively very similar to *P. epiphylla* with thalli about 1 cm wide, but the tendency of *P. neesiana* to develop reddish or purple tints and its sharp, aromatic smell are good distinguishing characteristics (Atherton *et al.* 2010). *P. neesiana* is dioicous, with separate male and female individuals. Females develop a short, vertical tube of tissue around the sex organ. This tube is not closely-toothed at its mouth. *P. neesiana* is ranked S2 (imperiled) in Alberta and is secure (G5) globally (ACIMS 2014, NatureServe 2015). There were two occurrences of *P. neesiana* within the e1 ecosite phase (Subalpine) in the LSA.

***Racomitrium aciculare* – yellow fringe-moss**

Racomitrium aciculare is a moss that is often dark green or almost black, despite its' name (Atherton *et al.* 2010). The broad, oblong leaves with obtuse apices are 2.5 to 3.5 mm long, blunt, and usually have widely spaced, blunt teeth that are visible with a hand lens (Atherton *et al.* 2010). The capsules are long, approximately 3 mm, narrow, straight on long seta. *R.aciculare* grows in cushions and tufts, attached to the substarte at the base (Vitt 1988). When moist the leaves are wide-spreading compared to being dry where the leaves are tightly imbricate and erect (Atherton *et al.* 2010, Vitt 1988). *R. aciculare* is ranked S1 (critically imperiled) in Alberta and is secure (G5) globally (ACIMS 2014, NatureServe 2015). There were two occurrences of *R. aciculare* within the LSA, both within an e1 ecosite phase of the Subalpine Subregion.

***Rhytidiopsis robusta* – pipecleaner moss**

Rhytidiopsis robusta is a large yellow-green to brownish plant that grows in loose mats or scattered (Lawton 1991). It is described by Lawton (1991) as having irregularly branching ovate to broadly ovate-lanceolate branching leaves that are closely placed, giving the plant a thick appearance. The stems are prostrate to ascending and curved at the ends. Large, branched paraphyllia cover the stems and are sometimes attached to the leaf base. Perigoinia, often in groups of 2-3, and perichaetia are found on the main stems. *R. robusta* is found in the woods at elevations of 400 to 2,500 m, rarely below 500 m, on soil amongst the litter. Species distribution is incomplete or has not been reviewed for this taxon (NatureServe 2015). *L. wenzelii* is ranked S3 in Alberta and G4 globally (ACIMS 2014, NatureServe 2015). This species was observed once in an e1 ecosite phase (Subalpine).

***Schistidium tenerum* – thread bloom moss**

Schistidium tenerum is a densely compact, brownish green to nearly black moss with reddish or orang-brown capsules that grow in fragile cushions or mats (Flora of North America Association 2007). As described by Flora of North America Association (2007), the leaves are erect, imbricate when dry and ovate-triangular to ovate-lanceolate in shape. Distinguished by the uneven 2-stratose, ovate-triangular, small laminae tipped with long, often flexuose, spinulose-denticulate awns. *S. tenerum* grows on dry calcareous and siliceous rocks forming deep reddish tufts with a silvery sheen (NatureServe 2015). Primarily an arctic species *S. tenerum* can also be found at high altitudes in southern parts of the Rocky Mountains (NatureServe 2015). *S. tenerum* is ranked S2 in Alberta and G5? globally (ACIMS 2014, NatureServe 2015). This species was observed once in an e1 ecosite phase (Subalpine).

C. LICHENS

***Caloplaca sinapisperma* – firedot lichen**

Caloplaca sinapisperma is a musicolous, grey lichen with a crustose, continuous thallus (Nash *et al.* 2002). As described by Nash *et al*. (2002), the discs are convex and brownish orange or brown in colour; apothecia are dark red-brown and lack a grey thalline margin. This species grows on bryophytes or detritus and is circumpolar artic-alpine and extends as far south as Colorado in North America (NatureServe 2015). *C. sinapisperma* is ranked S2S3 in Alberta and GNR globally (ACIMS 2014, NatureServe 2015). This species was observed once in c1 ecosite phase of the Subalpine Subregion.

***Cladonia ochrochlora* – smooth-footed powderhorn**

Cladonia ochrochlora is a lichen with large, lobed primary squamules (Brodo *et al.* 2001). As described by Brodo *et al.* (2001), the greeinish or olive and rarely brown podetia are unbranched, with or without very narrow cups and a continuous cortex on the lower half. *C. ochrochlora* typically grows on decaying wood and rarely on soil. Species distribution is incomplete or has not been reviewed for this taxon (NatureServe 2015). *C. ochrochlora* is ranked S1? in Alberta and G5 globally (ACIMS 2014, NatureServe 2015). This species was observed once in an e1 ecosite phase of the Subalpine Natural Subregion.

***Cladonia umbricola* - Shaded cladonia**

Cladonia umbricola is a variable fruticose lichen that has unbranched, finely-sorediate podetia that either form small cups or taper to a blunt tip (Goward 1999, Brodo *et al.* 2001). Its colour ranges from yellowish- to greyish-green. Its basal squamules are medium sized, deeply lobed, and often turn orange towards the bases of the podetia. *C. umbricola* grows strictly over wood or bark, generally in shady old-growth forests, at middle to lower elevations (Goward 1999). This species has a global status of G3G5 (NatureServe 2015). In Alberta, *C. umbricola* is considered critically imperilled (S1). It is secure in British Colombia (S5), and is unrankable in Manitoba and the Yukon Territories. This species was observed once in an e3 ecosite phase of the Montane Natural Subregion.

***Cladonia symphycarpa* – Split-peg lichen**

Cladonia symphycarpa is a club lichen of the family Cladoniaceae (Brodo *et al.* 2001). It has large gray-green primary squamules, which are deeply lobed and have a white lower surface. Podetia are rarely produced, but when they are, they are also greenish gray, short, and lack cups, occasionally with branches at the summit (Brodo *et al.* 2001). Split-peg lichen grows on thin or sandy soil, especially in calcium-rich areas, in old fields, along roadsides, or in open woods (Brodo *et al.* 2001, NatureServe 2015). Globally, it has a status of G3G5, and in Saskatchewan, its rank is S3S5 (NatureServe 2015). *C. symphycarpa* as S2 in Alberta (ACIMS 2014). *C. symphycarpa* was observed at three e1 ecosite phase sites, once in the Montane Natural Subregion and twice in the Subalpine Subregion.

***Hypogymnia enteromorpha* – budding tube lichen**

Hypogymnia rugosa is an appressed, irregularly branched, thallus forming lichen (Brodo *et al.* 2001). As described by Brodo *et al.* (2001), the surfaces of older lobes are strongly wrinkled, with infrequently perforated tips. Soredia and lobules are absent, and apothecia are common. *H. rugosa* grows on conifers at high elevations within the intermontane forests. Species distribution is incomplete or has not been reviewed for this taxon (NatureServe 2015). *H. rugosa* is ranked S1S2 in Alberta and G4G5 globally (ACIMS 2014, NatureServe 2015). This species was observed once in an e3 ecosite phase of the Subalpine Natural Subregion.

Hypogymnia rugosa – wrinkled tube lichen

Hypogymnia rugosa is an appressed, irregularly branched, thallus forming lichen (Brodo *et al.* 2001). As described by Brodo *et al.* (2001), the surfaces of older lobes are strongly wrinkled, with infrequently perforated tips. Soredia and lobules are absent, and apothecia are common. *H. rugosa* grows on conifers at high elevations within the intermontane forests. Species distribution is incomplete or has not been reviewed for this taxon (NatureServe 2015). *H. rugosa* is ranked S1S2 in Alberta and G4G5 globally (ACIMS 2014, NatureServe 2015). This species was observed twice within the Montane Subregion, in c2 and c4 ecosite phases.

Nodobryoria abbreviata – tufted foxtail lichen

Nodobryoria abbreviata is a shrubby, thallus forming lichen (Brodo *et al.* 2001). As described by Brodo *et al.* (2001), the main branches are angular, pitted, and spiny in appearance. Red-brown apothecia with spiny cilia on their margins are common on or close to the branch tips. *N. abbreviata* primarily grows on the bark of ponderosa pine and Douglas fir in dry forests. Endemic to North America, *N. abbreviata* is found in dry inland mountainous areas as far east as the Rocky Mountains at elevations of 700 to 1,400 m (NatureServe 2015). *N. abbreviata* is ranked S1 in Alberta and G4? globally (ACIMS 2014, NatureServe 2015). There were four occurrences of *N. abbreviata* within the Subalpine Subregion in e1 and f1 sites, and one occurrence within a c4 ecosite phase of the Montane Subregion.

Peltigera cinnamomea

Peltigera cinnamomea is a foliose fungi with large (10-30 cm across), loosely appressed, stiff thallus (Goward *et al.* 1994). The name *cinnamomea* refers to the cinnamon-coloured veins. Lobes are somewhat leathery, rounded at the tips, plane to downturned; lobe margins are essentially even. Colour ranges from pale bluish grey to pale brownish grey or infused in part with cinnamon brownish, dull, on the upper surface. Veins on the lower surface are pale tan, grading inward to rusty brown, rhizines are abundant and concoloros with veins. The tomentum is appressed, usually disappearing abruptly toward thallus centre. Soredia are absent as well as isidia and marginal lobules. *P. cinnamomea* is easily recognized in the field but has long-escaped taxonomic notice, being confused with *P. praetextata* (Goward *et al.* 1994). *P. praetextata*, however, has brownish or occasionally tan-coloured veins that are also often at least partially erect-tomentose. Additionally, *P. praetextata* tends to have somewhat crisped lobe margins that are lined, at least in older parts of the thallus, with lobules. *P. cinnamomea* has not been ranked globally (GNR) or nationally in Canada (NNR). Provincially, *P. cinnamomea* occurs in AB and BC where it is ranked S2 and S4, respectively (NatureServe 2015). This species prefers mesophytic to hygrophytic growing over moss and mossy rocks and logs in open to somewhat sheltered inland forests at all forested elevations (Goward *et al.* 1994). There were three occurrences of *P. cinnamomea* within the LSA, two in a g1 ecosite phase of the Subalpine Subregion and once in a c1 ecosite phase of the Montane Subregion.

Umbilicaria americana – American rock tripe lichen

Umbrillicaria americana is a lichen with a thick, rather stiff pale grey or brownish grey thallus covered by coarse white pruina (Brodo *et al.* 2001). As described by Brodo *et al.* (2001), the lower surface is covered with closely packed, velvet-like, unbranched or forked, black rhizines that are coated with a layer of black granules. *U. americana* grows on granitic, steep rock faces that are shaded or relatively protected. Species distribution is incomplete or has not been reviewed for this taxon (NatureServe 2014). *U. americana* is ranked S2S3 in Alberta and G5? globally (ACIMS 2014, NatureServe 2015). This species was observed once in an e1 ecosite phase (Subalpine).

Vulpicida canadensis – brown-eyed sunshine lichen

Vulpicida canadensis is a thallus-forming lichen with large tufts (Brodo *et al*. 2001). The lobes are a network of depressions and sharp ridges or wrinkled; rounded, 2 to 7 mm across (Brodo *et al*. 2001). Soredia are absent; red-brown apothecia are abundant, up to 7 mm in diameter (Brodo *et al*. 2001). The lower surface is yellow and slightly paler than the upper surface (Brodo *et al*. 2001). Rhizines are spares or absent and range in colour from pale to dark; pycnidia are immersed in the thallus lobes and appear as black dots (Brodo *et al*. 2001). *V. canadensis* is conspicuous and commonly located on the bark wood of conifers in open, relatively dry sites. *Letharia columbiana* can resemble *V. canadensis*, but reveals its shrubby, angular branches and white medulla upon closer inspection (Brodo *et al*. 2001). Most species of *Vulpicida* have been utilized as a source of bright yellow dye (Brodo *et al*. 2001). This species distribution is either incomplete or has not been reviewed for this taxon (NatureServe 2015). *V. Canadensis* is ranked S2 (imperiled) in Alberta and is vulnerable-secure (G3G5) globally (ACIMS 2014, NatureServe 2015). This species was observed twice within the LSA, in an e1 ecosite phase of the Subalpine Natural Subregion.

Xylographa parallela – black woodscript lichen

Xylographa parallela is a crust lichen often found growing on old decaying wood. The thallus is immersed in the wood but stains it grayish (Brodo *et al.* 2001). It produces black to brown, long and slender soralia (called lirellae) that follow the wood's grain. The medulla under the lirellae reacts positively in potassium hydroxide and in *para*-phenylenediamine. Spores are one-celled and hyaline. This species has a rank of S2S4 (imperiled to possibly secure) in Alberta, and G5 (widespread, abundant, and secure) globally (NatureServe 2015). *X. parallela* was found once within the LSA , in an f1 ecosite phase of the Subalpine Subregion.

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APPENDIX E: TEK VEGETATION SPECIES IN THE LSA

Table E-1 TEK Vegetation Species in the LSA

Name[1]		Ecosite Phase															
		Montane										Subalpine					
Provided TEK	**Scientific**	**a1**	**b1**	**c1**	**c2**	**c3**	**c4**	**d1**	**d2**	**e1**	**g1**	**a1**	**b1**	**e1**	**e3**	**f1**	**h1**
Sweet pine	*Abies lasiocarpa*		x	x		x		x				x		x		x	
Yarrow	*Achillea millefolium*	x			x	x	x			x	x	x	x	x		x	x
Saskatoon berry	*Amelanchier alnifolia*		x	x	x	x	x	x	x			x	x	x		x	
Tall everlasting	*Antennaria anaphaloides*					x											
Bearberry	*Arctostaphylos uva-ursi*	x	x	x	x	x	x	x				x	x	x			
Heart-leaved arnica	*Arnica cordifolia*		x	x	x	x	x		x	x	x		x	x	x	x	
Balsamroot	*Balsamorhiza sagittata*		x														
Prince's pine	*Chimaphila umbellata*		x	x		x	x		x	x		x		x		x	
Thistle	*Cirsium edule*					x											
Buffalo horn lichen	*Cladonia* spp. (n=20 species)	x	x	x	x	x	x	x	x		x		x	x	x	x	x
Dogberry	*Cornus stolonifera*			x										x			
Ferns	*Cystopteris fragilis*						x							x			
Fireweed	*Epilobium angustifolium*	x	x	x	x		x	x		x	x		x	x			
Horsetail	*Equisetum arvense*						x			x	x			x		x	
Horsetail	*Equisetum fluviatile*										x						
Scouring-rush	*Equisetum scirpoides*						x			x	x					x	
Strawberry	*Fragaria virginiana*		x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Three-flowered avens	*Geum triflorum*						x					x	x	x			

Table E-1 TEK Vegetation Species in the LSA

Name[1]		Ecosite Phase															
		Montane										Subalpine					
Provided TEK	**Scientific**	**a1**	**b1**	**c1**	**c2**	**c3**	**c4**	**d1**	**d2**	**e1**	**g1**	**a1**	**b1**	**e1**	**e3**	**f1**	**h1**
Bear root or Indian potato	*Heracleum lanatum*										x					x	
Common sweetgrass	*Hierochloe hirta*							x									
Juniper	*Juniperus communis*	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Juniper	*Juniperus scopulorum*	x	x	x	x	x	x		x	x	x			x		x	
Cream-colored vetchling	*Lathyrus ochroleucus*		x	x	x	x	x	x	x	x	x	x		x	x	x	
Tree lichen	*Letharia vulpina*	x								x							
Lupine	*Lupinus arcticus*													x			
Lupine	*Lupinus argenteus*		x	x	x	x					x		x	x			
Lupine	*Lupinus sericeus*											x	x	x		x	
Lupine	*Lupinus sulphureus*													x			
	Phacelia hastata											x					
Lodgepole pine	*Pinus contorta*	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Poplar	*Populus balsamifera*									x	x			x			
Cottonwood or poplar	*Populus tremuloides*			x	x	x	x	x	x	x	x		x	x			
Rose hip	*Rosa acicularis*	x	x	x	x	x	x	x	x	x	x	x	x	x		x	
Rose hip	*Rosa woodsii*			x			x	x									
Raspberry	*Rubus idaeus*						x				x						
Thimbleberry	*Rubus parviflorus*								x	x				x		x	

Table E-1 TEK Vegetation Species in the LSA

Name[1]		Ecosite Phase															
		Montane										Subalpine					
Provided TEK	**Scientific**	**a1**	**b1**	**c1**	**c2**	**c3**	**c4**	**d1**	**d2**	**e1**	**g1**	**a1**	**b1**	**e1**	**e3**	**f1**	**h1**
Willow	*Salix bebbiana*							x						x			x
Willow	*Salix scouleriana*			x			x						x	x			
Lance-leaved stonecrop	*Sedum lanceolatum*	x				x	x					x		x			
Clasping-leaved twisted-stalk	*Streptopus amplexifolius*										x			x			
Dandelion	*Taraxacum officinale*			x	x	x	x			x	x			x			
Tree lichen	*Usnea* and *Bryoria* spp. (n=8 species)			x	x		x	x	x	x	x	x			x		x
Low-bush cranberry	*Viburnum edule*						x				x						

[1] Includes only those species observed during the vegetation surveys of the LSA

APPENDIX F: WETLAND TYPE DESCRIPTIONS FOR THE LSA

Four types of wetlands were observed in the Grassy Mountain LSA – open shrubby fen, wooded coniferous swamp, marsh, and shallow open water. These wetland types are described below.

Fens

All fens are peatlands with greater than 40 cm of peat accumulation and contact with ground and/or surface waters that form channels and pools. Due to exposure to mineral-rich water, fens are more fertile and productive than bogs, thereby supporting species that require a medium to rich nutrient status including sedges, bog birch, golden and brown mosses, and tamarack. Fens can be nutrient poor to extremely nutrient rich, with poor fens being transitional to bogs that support *Sphagnum* species and ericaceous shrubs. The dominant vegetative layer is determined by the water table location; drier sites support tree and shrub species while wetter sites promote the growth of graminoids and bryophytes (National Wetlands Working Group 1997). One type of fen was observed within the Grassy Mountain LSA: FONS.

Open shrubby fens without patterning or permafrost (FONS)

These fens are open with tree cover less than or equal to 6% and shrub cover greater than 25%. The dominant shrubs are either bog birch or willows growing below shoulder height. This type of fen usually occurs in small basins or flat areas that slope in the direction of drainage. No patterning or permafrost was present. In the TSA, the majority of FONS were found in the Yellowhead Tower area dominated by bog birch and were located near the river and major streams (g1 ecosite phase). Other fens characterized as FONS were part of treed fen complexes found between the ridges of the foothills.

Swamps

The term swamp is generally applied to forested or wooded wetlands occurring on either organic or mineral soil. Swamps are dominated by tree or shrub cover typically greater than 30%, in addition to having wood-rich peat if they occur on organic soils. They are characterized by their location, which is near water bodies that flood frequently or along peatlands that have fluctuating water levels (Halsey *et al*. 2003). The water table is usually at the ground surface, which allows shrubs and trees to grow taller than in most fens or bogs. Swamps may be open (shrubby) or forested. No patterning or internal lawns are present in swamps. Wooded coniferous swamps (STNN) were found in the LSA.

Wooded Coniferous Swamps (STNN)

Wooded swamps have 6 – 70% tree cover and usually exhibit denser and taller tree cover than fens or bogs due to shallow peat depths composed of woody material, allowing trees to achieve a greater rooting depth and growth index.

Marshes (MONG)

Marshes are open graminoid-dominated wetlands that occur on mineral soil. Characterized by seasonal changes in water level and high volumes of water flow, marshes are largely influenced by ground and surface waters (Halsey *et al*. 2003). Nitrogen and phosphorus concentrations are high, leading to rapid and abundant vascular plant growth. Marshes can be alkaline or saline, and water chemistry greatly influences species composition. Marshes are distinguished from other types by their lack of trees or shrubs, and by their association with streams, lakes, and shallow open water.

Shallow open waters (WONN)

This type of wetland represents small pools of water and is commonly associated with the other wetland types. Excluded from this type of wetland are water bodies greater than 2 m deep that function as aquatic systems. These wetland types are transitionary between terrestrial and aquatic environments, as evidenced by the presence of terrestrial and aquatic vegetation. There is no ecosite equivalent for this wetland type.

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APPENDIX G: NOXIOUS AND INVASIVE VEGETATION WITHIN THE LSA

Table G-1 Noxious and Invasive Vegetation in the LSA

Scientific Name	Common Name	Designation[1]	Easting[2]	Northing[2]
Agropyron repens	Quack grass	Agronomic invasive	687634	5507260
Bromus inermis	Smooth brome	Agronomic invasive	683979	5503966
			686307	5505561
			684112	5510221
			684634	5506297
			684104	5502449
Bromus tectorum	Downy brome	Noxious	686404	5506049
Cerastium arvense	Field chickweed	Agronomic invasive	683937	5500900
			684906	5504171
			686308	5505591
			686307	5505561
			686133	5506510
			686495	5507364
			685249	5509604
			684008	5501787
			684104	5502449
Chrysanthemum leucanthemum	Ox-eye daisy	Noxious	684621	5507053
			687663	5506257
			684973	5505234
			683935	5500867
			684648	5507056
			686808	5505278
Cirsium arvense	Creeping thistle	Noxious	683935	5500867
			686752	5504807
			684104	5502449
			686404	5506049
Cirsium vulgare	Bull thistle	Agronomic invasive	686404	5506049
Cynoglossum officinale	Hound's-tongue	Noxious	683935	5500867
Dactylis glomerata	Orchard grass	Agronomic invasive	683937	5500900
			686808	5505278
Echium vulgare	Blueweed	Noxious	686404	5506049
Glyceria grandis	Great manna grass	Agronomic invasive	686752	5504807
			683718	5500368
Linaria dalmatica	Dalmatian toadflax	Noxious	683937	5500900
			683935	5500867
			686404	5506049
			686404	5506049
			686404	5506049
Linaria vulgaris	Common toadflax	Noxious	686404	5506049

Table G-1 Noxious and Invasive Vegetation in the LSA				
Scientific Name	**Common Name**	**Designation[1]**	**Easting[2]**	**Northing[2]**
Medicago lupulina	Black medick	Agronomic invasive	683937	5500900
			684648	5507056
			685311	5504575
			683160	5500931
			683739	5500512
			684104	5502449
Phleum pratense	Timothy	Agronomic invasive	684028	5504203
			684350	5503928
			684203	5504313
			684284	5499714
			684973	5505234
			687398	5507936
			685345	5507690
			685605	5506814
			686808	5505278
			685311	5504575
			687200	5507354
			687634	5507260
			683474	5501748
			684104	5502449
			686404	5506049
Plantago major	Common plantain	Agronomic invasive	686752	5504807
			685311	5504575
Poa pratensis	Kentucky bluegrass	Agronomic invasive	686307	5505561
			684284	5499714
			687200	5507354
			686818	5507180
			685404	5504169
			683160	5500931
			683474	5501748
			683739	5500512
			684104	5502449
			685455	5504820
Potentilla argentea	Silvery cinquefoil	Agronomic invasive	684284	5499714

Table G-1 Noxious and Invasive Vegetation in the LSA

Scientific Name	Common Name	Designation[1]	Easting[2]	Northing[2]
Ranunculus acris	Tall buttercup	Noxious	684221	5504032
			684350	5503928
			684634	5506297
			683935	5500867
			684648	5507056
			684195	5507844
			683781	5505860
			684611	5505149
			686752	5504807
			686162	5504314
			685311	5504575
Rumex crispus	Curled dock	Agronomic invasive	686752	5504807
Senecio vulgaris	Common groundsel	Agronomic invasive	684051	5510410
			686808	5505278
Taraxacum officinale	Dandelion	Agronomic invasive	684906	5504171
			686133	5506510
			684350	5503928
			684203	5504313
			684425	5502680
			684284	5499714
			684973	5505234
			684634	5506297
			684648	5507056
			684051	5510410
			684829	5510469
			686808	5505278
			685311	5504575
			683739	5500512
Thlaspi arvense	Stinkweed	Agronomic invasive	686404	5506049
Tragopogon dubius	Common goat's-beard	Agronomic invasive	686307	5505561
			684203	5504313
			684284	5499714
Trifolium aureum	Yellow clover	Agronomic invasive	684284	5499714

Table G-1 Noxious and Invasive Vegetation in the LSA

Scientific Name	Common Name	Designation[1]	Easting[2]	Northing[2]
Trifolium hybridum	Alsike clover	Agronomic invasive	684350	5503928
			685311	5504575
			683160	5500931
			684183	5503336
			683739	5500512
			684008	5501787
			684104	5502449
Trifolium pratense	Red clover	Agronomic invasive	684195	5507844
Trifolium repens	White clover	Agronomic invasive	685076	5505105
			684734	5506090
			684221	5504032
			684350	5503928
			684104	5502449
Verbascum thapsus	Common mullein	Noxious	686307	5505561
			683935	5500867
			686404	5506049
			686404	5506049

[1] The Government of Alberta's *Weed Control Regulation* (2010) was used to determine noxious and prohibited noxious status of each species observed. For non-regulated species, the ACIMS (2014) tracking list was used to determine which vegetation species were categorized as invasive.

[2] UTM zone 11, NAD 83

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APPENDIX H: PDC COMPARISON SCENARIOS

Table H1 Fragmentation Statistics for PDC Comparison Scenarios in the RSA

ELC Class	# of Patches	Patch Area (ha)		% of RSA	Core Area		Patch Density (#/100 km²)	Total Perimeter (m)	Mean Perimeter: Area (m/ha)	Mean Distance to Nearest Neighbour (m)
		Mean	Total		ha	Index %				
Baseline Case (age 14 years) (T14)										
Barren Land	972	19.2	18650.5	6.6	16958.2	90.9	34	1797520.8	96.4	422.1
Open Regeneration - Herbaceous	85	1.2	98	<0.01	59.9	61.1	2	45102.4	460.3	528.3
Open Regeneration - Shrub	1434	12.7	18238.8	6.4	15738.6	86.3	50	2715866.6	148.9	328.7
Closed Regeneration - Forest	1428	12.1	17322.5	6.1	14797.1	85.4	50	2697887.2	155.7	341.7
Open Deciduous Young Forest	29	3.6	103.7	<0.01	77.2	74.5	1	28846.2	278.3	1729.4
Open Deciduous Mature Forest	237	6.3	1503.6	0.5	1144.4	76.1	8	384771.8	255.9	613.1
Open Deciduous Old Forest	129	5.9	761.8	0.3	571.1	75	4	203656.9	267.4	891.2
Open Mixed Young Forest	19	3.8	71.5	<0.01	53.6	75	0	19660.1	274.9	1434.3
Open Mixed Mature Forest	128	8.5	1081.8	0.4	862.4	79.7	4	233274.1	215.6	750.9
Open Mixed Old Forest	121	8.6	1035.4	0.4	783.6	75.7	4	268138.6	259	861.7
Open Conifer Young Forest	355	6.5	2302.3	0.8	1829.9	79.5	12	510544.5	221.8	563
Open Conifer Mature Forest	2762	9.5	26244.4	9.2	21196.8	80.8	97	5317128.1	202.6	371
Open Conifer Old Forest	859	7.7	6621.2	2.3	5247.1	79.2	30	1469300.1	221.9	459.7
Moderate Deciduous Young Forest	22	3.2	71.2	<0.01	50	70.2	0	22760.9	319.7	2171.3
Moderate Deciduous Mature Forest	788	3.5	2722.9	1	1926.8	70.8	27	860888.8	316.2	413.5
Moderate Deciduous Old Forest	281	4.6	1293.4	0.5	953.3	73.7	9	366770.1	283.6	632.2
Moderate Mixed Young Forest	10	11	109.9	<0.01	91.9	83.6	0	18548.4	168.8	1924.3

Table H1	Fragmentation Statistics for PDC Comparison Scenarios in the RSA									
ELC Class	# of Patches	Patch Area (ha)		% of RSA	Core Area		Patch Density (#/100 km²)	Total Perimeter (m)	Mean Perimeter: Area (m/ha)	Mean Distance to Nearest Neighbour (m)
		Mean	Total		ha	Index %				
Moderate Mixed Mature Forest	104	4.6	473.4	0.2	342.5	72.3	3	140484.7	296.7	924.4
Moderate Mixed Old Forest	935	3.6	3383.3	1.2	2275.4	67.3	32	1214231.8	358.9	293.4
Moderate Conifer Young Forest	369	6.8	2494.4	0.9	2010.9	80.6	12	530362.5	212.6	562.9
Moderate Conifer Mature Forest	2476	7.9	19484.1	6.9	15352.1	78.8	87	4373698.8	224.5	378.5
Moderate Conifer Old Forest	689	9.9	6791	2.4	5494.7	80.9	24	1394805.8	205.4	510
Closed Deciduous Young Forest	15	5.1	76.5	<0.01	55.8	72.9	0	22052.2	288.4	2257.7
Closed Deciduous Mature Forest	437	8.1	3521.4	1.2	2699.3	76.7	15	861435.6	244.6	549.4
Closed Deciduous Old Forest	374	6.7	2510.5	0.9	1943.2	77.4	13	597258.3	237.9	494.1
Closed Mixed Young Forest	301	7.2	2162.1	0.8	1747.4	80.8	10	453620.4	209.8	435.1
Closed Mixed Mature Forest	97	6.2	603.8	0.2	446.4	73.9	3	166659.1	276	929.7
Closed Mixed Old Forest	66	5.8	384.2	0.1	286.1	74.5	2	104714.4	272.5	1077.3
Closed Conifer Young Forest	239	7.9	1880.3	0.7	1537.3	81.8	8	371707.2	197.7	603
Closed Conifer Mature Forest	2783	11.9	33066.8	11.6	27242.9	82.4	97	6111724.9	184.8	348.9
Closed Conifer Old Forest	415	10.5	4345.2	1.5	3556.5	81.9	14	839802.6	193.3	530.7
Dense Deciduous Mature Forest	113	6.6	742.2	0.3	572.4	77.1	3	179945.2	242.4	647.4
Dense Deciduous Old Forest	86	5.6	477.8	0.2	373.9	78.3	3	111418.1	233.2	499
Dense Mixed Mature Forest	13	6.9	90	<0.01	69.3	77	0	22395.3	248.8	272.9
Dense Mixed Old Forest	1	15.1	15.1	<0.01	12.5	82.9	0	2620.2	173.9	-1
Dense Conifer Young Forest	25	7.8	194.8	0.1	158.1	81.2	0	39509.6	202.8	663
Dense Conifer Mature Forest	1283	11.6	14888.6	5.2	12389.9	83.2	45	2628957.8	176.6	354.9

Table H1 Fragmentation Statistics for PDC Comparison Scenarios in the RSA

ELC Class	# of Patches	Patch Area (ha)		% of RSA	Core Area		Patch Density (#/100 km²)	Total Perimeter (m)	Mean Perimeter: Area (m/ha)	Mean Distance to Nearest Neighbour (m)
		Mean	Total		ha	Index %				
Natural Shrub	1541	4.9	7555.5	2.7	5718.6	75.7	54	1966882.8	260.3	381
Natural Upland Herbaceous	2133	18.1	38513.7	13.6	33710	87.5	75	5080308.1	131.9	386.4
Natural Graminoid Wetland	41	3.9	158.5	0.1	116	73.2	10	45281.1	285.6	2538.2
Natural Shrub Wetland	107	7.1	762.7	0.3	593.5	77.8	3	181367.8	237.8	1187.9
Treed Wetland	50	2.5	126.5	<0.01	83.4	65.9	1	47394.5	374.7	2505.6
Industrial (Mining)	648	4.9	3183.6	1.1	2637.9	82.9	22	605400	190.2	427.1
Settlement	393	1.5	595.5	0.2	364.6	61.2	13	276768.8	464.8	235.8
Open Water	404	3.8	1544	0.5	1032	66.8	14	543673.4	352.1	761.9
Linear Disturbance	4940	1.5	7626	2.7	2710.8	35.5	173	8977126	1177.2	273
Agriculture	856	31.6	27010.7	9.5	24505.3	90.7	30	2647525.4	98	444.2
Dense Conifer Old Forest	62	12.4	767.4	0.3	635.6	82.8	2	138184	180.1	901.5
Dense Deciduous Young Forest	2	5.2	10.4	<0.01	8	76.9	0	2472.2	238.6	-1
Lush Herb	142	2.5	352	0.1	207.6	59	4	157693.9	447.9	296.7
Baseline Case (age 27 years) (T27)										
Barren Land	972	19.2	18650.5	6.6	16958.2	90.9	34	1797520.8	96.4	422.1
Open Regeneration - Herbaceous	85	1.2	98	<0.01	59.9	61.1	2	45102.4	460.3	528.3
Open Regeneration - Shrub	1434	12.7	18238.8	6.4	15738.6	86.3	50	2715866.6	148.9	328.7
Closed Regeneration - Forest	1428	12.1	17322.5	6.1	14797.1	85.4	50	2697887.2	155.7	341.7
Open Deciduous Young Forest	29	3.6	103.7	<0.01	77.2	74.5	1	28846.2	278.3	1729.4

Table H1 Fragmentation Statistics for PDC Comparison Scenarios in the RSA

ELC Class	# of Patches	Patch Area (ha)		% of RSA	Core Area		Patch Density (#/100 km²)	Total Perimeter (m)	Mean Perimeter: Area (m/ha)	Mean Distance to Nearest Neighbour (m)
		Mean	Total		ha	Index %				
Open Deciduous Mature Forest	237	6.3	1503.6	0.5	1144.4	76.1	8	384771.8	255.9	613.1
Open Deciduous Old Forest	129	5.9	761.8	0.3	571.1	75	4	203656.9	267.4	891.2
Open Mixed Young Forest	19	3.8	71.5	<0.01	53.6	75	0	19660.1	274.9	1434.3
Open Mixed Mature Forest	128	8.5	1081.8	0.4	862.4	79.7	4	233274.1	215.6	750.9
Open Mixed Old Forest	121	8.6	1035.4	0.4	783.6	75.7	4	268138.6	259	861.7
Open Conifer Young Forest	355	6.5	2302.3	0.8	1829.9	79.5	12	510544.5	221.8	563
Open Conifer Mature Forest	2762	9.5	26244.4	9.2	21196.8	80.8	97	5317128.1	202.6	371
Open Conifer Old Forest	859	7.7	6621.2	2.3	5247.1	79.2	30	1469300.1	221.9	459.7
Moderate Deciduous Young Forest	22	3.2	71.2	<0.01	50	70.2	0	22760.9	319.7	2171.3
Moderate Deciduous Mature Forest	788	3.5	2722.9	1	1926.8	70.8	27	860888.8	316.2	413.5
Moderate Deciduous Old Forest	281	4.6	1293.4	0.5	953.3	73.7	9	366770.1	283.6	632.2
Moderate Mixed Young Forest	10	11	109.9	<0.01	91.9	83.6	0	18548.4	168.8	1924.3
Moderate Mixed Mature Forest	104	4.6	473.4	0.2	342.5	72.3	3	140484.7	296.7	924.4
Moderate Mixed Old Forest	935	3.6	3383.3	1.2	2275.4	67.3	32	1214231.8	358.9	293.4
Moderate Conifer Young Forest	369	6.8	2494.4	0.9	2010.9	80.6	12	530362.5	212.6	562.9
Moderate Conifer Mature Forest	2476	7.9	19484.1	6.9	15352.1	78.8	87	4373698.8	224.5	378.5
Moderate Conifer Old Forest	689	9.9	6791	2.4	5494.7	80.9	24	1394805.8	205.4	510
Closed Deciduous Young Forest	15	5.1	76.5	<0.01	55.8	72.9	0	22052.2	288.4	2257.7

Table H1 Fragmentation Statistics for PDC Comparison Scenarios in the RSA

ELC Class	# of Patches	Patch Area (ha)		% of RSA	Core Area		Patch Density (#/100 km²)	Total Perimeter (m)	Mean Perimeter: Area (m/ha)	Mean Distance to Nearest Neighbour (m)
		Mean	Total		ha	Index %				
Closed Deciduous Mature Forest	437	8.1	3521.4	1.2	2699.3	76.7	15	861435.6	244.6	549.4
Closed Deciduous Old Forest	374	6.7	2510.5	0.9	1943.2	77.4	13	597258.3	237.9	494.1
Closed Mixed Young Forest	301	7.2	2162.1	0.8	1747.4	80.8	10	453620.4	209.8	435.1
Closed Mixed Mature Forest	97	6.2	603.8	0.2	446.4	73.9	3	166659.1	276	929.7
Closed Mixed Old Forest	66	5.8	384.2	0.1	286.1	74.5	2	104714.4	272.5	1077.3
Closed Conifer Young Forest	239	7.9	1880.3	0.7	1537.3	81.8	8	371707.2	197.7	603
Closed Conifer Mature Forest	2783	11.9	33066.8	11.6	27242.9	82.4	97	6111724.9	184.8	348.9
Closed Conifer Old Forest	415	10.5	4345.2	1.5	3556.5	81.9	14	839802.6	193.3	530.7
Dense Deciduous Mature Forest	113	6.6	742.2	0.3	572.4	77.1	3	179945.2	242.4	647.4
Dense Deciduous Old Forest	86	5.6	477.8	0.2	373.9	78.3	3	111418.1	233.2	499
Dense Mixed Mature Forest	13	6.9	90	<0.01	69.3	77	0	22395.3	248.8	272.9
Dense Mixed Old Forest	1	15.1	15.1	<0.01	12.5	82.9	0	2620.2	173.9	-1
Dense Conifer Young Forest	25	7.8	194.8	0.1	158.1	81.2	0	39509.6	202.8	663
Dense Conifer Mature Forest	1283	11.6	14888.6	5.2	12389.9	83.2	45	2628957.8	176.6	354.9
Natural Shrub	1541	4.9	7555.5	2.7	5718.6	75.7	54	1966882.8	260.3	381
Natural Upland Herbaceous	2133	18.1	38513.7	13.6	33710	87.5	75	5080308.1	131.9	386.4
Natural Graminoid Wetland	41	3.9	158.5	0.1	116	73.2	1	45281.1	285.6	2538.2
Natural Shrub Wetland	107	7.1	762.7	0.3	593.5	77.8	3	181367.8	237.8	1187.9
Treed Wetland	50	2.5	126.5	<0.01	83.4	65.9	1	47394.5	374.7	2505.6
Industrial (Mining)	648	4.9	3183.6	1.1	2637.9	82.9	22	605400	190.2	427.1

Table H1 Fragmentation Statistics for PDC Comparison Scenarios in the RSA

ELC Class	# of Patches	Patch Area (ha)		% of RSA	Core Area		Patch Density (#/100 km²)	Total Perimeter (m)	Mean Perimeter: Area (m/ha)	Mean Distance to Nearest Neighbour (m)
		Mean	Total		ha	Index %				
Settlement	393	1.5	595.5	0.2	364.6	61.2	13	276768.8	464.8	235.8
Open Water	404	3.8	1544	0.5	1032	66.8	14	543673.4	352.1	761.9
Linear Disturbance	4940	1.5	7626	2.7	2710.8	35.5	173	8977126	1177.2	273
Agriculture	856	31.6	27010.7	9.5	24505.3	90.7	30	2647525.4	98	444.2
Dense Conifer Old Forest	62	12.4	767.4	0.3	635.6	82.8	2	138184	180.1	901.5
Dense Deciduous Young Forest	2	5.2	10.4	<0.01	8	76.9	0	2472.2	238.6	-1
Lush Herb	142	2.5	352	0.1	207.6	59	4	157693.9	447.9	296.7
Baseline Case (age 41 years) (T41)										
Barren Land	972	19.2	18650.5	6.6	16958.2	90.9	34	1797520.8	96.4	422.1
Open Regeneration - Herbaceous	85	1.2	98	<0.01	59.9	61.1	2	45102.4	460.3	528.3
Open Regeneration – Shrub	1	0.5	0.5	<0.01	0.2	38.9	0	342.7	698	-1
Closed Regeneration - Forest	0	0	0	0	0	0	0	0	0	0
Open Deciduous Young Forest	7	8.9	62.2	<0.01	50.8	81.5	0	11935.1	191.7	7787.2
Open Deciduous Mature Forest	87	4.9	430.1	0.2	320.4	74.5	3	120390.5	279.9	801.5
Open Deciduous Old Forest	304	6.3	1922.9	0.7	1464.6	76.2	10	488176.2	253.9	664.8
Open Mixed Young Forest	0	0	0	0	0	0	0	0	0	0
Open Mixed Mature Forest	41	11.2	460.2	0.2	386.8	84	1	78386.9	170.3	868
Open Mixed Old Forest	221	7.8	1728.5	0.6	1315.4	76.1	7	439617.4	254.3	722.1
Open Conifer Young Forest	35	5.7	198.8	0.1	156.4	78.7	1	44905.6	225.9	821.4

Table H1 Fragmentation Statistics for PDC Comparison Scenarios in the RSA

ELC Class	# of Patches	Patch Area (ha)		% of RSA	Core Area		Patch Density (#/100 km²)	Total Perimeter (m)	Mean Perimeter: Area (m/ha)	Mean Distance to Nearest Neighbour (m)
		Mean	Total		ha	Index %				
Open Conifer Mature Forest	2318	8.7	20236.6	7.1	16340.3	80.7	81	4115094.4	203.3	382.7
Open Conifer Old Forest	1653	8.9	14732.5	5.2	11742.8	79.7	58	3167884.1	215	399.8
Moderate Deciduous Young Forest	2	0.9	1.8	<0.01	0.5	29.9	0	1441.7	789.6	47.3
Moderate Deciduous Mature Forest	97	4.8	469.5	0.2	346.2	73.7	3	132174.6	281.5	991.6
Moderate Deciduous Old Forest	994	3.6	3616.2	1.3	2580.2	71.3	34	1120013.7	309.7	390
Moderate Mixed Young Forest	0	0	0	0	0	0	0	0	0	0
Moderate Mixed Mature Forest	15	11.5	172.1	0.1	139.7	81.1	0	33304.4	193.5	1736.1
Moderate Mixed Old Forest	1029	3.7	3794.5	1.3	2572.5	67.8	36	1337389.3	352.5	304.2
Moderate Conifer Young Forest	23	6.5	149.9	0.1	113.9	75.9	0	38130.5	254.3	1430
Moderate Conifer Mature Forest	2111	7.6	15981.1	5.6	12673.6	79.3	74	3515381.2	220	395.5
Moderate Conifer Old Forest	1342	9.4	12638.5	4.4	10099.7	79.9	47	2693393.9	213.1	443.3
Closed Deciduous Young Forest	29	3.9	113.4	<0.01	82.7	72.9	1	32733.6	288.6	688.7
Closed Deciduous Mature Forest	117	8.4	986.7	0.3	769.3	78	4	228026	231.1	772
Closed Deciduous Old Forest	702	7.4	5208.3	1.8	4009.5	77	24	1259179.6	241.8	462.8
Closed Mixed Young Forest	1619	14.6	23598.2	8.3	20638.8	87.5	57	3224817.1	136.7	312.2
Closed Mixed Mature Forest	80	6.6	529.8	0.2	432.9	81.7	2	103067.4	194.5	780.8
Closed Mixed Old Forest	167	5.7	950	0.3	702.5	74	5	264565.4	278.5	666.3
Closed Conifer Young Forest	789	14.2	11189.2	3.9	9439.9	84.4	27	1835837.1	164.1	410.1

Table H1 Fragmentation Statistics for PDC Comparison Scenarios in the RSA

ELC Class	# of Patches	Patch Area (ha)		% of RSA	Core Area		Patch Density (#/100 km²)	Total Perimeter (m)	Mean Perimeter: Area (m/ha)	Mean Distance to Nearest Neighbour (m)
		Mean	Total		ha	Index %				
Closed Conifer Mature Forest	2688	11.7	31526.8	11.1	26067.1	82.7	94	5729858	181.7	349.9
Closed Conifer Old Forest	934	10.7	9962.9	3.5	8114.5	81.4	32	1951899.9	195.9	475.9
Dense Deciduous Mature Forest	9	8.8	79.2	<0.01	63.2	79.8	0	16689.6	210.7	4660.9
Dense Deciduous Old Forest	185	6.2	1151.2	0.4	892.9	77.6	6	274887.7	238.8	478.9
Dense Mixed Mature Forest	4	0.9	3.7	<0.01	1.9	51.8	0	2039	557	98.1
Dense Mixed Old Forest	10	10.1	101.4	<0.01	79.9	78.8	0	22976.5	226.6	5435.3
Dense Conifer Young Forest	0	0	0	0	0	0	0	0	0	0
Dense Conifer Mature Forest	1193	11.9	14164.4	5	11802.6	83.3	42	2482073.1	175.2	354
Natural Shrub	1541	4.9	7555.5	2.7	5718.6	75.7	54	1966882.8	260.3	381
Natural Upland Herbaceous	2133	18.1	38513.7	13.6	33710	87.5	75	5080308.1	131.9	386.4
Natural Graminoid Wetland	41	3.9	158.5	0.1	116	73.2	1	45281.1	285.6	2538.2
Natural Shrub Wetland	107	7.1	762.7	0.3	593.5	77.8	3	181367.8	237.8	1187.9
Treed Wetland	50	2.5	126.5	<0.01	83.4	65.9	1	47394.5	374.7	2505.6
Industrial (Mining)	648	4.9	3183.6	1.1	2637.9	82.9	22	605400	190.2	427.1
Settlement	393	1.5	595.5	0.2	364.6	61.2	13	276768.8	464.8	235.8
Open Water	404	3.8	1544	0.5	1032	66.8	14	543673.4	352.1	761.9
Linear Disturbance	4940	1.5	7626	2.7	2710.8	35.5	173	8977126	1177.2	273
Agriculture	856	31.6	27010.7	9.5	24505.3	90.7	30	2647525.4	98	444.2
Dense Conifer Old Forest	180	9.4	1686.4	0.6	1384.5	82.1	6	319172.4	189.3	635
Dense Deciduous Young Forest	0	0	0	0	0	0	0	0	0	0

Table H1 Fragmentation Statistics for PDC Comparison Scenarios in the RSA

ELC Class	# of Patches	Patch Area (ha)		% of RSA	Core Area		Patch Density (#/100 km²)	Total Perimeter (m)	Mean Perimeter: Area (m/ha)	Mean Distance to Nearest Neighbour (m)
		Mean	Total		ha	Index %				
Lush Herb	142	2.5	352	0.1	207.6	59	4	157693.9	447.9	296.7
Application Case (age 14 years) (T14)										
Barren Land	971	19.2	18647.4	6.6	16956.2	90.9	34	1796461.5	96.3	422.7
Open Regeneration - Herbaceous	87	1	84.8	<0.01	47.6	56.1	3	44320.5	522.6	513.5
Open Regeneration - Shrub	1434	12.7	18168.8	6.4	15684.3	86.3	50	2699429.2	148.6	327.1
Closed Regeneration - Forest	1417	12.2	17256.6	6.1	14745.8	85.5	49	2681765.5	155.4	341.4
Open Deciduous Young Forest	29	3.6	103.7	<0.01	77.2	74.5	1	28846.2	278.3	1729.4
Open Deciduous Mature Forest	237	6.3	1503.6	0.5	1144.4	76.1	8	384771.8	255.9	613.1
Open Deciduous Old Forest	127	5.9	753.6	0.3	565.3	75	4	201257.6	267.1	902.9
Open Mixed Young Forest	19	3.8	71.5	<0.01	53.6	75	0	19660.1	274.9	1434.3
Open Mixed Mature Forest	133	8.1	1079.7	0.4	860.6	79.7	4	233114.1	215.9	723.7
Open Mixed Old Forest	121	8.6	1035.4	0.4	783.6	75.7	4	268138.6	259	861.7
Open Conifer Young Forest	355	6.5	2302.3	0.8	1830	79.5	12	510505.9	221.7	563
Open Conifer Mature Forest	2764	9.4	26089.9	9.2	21069.6	80.8	97	5290532.8	202.8	369.8
Open Conifer Old Forest	851	7.8	6607.9	2.3	5236.2	79.2	29	1466608.7	221.9	462.4
Moderate Deciduous Young Forest	22	3.2	71.2	<0.01	50	70.2	0	22760.9	319.7	2171.3
Moderate Deciduous Mature Forest	788	3.5	2722.9	1	1926.8	70.8	27	860891.9	316.2	413.5

Table H1 Fragmentation Statistics for PDC Comparison Scenarios in the RSA										
ELC Class	# of Patches	Patch Area (ha)		% of RSA	Core Area		Patch Density (#/100 km²)	Total Perimeter (m)	Mean Perimeter: Area (m/ha)	Mean Distance to Nearest Neighbour (m)
		Mean	Total		ha	Index %				
Moderate Deciduous Old Forest	281	4.6	1293.4	0.5	953.3	73.7	9	366781.2	283.6	632.2
Moderate Mixed Young Forest	19	7.2	136	<0.01	112.9	83	0	25219.6	185.4	1415.9
Moderate Mixed Mature Forest	104	4.6	473.4	0.2	342.5	72.3	3	140492	296.8	924.4
Moderate Mixed Old Forest	931	3.6	3348.5	1.2	2247.7	67.1	32	1207160.2	360.5	295.8
Moderate Conifer Young Forest	368	6.7	2482.7	0.9	2001.1	80.6	12	528563.9	212.9	561.5
Moderate Conifer Mature Forest	2462	7.8	19269.4	6.8	15177.1	78.8	86	4331908.9	224.8	378.1
Moderate Conifer Old Forest	698	9.7	6742.4	2.4	5449.5	80.8	24	1392228	206.5	502.9
Closed Deciduous Young Forest	15	5.1	76.5	<0.01	55.8	72.9	0	22052.2	288.4	2257.7
Closed Deciduous Mature Forest	437	8.1	3521.4	1.2	2699.3	76.7	15	861550.1	244.7	549.4
Closed Deciduous Old Forest	374	6.7	2510.5	0.9	1943.2	77.4	13	597245.7	237.9	494.1
Closed Mixed Young Forest	301	7.2	2162.1	0.8	1747.4	80.8	10	453624.5	209.8	435.1
Closed Mixed Mature Forest	97	6.2	603.8	0.2	446.4	73.9	3	166659.1	276	929.7
Closed Mixed Old Forest	64	5.7	361.6	0.1	268.7	74.3	2	99374.2	274.8	1101.7
Closed Conifer Young Forest	248	8.9	2205.1	0.8	1837.2	83.3	8	397978.8	180.5	584.5
Closed Conifer Mature Forest	2806	11.7	32809.5	11.6	27018.5	82.3	98	6080023.3	185.3	346.3
Closed Conifer Old Forest	405	10.6	4292.7	1.5	3515.9	81.9	14	827082.5	192.7	548.4
Dense Deciduous Mature Forest	113	6.6	742.2	0.3	572.4	77.1	3	179945.2	242.4	647.4
Dense Deciduous Old Forest	86	5.6	477.8	0.2	373.9	78.3	3	111418.1	233.2	499
Dense Mixed Mature Forest	13	6.9	90	<0.01	69.3	77	0	22395.3	248.8	272.9
Dense Mixed Old Forest	1	15.1	15.1	<0.01	12.5	82.9	0	2620.2	173.9	-1

Table H1 Fragmentation Statistics for PDC Comparison Scenarios in the RSA										
ELC Class	# of Patches	Patch Area (ha)		% of RSA	Core Area		Patch Density (#/100 km²)	Total Perimeter (m)	Mean Perimeter: Area (m/ha)	Mean Distance to Nearest Neighbour (m)
		Mean	Total		ha	Index %				
Dense Conifer Young Forest	25	7.8	194.8	0.1	158.1	81.2	0	39525.9	202.9	663
Dense Conifer Mature Forest	1286	11.4	14690.5	5.2	12213.3	83.1	45	2607632.3	177.5	352.4
Natural Shrub	1543	4.9	7555.2	2.7	5718.2	75.7	54	1967051.4	260.4	379.6
Natural Upland Herbaceous	2120	18.2	38485.8	13.6	33691.7	87.5	74	5069688.4	131.7	386.4
Natural Graminoid Wetland	41	3.9	158.5	0.1	116	73.2	1	45281.1	285.6	2538.2
Natural Shrub Wetland	93	8.2	762.7	0.3	593.5	77.8	3	180937.9	237.2	1354
Treed Wetland	50	2.3	115.7	<0.01	74.3	64.2	1	45678.2	394.7	2501.8
Industrial (Mining)	637	6.4	4047	1.4	3488.7	86.2	22	615327.2	152	430.3
Settlement	397	1.5	586.1	0.2	356.3	60.8	13	275810.3	470.6	234.1
Open Water	402	3.8	1542.6	0.5	1031.5	66.9	14	542709.1	351.8	764.2
Linear Disturbance	4940	1.5	7635.5	2.7	2731.8	35.8	173	8912085.8	1167.2	272.9
Agriculture	855	31.6	27010.7	9.5	24505.3	90.7	30	2647555.3	98	444.7
Dense Conifer Old Forest	57	13.4	763.7	0.3	633.4	82.9	2	136430.1	178.6	974.7
Dense Deciduous Young Forest	2	5.2	10.4	<0.01	8	76.9	0	2472.2	238.6	-1
Lush Herb	142	2.5	352	0.1	207.6	59	4	157698.7	448	296.7
Planned Development Case with Project (age 14 years) (T14)										
Barren Land	975	19.1	18642.9	6.6	16953	90.9	34	1795582.1	96.3	418.5
Open Regeneration - Herbaceous	2900	5.8	16682.5	5.9	13355.9	80.1	102	3644943	218.5	240.4
Open Regeneration - Shrub	1954	8.7	16973.9	6	14617.5	86.1	68	2636300.2	155.3	248.9

Table H1 Fragmentation Statistics for PDC Comparison Scenarios in the RSA

ELC Class	# of Patches	Patch Area (ha)		% of RSA	Core Area		Patch Density (#/100 km²)	Total Perimeter (m)	Mean Perimeter: Area (m/ha)	Mean Distance to Nearest Neighbour (m)
		Mean	Total		ha	Index %				
Closed Regeneration - Forest	1554	10.9	16904.2	6	14410.4	85.2	54	2679873.8	158.5	309.8
Open Deciduous Young Forest	28	3.3	91.1	<0.01	68.1	74.8	0	25442.7	279.4	1663
Open Deciduous Mature Forest	242	6	1443.9	0.5	1098.4	76.1	8	373744.9	258.8	584.9
Open Deciduous Old Forest	134	5.6	746.9	0.3	559.7	74.9	4	200357.2	268.3	838.1
Open Mixed Young Forest	19	3.5	67.4	<0.01	50.2	74.5	0	19025.3	282.3	1366.6
Open Mixed Mature Forest	129	8	1027.6	0.4	825.1	80.3	4	215396.1	209.6	735
Open Mixed Old Forest	132	7.8	1023.6	0.4	775.4	75.8	4	265949.6	259.8	690.1
Open Conifer Young Forest	364	6.3	2291.9	0.8	1819.6	79.4	12	511771.2	223.3	551.3
Open Conifer Mature Forest	3394	7.1	24215.4	8.5	19469.5	80.4	119	5097595.7	210.5	297
Open Conifer Old Forest	1610	3.6	5826.5	2.1	4580.1	78.6	56	1424033	244.4	245.4
Moderate Deciduous Young Forest	23	3	69.3	<0.01	48.6	70.2	0	22345.8	322.4	1910.8
Moderate Deciduous Mature Forest	804	3.3	2676.2	0.9	1892.5	70.7	28	850545.7	317.8	397.6
Moderate Deciduous Old Forest	288	4.5	1281.8	0.5	944.3	73.7	10	364257.9	284.2	592.7
Moderate Mixed Young Forest	20	6.7	133.7	<0.01	111	83	0	24997.5	186.9	978.9
Moderate Mixed Mature Forest	113	4.1	460	0.2	331.6	72.1	3	139230.3	302.7	778.6
Moderate Mixed Old Forest	970	3.4	3303.6	1.2	2212.2	67	34	1200573.3	363.4	277.3
Moderate Conifer Young Forest	393	6.3	2460.2	0.9	1979.9	80.5	13	530834.1	215.8	526.7
Moderate Conifer Mature Forest	4815	3.5	16829.2	5.9	13224.4	78.6	169	4086697.7	242.8	198.6
Moderate Conifer Old Forest	1325	4.6	6132	2.2	4941.2	80.6	46	1359061.5	221.6	265

Table H1 Fragmentation Statistics for PDC Comparison Scenarios in the RSA										
ELC Class	# of Patches	Patch Area (ha)		% of RSA	Core Area		Patch Density (#/100 km²)	Total Perimeter (m)	Mean Perimeter: Area (m/ha)	Mean Distance to Nearest Neighbour (m)
		Mean	Total		ha	Index %				
Closed Deciduous Young Forest	15	5.1	76.5	<0.01	55.8	72.9	0	22052.3	288.4	2257.6
Closed Deciduous Mature Forest	451	7.8	3509.4	1.2	2690.3	76.7	15	860255.7	245.1	518.1
Closed Deciduous Old Forest	383	6.5	2490.8	0.9	1924.5	77.3	13	597671.5	240	476.3
Closed Mixed Young Forest	292	7.4	2148.3	0.8	1738.7	80.9	10	447266	208.2	445.2
Closed Mixed Mature Forest	112	5.3	593	0.2	439.9	74.2	3	164002	276.6	698.8
Closed Mixed Old Forest	97	3.6	345.4	0.1	256.9	74.4	3	97877.1	283.4	700.7
Closed Conifer Young Forest	278	7.8	2179.2	0.8	1812.7	83.2	9	400164.6	183.6	513.4
Closed Conifer Mature Forest	7304	3.8	27536.8	9.7	22284	80.9	257	6028972.8	218.9	153.7
Closed Conifer Old Forest	955	3.9	3728.6	1.3	3005.7	80.6	33	836093.1	224.2	236.2
Dense Deciduous Mature Forest	113	6.5	738.7	0.3	569.7	77.1	3	179099.3	242.5	628.1
Dense Deciduous Old Forest	86	5.6	477.8	0.2	373.9	78.3	3	111418.1	233.2	499
Dense Mixed Mature Forest	19	4.6	86.9	<0.01	67.5	77.6	0	21693.9	249.5	193.3
Dense Mixed Old Forest	1	15.1	15.1	<0.01	12.5	82.9	0	2620.2	173.9	-1
Dense Conifer Young Forest	27	7.2	194.8	0.1	158.1	81.2	0	39498.3	202.8	607.9
Dense Conifer Mature Forest	3783	3.1	11856.4	4.2	9741	82.2	133	2514082.7	212	146.3
Natural Shrub	1544	4.9	7554.5	2.7	5717.5	75.7	54	1967106.7	260.4	378.2
Natural Upland Herbaceous	2141	18	38471	13.5	33682.7	87.6	75	5065186	131.7	383.1
Natural Graminoid Wetland	52	2.9	151.9	0.1	110.2	72.6	1	45445.1	299.2	2003.1
Natural Shrub Wetland	95	8	761.2	0.3	592.5	77.8	3	180753.3	237.4	1306.8
Treed Wetland	62	1.6	102.1	<0.01	65.5	64.2	2	43443.5	425.5	1806
Industrial (Mining)	636	6.3	4035.7	1.4	3480.4	86.2	22	612307.5	151.7	425

Table H1 Fragmentation Statistics for PDC Comparison Scenarios in the RSA

ELC Class	# of Patches	Patch Area (ha)		% of RSA	Core Area		Patch Density (#/100 km²)	Total Perimeter (m)	Mean Perimeter: Area (m/ha)	Mean Distance to Nearest Neighbour (m)
		Mean	Total		ha	Index %				
Settlement	397	1.5	586.1	0.2	356.3	60.8	13	275810.3	470.6	234.1
Open Water	403	3.8	1540.5	0.5	1030.1	66.9	14	542436.7	352.1	760.9
Linear Disturbance	5626	1.3	7486.7	2.6	2680.8	35.8	198	8668739.2	1157.9	244.9
Agriculture	855	31.6	27010.7	9.5	24505.3	90.7	30	2647556.3	98	444.7
Dense Conifer Old Forest	120	5.8	700.7	0.2	579	82.6	4	133895	191.1	469.7
Dense Deciduous Young Forest	2	5.2	10.4	<0.01	8	76.9	0	2472.2	238.6	-1
Lush Herb	142	2.5	352	0.1	207.6	59	4	157698.7	448	296.7
Planned Development Case with Project (age 27 years) (T27)										
Barren Land	985	19	18675	6.6	16981	90.9	34	1800615.9	96.4	414
Open Regeneration - Herbaceous	1832	1.8	3296.5	1.2	2249.2	68.2	64	1262922.6	383.1	229.6
Open Regeneration - Shrub	1843	7.3	13372.7	4.7	11011.7	82.3	64	2527304.7	189	234.8
Closed Regeneration - Forest	1978	8.8	17309.6	6.1	14886.3	86	69	2706044.8	156.3	247.8
Open Deciduous Young Forest	11	8.6	95.1	<0.01	77.9	81.9	0	17906.4	188.3	3888.3
Open Deciduous Mature Forest	235	5.7	1336.6	0.5	1006.3	75.3	8	356348.9	266.6	614.2
Open Deciduous Old Forest	168	5.3	896.1	0.3	675	75.3	5	239020.6	266.7	831.6
Open Mixed Young Forest	6	2.1	12.6	<0.01	8.8	69.4	0	4204	332.9	4287.9
Open Mixed Mature Forest	96	8.1	780.9	0.3	632.4	81	3	158383.6	202.8	916.7
Open Mixed Old Forest	171	7.7	1316.4	0.5	1003.6	76.2	6	334600.5	254.2	606.6
Open Conifer Young Forest	178	4.8	862.4	0.3	668.9	77.6	6	211601.1	245.3	680.6

Table H1 Fragmentation Statistics for PDC Comparison Scenarios in the RSA

ELC Class	# of Patches	Patch Area (ha)		% of RSA	Core Area		Patch Density (#/100 km²)	Total Perimeter (m)	Mean Perimeter: Area (m/ha)	Mean Distance to Nearest Neighbour (m)
		Mean	Total		ha	Index %				
Open Conifer Mature Forest	3142	7.5	23428.6	8.2	18862.1	80.5	110	4885612.8	208.5	313.7
Open Conifer Old Forest	2101	3.8	8020	2.8	6296.2	78.5	73	1955250.4	243.8	234.3
Moderate Deciduous Young Forest	11	3.8	42.2	<0.01	30.5	72.3	0	12546.4	297.1	1268.5
Moderate Deciduous Mature Forest	310	5.7	1760.9	0.6	1303.1	74	10	486177.8	276.1	604.2
Moderate Deciduous Old Forest	798	2.8	2224.1	0.8	1550.5	69.7	28	740010.5	332.7	377.2
Moderate Mixed Young Forest	359	0.7	242.1	0.1	200.2	82.7	12	52404.4	216.5	86.6
Moderate Mixed Mature Forest	91	4.1	374.1	0.1	272.7	72.9	3	110508.6	295.4	869.1
Moderate Mixed Old Forest	995	3.4	3394.8	1.2	2275	67	35	1230878.2	362.6	282.3
Moderate Conifer Young Forest	234	6.2	1455.2	0.5	1176.5	80.8	8	311079.8	213.8	576.6
Moderate Conifer Mature Forest	4570	3.6	16654.8	5.9	13094.3	78.6	160	4016000.3	241.1	207.1
Moderate Conifer Old Forest	1726	4.2	7216.6	2.5	5792.2	80.3	60	1634210.1	226.5	242.8
Closed Deciduous Young Forest	4	2.4	9.4	<0.01	6.3	66.8	0	3338.9	354.7	3144.4
Closed Deciduous Mature Forest	440	7.7	3382.5	1.2	2593	76.7	15	829664.1	245.3	492.8
Closed Deciduous Old Forest	414	6.5	2679.3	0.9	2063.4	77	14	650129.1	242.7	496.7
Closed Mixed Young Forest	1189	9.6	11400	4	9608	84.3	41	1948870.9	171	306.3
Closed Mixed Mature Forest	81	5.7	459.7	0.2	344.2	74.9	2	122119.4	265.7	693
Closed Mixed Old Forest	131	3.6	471.5	0.2	344.7	73.1	4	140550.9	298.1	617.5
Closed Conifer Young Forest	1043	9.2	9551.5	3.4	8221.8	86.1	36	1448618.7	151.7	280.5

Table H1 Fragmentation Statistics for PDC Comparison Scenarios in the RSA

ELC Class	# of Patches	Patch Area (ha)		% of RSA	Core Area		Patch Density (#/100 km²)	Total Perimeter (m)	Mean Perimeter: Area (m/ha)	Mean Distance to Nearest Neighbour (m)
		Mean	Total		ha	Index %				
Closed Conifer Mature Forest	7315	3.8	27620.8	9.7	22374.2	81	257	6019343.3	217.9	153.3
Closed Conifer Old Forest	1041	4.1	4307.8	1.5	3469.5	80.5	36	962067.5	223.3	250.4
Dense Deciduous Mature Forest	112	6.5	724.3	0.3	558.9	77.2	3	175450.7	242.2	598.3
Dense Deciduous Old Forest	88	5.6	497.1	0.2	388.6	78.2	3	116086	233.5	568.3
Dense Mixed Mature Forest	11	1	11.2	<0.01	7.9	70.5	0	4182.5	373.8	174.3
Dense Mixed Old Forest	9	10.1	90.8	<0.01	72.1	79.4	0	20131.6	221.7	916.6
Dense Conifer Young Forest	10	5	50.1	<0.01	38.5	76.7	0	12847.7	256.3	308
Dense Conifer Mature Forest	3762	3.2	11915.3	4.2	9806.9	82.3	132	2504300.5	210.2	146.1
Natural Shrub	1544	4.9	7547.8	2.7	5711.5	75.7	54	1966032.6	260.5	378.7
Natural Upland Herbaceous	2260	17.1	38656.5	13.6	33852.1	87.6	79	5085205.5	131.5	365.4
Natural Graminoid Wetland	52	2.9	151.9	0.1	110.2	72.6	1	45445.1	299.2	2003.1
Natural Shrub Wetland	95	8	760.9	0.3	592.2	77.8	3	180724.9	237.5	1306.8
Treed Wetland	65	1.7	108.1	<0.01	69.8	64.6	2	45244.4	418.5	1699.1
Industrial (Mining)	631	4.8	3036.5	1.1	2525.3	83.2	22	567739.9	187	426.5
Settlement	397	1.5	585.9	0.2	356.3	60.8	13	275703	470.6	234.1
Open Water	407	3.9	1591.8	0.6	1075.9	67.6	14	548443.7	344.5	770.2
Linear Disturbance	5602	1.3	7503	2.6	2703.7	36	197	8649836.4	1152.9	245
Agriculture	855	31.6	27010.7	9.5	24505.3	90.7	30	2647556.3	98	444.7
Dense Conifer Old Forest	125	6.2	775.3	0.3	640.4	82.6	4	147518.6	190.3	587.1
Dense Deciduous Young Forest	1	5.4	5.4	<0.01	4	74	0	1452.9	266.7	-1

Table H1 Fragmentation Statistics for PDC Comparison Scenarios in the RSA

ELC Class	# of Patches	Patch Area (ha)		% of RSA	Core Area		Patch Density (#/100 km²)	Total Perimeter (m)	Mean Perimeter: Area (m/ha)	Mean Distance to Nearest Neighbour (m)
		Mean	Total		ha	Index %				
Lush Herb	142	2.5	352	0.1	207.6	59	4	157698.7	448	296.7
Planned Development Case with Project (age 41 years) (T41)										
Barren Land	985	19	18675	6.6	16981	90.9	34	1800615.9	96.4	414
Open Regeneration - Herbaceous	87	1	82.9	<0.01	46.5	56	3	43580.2	525.5	513.4
Open Regeneration - Shrub	1	0.5	0.5	<0.01	0.2	38.9	0	342.7	698	-1
Closed Regeneration - Forest	2809	5.9	16585.9	5.8	13298.9	80.2	98	3597686.1	216.9	240
Open Deciduous Young Forest	7	8.9	62.1	<0.01	50.5	81.4	0	12079.7	194.6	7790.4
Open Deciduous Mature Forest	88	4.8	426.8	0.2	318.2	74.6	3	119382.3	279.7	791.7
Open Deciduous Old Forest	314	5.9	1839	0.6	1398.8	76.1	11	473237.4	257.3	638.2
Open Mixed Young Forest	0	0	0	0	0	0	0	0	0	0
Open Mixed Mature Forest	42	10.9	458.8	0.2	385.6	84	1	78374.9	170.8	826.7
Open Mixed Old Forest	231	7.1	1651.1	0.6	1259.1	76.3	8	418813.3	253.7	661.3
Open Conifer Young Forest	35	5.7	198.8	0.1	156.3	78.6	1	45006.2	226.4	823.7
Open Conifer Mature Forest	2620	7.3	19038.2	6.7	15307.5	80.4	92	3987214.7	209.4	334.7
Open Conifer Old Forest	2832	4.6	13074.2	4.6	10336.8	79.1	99	3053881.6	233.6	240
Moderate Deciduous Young Forest	2	0.9	1.8	<0.01	0.5	29.9	0	1441.7	789.6	47.3

Table H1 Fragmentation Statistics for PDC Comparison Scenarios in the RSA

ELC Class	# of Patches	Patch Area (ha)		% of RSA	Core Area		Patch Density (#/100 km²)	Total Perimeter (m)	Mean Perimeter: Area (m/ha)	Mean Distance to Nearest Neighbour (m)
		Mean	Total		ha	Index %				
Moderate Deciduous Mature Forest	98	4.8	466.9	0.2	344.3	73.7	3	131644.6	282	944.5
Moderate Deciduous Old Forest	1017	3.5	3558.6	1.3	2537.4	71.3	35	1107273.3	311.2	373.8
Moderate Mixed Young Forest	352	0.4	139.8	<0.01	114	81.6	12	35758.3	255.8	30.1
Moderate Mixed Mature Forest	16	10.6	169.8	0.1	137.7	81.1	0	33083.1	194.9	1169.9
Moderate Mixed Old Forest	1073	3.4	3701.4	1.3	2498.4	67.5	37	1322545	357.3	289.6
Moderate Conifer Young Forest	40	3.2	129.4	<0.01	97.3	75.2	1	35870.7	277.3	604.2
Moderate Conifer Mature Forest	3302	4.3	14305.5	5	11302.1	79	116	3336205	233.2	254.4
Moderate Conifer Old Forest	3201	3.4	10891.7	3.8	8643	79.4	112	2607926	239.4	194.8
Closed Deciduous Young Forest	36	3	107.7	<0.01	78.6	73	1	31827.8	295.5	539.6
Closed Deciduous Mature Forest	117	7.7	901.7	0.3	696.1	77.2	4	216118.5	239.7	716.4
Closed Deciduous Old Forest	726	7.1	5169.5	1.8	3973.5	76.9	25	1259630.4	243.7	439.5
Closed Mixed Young Forest	1852	12.4	22951.8	8.1	20058.6	87.4	65	3185907.9	138.8	275.5
Closed Mixed Mature Forest	74	7.1	526.5	0.2	431.1	81.9	2	100810.3	191.5	861
Closed Mixed Old Forest	205	4.3	882.1	0.3	652.7	74	7	249389.7	282.7	538.4
Closed Conifer Young Forest	1569	7.3	11400.6	4	9674.1	84.9	55	1913183.6	167.8	223.3
Closed Conifer Mature Forest	6670	4	26795.2	9.4	21823.3	81.4	234	5662892.1	211.3	160.2
Closed Conifer Old Forest	2225	3.8	8457.1	3	6806	80.5	78	1901512.1	224.8	209.6
Dense Deciduous Mature Forest	9	8.8	79.2	<0.01	63.2	79.8	0	16689.6	210.7	4660.9

Table H1 Fragmentation Statistics for PDC Comparison Scenarios in the RSA										
ELC Class	# of Patches	Patch Area (ha)		% of RSA	Core Area		Patch Density (#/100 km²)	Total Perimeter (m)	Mean Perimeter: Area (m/ha)	Mean Distance to Nearest Neighbour (m)
		Mean	Total		ha	Index %				
Dense Deciduous Old Forest	185	6.2	1147.6	0.4	890.2	77.6	6	274041.9	238.8	474.5
Dense Mixed Mature Forest	10	0.1	0.6	<0.01	0.1	15.8	0	1337.6	2212.5	51.9
Dense Mixed Old Forest	10	10.1	101.4	<0.01	79.9	78.8	0	22976.5	226.6	5435.3
Dense Conifer Young Forest	0	0	0	0	0	0	0	0	0	0
Dense Conifer Mature Forest	3639	3.1	11200.3	3.9	9215.9	82.3	128	2368965.1	211.5	141.8
Natural Shrub	1544	4.9	7547.8	2.7	5711.5	75.7	54	1966032.6	260.5	378.7
Natural Upland Herbaceous	2260	17.1	38656.5	13.6	33852.1	87.6	79	5085205.5	131.5	365.4
Natural Graminoid Wetland	52	2.9	151.9	0.1	110.2	72.6	1	45445.1	299.2	2003.1
Natural Shrub Wetland	95	8	760.9	0.3	592.2	77.8	3	180724.9	237.5	1306.8
Treed Wetland	65	1.7	108.1	<0.01	69.8	64.6	2	45244.4	418.5	1699.1
Industrial (Mining)	631	4.8	3036.5	1.1	2525.3	83.2	22	567739.9	187	426.5
Settlement	397	1.5	585.9	0.2	356.3	60.8	13	275703	470.6	234.1
Open Water	407	3.9	1591.8	0.6	1075.9	67.6	14	548443.7	344.5	770.2
Linear Disturbance	5602	1.3	7503	2.6	2703.7	36	197	8649836.4	1152.9	245
Agriculture	855	31.6	27010.7	9.5	24505.3	90.7	30	2647556.3	98	444.7
Dense Conifer Old Forest	321	4.8	1540.5	0.5	1263.2	82	11	307515.1	199.6	347.9
Dense Deciduous Young Forest	0	0	0	0	0	0	0	0	0	0
Lush Herb	142	2.5	352	0.1	207.6	59	4	157698.7	448	296.7

Table H1 Fragmentation Statistics for PDC Comparison Scenarios in the RSA

ELC Class	# of Patches	Patch Area (ha)		% of RSA	Core Area		Patch Density (#/100 km²)	Total Perimeter (m)	Mean Perimeter: Area (m/ha)	Mean Distance to Nearest Neighbour (m)
		Mean	Total		ha	Index %				
Planned Development Case without Project (age 41 years) (T41)										
Barren Land	976	19.1	18645.5	6.6	16954.4	90.9	34	1796853	96.4	417.4
Open Regeneration - Herbaceous	1131	2.1	2378	0.8	1793.6	75.4	39	698030.4	293.5	216.9
Open Regeneration - Shrub	1	0.5	0.5	<0.01	0.2	38.9	0	342.7	698	-1
Closed Regeneration - Forest	2822	5.9	16765.9	5.9	13452.1	80.2	99	3626002.1	216.3	240.1
Open Deciduous Young Forest	7	8.9	62.1	<0.01	50.5	81.4	0	12079.7	194.6	7790.4
Open Deciduous Mature Forest	88	4.8	426.8	0.2	318.2	74.6	3	119382.3	279.7	791.7
Open Deciduous Old Forest	313	5.9	1835.9	0.6	1396.7	76.1	11	472242.2	257.2	641.3
Open Mixed Young Forest	0	0	0	0	0	0	0	0	0	0
Open Mixed Mature Forest	40	11.5	458.6	0.2	385.6	84.1	1	77873.3	169.8	860.9
Open Mixed Old Forest	229	7.2	1659.7	0.6	1265.5	76.2	8	421261.9	253.8	654
Open Conifer Young Forest	35	5.7	198.8	0.1	156.3	78.6	1	45006.2	226.4	823.7
Open Conifer Mature Forest	2572	7.3	18689.5	6.6	15022.5	80.4	90	3918371.3	209.7	335.9
Open Conifer Old Forest	2705	4.7	12726.4	4.5	10072.2	79.1	95	2954061.1	232.1	245.5
Moderate Deciduous Young Forest	2	0.9	1.8	<0.01	0.5	29.9	0	1441.7	789.6	47.3
Moderate Deciduous Mature Forest	98	4.8	466.9	0.2	344.3	73.7	3	131644.6	282	944.5

Table H1 Fragmentation Statistics for PDC Comparison Scenarios in the RSA										
ELC Class	# of Patches	Patch Area (ha)		% of RSA	Core Area		Patch Density (#/100 km²)	Total Perimeter (m)	Mean Perimeter: Area (m/ha)	Mean Distance to Nearest Neighbour (m)
		Mean	Total		ha	Index %				
Moderate Deciduous Old Forest	1006	3.5	3547.7	1.2	2530.5	71.3	35	1102517.3	310.8	377.1
Moderate Mixed Young Forest	0	0	0	0	0	0	0	0	0	0
Moderate Mixed Mature Forest	16	10.6	169.8	0.1	137.7	81.1	0	33083.1	194.9	1169.9
Moderate Mixed Old Forest	1069	3.5	3722.1	1.3	2516.6	67.6	37	1324556.7	355.9	286.9
Moderate Conifer Young Forest	44	3.1	134.9	<0.01	101	74.9	1	38786.1	287.6	535
Moderate Conifer Mature Forest	3195	4.4	14130.1	5	11163.6	79	112	3291410.7	232.9	259.1
Moderate Conifer Old Forest	3161	3.4	10813.4	3.8	8588.9	79.4	111	2581311.1	238.7	196
Closed Deciduous Young Forest	36	3	107.7	<0.01	78.6	73	1	31827.9	295.5	539.6
Closed Deciduous Mature Forest	116	7.7	888.8	0.3	685.9	77.2	4	213356.8	240	730.4
Closed Deciduous Old Forest	726	7.1	5169.5	1.8	3973.5	76.9	25	1259630.4	243.7	439.5
Closed Mixed Young Forest	1846	12.5	23069.9	8.1	20153.8	87.4	64	3209454	139.1	277.9
Closed Mixed Mature Forest	74	7.1	526.5	0.2	431.1	81.9	2	100810.3	191.5	861
Closed Mixed Old Forest	204	4.3	882.7	0.3	652.7	73.9	7	250111.3	283.3	525
Closed Conifer Young Forest	1216	8.4	10272.1	3.6	8622.9	83.9	42	1788744.5	174.1	271.3
Closed Conifer Mature Forest	6401	4.1	26509.7	9.3	21595.6	81.5	225	5577963	210.4	163.5
Closed Conifer Old Forest	2209	3.8	8391.4	3	6756.8	80.5	77	1884229.4	224.5	210.8
Dense Deciduous Mature Forest	9	8.8	79.2	<0.01	63.2	79.8	0	16689.6	210.7	4660.9
Dense Deciduous Old Forest	185	6.2	1147.6	0.4	890.2	77.6	6	274041.9	238.8	474.5

Table H1 Fragmentation Statistics for PDC Comparison Scenarios in the RSA										
ELC Class	# of Patches	Patch Area (ha)		% of RSA	Core Area		Patch Density (#/100 km²)	Total Perimeter (m)	Mean Perimeter: Area (m/ha)	Mean Distance to Nearest Neighbour (m)
		Mean	Total		ha	Index %				
Dense Mixed Mature Forest	10	0.1	0.6	<0.01	0.1	15.8	0	1337.6	2212.5	51.9
Dense Mixed Old Forest	2	12.8	25.6	<0.01	20.3	79.1	0	5465	213.1	-1
Dense Conifer Young Forest	0	0	0	0	0	0	0	0	0	0
Dense Conifer Mature Forest	3561	3.2	11221.5	4	9252	82.4	125	2349188.4	209.3	142.8
Natural Shrub	1542	4.9	7548.1	2.7	5711.8	75.7	54	1965821.5	260.4	379
Natural Upland Herbaceous	2162	17.8	38480	13.5	33682.2	87.5	76	5076581.3	131.9	381
Natural Graminoid Wetland	52	2.9	151.9	0.1	110.2	72.6	1	45445.1	299.2	2003.1
Natural Shrub Wetland	95	8	760.9	0.3	592.2	77.8	3	180724.9	237.5	1306.8
Treed Wetland	62	1.8	112.8	<0.01	74.6	66.1	2	45159.7	400.2	1809
Industrial (Mining)	647	5	3252.4	1.1	2705.2	83.2	22	606839.4	186.6	421.9
Settlement	392	1.5	595.3	0.2	364.6	61.2	13	276658.3	464.8	236.2
Open Water	405	3.8	1539.9	0.5	1029.1	66.8	14	543214.9	352.7	759
Linear Disturbance	5635	1.3	7556.4	2.7	2723.4	36	198	8744165.3	1157.2	244.4
Agriculture	855	31.6	27010.7	9.5	24505.3	90.7	30	2647556.3	98	444.7
Dense Conifer Old Forest	298	5.2	1537.2	0.5	1260.7	82	10	304466.4	198.1	372
Dense Deciduous Young Forest	0	0	0	0	0	0	0	0	0	0
Lush Herb	142	2.5	352	0.1	207.6	59	4	157698.7	448	296.7

Fragmentation Statistics for a Comparison Scenario in the RSA – Baseline Case and Application Case at T27										
ELC Classes	**Difference Between Baseline and Application at T14**									
	# of Patches	**Mean Patch Size (ha)**	**Total Area of Patch Type (ha)**	**Core Area (ha)**	**Patch Density (#/100 km²)**	**% of RSA**	**Perimeter Length (m)**	**Mean Perimeter : Area (m / ha)**	**Core Area Index (%)**	**Mean Distance to Nearest Neighbour (m)**
Open Regeneration - Herbaceous	-1747	-0.6	-3198.6	-2189.3	-62	-1.1	-1217820.2	77.2	-7.1	298.7
Open Regeneration - Shrub	-1842	-6.8	-13372.2	-11011.5	-64	-4.7	-2526962.0	509.0	-43.4	-235.8
Closed Regeneration - Forest	-524	4.0	1266.6	1122.0	-18	0.4	79918.5	-6.4	0.2	78.6
Open Deciduous Young Forest	0	<0.01	0.4	0.4	0	<0.01	-106.9	-1.9	0.1	-1.8
Open Deciduous Mature Forest	3	0.1	32.5	23.0	0	<0.01	9065.2	0.3	-0.1	9.5
Open Deciduous Old Forest	-14	0.8	54.4	44.8	0	<0.01	6844.0	-8.1	0.4	98.3
Open Mixed Young Forest	-1	0.5	0.3	0.3	0	<0.01	-97.3	-14.8	0.5	5332.3
Open Mixed Mature Forest	5	0.2	65.4	45.3	0	<0.01	21587.3	9.8	-0.9	-28.8
Open Mixed Old Forest	-11	0.6	13.1	9.4	-1	<0.01	2297.1	-0.8	0.0	120.2

Fragmentation Statistics for a Comparison Scenario in the RSA – Baseline Case and Application Case at T27

ELC Classes	Difference Between Baseline and Application at T14									
	# of Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)	Core Area (ha)	Patch Density (#/100 km²)	% of RSA	Perimeter Length (m)	Mean Perimeter : Area (m / ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
Open Conifer Young Forest	-4	0.1	6.6	6.1	0	<0.01	-422.3	-2.3	0.1	13.3
Open Conifer Mature Forest	-468	1.9	1654.6	1423.6	-16	0.6	167758.5	-7.1	0.4	60.0
Open Conifer Old Forest	-985	4.4	1195.5	1013.3	-34	0.4	71251.5	-23.9	0.8	197.1
Moderate Deciduous Young Forest	1	-0.3	0.3	0.3	0	<0.01	64.2	-0.3	0.2	-121.9
Moderate Deciduous Mature Forest	-3	0.2	36.5	27.2	0	<0.01	8506.8	-0.9	<0.01	26.1
Moderate Deciduous Old Forest	-22	0.1	23.5	17.2	-1	<0.01	4699.4	-1.4	<0.01	15.6
Moderate Mixed Young Forest	-352	14.2	-137.6	-112.2	-12	<0.01	-35582.2	-55.4	1.6	5285.5
Moderate Mixed Mature Forest	-9	0.6	12.8	10.2	-1	<0.01	1342.2	-6.3	0.2	193.9
Moderate Mixed Old Forest	-36	0.2	80.4	63.9	-2	<0.01	13617.4	-4.5	0.3	18.1

Fragmentation Statistics for a Comparison Scenario in the RSA – Baseline Case and Application Case at T27

ELC Classes	Difference Between Baseline and Application at T14									
	# of Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)	Core Area (ha)	Patch Density (#/100 km^2)	% of RSA	Perimeter Length (m)	Mean Perimeter : Area (m / ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
Moderate Conifer Young Forest	-20	0.7	30.6	27.2	-1	<0.01	426.9	-4.1	0.2	59.1
Moderate Conifer Mature Forest	-2167	4.3	2419.5	1978.7	-76	0.9	216669.9	-19.2	0.4	177.0
Moderate Conifer Old Forest	-910	5.9	992.9	827.2	-32	0.3	58627.7	-20.2	0.4	261.2
Closed Deciduous Young Forest	5	8.0	83.4	72.1	0	<0.01	11710.0	-192.6	17.6	-1054.8
Closed Deciduous Mature Forest	-19	0.4	19.5	17.1	-1	<0.01	549.9	-1.2	0.1	28.7
Closed Deciduous Old Forest	-10	0.2	21.0	20.0	0	<0.01	-803.2	-2.2	0.1	25.4
Closed Mixed Young Forest	-99	1.1	220.3	207.7	-3	0.1	2913.7	-3.0	0.2	29.6
Closed Mixed Mature Forest	5	<0.01	24.6	17.3	1	<0.01	8409.8	3.9	-0.2	51.7
Closed Mixed Old Forest	-38	1.9	44.3	32.7	-1	<0.01	8242.5	-9.6	0.1	295.9

Fragmentation Statistics for a Comparison Scenario in the RSA – Baseline Case and Application Case at T27										
ELC Classes	Difference Between Baseline and Application at T14									
	# of Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)	Core Area (ha)	Patch Density (#/100 km²)	% of RSA	Perimeter Length (m)	Mean Perimeter : Area (m / ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
Closed Conifer Young Forest	-390	3.9	-1011.5	-943.7	-14	-0.4	-119879.5	3.9	-0.9	146.5
Closed Conifer Mature Forest	-4552	8.2	5462.7	4909.3	-160	1.9	66787.9	-34.0	1.5	196.4
Closed Conifer Old Forest	-561	6.4	742.4	656.2	-20	0.3	20375.8	-28.8	1.2	285.9
Dense Deciduous Mature Forest	0	0.0	3.6	2.7	0	<0.01	845.9	0.0	<0.01	19.5
Dense Deciduous Old Forest	0	0	0	0	0	0	0	0	0	0
Dense Mixed Mature Forest	-6	1.8	3.1	1.8	0	<0.01	701.3	-31.0	-2.5	184.0
Dense Mixed Old Forest	0	0	0	0	0	0	0	0	0	0
Dense Conifer Young Forest	0	<0.01	<0.01	<0.01	0	<0.01	<0.01	<0.01	<0.01	<0.01
Dense Conifer Mature Forest	-2487	8.6	3042.8	2659.4	-88	1.1	115797.9	-35.0	1.0	207.2

Fragmentation Statistics for a Comparison Scenario in the RSA – Baseline Case and Application Case at T27										
ELC Classes	Difference Between Baseline and Application at T14									
	# of Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)	Core Area (ha)	Patch Density (#/100 km²)	% of RSA	Perimeter Length (m)	Mean Perimeter : Area (m / ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
Barren Land	-13	0.2	-24.5	-22.8	0	0.0	-3095.1	0.0	0.0	8.1
Natural Shrub	-3	0.0	7.7	7.1	0	0.0	850.2	-0.2	0.0	2.3
Natural Upland Herbaceous	-127	1.0	-142.8	-142.1	-4	-0.1	-4897.5	0.4	0.0	21.0
Natural Graminoid Wetland	-11	0.9	6.6	5.7	0	0.0	-164.0	-13.6	0.6	535.1
Natural Shrub Wetland	12	-0.9	1.7	1.3	0	0.0	642.9	0.3	0.0	-118.9
Treed Wetland	-15	0.9	18.4	13.5	-1	0.0	2150.0	-43.7	1.3	806.4
Industrial (Mining)	17	0.1	147.1	112.6	0	0.1	37660.1	3.2	-0.3	0.7
Settlement	-4	0.0	9.6	8.4	0	0.0	1065.8	-5.8	0.4	1.8
Open Water	-3	-0.1	-47.8	-43.9	0	0.0	-4770.3	7.6	-0.7	-8.2
Linear Disturbance	-662	0.2	123.1	7.1	-24	0.0	327289.6	24.3	-0.5	27.9
Agriculture	1	0.0	0.0	-0.1	0	0.0	-30.9	<0.01	<0.01	-0.5
Dense Conifer Old Forest	-58	6.4	67.2	57.2	-2	0.0	4204.4	-10.2	0.2	500.2

Fragmentation Statistics for a Comparison Scenario in the RSA – Baseline Case and Application Case at T27										
ELC Classes	Difference Between Baseline and Application at T14									
	# of Patches	Mean Patch Size (ha)	Total Area of Patch Type (ha)	Core Area (ha)	Patch Density (#/100 km²)	% of RSA	Perimeter Length (m)	Mean Perimeter : Area (m / ha)	Core Area Index (%)	Mean Distance to Nearest Neighbour (m)
Dense Deciduous Young Forest	0	0	0	0	0	0	0	0	0	0
Lush Herb	0	<0.01	<0.01	<0.01	0	<0.01	-4.8	<0.01	<0.01	<0.01