SECTION 6.5

EFFECTS OF THE ENVIRONMENT ON THE PROJECT

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6.5 EFFECTS OF THE ENVIRONMENT ON THE PROJECT

This Section includes a summary of available information on natural hazards and their potential effect on the Project. An overview of climate change and potential effects on the Project is also included.

6.5.1 Natural Hazards

A natural hazard is a potentially damaging process or phenomenon that occurs, or has the potential to occur, in nature.

6.5.1.1 Introduction

The objective of the natural hazards baseline survey was to collect potential natural hazards information that may occur within the Project area. The results of the natural hazards baseline survey were used to determine potential effects of the environment on the Project and to develop appropriate avoidance, mitigation and compensation strategies as needed.

Natural hazards considered for this Project include the following:

- forest fires;
- floods;
- terrain stability;
- seismic activity;
- weather and climate extremes; and
- climate change (discussed in Section 6.5.2, Effects Assessment below).

6.5.1.2 Information Sources and Methodology

Natural hazards were described using existing data sources on the internet and available baseline information compiled by others in support of the EIS. The primary internet references used for describing the natural hazards baseline conditions in the region included the following:

- Natural Resources Canada (NRCAN):
  - Atlas of Canada website (NRCAN 2004);
  - Earthquakes Canada website (NRCAN 2010); and
  - Floods Disasters in Canada website (NRCAN 2006). This database contains summary information on 168 Canadian flood disasters that occurred between 1900 and June 1997. The database is not a complete list of flood events in Canada since the vast majority of the floods did not cause disasters. All mentions of damage costs have not been corrected for inflation. The database also is biased towards the more densely populated areas of Canada where floods are more likely to impact humans.

- Saskatchewan Ministry of Environment (SMOE 2007) website; and
- Encyclopaedia of Saskatchewan (2006).

Available baseline information was summarized and reviewed. Those natural hazards that appeared to have occurred in the Project area within recorded history were carried forward into the effects assessment.

6.5.1.3 Forest Fires

Past/historical forest fire activity was provided by SMOE (2010). A map summarizing the forest fires between 1945 and 2009, as well as detailed maps showing fire activity for the years 2007, 2008 and 2009 are provided in Appendix 6.5-A.

The Project is located in an area that has been affected by several fires. According to the SMOE (2010) website, at least six fires greater than 100 ha have been recorded in the FalC forest, within 20 km of the Project since 1945 (Appendix 6.5-A), including two large fires (one occurring in the 1960's and the other in the 1980's) within the LSA and one 291 ha fire (09PA-English) occurring in 2009 approximately 5 km north of the LSA. Information from the NRCAN Atlas of Canada (NRCAN 2004) indicates that there were two fires in the Project area, in 1995 and 2000, with areas of 28,546 and 2,119 ha, respectively. The exact location of these two forest fires could not be determined from NRCAN (2004), but likely refer to the English Fire and Beaver Fire as identified below and are also included in SMOE (2010).

The FalC Integrated Forest Land Use Plan (FalC IFLUP) indicates that the extensive wildfire history in the FalC forest has contributed to a predominately over-mature and very young forest. Most wildfires have been small but significant wildfires have occurred, some overlapping onto previously burned areas, for example:

Steep Hill Fire – 1967	13,700 ha
Henderson fire – 1989	10,913 ha
English fire – 1995	28,400 ha
Beaver fire – 2000	2,119 ha

The total area burned by these wildfires is 55,132 ha or 41.6% of the forest; however,3,000 ha of this area was burnt by overlapping fires. Overlapping wildfires are one of the major causes of non-sufficiently regenerated areas.

Forest Protection Areas have been established across the Province of Saskatchewan to be operationally more effective when fighting wildfire. Forest Protection Offices with Forest Protection Officers and Forest Protection Fire Crews operate within each of these Forest Protection Areas.. The FalC forest is in the full response zone, and within the burning permit area. ‘Full response’ means that all wildfires are aggressively actioned until extinguished.

6.5.1.4 Floods

A detailed description of the hydrology within the project area is provided in Section 5.2.6 (Hydrology). Most flooding in Canada is caused by weather-related mechanisms, specifically runoff from snowmelt, storm rainfall, rainfall on snow and the obstruction of flow in rivers and streams by ice jams.

Available information from the NRCAN Atlas of Canada (NRCAN 2004) indicates that there have been no significant flooding events near the Project area. However, the Atlas of Canada did indicate that the Project was located within a river region that was more sensitive and vulnerable to climate change (Appendix 6.5-B).

The Project is located north of the Saskatchewan River, approximately 40 km downstream of the confluence of the North and South Saskatchewan Rivers. The flow in the Saskatchewan River is directly related to the amount of snowfall and rain in the mountains and foothills of Alberta. Where runoff rates from the Prairie portion of the watershed are in the order of 10 to 30 mm, median unit runoff from the mountains is in excess of 500 mm. With larger snowfall accumulations and higher elevations, snowmelt from the mountains typically peaks in June or July. Glaciers at the higher mountain elevations act as reservoirs, as melt of the annual snowfall accumulation is usually extended into August. Flood flows are usually associated with high snowmelt from the mountains in combination with widespread rainfall across the foothills.

Figure 6.5-1 shows the average monthly flows in the Saskatchewan River based on the combined records of the North and South Saskatchewan Rivers. Flows in the Saskatchewan River near the Project have been regulated since 1968 by the Gardiner Dam on the South Saskatchewan River, and to a lesser extent, since 1963 by the Brazeau and Bighorn dams in Alberta.

The Flood Disasters in Canada database contains two records of North Saskatchewan River (Alberta and Saskatchewan) flood disasters that occurred between 1900 and June 1997. One record indicated that during 1915 the combination of rain in the foothills and snowmelt resulted in the highest recorded spring flows on the North Saskatchewan River and multiple floods of the cities of Edmonton, Alberta and Prince Albert, Saskatchewan (Public Safety Canada 1997). The second record indicates that during 1986 the following events occured:

- Multiple floods of the North Saskatchewan River (Alberta and Saskatchewan);
- Between July 16 to 24 McLeod and Pembina (Alberta and Saskatchewan) rivers flooded;
- On July 18, a flood occurred in west central Alberta on the North Saskatchewan River, on several of its tributaries, and on tributaries of the Athabasca River;

- On July 19 records indicate that eventually Edmonton, Alberta, Battlefords and Prince Albert, Saskatchewan (July 22 and 24, respectively) also experienced flooding;
- The floods resulted from high precipitation amounts in the mountains, foothills and Great Plain regions, compounded by high antecedent soil moisture conditions;
- Crops were destroyed and farm buildings damaged;
- Hundreds of homes were flooded and severe erosion occurred within communities causing road and bridge damage and several washouts; and
- The extensive flooding also caused an overflow of several municipal sewer systems; 1 dead; estimated damage $28.3 million (Public Safety 1997).

It is not known how the Project area was affected during the 1915 and 1986 flood events. No major regional flood events were recorded on the South Saskatchewan River downstream of the Gardiner Dam, nor on the Saskatchewan River near the Project between 1902 and 2005 (NRCAN, 2005).

6.5.1.5 Terrain Stability

Terrain stability is identified in Section 6.2.1 (Soils, Terrain and Geology) as an issue for further discussion because of areas of steep slopes associated with Saskatchewan River tributary valleys and the Saskatchewan River valley within the LSA (see Figure 5.2.2-2).

Seismic activity can result in displacement and upheaval of surficial sediments and underlying bedrock, in initiating slides and slumps in sensitive terrain, in destructive effects on Project excavations and facilities, and in potentially unsafe situations (see Section 6.2.1). The 2005 National Building Code of Canada seismic hazard maps show that the peak ground disturbance with 2% probability of exceedance in 50 years (0.000404 per annum) for firm ground conditions is 0.059 g (1 g = 9.8 m/sec^2). This can otherwise be stated as probability being 10% for exceedance of peak ground acceleration of <0.2 m/s^2, on a 475 year return period (NRCAN 2010). These seismic parameters characterize the region of lowest seismic hazard in Canada.

Earthquakes of magnitude up to about 5.5 have been recorded in Saskatchewan, although all of these were located in the southern and south-western parts of the province (Gendzwill 2006).

Based on the above Geological Survey of Canada probability assessments and the historical information (Gendzwill 2006), it is considered improbable that seismicity will have an effect on the Project (Figure 6.5-2). This does not imply that earthquake events will not occur, but that it is considered improbable damage would result from an event, resulting in no further assessment required. With respect to local seismicity due to blasting operations, unstable terrain and mine walls could be affected. However, these issues will be mitigated through geotechnical design, mine operation and safety protocols, as defined within Section 2.0 (Project Description).

6.5.1.6 Weather and Climate Extremes

A detailed description of the climate is provided in Section 5.2.4.7 (Meteorology Results) in the air quality and meteorology section (Section 5.2.4). The air quality RSA is defined as a 25 km by 25 km area around the Project (see Section 6.2.4, Air Quality).

Weather can change from minute-to-minute, hour-to-hour, day-to-day, and season-to-season. Weather includes sunshine, rain, cloud cover, winds, hail, snow, sleet, freezing rain, blizzards, ice storms, thunderstorms, steady rains from a cold front or warm front, and excessive heat.

Climate is the average of weather over time and space. In short, climate is the description of the long-term pattern of weather in a particular area, usually taken over 30 years and is described as averages of precipitation, temperature, humidity, sunshine, wind velocity, phenomena such as fog, frost, and hail storms, and other measures of the weather that occur over a long period in a particular place.

Tornados

Tornadoes are columns of air that spin at a high rate of speed (Appendix 6.5-C). They are small in scale but can be very violent. The area affected by a tornado's passage is between about 40 and 400 m in width and between 1.7 and 36 km in length. During a tornado the damage is due to wind as well as an extremely sudden drop in pressure. Tornadoes vary in intensity, measured on the Fujita or F scale, graduated from 0 to 5 based on the level of damage. The main season for tornadoes is from April to October. The area of destruction is clearly demarcated next to the undamaged area. Also, tornadoes do not always remain on the ground, so the amount of damage is sometimes irregular along their paths. During a tornado, damage is not only due to the wind, but also to the sharp, extremely sudden drop in pressure, which can cause, among other things, the explosion of windows in buildings. The pressure inside the funnel can be as much as 90% lower than normal atmospheric pressure. This creates a suction effect within a tornado which can lift heavy objects into the air. The Project is located in an area estimated to have between 1.0 and 2.49 tornadoes per year per 10,000 km^2 as indicated in Figure 6.5-3.

The tornado risk is not considered high in the Project area, however tornadoes have been known to occur in the region.

Dust Storms and Wind Erosion

The regions that would have the highest sensitivity to a warming climate are likely to occur in the southern and central Prairies and in the southernmost part of Ontario. The levels of climate sensitivity were derived by comparing present and future ecoclimatic regions of Canada, based on the assumption of a doubling of atmospheric carbon dioxide concentrations over pre-industrial levels. Figure 6.5-4 below shows both the projected general patterns and the local details of these patterns. The NRCAN (2004) Atlas of Canada indicates that the Project is located in an area with moderate climatic sensitivity and severe wind erosion risk.

Wind erosion risk is based on the nature of local climate and vegetation. Areas with dryer, warmer climates and with sparse vegetation cover are more vulnerable to wind erosion. The degree of wind erosion risk is shown on the map by using heavier saturation of any of the colours (dark colour shades of any colour indicate a higher wind erosion risk).

The levels of climate sensitivity were derived by comparing present and future ecoclimatic regions of Canada, based on the assumption of a doubling of atmospheric carbon dioxide concentrations over pre-industrial levels. The projection of future ecoclimatic regions of Canada was developed by Rizzo and Wiken (1992).

Hail Storms

Hail is precipitation consisting of ice pellets with a diameter of 5 mm or more which is formed in the core of thunderstorms. Hail pelletscan exceed 10 cm in diameter and cause crop and property damage. Hail storms with large pellets are more common in the continental interior (from the eastern slope of the Rockies to southernmost Saskatchewan). Hailstorms are most common in the May to July period, usually with storms occurring in the afternoon. The hail portion of a storm (the hailfall) usually lasts from six to ten minutes.

There are no records of significant hail storms in the the Project (Appendix 6.5-D). However, severe hail storms did occur in the prairie provinces in 1994 and 1995 that caused $200 million in crop damage insurance and $50 million as a result of residence and vehicle damage. The specific location of these hail storms was not available.

6.5.2 Effects Assessment

The environment in which the Project is located may have minor (inconvenience) to more profound (Project damage that may require operations to cease for some period) effects on the Project. Following a review of the available baseline information the following natural hazards were selected which may affect the Project:

- Forest Fires;
- Terrain Stability;
- Floods; and
- Extreme Weather Events.

The environmental risks of each of the project components are assessed in Section 7.2 (Environmental Risk Management) and rated for both likelihood and potential consequence.

The assessment includes the hazard potential of occurrence and impact on Project facilities for the following potential environmental effects on the Project from:

- Naturally occurring events such asice storms; tornados, earthquakes and , forest fires; and
- off site anthropogenic forest fires.

6.5.2.1 Forest Fires

Wildfire is considered to have a medium likelihood, and is listed here as a result of the potential long term interruption of operations and potential effect on health and safety.

Based on the Forest Fire Management Strategy Zones developed by the Fire Management and Forest Protection Branch (SMOE 2010) the Project is located within the Prince Albert Fire Center Area Community Full Response Zone. Under Saskatchewan's fire management strategies, Community Full Response Zones are afforded the highest level of protection. Within 20 km of communities, all fires that pose a threat are managed with the intent of extinguishing them in order to relieve the danger they pose to communities.

A Wildfire Management Plan is included in the Draft Emergency Response Plan (Section 7.2.3.1; Appendix 7-A).

6.5.2.2 Terrain Stability

Terrain instability can affect the Project, with potential to disrupt Project activities and to compromise safety. Terrain stability mapping (TSM) completed for the LSA is reported in the Terrain, Soils and Geology baseline (Section 5.2.2). Five terrain stability classes were identified based on the parent material type, drainage conditions, slope gradient, and presence of geomorphic processes within a terrain polygon (British Columbia Ministry of Forests 1999). In general, terrain instability and the associated likelihood of landslide initiation increases with slope gradient, moisture content, and the presence of existing instability features. Terrain instability increases as the class increases, with terrain stability Class 5 having high potential for landslide initiation.

Within the Project footprint, Class 4 and 5 polygons, (see below Figure 6.5-4) which indicate the greatest potential for instability, occupy approximately 74 ha, and less than 1 ha, respectively (Table 6.2.2-5 in Section 6.2.1, Terrain, Soils and Geology). These ratings reflect the steep gullied slopes leading to the Saskatchewan River. As noted in the Terrain, Soils and Geology baseline (Section 5.2.2), terrain stability mapping within the LSA was based on mapping at a 1:30,000 scale.

Table 6.5-1: Terrain Stability Classes within Disturbance Areas in the LSA

Terrain Stability=Class 1	Likelihood of Landslide Initiation	LSA Baseline Area (ha)	LSA Baseline Area (% of LSA)	LSA Disturbance Area (ha)
1	Negligible	3,948	32.3	1,861.9
2	Very Low	6,066	49.6	2,031.5
3	Low	758	6.2	194.9
4	Moderate	796	6.5	74.1
5	High	240	2.0	0.8
Water	-	407	3.4	0.1
Disturbed Land	-	251	2.1	164
Total	-	12,218	100.0	4,163.1

Note: [1] Adapted from Forest Practices Code of British Columbia (British Columbia Ministry of Forests 1999).

Figure 6.5-5 shows that the following Project facilities may be affected from landslides rated as having a moderate to high likelihood of initiation:

- Star Pit along the East Ravine and along the northern bank to the Saskatchewan River;
- the southern end of the water management reservoir along the Duke Ravine; and
- the outfall pipeline crossing the northern bank of the Saskatchewan River.

6.5.2.3 Floods

As mentioned in Section 2.9.2 (Catastrophic Events), pit flooding of either the Star Pit or Orion South pit could occur by: failure of the dewatering wells leading to an influx of groundwater; or extreme precipitation events. Prevention and mitigation measures have been developed for each of these potential catastrophic events and include inspections and surveys, mine planning, and designing redundancy into the dewatering system.

There are four phases in dealing with any type of natural disaster, including flooding. They are: mitigation, preparation, response, and recovery. These phases can be followed by communities, businesses, organizations, and individuals. Mitigation means taking measures in advance to avoid and/or minimize the risk. Preparation implies planning for how you will respond to the event (SWA 2007).

Based on recent review of watershed data for the North Saskatchewan River (SWA 2007) all communities in the North Saskatchewan River watershed are at flood risk from locally generated runoff from intense thunderstorms. Portions of the communities of Battleford, North Battleford, and Prince Albert are also at risk from flooding on the North Saskatchewan River, and in the case of Battleford, from the Battle River as well. A portion of Prince Albert is also vulnerable to floods from the Spruce River. The Shell River Heights subdivision just outside of Prince Albert is vulnerable to floods on the Sturgeon River as well as from the North Saskatchewan. Floods at all these communities can either be from high flows in the rivers, or from ice jams. Ice jam flooding occurred in 1943 on the North Saskatchewan River at Prince Albert and in 2005 on the Battle River. Particularly high flow rates on the North Saskatchewan River have been observed in 1915, 1974, and 1986. Historic information also indicates an extreme flood occurred on the North Saskatchewan in 1899. Severe flooding on the South Saskatchewan River downstream on the Gardiner Dam is unlikely.

Flood levels may occur in response to precipitation and snow melt events. The percent difference in discharges due to flood events during construction and operations will stay the same within the watershed compared to baseline conditions. A reduction in flood discharges will be proportional to the reduction in drainage areas of affected watersheds.

An overflow to account for the 1:100 year flood has been designed for the water management reservoir.

Potential flooding of the North Saskatchewan River (and to a lesser extent, the South Saskatchewan River due to flow regulation) caused by high precipitation amounts in the mountains, foothills and Great Plain regions, compounded by high antecedent soil moisture conditions may result in the following process and effects:

- erosion of the Saskatchewan River;
- trigger landslides on the north bank of the Saskatchewan River;
- reduce the width of land separating the Star Pit and the Saskatchewan River
- flood the Star Pit by inflow from Saskatchewan River through East Ravine and or breach of adjacent Saskatchewan River northern bank.

To evaluate the flooding potential in the area of the Project a frequency analysis was conducted to get a value for the 1 in 250 year flood (1:250 year flood) based on the 41 years of record on the North and South Saskatchewan Rivers. This approach indicated an approximate 1:250 year flood value of 5,950 m^3/s. Based on the length of record and range of recorded flood magnitudes, this 1:250 should be considered an estimate.

The estimated flood value was then input into the River2D model that was designed for the outfall modelling based on the bathymetry and flow surveys, to get water levels and velocities. The model shows a water level rise to approximately 358 masl for the 1:250 year flood discharge estimate of 5,950 m^3/s. Velocities of 2.5 to 3.0 m/s are indicated in the upper reach near the diffuser. For comparison for the 1 in 100 year (1:100) flood event, the model predicted a water surface elevation of 357.15 masl and a velocity of about 2.2 m/s.

In the area of the Project, the northern bank of the Saskatchewan River valley rises approximately 50 m above the normal water level of the Saskatchewan River at this location. Whereas the southern bank of the Saskatchewan River valley in this area is approximately 12 m lower than the northern bank. In addition, the elevation of the East Ravine where it intersects the Star pit is approximately 387 masl. This low point it about 29 m higher than the 1:250 flood event elevation. As a result there is no risk of the Saskatchewan River flooding into the Star Pit.

While the higher velocities would be expected during a 1:250 flood event, they are not much greater than those experienced during smaller (i.e. 1:100 or 1:50 year) flood events, due to the widening of the river valley. There is at least approximately 400 m (at the closest point) separation between the Saskatchewan River and the top of the Star Pit. The dewatering of the area around the Star Pit is partially being implemented to increase the stability of the sediments around the Star Pit. There will also be on-going monitoring of the slope stability in the area of the Star Pit. Therefore, during flood event such as a 1:250 year event, while some additional erosion would be expected and potentially minor slides, an impact on the Star Pit is not expected.

If soil erosion or minor landslides did occur during such a flood event then remedial actions could be undertaken to protect the remaining land bridge and/or armour or protect the land bridge from future flood events. These remedial actions could include:

- the addition of soil on either side of the land bridge, and
- armouring with rocks or geotextiles.

In addition, at the end of mining in the Star Pit (approximately Year 9), the plan is to start reinforcing the southern side of the Star pit with overburden excavated from the Orion South pit. As a result, remedial mitigative measures are already included in the Project design.

6.5.2.4 Extreme Weather Events

Extreme storm events (i.e. those involving high winds, intense rain or hail/snow storms) may occur resulting in a temporary decrease or halt of mining operations. Implementation of specific management strategies (Section 7.2.2, Appendix 7-A) to deal with extreme storm events developed to mitigate potential adverse effects will reduce or eliminate potential Project effects.

6.5.3 Climate Change

The global climate has warmed over the past century (1900 to 1999), and it is generally accepted that the warming has been accelerating in the past two decades. There is a widely-accepted scientific consensus that this change is largely due to an increase in the atmospheric concentration of CO_2 and other greenhouse gases (GHGs) as a result of human activity. The island forests of central Saskatchewan, which includes the FalC forest, are climatically marginal for boreal forest, and climate change modeling suggest that forest in these areas may be converted to grassland over the coming century. One way in which this could occur is by failure of tree regeneration following disturbances such as fire and timber harvest (SRC 2008).

This section provides a general summary of climate change associated with the province of Saskatchewan and discusses the potential effects that climate change may have on the Project.

6.5.3.1 Regional Climate Change

The following main references were reviewed and used to compile the regional climate change summary section:

- Climate Scenarios for Saskatchewan (Barrow 2009);
- Prairies; From Impacts to Adaptation: Canada in a Changing Climate 2007 (Sauchyn and Kulshreshtha 2008); and
- National Research Council, Atlas of Canada Climate Change Scenarios (NRCAN 2004).

Due to the many unknown factors associated with climate change it is difficult to predict associated effects that the environment may have on the Project. Natural variability must be considered when assessing climate change. Analysis of temperature data from 12 climate stations across the prairies shows a warming trend shown in Figure 6.5-6 (Sauchyn and Kulshreshtha 2008) has been occurring throughout the prairies, especially since the 1970s. The average increase in mean annual temperature for the 12 stations is 1.6°C.

Along with the trend in increasing minimum temperatures throughout the region, the numbers of frost free days have also been increasing across the region. The Canadian Prairies are now experiencing on average 19 more frost free days a year than 75 years ago. This lengthening of the freeze-free season can improve agricultural growing conditions, but may also increase problems with plant pests and disease.

The Prairie Adaptation Research Collaborative (PARC) completed a project that projected changes in global average climate mean for Saskatchewan specifically (Barrow 2009). Figures 6.5-7 and 6.5-8 show the modelling results into the 2050s which indicate that temperatures and precipitation respectively would increase.

Environment Canada's Coupled Global Climate Model (Environment Canada no date) has predictions of temperature and precipitation for Saskatchewan. Change from 1961-1990 (averages) by 2040 to 2060 would be as follows:

Annual temperature	+3 to +4°C	Annual precipitation	+10 to +20%
Winter temperature	+4 to +5°C	Winter precipitation	+10 to +20%

Summer temperature +2 to +3°C Summer precipitation 0 to +10%

The most substantial changes in temperature are not in the summer highs and the winter lows, but the changes during the shoulder seasons (spring and fall). Precipitation patterns are more complex, because of geographical impacts. Warmer average temperatures in the Project region could lead to earlier springs and possibly more intense spring freshet which may need to be accounted for by water management planning and structures.

There is considerable uncertainty about applying the results of climate change models to a specific regions, however, the evidence suggests future warming in Saskatchewan, but at a rate that is difficult to estimate.

6.5.3.2 Effects of Climate Change on the Project

Climate change is expected to result in greater variability in weather patterns compared to present. Droughts will still occur and some events may be more extreme. At the same time there may also be very wet periods.

It has been argued (SRC 2008) that the island forests in central Saskatchewan may already be showing signs of climate change impacts, and are likely to be more affected in the future. Particular sources of vulnerability of the island forests including the FalC forest are: an aging forest, large areas affected by dwarf mistletoe, susceptibility to a future mountain pine beetle outbreak, a relatively large fire hazard and negative impacts on tree growth due to drought and low water-holding capacity soils (SRC 2008).

The transition from forest to grassland in this region of the Canadian Prairies is linked to climatic moisture balance, and the Island Forests are close to the threshold at which moisture becomes insufficient to support continuous forest vegetation (SRC 2008). Hogg (1994) mapped a climate moisture index (CMI) for the prairie provinces, which he calculated as annual precipitation minus annual potential evapotranspiration. The zero value of Hogg's CMI coincides almost exactly with the southern boundary of the boreal forest across Alberta, Saskatchewan and Manitoba. This correlation suggests that positive values support forest while negative values support grassland/aspen parkland vegetation. Maps of average CMI presented by Hogg et al. (2007) showed that the FalC forest is roughly at a CMI of 5 cm (SRC 2008). Hogg's work suggest that a shift from forest to grassland in the island forests in response to climate is a strong possibility. This shift to grasslands could be accelerated by major disturbance events such as wildfire and timber harvesting. Failure of tree regeneration following disturbance is a likely mechanism for the predicted change in vegetation zonation (SRC 2008).

Forest management also has the potential to help deal with some of the identified climate effects on island forests. Some of the potential management strategies (SRC 2008) are:

- immediate and aggressive regeneration of harvested (and possibly burned) stands will help ensure that forest cover is maintained;
- selection of seed from drought-resistant individuals could also help maintain forest cover in the future; and
- experimental planting and monitoring of exotic species (e.g. red pine, ponderosa pine) may help identify species that will grow better under future conditions.

It is recognized (SRC 2008) that even with adoption of these management practices for reducing risk, the island forests may permanently lose forest cover in the future as a result of climate change and increased development pressure. Therefore management planning of the FalC forest needs to include the potential for a change to grassland in the future.

From a climate change perspective, effects of the environment on the Project would be predicted to be associated with changes in regional temperatures which would increase the potential for forest fires and flooding. Specific information associated with potential effects of forest fires and flooding on the Project associated with climate change is provided below.

Forest Fires

Forest fire frequency and severity are expected to increase in Western Canada under future climate scenarios (SRC 2008). Forest fires in Canada's boreal forests currently burn an average of 2.5 million hectares annually. Fire is a natural and necessary force, shaping the landscape and ensuring the healthy growth of new forests. The frequency, extent and impact of boreal fires are primarily controlled by fire management measures, short-term weather conditions, as well as the age structure of the forest. Climate simulations were used to project forest fire danger levels with relation to global warming. The climate simulations indicated that large increases in the areal extent of extreme fire danger and a lengthening of the fire season were predicted for the periods 1980-1989, 2050-2059 and 2090-2099. Moreover, the warming impacts may include more frequent and severe fires, shorter growth periods between fires, proportionally younger stands, and a decrease in the carbon storage of northern Canadian forests.

The forest fire maps for the three time periods demonstrate the same general spatial pattern in terms of the fire severity level (Appendix 6.5-E). Historically, the regions having the most significant forest fire activity in Canada have been in west-central Canada. However, the areas with high sensitivity to forest fire are expected to expand geographically through time.

For the period 1980 to 1989, the areas with the highest forest fire danger levels were in the southern Prairies, southern Ontario and the north-western parts of the North West Territories. For the period 2050 to 2059, the projected distribution of forest fire severity levels is similar to the 1980 to 1989 map, with a general geographic expansion. The areas with high severity ratings are projected to expand into the central Prairies, southern British Columbia and south-western Yukon. For the period 2090 to 2099, the areas sensitive to forest fire are further expanded in the central and northern parts of the Prairies, southern and eastern British Columbia, southern-central Yukon, and the north-western Ontario.

The Seasonal Severity Rating (SSR) is a measure of fire danger conditions over a complete fire season. Information provided by NRCAN (Appendix 6.5-E) indicates that the Project is located in area rated 4.0 to 6.0, with the most extreme rating being >6.0.

Drier conditions due to climate change will likely lead to regeneration failure following fire or harvest on some sites (SRC 2008).

Flooding

A summary of potential effects of climate change on flooding within the Project area is provided in Section 5.2.6.8 (Climate Change). Current global climate change models are not directly used to predict extreme rainfall or flooding. They can only provide predictions over large areas, much larger in size than the Project area.

NRCAN (2009) indicates that while most climate change predictions suggest an increase in the frequency of drought within the southern Prairies, some suggest that there may be no major change in drought frequency. These models also indicate that while air temperatures in the Prairie Provinces have warmed over the past 50 years, most of that warming has occurred in the winter, with a modest increase in the summer.

Analysis of several climate change scenarios indicates the frequency of drought could increase, and drought could be exacerbated by increased evaporation. Conversely, periods of wet cool weather could also occur. The overall results would be more variable conditions.

There is conflicting information about winter snowfall changes. Warmer winter conditions may result in reduced snowfall and earlier spring freshet (NRCAN 2009). Research at the University of Saskatchewan by Pomeroy (Rowley 2008) indicates that as winters become warmer, more snowfall and rainfall are predicted. More snowpack may result as the heavier, wetter snow may not be blown around and sublimated as readily by the fewer number of snowstorms (expected to be suppressed during warmer winters). Warm winters may also create ice layers in the snow and soil which can result in greater runoff to streams and sloughs.

Information from the NRCAN website (Appendix 6.5-B) indicated that the site is located in a river region identified as more sensitive and vulnerable to climate change from a flooding perspective.

Changes in the environment are not expected to affect the regional geology and hydrogeology of the Project directly. However, climate change or long term climate variations that lead to drier conditions may make it difficult to distinguish between the effect of mine dewatering on local creeks and wells and dry conditions. Long term monitoring of groundwater, surface water and climate data from the mine site and in area(s) outside the LSA as described in Section 7.4 will help to distinguish between mine induced effects and climate related variations.